FINAL

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT
INTEGRATED OCEAN DRILLING PROGRAM –
U.S. IMPLEMENTING ORGANIZATION (IODP-USIO)

Prepared By:
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on Behalf of
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in Collaboration with
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June 2008

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EXECUTIVE SUMMARY

This Programmatic Environmental Impact Statement (PEIS) evaluates potential environmental impacts associated with the NSF funding of the United States Implementing Organization's (USIO) participation in the Integrated Ocean Drilling Program (IODP). The IODP is an international research program that explores the history and structure of the earth as recorded in seafloor sediments, fluids, and rocks. Based on international agreements, the IODP-USIO proposes to operate the modernized and retrofitted *JOIDES Resolution,* also referred to as the Scientific Ocean Drilling Vessel (SODV), to provide a light, riserless drilling vessel to conduct earth sciences research throughout the world's oceans as part of the IODP.

The Consortium for Ocean Leadership formerly the Joint Oceanographic Institutions, Incorporated (JOI) and its partners, the Lamont-Doherty Earth Observatory of Columbia University (LDEO) and Texas A&M University (TAMU) through the Texas A&M Research Foundation (TAMRF), have been selected by the National Science Foundation (NSF) to be the IODP-USIO for the light drilling vessel and related activities.

The proposed action encompasses the USIO's implementation of riserless ocean drilling techniques that have evolved and been refined for over thirty years. Proposed activities include the mechanical operation of the vessel, riserless ocean drilling, core sampling, seismic surveys or long-term deployment of reentry devices and instrumentation at selected sites, seismic profile experiments or supplemental seismic surveys at certain sites, and related onboard research activities. The *JOIDES Resolution* will provide a modernized riserless drilling platform incorporating improvements to the quality and rate of core samples, and will feature twelve modernized laboratories, allowing for a greater variety of instrumentation that onboard scientists can use to analyze cores samples while at sea.

This PEIS addresses the use of the *JOIDES Resolution* and the USIO's participation in IODP Phase 2 drilling operations for at least the next 20 years. The PEIS evaluated three alternatives including: (A) ocean drilling as dictated by specific scientific research needs and consistent with robust IODP policies; (B) riserless ocean drilling expeditions designed and conducted to meet site-specific scientific objectives, however without input from the IODP Science Advisory Structure process including the review of environmental conditions at each drillsite that may be adversely affected by drilling activities; and (C) the no action alternative.

The PEIS is designed to view the USIO drilling program as a whole and thereby assembles and analyzes the broadest range of direct, indirect, and cumulative impacts associated with the entire program independent of specific geographic location rather than assessing individual cruises separately. Activities addressed in the PEIS include operations associated with the vessel while in transit, outputs occurring during drilling and the completion of boreholes, and research-related activities including the long-term deployment of instruments. The PEIS evaluated potential effects on marine water quality, sea bottom and sediment quality, air quality, acoustic environment, marine biological resources including marine mammals, fish, sea turtles, invertebrates, Essential Fish Habitats (EFH), and threatened and endangered species, commercial and recreational fisheries, marine vessel transportation, and cultural resources as well as impacts resulting from accidental events.

The potential impacts resulting from the proposed activities for each of the alternatives under consideration are summarized in Table ES-1. In the event that a proposed ocean drilling expedition is planned to be conducted in a highly sensitive environment which is beyond the conditions described in this PEIS, a supplemental assessment will be prepared to evaluate those site-specific conditions and potential impacts. This process enables NSF to identify any prudent conservation practices and mitigation measures that may be applied across the entire program or applicable to a particular expedition.

The findings of this PEIS indicate that a majority of the outputs associated with the performance of riserless drilling expeditions in either Alternatives A or B would have minor and transitory effects on the environment. Most impacts associated with the proposed action would be highly localized and would disappear once the vessel completes drilling activities at a particular site and leaves the area. Many of the outputs associated with the operation of the *JOIDES Resolution*, exclusive of drilling outputs, such as wastewater discharges, air emissions, noise from propulsion equipment and transducer-based equipment are common to most merchant marine vessels. Some outputs associated with riserless drilling activities (seafloor disturbance, deposition of sediment drill cuttings, deployment of equipment or materials) may remain evident on the seafloor after borehole drilling is complete on a long-term basis; however the effects on the benthic environment would be minor.

The potential scientific benefits of the proposed operation of the *JOIDES Resolution* including riserless drilling and related research activities are known to be substantial. The knowledge that will be gained from the scientific research will far outweigh the relatively localized and minor impacts to the marine environment.

This EIS has been prepared consistent with the requirements of the National Environmental Policy Act (NEPA). The NSF is the lead agency for the proposed action, with National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service acting as a cooperating agency. This PEIS is also consistent with Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, which directs federal agencies to provide for informed decision making for major federal actions outside the U.S., including the global commons, the environment of a non-participating foreign nation, or impacts on protected global resources.

The scoping process for this PEIS was initiated by the publication of a Notice of Intent (NOI) in the Federal Register. Scoping presentations were held in San Diego, CA (15 February 2006), College Station, TX (17 February 2006), and Silver Spring, MD (February 23, 2006) notifying the public of the beginning of the PEIS process. No responses were received from the general public however federal agencies and earth sciences researchers attended the scoping presentations.

After scoping, the Draft PEIS was prepared, which provided an evaluation of the potential impacts of proposed federal action on the human or natural environment. The draft PEIS also informed decision makers and the public of reasonable alternatives that would avoid or minimize adverse impacts, or enhance the quality of the environment. A Notice of Availability (NOA) of the Draft PEIS was published by the U.S. Environmental Protection Agency (USEPA) in the 17 August 2007 Federal Register, and the document was made available for review and comment over a 45-day period to government agencies and to those persons or organizations that may be interested or affected. In addition, two public meetings were held in Silver Spring, MD (21 September 2007) and Washington D.C. (28 September 2007) to seek comments and additional input. No comments on the Draft PEIS were received from any agencies, organizations, or the public.

Subsequent to this final PEIS, a Record of Decision (ROD) will be issued and will be published in the Federal Register. The ROD will establish the proposed action, describe the public involvement and agency decision-making processes, and present commitments to specific mitigation measures. The proposed action can then be implemented.

Table ES-1. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
Operate the SODV (vessel in transit and at a drill site using thrusters for dynamic positioning; note: impacts associated with drilling and coring activities are summarized below)	Discharges (treated wastewater, greywater, treated bilgewater, deck drainage, ballast water, treated lab discharges)	Water Quality	Short term	Local	Minimal	Unlikely (A,B)	1
		Seafloor	No environmental impacts				0
		Biological Resources					
		Typical	Short term	Local	Minimal	Unlikely (A,B)	2
		Sensitive Areas	Long term	Local	Minimal	Possible (A)	3
			Short term			Unlikely (B)	2
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
	Physical Disturbances	Water Quality	Short term	Local	Minimal	Unlikely (A,B)	1
		Seafloor	No environmental impacts (A,B)				0
		Marine Traffic	Short term	Local	Minimal	Unlikely (A,B)	1
	Underwater Noise (operation of vessel engines, generators, thrusters, mechanical systems, instruments, transponder beacons)	Acoustical Environment	Short term	Local	Minimal	Unlikely (A,B)	2
		Biological Resources					
		Typical	Short term	Local	Minimal	Unlikely (A,B)	1
		Sensitive Areas	Long term	Local	Minimal	Possible (A)	2
			Short term			Unlikely (B)	1
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
	Air Emissions • exhaust, vapors	Air Quality	Short term	Local	Minimal	Unlikely (A,B)	1
	• laboratory	Air Quality	Short term	Local	Minimal	Unlikely (A,B)	1
	Hazardous Materials (storage & use)	Vessel Crew & Resources	Continuous	(Not Applicable)	Minimal	Unlikely (A,B)	0

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Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
	Solid & Hazardous Waste (handling, storage, incineration)	Vessel Crew & Resources	Continuous	(Not Applicable)	Minimal	Unlikely (A,B)	0
Conduct Riserless Drilling and Coring (in addition to impacts associated with the operation of the SODV)	Discharges (seawater drilling fluid, sediment displaced from the borehole, drilling mud, cement, tracers)	Water Quality	Short term	Local; seawater drilling fluid injected into the borehole at ≤ 1,900 L/min; suspended fine grain particles may extend 100+ m from the borehole	Minimal	Certain (A,B)	2
		Seafloor	Short term	Local; fine grain particles deposited within 100 m of the borehole	Minimal	Certain (A,B)	2
		Biological Resources					
		Typical	Moderate	Local; benthos & fish eggs/larva may be displaced	Minimal	Possible (A,B)	2
		Sensitive Areas	Long term	Local; habit may be disturbed	Moderate	Possible (A)	3
						Unlikely (B)	3
		Fisheries	Short term	Local; fish may be displaced	Minimal	Possible (A)	2
						Unlikely (B)	2
		Cultural Resources	Long term	Local; sediment deposition	Minimal	Unlikely (A)	3
						Highly Unlikely (B)	3
	Physical Disturbances	Water Quality	No environmental impacts (A,B)				0
		Seafloor	Long term	Local; drill cuttings mound within ~5 m of borehole	Minimal	Certain (A,B)	3
		Biological Resources					

Table ES-1. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
		Typical	Moderate	Local; benthos may be displaced or smothered	Minimal	Possible (A,B)	3
		Sensitive Areas	Moderate	Local; benthos may be displaced or smothered	Moderate	Possible (A)	3
						Unlikely (B)	3
		Fisheries	Moderate	Local	Minimal	Possible (A)	3
						Unlikely (B)	3
		Marine Traffic	Short term	Local	Minimal	Unlikely (A,B)	1
		Cultural Resources	Long term	Local; damage or alteration	Minimal	Unlikely (A)	3
						Highly Unlikely (B)	3
	Underwater Noise (operation of vessel engines, generators, thrusters, mechanical systems, instruments, transponder beacons, drilling/coring)	Acoustical Environment	Short term	Local	Minimal	Unlikely (A,B)	2
		Biological Resources					
		Typical	Short term	Local	Minimal	Unlikely (A,B)	1
		Sensitive Areas	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
Conduct Research Activities (geophysical logging, downhole measurements)	Discharges (none)	Water Quality	No environmental impacts (A,B)				0
		Seafloor	No environmental impacts (A,B)				0
		Biological Resources					
		Typical	No environmental impacts (A,B)				0
		Sensitive Areas	No environmental impacts (A,B)				0
		Fisheries	No environmental impacts (A,B)				0
	Underwater Noise (small seismic sources)	Acoustical Environment	Short term	Local	Minimal	Unlikely (A,B)	2

Table ES-1. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts				
			Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
		Biological Resources					
		Typical	Short term	Local	Minimal	Possible (A,B)	1
		Sensitive Areas	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
Complete Boreholes and Install Equipment	Releases/Discharges (heavy drilling mud for borehole closure, cement for casings and borehole seal, deployment of reentry devices, observatories and instruments)	Water Quality	Short term	Local	Minimal	Unlikely (A,B)	2
		Seafloor	Long term	Local	Minimal	Likely (A,B)	3
		Biological Resources					
		Typical	No environmental impacts (A,B)				0
		Sensitive Areas	No environmental impacts (A,B)				0
		Fisheries	No environmental impacts (A,B)				0
Accidental Events	Discharges (petroleum hydrocarbons from major fuel spill from the vessel; liquids and/or gases from blowout caused by drilling into geological source)	Air Quality	Short term	Local (petroleum vapors, geologic gasses)	Severe	Highly Unlikely (A,B)	2
		Water Quality	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Seafloor	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Acoustical Environment	No environmental impacts (A,B)				0
		Biological Resources					
		Typical	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Sensitive Areas	Long term	Major	Severe	Highly Unlikely (A,B)	4

Table ES-1. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts				
			Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
		Fisheries	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Marine Traffic	Long term	Major	Severe	Highly Unlikely (A,B)	4

Notes: **Severity Ratings: 0** = no impact; **1** = minimal local effect that ceases immediately after the vessel leaves a particular drill site; **2** = minimal local effect that continues for a limited period of time after the vessel has left a particular drill site; **3** = minimal local long-term effect; **4** = substantial effects that may be realized on a major (regional) and long-term basis.

1.0 INTRODUCTION

1.1 United States Participation in the Development of Scientific Ocean Drilling

Scientific ocean drilling represents one of earth science's longest running and most successful international collaborations. In 1961 when drilling technology was used to successfully recover the first sample of oceanic crust, scientific drilling took root as a new scientific discipline. Over the next 45 years, scientific ocean drilling revolutionized earth science, as it continues to do today (see Figure 1-1).

1.1.1 Project Mohole

The vision and reality of deep ocean drilling began in 1961 with Project Mohole. Project Mohole, led by the American Miscellaneous Society with funding from the National Science Foundation, was an ambitious attempt to drill through the Earth's crust into the Mohorovičić discontinuity and to provide an earth science complement to the high profile Space Race.

Project Mohole contracted with Global Marine of Los Angeles for the use of its oil drillship called CUSS I. Consortia of Continental, Union, Superior and Shell Oil Companies (CUSS) had originally developed the drillship in 1956 as a technological test bed for the nascent offshore oil industry. While "CUSS I" was one of the first vessels in the world capable of drilling in water depth up to 183 m (600 ft), Project Mohole expanded its operational range by virtually inventing what is now known as dynamic positioning (See Figure 1-2).

Phase One was executed in the spring of 1961. Off the coast of Guadalupe, Mexico, five holes were drilled, the deepest at 183 m (601 ft) below the sea floor in 3,500 m (11,700 ft) of water. This was unprecedented, not in the hole's depth but because of the depth of the ocean and because it was drilled from an untethered platform. Also, the core sample proved quite valuable, showing Miocene age sediments with the lowest 13 m (44 ft) consisting of basalt. Phase One proved that both the technology and expertise were available to drill into the Earth's mantle. However, Mohole-Phase Two was dissolved in 1966 for budgetary reasons.

Figure 1-1. History of U.S. Scientific Ocean Drilling

1950s

- The **American Miscellaneous Society** (AMSOC) submits proposal to NSF in **1957** to drill a hole on the seafloor to reach the Mohorovicic seismic discontinuity that marks the boundary between the Earth's crust and mantle.

"It is an amazing experience to be able to walk onto a ship and carry out a scientific program that is technically very complex...The overall reliability of the operation is something that ODP can be proud of."

1960s

- During **PROJECT MOHOLE**, the *CUSS I* cores through 200 m of sediment and 14 m of basalt in 3,800 m water depth west of Mexico in **APRIL 1961**. This was made possible by the invention of dynamic positioning, which keeps the drilling vessel stationary over a point on the seafloor.
- During **PROJECT LOCO**, the *Submarex* cores through 55 m of sediment near Jamaica in **1963**.
- The Joint Oceanographic Institutions for Deep Earth Sampling (**JOIDES**) form an ocean drilling consortium in **1964**.
- During **PROJECT CALDRILL**, the *Caldrill* cores six holes across the Blake Plateau in **1965**.
- The *Glomar Challenger* sets sail on the first **Deep Sea Drilling Project** cruise (DSDP Leg 1; Gulf of Mexico) in **1968**.
- The theory of seafloor spreading is confirmed during Leg 3 in the southern Atlantic Ocean, **JANUARY 1969**.

1970s

- The first use of a reentry cone on **14 JUNE 1970** allows the reoccupation of an existing borehole during Leg 11, western North Atlantic.
- Evaporites recovered during Leg 13 show that the Mediterranean was a dry basin in the late Miocene, **OCTOBER 1970**.
- Site 270 is cored at a southernmost latitude of 77.5°S in the Ross Sea on **29 JANUARY 1973**, during Leg 28.
- Climate cycles correlated to periodicities in Earth's orbit are seen in sediments recovered during Leg 39, western South Atlantic, **OCTOBER 1974**.
- France, Germany, Japan, the United Kingdom, and the USSR join JOIDES in **1975**, initiating the **International Program for Ocean Drilling** (IPOD) phase.
- Site 461A is cored in the deepest water depth of 7,034 meters at the Mariana Trench on **10 MAY 1978**, during Leg 60.
- Living microorganisms in shallow marine sediments are recovered in the Gulf of California during Leg 64, **JANUARY 1979**. The introduction of the hydraulic piston corer enables the recovery of undisturbed sediments.

1980s

- Evidence for major Northern Hemisphere glaciation around 2.4 million years ago is recovered from the Rockall Plateau during Leg 81, **AUGUST 1981**.
- The first short-term ocean-bottom seismometer is installed in the northwest Pacific during Leg 88, **AUGUST 1982**.
- The *JOIDES Resolution* sets sail on the first **Ocean Drilling Program** cruise (ODP Leg 100; Gulf of Mexico) on **29 JANUARY 1985**.
- A shift to a dryer climate in central Africa thought to have led to human migration from Africa starting 2 million years ago is documented during Leg 108, northwestern margin of Africa, **APRIL 1986**.
- The establishment of a permanent West Antarctic ice sheet around 5 million years ago is documented during Leg 113 in the Weddell Sea, **JANUARY 1987**.
- Evidence of long-lived hotspot tracks is recovered during Leg 115 in the Indian Ocean, **JUNE 1987**.
- Uplift of the Himalayas is proposed to have enhanced global cooling, Leg 116, Indian Ocean, **AUGUST 1987**.
- The oldest ocean crust in the northwest Pacific is confirmed to be Jurassic in age (~170 Ma) during Leg 129, **DECEMBER 1989**.

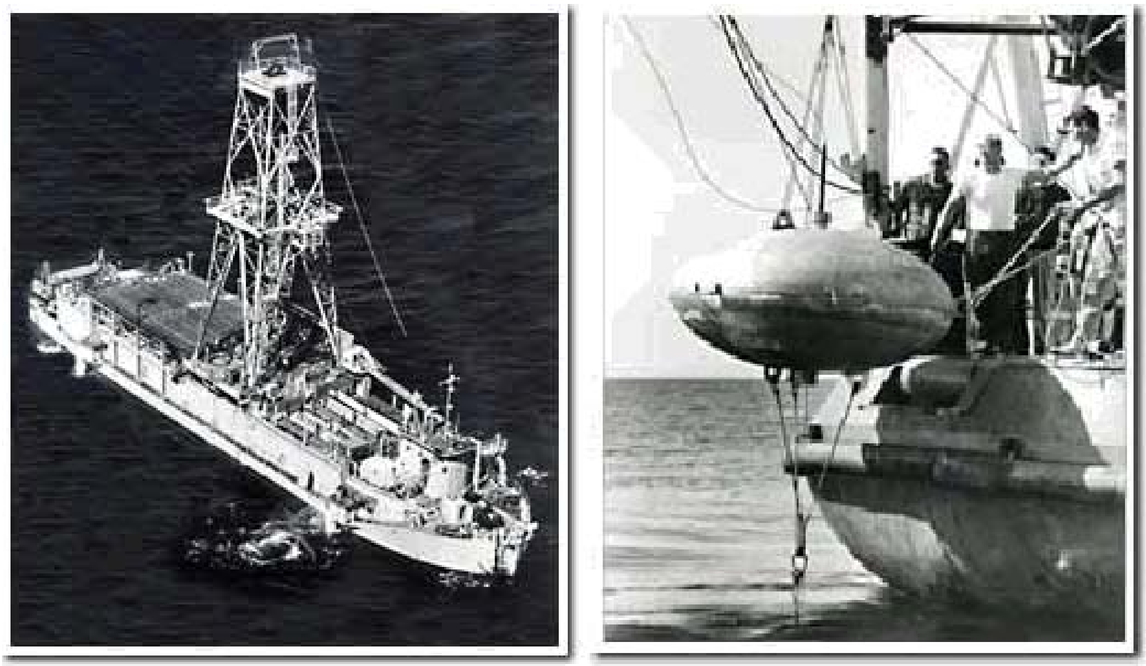
1990s

- Hydrothermal metal deposits are recovered from the Juan de Fuca Ridge during Leg 139, **JULY 1991**.
- Hole 504B penetrates into pillow lavas and sheeted dikes of the Costa Rica Rift during Leg 140, **NOVEMBER 1991**.
- Hole 504B becomes the deepest ocean borehole at 2,111 m on **23 FEBRUARY 1993** during Leg 148.
- A link between ice sheet volume and sea level change is demonstrated during Leg 150, eastern margin of North America, **JULY 1993**.
- Large amounts of gas hydrates are found in sediments during Leg 164, eastern margin of North America, **DECEMBER 1995**.
- Evidence of the impact of a meteorite with Earth 65 million years ago, believed to have contributed to the extinction of the dinosaurs, is recovered during Leg 171B on the Blake Nose, **JANUARY 1997**.
- A record amount of core (8,003 meters) is recovered during Leg 175 west of Africa, **OCTOBER 1997**.
- Microbes living in sediments 800 meters beneath the seafloor are discovered during Leg 180 in the Woodlark Basin, **AUGUST 1998**.
- The first long-term ocean-bottom seismometer is installed during Leg 186 off the east coast of Japan, **JUNE 1999**.

2000s

- The timing of the opening between Australia and Antarctica, which was critical to the formation of the Antarctic Circumpolar Current and cooling of the Earth that started 33 million years ago, is confirmed during Leg 189 south of Australia, **MARCH 2000**.
- Abrupt climate change during the Paleocene/Eocene Thermal Maximum and Eocene hyperthermals is documented during Legs 198 and 199, central Pacific Ocean, **DECEMBER 2001**.
- The *JOIDES Resolution* sets sail on the first **Integrated Ocean Drilling Program** cruise (IODP Expedition 301; Juan de Fuca Ridge) on **28 JUNE 2004**.
- The *Vidar Viking* cores Site M0003 at a northernmost latitude of 87.9°N at the Lomonosov Ridge during Expedition 302, **AUGUST 2004**.
- Site 1256 penetrates the sheeted dike–gabbro transition in intact ocean crust during Expedition 312 in the Guatemala Basin, **DECEMBER 2005**.
- The *Chikyu* sets sail on her first IODP cruise (Expedition 314; east of Japan) on **21 SEPTEMBER 2007**.
- The converted *JOIDES Resolution* with enhanced science laboratories and improved drilling capabilities resumes IODP operations in **2008**.

Figure 1-2. Project Mohole Drillship, CUSS I



(Left) Overhead view of CUSS I, the converted Navy Barge used for Project Mohole's deep-sea drilling tests in spring of 1961 (NSF photograph). (Right) CUSS I crew lowering one of the six taut line submerged buoys used for dynamic positioning. The six buoys were lowered into a circular pattern at a depth of about 200 feet. The ship would then use sonar to position itself in the center of the circle (NSF photo).

1.1.2 DSDP

The Deep Sea Drilling Project (DSDP), based out of Scripps Institution of Oceanography at the University of California, San Diego began June 24, 1966. Starting in August of 1968, the Glomar Challenger (Figure 1-3) took DSDP into the Atlantic, Pacific, and Indian Oceans as well as the Mediterranean and Red Seas.

From August 11, 1968, to November 11, 1983 an impressive list of drilling accomplishments were achieved from the Challenger. Core samples revealed the existence of salt domes, provided definitive proof for continental drift and seafloor renewal at rift zones confirming Alfred Wegner's theory of continental drift, gave further evidence to support the plate tectonics theory of W. Jason Morgan and Xavier Le Pichon, and enabled many more important discoveries (see http://www.iodp.tamu.edu/publicinfo/glomar_challenger.html for more details).

With the advent of larger and more advanced drilling ships, the *JOIDES Resolution* replaced the Glomar Challenger in January 1985, to start the Ocean Drilling Program.

Figure 1-3. Glomar Challenger

From 1968 to 1983, the Glomar Challenger pioneered scientific ocean drilling as the research vessel for the Deep Sea drilling Project, operated by the Scripps Institution of Oceanography, University of California, San Diego.

1.1.3 ODP

The Ocean Drilling Program (ODP) was an international cooperative effort to explore and study the composition and structure of the Earth's ocean basins. ODP operations, which began in 1985, directly succeeded DSDP. ODP was a truly international effort with contributions from Australia, Germany, France, Japan, the United Kingdom and the European Science Foundation Consortium for Ocean Drilling (ECOD) consisting of 12 additional European countries. The program used the drillship *JOIDES Resolution* (originally known as SEDCO/BP 471) (Figure 1-4) on 110 expeditions to drill about 2000 holes from major geological features located in the ocean basins of the world. The sediments recovered ranged in age from the last decade all the way back to the Triassic Period, nearly 227 million years ago. ODP advanced scientific discovery deep below the seafloor and provided evidence of 1) fluids circulating through the ridge flanks of the ocean floor, 2) the formation of volcanoes and volcanic plateaus at rates unknown today, 3) natural methane frozen deep within marine sediments as gas hydrate, 4) a vibrant microbial community living deep within oceanic crust, and 5) persistently rhythmic climate history. Drilling discoveries led to further questions and hypotheses, as well as to new disciplines in earth sciences such as the field of pale-oceanography. In 2003 ODP was replaced by the Integrated Ocean Drilling Program (IODP).

Figure 1-4. *JOIDES Resolution*

(Left) JOIDES Resolution (originally known as SEDCO/BP 471) *was converted in Pascagoula, Mississippi, in the fall of 1984. She was built in Halifax, Nova Scotia in 1978 and had previously sailed the world as a top-class oil-exploration vessel. (Right) The ship can deploy up to 30,000 feet of drill string.*

Detailed information on program administration, scientific results, engineering and science operations, samples, data, publications, or outreach materials is located on the ODP legacy website (http://www-odp.tamu.edu/index.html). A summary of past USIO riserless drilling activities is provided in Appendix A.

1.2 IODP Scientific Goals: The Initial Science Plan

The first program principle developed by the International Working Group charged with formulating IODP states "The IODP is an [integrated, multi-drilling platform] scientific research program with objectives identified in the IODP Science Plan". Thus the Initial Science Plan (ISP) is the heart of IODP, providing fundamental guidance as to the scientific and technical objectives that are of greatest interest to IODP. Exciting discoveries are certain to lead to new priorities in the future and IODP will be flexible in responding to unique opportunities, but the ISP lays out an essential framework for the design and evaluation of scientific studies that will help to achieve critical goals. IODP studies will lead to a better understanding of the deep biosphere and the sub-seafloor ocean; environmental change, processes, and impacts; and solid earth cycles and geodynamics.

The full title of the Initial Science Plan for IODP is "Earth, Oceans and Life: Scientific Investigations of the Earth System Using Multiple Drilling Platforms and New Technologies." The ISP grew out of numerous workshops, conferences, and discussions among hundreds of scientists, engineers, and agency representatives. The contents of the ISP were formulated mainly during the periods from 1997 to 2001 by an international, multi-disciplinary, scientific community, drawn together by common interests, technical needs, an appreciation for the wonder of scientific discovery, and dedication to the success of the complete enterprise. Some of the objectives discussed in the ISP date back to the original Conference on Scientific Ocean Drilling (COSOD, 1982), while others were developed only in the last few years leading to the establishment of IODP. The Conference on Cooperative Ocean Riser Drilling (CONCORD, 1997) and the Conference on Multiple Platform Exploration for the Ocean (COMPLEX, 1999) were particularly important in formulating the scientific objectives for IODP and drafting the ISP (http://www.iodp.org/isp/).

1.2.1 Initial Science Plan Themes

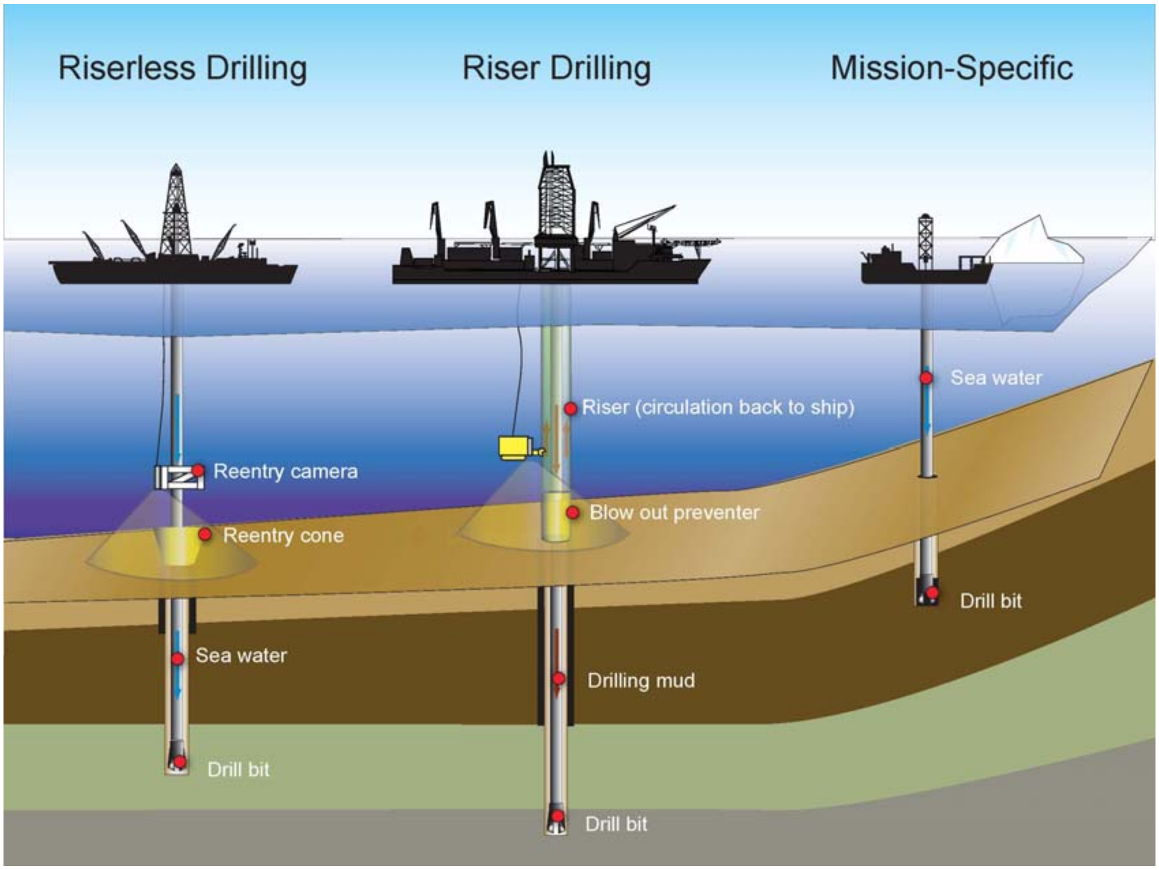
The ISP identifies three broad themes on which scientific ocean drilling efforts will be concentrated beyond the year 2003. The first is the study of the deep biosphere and associated sub-seafloor ocean. The second involves investigating Earth's environmental change, in terms of both its processes and effects. The final theme encompasses a range of inter-related scientific problems pertaining to the cycles and geodynamics of the solid Earth. Within these broad themes, specific areas of concentration are identified for which ocean drilling is either the best, or only, way to solve scientific problems of a fundamental nature. These areas of concentration include studies of: seismogenic zones, gas hydrates, rapid climate change and periods of extreme climates, continental breakup and sedimentary basin formation, large igneous provinces, and the fundamental nature of oceanic crust.

1.2.2 Implementation Strategy

The integration of multiple drilling platforms, exploratory tools, and diverse strategies in resolving outstanding questions is discussed throughout the ISP and is central to the success of IODP. A detailed discussion of the IODP is presented in Appendix B.

The specific IODP initial drilling initiatives require the IODP to deploy closely linked drilling platform types simultaneously (Figure 1-5). A riserless drillship such as the modernized *JOIDES Resolution* will enable IODP to reach the ocean's greatest depths, while continuing to expand the global sampling coverage and disciplinary breadth characteristic of ODP and DSDP.

Figure 1-5. IODP's Multi-platform Approach



The Riserless vessel enables IODP to drill in the deepest water, the Riser vessel provides the ability to drill deepest into the Earth, and the Mission-specific platform allows IODP to complete projects in areas too shallow for the other two drillships. The three platforms enable IODP to conduct scientific ocean drilling in almost any condition.

A riser-equipped drillship will permit IODP to address deep objectives that require drilling for months to a year or more at a single location. Deep objectives include the "seismogenic zone" experiment, designed to determine the behavior of earthquake-generating faults in subduction zones; the deep crustal and intra-sedimentary biosphere; the three-dimensional structure of oceanic and Large Igneous Province (LIP) crust; and the processes of continental breakup and sedimentary basin formation. Mission-specific platforms will permit unprecedented examination of the history of sea-level change in the critical region near the shoreline, the recovery of high-resolution climate records from atolls and reefs in shallow water areas, and the exploration of climatically sensitive, ice-covered regions not yet sampled by drilling, such as the Arctic Ocean basin.

Of fundamental importance to successful drilling from these platforms is the deployment of new or improved drilling, sampling and downhole petrophysical tools, which allow scientists to recover drilled sections more completely, to obtain uncontaminated samples at ambient pressures, to isolate and record data on the physical properties of specific intervals within boreholes and to initiate drilling and recovery of exposed hard rocks. DSDP and ODP have laid a solid technological foundation in most of these areas. Some tools, such as the advanced piston corer (APC) developed for scientific ocean drilling by ODP, require little engineering improvement. Significant improvement of other tools, such as hard rock drilling systems, require that IODP closely interact with scientific users, and call upon the advice and technical expertise of the drilling industries. As IODP drilling progresses into harsher environments, where the challenge of recovering biologically, chemically and physically intact samples continues to increase, improved tools will be critical for achieving the program's scientific goals.

Post-drilling observations and experiments in boreholes, pioneered by ODP, are of great importance in IODP. Sustained time-series recordings by instruments sealed within boreholes are required to investigate active processes such as pore-water flow, thermal and chemical advection and crustal changes. Boreholes will also be used for perturbation experiments to investigate in situ physical properties of sediments and/or crust, and their associated microbial communities. A global network of geophysical observatories for imaging Earth's deep interior is also planned.

Another important element of the IODP's new vision for scientific drilling is the development of closer links between marine geoscientists and their continental drilling and industry colleagues. For example, many fundamental scientific questions to be addressed over the next decade "cross the shoreline." Attacking these problems will require an integrated approach combining continental studies (e.g., lake and continental crust drilling, field-based mapping, onshore-offshore geophysical transects) and drilling into the seafloor. Close interaction with international scientific programs, such as InterRidge, InterMargins, the International Ocean Network (ION), International Geosphere-Biosphere Program of Past Global Changes (PAGES), International Marine Past Global Change Study (IMAGES), Nansen Arctic Drilling (NAD) and the International Continental Drilling Program (ICDP) will continue to contribute greatly to the quality of IODP science. Ongoing industry-academic dialogue is also defining broad overlap in fundamental research problems that are of interest to both communities. As hydrocarbon exploration rapidly expands into deeper water and the international scientific community gains interest in using deep-water riser technology, opportunities for intellectual and technological collaboration should continue to grow.

1.3 Scope of the Proposed Action

The scope of the proposed action and this Programmatic Environmental Impact Statement (PEIS) encompasses all aspects of the operation of the modernized *JOIDES Resolution* by the United States Implementing Organization (USIO) and a member of the IODP. Proposed activities to be conducted by the *JOIDES Resolution* and addressed in this impact statement include the mechanical operation of the vessel, riserless ocean drilling, core sampling, and related onboard research activities. Depending upon the specific research objectives of each ocean drilling expedition and guidance provided by the IODP scientific community, it is anticipated that the

JOIDES Resolution will perform earth sciences research throughout the world's oceans in marine conditions where riserless drilling is optimally suited.

This PEIS focuses on the evaluation of all operations and research activities to be conducted by the modernized *JOIDES Resolution* independent of specific geographic locations. The operation of the vessel, ocean drilling, and implementation of research procedures as described herein, incorporate various mitigating measures designed to minimize or avoid adverse impacts to the marine environment. In the event that a proposed ocean drilling expedition is planned to be conducted in a highly sensitive environment which is beyond the conditions described in this PEIS, a supplemental assessment will be prepared to evaluate those site-specific conditions and potential impacts.

1.4 **Purpose of the Programmatic Environmental Impact Statement**

In 1969, Congress enacted National Environmental Policy Act (NEPA), which provides for the consideration of environmental issues in federal agency planning and decision-making. Regulations for federal agency implementation of the act were established by the President's Council on Environmental Quality (CEQ). In addition, NEPA requires federal agencies to prepare an Environmental Impact Statement (EIS) for actions that may significantly affect the quality of the human and natural environments.

The scope of this EIS addresses all aspects of the proposed action involving IODP-USIO riserless ocean drilling program and therefore is designated a Programmatic EIS. Assessment of other IODP activities such as riser drilling and drilling from mission-specific platforms are not included in this PEIS and will be addressed in separate environmental documents. The National Science Foundation (NSF) is the lead agency for the proposed action, with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) acting as a cooperating agency. Cooperating agencies have jurisdiction by law or special expertise with respect to certain environmental impacts from a proposed action by another agency.

Under NEPA, the PEIS must disclose significant environmental impacts and inform decision makers and the public of the reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment. The first step in the NEPA process is the preparation of a notice of intent (NOI) to develop the PEIS. The NOI provides an overview of the proposed project and the scope of the PEIS. The NOI for this project was published in the *Federal Register* on January 10, 2006.

Scoping is an early and open process for developing the "scope" of issues to be addressed in the PEIS and for identifying potentially significant environmental effects associated with the proposed action. The scoping process for this PEIS was initiated by the publication of the NOI. During this process, the public was provided an opportunity to define, prioritize, and convey these environmental concerns to the agency through both oral and written comments. The public comment period was 45 days. Scoping presentations were held in San Diego, CA (15 February 2006), College Station, TX (17 February 2007), and Silver Spring, MD (February 23, 2006) notifying the public of the beginning of the PEIS process. No responses were received from the general public; however, federal agencies and earth sciences researchers attended the scoping presentations.

After scoping, the Draft PEIS was prepared, which provided the complete description of the proposed federal action and an evaluation of the potential impacts on the human or natural environment. The Draft PEIS also informed decision makers and the public of reasonable alternatives that would avoid or minimize adverse impacts, or enhance the quality of the environment.

The Draft PEIS was released on 7 August 2007 and the US Environmental Protection Agency (USEPA) placed a notice of availability in the 17 August 2007 *Federal Register*. Printed, CD, and downloadable copies of the Draft PEIS were made available for review over the 45-day comment period. The Draft PEIS was provided to the following government agencies and persons or organizations:

<u>Federal Agencies and Offices</u>

Bureau of Land Management
Council for Environmental Quality
Department of the Interior
Environmental Protection Agency
Fish and Wildlife Service
Food and Drug Administration
Marine Mammal Commission
Mineral Management Service
National Institute of Health
National Marine Fisheries Service
National Oceanographic and Atmospheric Administration
National Park Service
Office of Surface Mining
State Department
U.S. Coast Guard
U.S. Geological Survey
U.S. Navy

<u>U.S. State Agencies and Offices</u>

California Coastal Commission

<u>Canadian Agencies and Offices</u>

Canadian Hydrographic Service
Natural Sciences and Engineering Research Council of Canada

<u>Private and Other Organizations or Individuals</u>

Acoustic Ecology Institute
American Geological Institute
American Petroleum Institute
Audubon Society
Blue Ventures
Conservation International
Consortium for Ocean Research and Education
Coral Reef Alliance
Cousteau Society

Deep Sea Conservation Coalition
Earth First
ExxonMobil
Friends of the Earth
Global Coral Reef Alliance
Green Peace
Humane Society
International Association of Geophysical Contractors
International Council for Exploration of the Sea
International Coral Reef Action Network
International Ocean Institute
IUCN - The World Conservation Union
Dr. Larry Mayer, University of New Hampshire
Living Oceans Society
National Geographic Society
Nature Conservancy
Natural resources Defense Council
Ocean Alliance
Ocean Conservation Research
Oceana
Oceanic Environmental Solutions
Oceanic Society
Oceanography Society
Seas at Risk
Sierra Club
Whale and Dolphin Conservation Society)
Wildlife Conservation Society
Woodside Energy Ltd.
World Ocean Network
World Wildlife Fund

Public meetings were held at NOAA in Silver Spring, MD on 21 September 2007 and Consortium for Ocean Leadership, formerly the Joint Oceanographic Institutions (JOI) in Washington D.C. on 28 September 2007 to address questions or comments on the Draft PEIS. No comments were received; therefore the Draft PEIS only required minor revision to describe the review process. A record of decision (ROD) will be prepared and published in the *Federal Register* to document the finalization of the PEIS. The proposed action can then be implemented.

The PEIS is consistent with Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, which directs federal agencies to provide for informed decision making for major federal actions outside the U.S., including the global commons, the environment of a non-participating foreign nation, or impacts on protected global resources

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2.0 DESCRIPTION OF THE PROPOSED ACTION

2.1 **Introduction**

The modernized *JOIDES Resolution* will serve as the state-of-the-art, riserless drilling research platform for the science community as well as the United States' contribution to support the scientific mission of the IODP. The U.S. will only conduct riserless ocean drilling and therefore potential impacts arising from riser-equipped drilling operations or drilling from other mission-specific platforms are beyond the scope of this PEIS. Overall, the IODP will build upon the successes of the DSDP and ODP by enhancing the capabilities of scientific ocean drilling through international partnerships using multiple drilling platforms. In this environmental impact statement, the *JOIDES Resolution* will also be referred to as the Scientific Ocean Drilling Vessel (SODV).

The information contained herein focuses on the identification and quantification of outputs resulting from proposed riserless ocean drilling activities which are known or suspected to interact with the environment. The section concludes with a description of the regulatory framework and compliance requirements applicable to each specific expedition.

2.2 **Vessel Operations and Associated Environmental Outputs**

2.2.1 Overview of Vessel Capabilities and Operations

After 20 years of service, the *JOIDES Resolution*, the pioneering scientific research vessel that has allowed scientists to retrieve samples of the Earth's crust and sediments from deep beneath the ocean, is being modernized and retrofitted with funding provided by the NSF Major Research Equipment and Facilities Construction (MREFC) Account to serve as a state-of-the-art riserless drillship for the IODP. As such, the modernized *JOIDES Resolution* (i.e., SODV) will improve the quality and rate of core samples brought up from the deep, while retaining many of the same mechanical systems of its predecessor.

During its history, the *JOIDES Resolution* has been adapted and upgraded with minor modifications several times. But the scale of the current conversion will be beyond any past upgrades. The SODV will continue to be a uniquely outfitted drillship that can dynamically position over specific seafloor locations while drilling up to 8,385 m (27,500 ft) total depth in water depths ranging from 75 to >6,000 m, depending on the desired penetration below the seafloor.

The SODV will feature a modernized laboratory, allowing for a greater variety of instrumentation that onboard scientists can use to analyze cores samples while at sea. The SODV will provide an enhanced drilling instrumentation system and a refurbished sub-sea camera system. Although the SODV conversion process will produce a riserless drilling vessel with numerous enhanced capabilities, the environmental outputs resulting from the operation of the ship will be similar to those realized during the past expeditions. For example, most of the drillship mechanical systems such as the engines and drill rig components will remain the same.

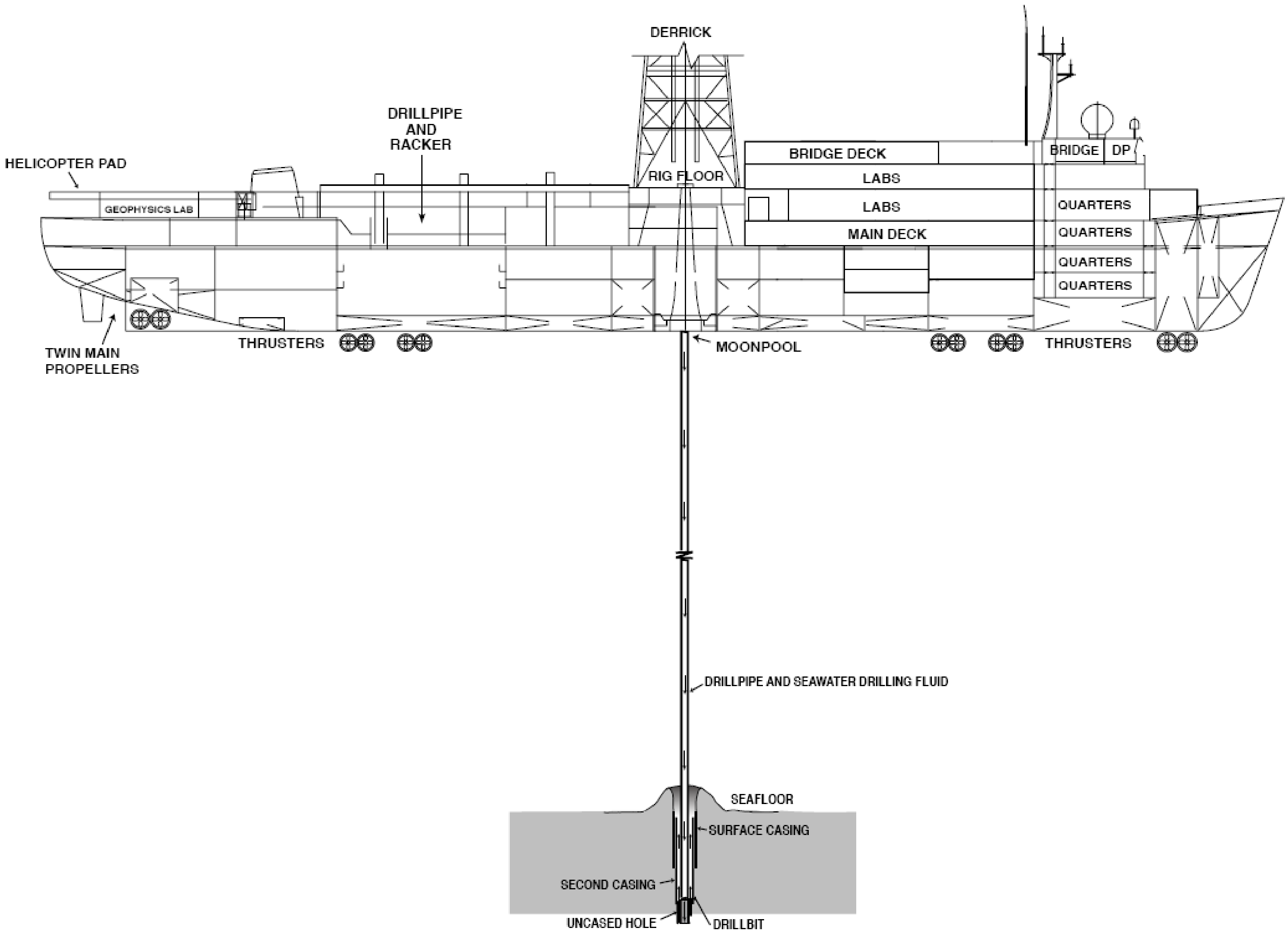
The SODV will be a completely self-sustained unit carrying sufficient fuel, water, and supplies to enable her to remain at sea for 60 days with a crew of up to 128. Navigational capabilities will include SATNAV, LORAN C, and GPS (Global Positioning System); the latter providing precise satellite positioning and thus enhanced accuracy of drill site location. The SODV's ice-strengthened hull will permit the vessel to navigate in medium ice conditions, and withstand air temperatures of -18°C to 43°C and sea temperatures of -2°C to 27°C. The SODV's ABS Ice Class 1B rating will afford the ship the highest ice classification of any drillship currently in service.

The drilling, propulsion, and positioning systems on the SODV are diesel-electric powered with the twin propellers able to provide an average cruising speed of 11 knots. The computer-controlled dynamic positioning (DP) system will use an acoustic referencing device (beacon or pinger) deployed on the seafloor to maintain the ship over a specific location, using a combination of 12 thrusters, each powered by a 750 hp electric motor and capable of producing 10,250 kg (100,525 newtons) of thrust. When operating in conjunction with the vessel's main propellers, the thrusters enable the drillship to move in any direction. Four hydrophones mounted in the hull will be used to continually receive signals transmitted from the beacon on the seafloor. A computer will automatically control the thrusters and main propulsion unit to maintain the SODV's heading and location over the borehole. The vessel will be able to maintain position within three percent of water depth in up to 7.5 m (25 ft) waves, 60 knot winds, and 3.0 knot currents. General specifications for the SODV are presented in Appendix C. Figure 2-1 provides a simplified schematic of the ship.

The proposed operator of the SODV, ODL/Transocean, will follow specific procedures designed to protect the environment and reduce environmental risk as documented in the Transocean Environmental Management System (EMS) (Transocean, 2006). Additional documents supporting the EMS and applicable regulatory requirements (e.g., MARPOL) include:

- Garbage Management Plan
- Power Management Plan
- Ballast Water Management Plan
- Shipboard Oil Pollution Emergency Plan (SOPEP)
- Spill Plan

Figure 2-1. SODV Profile



Based on recent IODP-USIO riserless drilling experience, and for the purpose of this PEIS, it is assumed that each typical SODV expedition may be up to 61 days in duration including five days in port and 56 days at sea either in transit or performing riserless drilling operations. This generic model will be used to quantify various vessel-related and drilling outputs which are time dependent such as exhaust emissions and liquid waste discharges.

2.2.2 Water Discharges

Routine vessel operations on the SODV are expected to result in the controlled discharge of sanitary wastewater (treated sewage), non-sanitary wastewater (greywater, victual wastes), bilge water (treated), deck drainage, cooling or other process water, desalination brinewater, ballast water, and laboratory wastewater (treated). Assuming the typical duration of a SODV expedition is 61 days, most of these discharges will occur during the 56–day period the SODV is at sea. Characteristics of these discharges are summarized in Table 2-1 and are described below.

Table 2-1. Projected Liquid Waste Discharges from the SODV

Source	Volume (liters/day)	Treatment
Sanitary wastewater (sewage, blackwater)	15,810	Activated sludge/ suspended aeration/disinfection
Non-sanitary wastewater (greywater)	55,000	Untreated
Bilge water	Variable	Oil/water separator [1]
Deck drainage	Variable	Oil/water separator (as needed) [1]
Noncontact cooling water	34,300,000	Untreated
Desalination brinewater	2,179,000	Untreated
Ballast water	Variable	Untreated
Laboratory wastewater	Variable	Neutralization

Note:
[1] The SODV will have the capability to treat up to 120,000 liters/day of bilge water and/or contaminated deck drainage through the oil/water separator; however these liquid waste streams are highly variable and will only require discharge on an intermittent basis.

2.2.2.1 Sanitary Wastewater

Sanitary wastewater (blackwater) generated onboard the SODV will consist of human wastes from restrooms. The SODV wastewater treatment system will consist of an extended aeration process and the resulting effluent will be disinfected by chlorination. Sanitary wastewater will be conveyed to the wastewater treatment device via a vacuum system. Approximately 15,810 liters of sewage would be treated and discharged each day. The treated effluent would equal or exceed MARPOL Annex IV requirements by exhibiting total suspended solids and 5-day biochemical oxygen demand (BOD_5) concentrations of less than 50 mg/L and a fecal coliform bacteria concentration of less than 250 MPN (most probable number) colonies per 100mL. The SODV will be capable of storing approximately 16 days of wastewater at typical generation rates.

2.2.2.2 Non-sanitary Wastewater

Non-sanitary wastewater will consist of greywater (wastewater from washing, bathing, laundry) and victual wastes (wastewater from food preparation and service sources). Victual wastes will be macerated before entering the greywater waste stream. Because greywater exhibits a significantly lower organic loading than blackwater and contains fewer pathogens, it decomposes and assimilates readily in the sea without treatment. It is estimated that up to 55,000 L of untreated greywater would be discharged daily including approximately 200 liters of macerated victual wastes. The SODV will be capable of storing approximately 3 days of greywater.

2.2.2.3 Bilge Water

Bilge water is the aqueous waste that accumulates in various chambers in the vessel's hull. Bilge water originating from drainage in the engine room or other mechanical areas may contain oil residues. Oily bilge water will be collected and treated through an IMO-approved oil/water separator resulting in an oil in water concentration of less than 15 parts per million (ppm) and discharged to the sea. The separated oil phase will be periodically combusted as needed in the onboard incinerators. Because bilge water will be generated on a variable and intermittent basis, the quantity discharged cannot be projected. The oil/water separator is capable of treating up to 120,000 liters of oily water per day.

2.2.2.4 Deck Drainage

Deck drainage will consist of rain, seawater, and washwater from the deck and drilling floor that may contain sediment, oil, or other residues. Generally, if the decks are free of residues, the drainage will be discharged to the sea through scuppers. However, if oil or other residues are present on the deck or the ship is in an area where discharge of deck drainage is prohibited, the scuppers will be sealed and the drainage conveyed to a settling tank for processing through an oil/water separator. After treatment, the aqueous phase will be discharged to the sea and the oily residue, if any, will be combusted in the onboard incinerators. Because deck drainage will be generated on a variable and intermittent basis, the quantity discharged cannot be projected. The oil/water separator is capable of treating up to 120,000 liters of oily water per day.

2.2.2.5 Cooling Water

Untreated seawater will be used as a heat exchange media to cool engines, pumps, and other mechanical components onboard the SODV. The cooling water will only come in contact with heat exchange coils, pumps, and piping and will not come in contact with combustion residues, oil, sludge, metal shavings, or chemicals such as descaling agents. Approximately 34.3 million liters of cooling water will be discharged each day.

2.2.2.6 Desalination Wastewater

Freshwater used onboard the SODV will be obtained through the desalination of seawater by flash evaporators. The desalination units produce freshwater and waste brinewater which will exhibit a salinity content approximately 25 percent higher than ambient seawater. It is estimated that 132.9 million liters of brinewater may be released to the sea during a typical expedition or approximately 2.1 million liters each day.

2.2.2.7 Ballast Water

Ballast water is used to lower a vessel's center of gravity, thereby improving stability, increasing propeller immersion, and helping to control trim. The ballast water holding tanks on the SODV have a nominal capacity of 745,000 liters. Seawater will be pumped to or from the vessel's ballast tanks as needed, consistent with regulatory requirements and the SODV's Ballast Water Management Plan. The volume of ballast water discharged will be variable and intermittent as required by operating conditions and cannot be predicted.

2.2.2.8 Laboratory Wastes

The laboratory protocol onboard the SODV prohibits discharge of chemicals directly to the environment or to the vessel's sewer system. The acid drain system in the laboratories will convey washwater potentially containing inorganic liquid acid residues to a chemical neutralization tank for treatment. Liquid chemical wastes such as solvents will be containerized for subsequent disposal onshore. The volume of treated laboratory wastewater discharged will be relatively minor and intermittent as required by laboratory operations.

2.2.3 Acoustic Sources

The marine environment in which the SODV will be operating is constantly exposed to background noise from various natural and man-made sources, including sounds generated on a continual basis and from discrete events. Natural sources of sound in the marine environment include wave, wind, rain, volcanic activity, earthquakes, biological sources such as fish and marine mammal vocalizations for foraging and echolocation, and the movement of ice in polar climates.

Sound levels in calm seas have been characterized at approximately 60 dB re 1 μPa[1] (Hurley and Ellis, 2004) typically in the 1 Hz to 30 kHz frequency range, although the combined wind and wave action can increase the noise level significantly (WDCS, 2004). Precipitation events may increase the sound level in the 100 to 500 Hz frequency range by up to 35 dB (Nystuen and Farmer, 1987), while thunderstorms may also produce additional noise up to 15 dB in the 50 to 250 Hz range (Dubrovsky and Kosterin, 1993). Volcanic activity and earthquakes will also contribute to background noise levels on an intermittent basis, typically in frequencies up to 500 Hz (WDCS, 2004). Earthquakes can be expected to result in intense, short-term increases in sound levels up to 30-40 dB above background (Schreiner et al., 1995), although major earthquakes may generate underwater sounds ranging from 200 to 240 dB re 1 μPa (ERT Ltd., 2006).

Anthropogenic (man-made) noise sources that may contribute to background levels in the open ocean primarily include shipping traffic and commercial fishing activities. Typical source levels during operation of an in-transit merchant vessels range from 158 dB re 1 μPa for fishing trawlers, 172 re 1 μPa for commercial freighters, and up to 190 dB re 1 μPa for larger vessels such as supertankers (Hurley and Ellis, 2004). The primary source of noise from commercial vessels are its propellers, particularly when the ship is cruising at high speed which can produce sound in the broadband range but focused at lower frequency ranges (5-500 Hz) (OSPAR, 2006). Taking both natural and anthropogenic acoustic sources into consideration, typical background sound levels of 95 dB re 1 μPa may be expected at deep ocean sites (Richardson, et al., 1995)

The SODV's acoustic and vibrational sources such as the engines, propellers, thrusters, mechanical systems, and transducer-based equipment such as a single beam sonar system, sub-bottom profiling system, and an acoustic Doppler current profiler (ADCP) unit will primarily affect the underwater marine environment. In general, underwater sounds attenuate with distance from the source; the distance that noise from the SODV travels will depend on the intensity of the individual source and oceanographic conditions. While in transit, the SODV will be cruise at an average speed of 20.3 km/hr (11 knots) using four of the seven diesel-electric engines which produce an average total power output of 7.0 megawatts (MW). Although specific acoustic data for the SODV

[1] The measurements used to characterize acoustical sources are typically expressed in decibels (dB) measured at a 1 meter distance and referenced to pressure units, microPascal (μPa). For acoustics in air, a standard reference pressure of 20μPa is used, while a standard reference pressure of 1μPa is used for acoustics in water. Additional units are used to measure the levels of sound intensity, including zero to peak (0-p), peak to peak (p-p) and root mean square (rms). In general, 0-p values will be lower than p- or rms. The rms pressure is an average over the pulse duration. Received levels of pulsed sounds are also expressed on an energy or Sound Exposure Levels (SEL) basis, for which the units are dB re $(1\ \mu Pa)^2 \cdot s$, typically 10-15 dB less than the rms level for the same pulse.

under cruise conditions is not available, it is reasonable to assume that the SODV will produce sound levels comparable to merchant vessels of the same size class. For example, the average source level for a typical merchant vessel in transit, ranges between 160 and 190 dB re 1 μPa in the 5 to 900 Hz frequency range and attenuates to 150 dB re 1 μPa within 100 m (ERT Ltd., 2006).

When the SODV is at a drill site, it will typically operate three diesel engines to produce sufficient electrical power to operate the 12 dynamic positioning thrusters that may be needed to maintain position. Based on data collected during a test of the drillship SEDCO/BP 471 (Honeywell, 1984) which was later designated the *JOIDES Resolution* and now the SODV, it was estimated that the sound level generated by the vessel's engines and all of the thrusters operating simultaneously is approximately 154 dB re 1 μPa. In a study unrelated to the SODV, the underwater noise from a ship equipped with thrusters exhibited 140 dB re 1 μPa at the source with frequencies ranging from 10 Hz to 100,000 Hz (Faugstadmo, 1998).

Transducer-based instrument systems that may be used onboard the SODV such as a single-beam echo sounder, an Acoustic Doppler Current Profiler, and a sub-bottom profiler will also generate acoustical outputs. The intensity and direction of the acoustical source will vary depending on the type of instrument. The single-beam echo sounder will operate at a frequency of 350 kHz and produce a source sound level in the range of 200-230 dB re 1μPa with the maximum intensity within a 45° beam from the source. The ADCP will produce a maximum acoustic source level of 224 dB re 1μPa at 307 kHz over a conically-shaped 30° beam. The sub-bottom profiler will operate in the 3.5 kHz frequency range and have an approximate acoustical source output of 204 dB re 1 μPa while emitting energy in a 30° beam from the bottom of the ship. It is expected that the echo sounder and sub-bottom profiler will be in continuous operation while the vessel is in transit and approaching a drill site but will be shut off when the vessel is drilling. Because all of these transducer-based sources are focused and directional, the emitted sound levels will be significantly attenuated outside the focus of the beams.

2.2.4 Physical Disturbances

The routine operation of the SODV will disturb the surrounding environment including physical changes to the water column and the seafloor.

2.2.4.1 Seawater Turbulence

It is anticipated that when the SODV is operating in Dynamic Positioning (DP) mode to hold a fixed location against the combined action of the wind, current, and waves, up to 12 of the vessel's thrusters and possibly the vessel's main propellers may be operating simultaneously. The turbulence created by these propulsion units will result in mixing of the surrounding water column.

2.2.4.2 Seafloor

Although the SODV anchors rarely, the anchor and chain when deployed will physically disturb the seafloor and benthic organisms, if present.

2.2.5 Air Emissions

The operation of the SODV will generate air emissions from the combustion of petroleum hydrocarbon fuel in the vessel's engines. The combustion of diesel fuel will result in the generation of gaseous and particulate pollutants including sulfur oxides, nitrogen oxides, carbon monoxide, carbon dioxide, particulate matter, and hydrocarbons. The amount of pollutants emitted to the atmosphere will be directly related to the engines fuel consumption and the sulfur content of the fuel (EPA, 2000).

There are seven electro-motive (diesel-electric) engines on the SODV, five rated at 2,100 kW each and two rated at 1,500 kW each. The average fuel consumption and power output of the SODV will be 6,800 L per day (1.2 MW) when is in port, 45,400 L per day (7.0 MW) while in transit, and 20,800 L per day (3.0 MW) while on-site and drilling. It is anticipated that the SODV will use standard marine gas oil fuel containing less than 0.5 percent sulfur. Based on these operating conditions, Table 2-2 presents the total estimated air emissions occurring during a typical 61-day expedition.

Table 2-2. Estimated SODV Engine Emissions During a Typical 61-Day Expedition

	Emissions (metric ton)			
	In-Port (5 days)	At Sea (56 days)		
Parameter	In-Port (5 days) Fuel Usage: 34,000 L	Transit (5 days) Fuel Usage: 227,000 L	On-Site (51 days) Fuel Usage: 1,061,000 L	**Total Emissions (metric-tons/ expedition)**
Carbon Dioxide	104	589	2,705	**3,399**
Carbon Monoxide	0.212	0.85	6.2	**7.2**
Nitric Oxide	1.4	8.1	36	**45**
Nitrogen Dioxide	2.3	13	59	**74**
Nitrogen Oxides	1.5	8.9	40	**50**
Particulate Matter	0.039	0.221	0.998	**1.2**
Sulfur Oxides	0.069	0.459	0.210	**0.738**
Total Hydrocarbons	0.022	0.074	0.693	**0.789**

In addition to the engine exhaust emissions, volatile chemicals associated with the operation and maintenance activities on the SODV will be intermittently released to the air. These substances may include cleaners, degreasers, solvents, paints, and aerosols. Because these materials are used routinely in small quantities but on an intermittent basis, the resulting emissions are relatively insignificant. Refrigerants will be used in closed systems (e.g., HVAC, refrigerators, freezers, specialized laboratory equipment) onboard the SODV and recovered when maintenance is performed on the equipment to prevent release to the environment. In addition, new refrigerant systems that are installed on the SODV during the conversion process will avoid the use of ozone depleting substances such as hydrocholorofluorocarbon (HCFC) compounds to the maximum extent possible.

Another air emissions source on the SODV involves the evaporative loss of volatile fuels. Fuel evaporative emissions can occur as a standing storage loss when a volatile fuel thermally expands in a rigid container or tank which is vented to the atmosphere. Working evaporative emission loss is caused by the displacement of vapors when a tank is filled or fuel is transferred. The type and amount of fuel, number of transfers, and movement of the ship will contribute to the evaporative emissions. An estimate of fuel evaporative emissions was developed using an USEPA model (EPA, 1995) and based on the assumption that marine gas oil fuel is chemically similar to distillate fuel oil no. 2. Conservatively, since the fuel aboard the SODV would be stored in bulk tanks and not exposed to rapid temperature changes, 16° C (60° F) was selected as a representative temperature for the emissions calculation. Standing losses were assumed to be twice the working loss to account for emissions resulting from motion of the fuel in the tanks while the vessel is at sea. Table 2-3 presents the estimated fuel evaporative emissions for a typical 61-day expedition.

Table 2-3. Estimated Evaporative Emissions from Diesel Engine Fuel During a Typical Expedition

Evaporative Loss	In Port (5 days)		At Sea (56 days)		**Total Evaporative Emissions (kg-petroleum hydrocarbons/ expedition)**
	Vessel Refueling: 1,224,000 L	Fuel Usage: 34,000 L	Transit (5 days) Fuel Usage: 227,000 L	On-site (51 days) Fuel Usage: 1,061,000	
	Emissions (kg-petroleum hydrocarbons)				
Working Loss [1]	3.62	---	---	**---**	**3.62**
Standing Loss [2]	---	0.19	1.24	5.82	**7.25**
				Total Evaporative Losses	**10.87**

Notes:

[1] Working Loss = [0.001] x [Fuel Vapor Molecular Weight] x [Fuel Vapor Pressure] x [Fuel Usage for Typical Expedition] x [Number of Diesel Fuel Transfers]

[2] Standing Loss = 2 x [Working Evaporative Losses]

Air emissions will also be produced by onboard incinerators which will be used to destroy combustible nonhazardous solid waste, used oil, and waste oil from the oil/water separator. The SODV will be equipped with two new incinerators with a total combined capacity to burn approximately 2 cubic meters of nonhazardous solid waste per day. The incinerators will consume approximately 12 liters of marine gas oil or waste oil per hour for fuel. A typical combustion cycle will require approximately 3 hours. Using USEPA emission factors for a small controlled air incinerator (EPA, 1995) and taking into consideration pollutants which may originate from the combustion of waste oil, Table 2-4 provides an estimate of the air emissions from the incinerators assuming the units only operate during the average 56-day period that the vessel is at sea. Noncombustible solid waste such as glass and metals containers will be segregated, compacted, and disposed onshore.

Table 2-4. Estimated Air Emissions from SODV Incinerators During A Typical Expedition

	Solid Waste 22.4 metric tons per expedition[1]		**Fuel/Waste Oil** 2,016 L per expedition[1]		
Parameter	Emission Factor (kg/metric ton combusted)	Emissions (kg)	Emission Factor (kg/L fuel combusted)	Emissions (kg)	**Total Emissions (kg/expedition)**
Characteristic Air Pollutants					
Carbon Monoxide	1.5	33	2.53E-04	0.5	**34**
Nitrogen Oxides	1.8	40	1.92E-03	3.9	**44**
Particulate Matter	2.3	52	7.94E-03	16	**68**
Sulfur Oxides	1.1	24	1.29E-02	26	**50**
Total Organic Carbon (TOC)	0.2	3.36	1.20E-04	0.24	**3.61**
Metals					
Aluminum	5.24E-03	1.17E-01			**1.17E-01**
Antimony	6.39E-03	1.43E-01	5.41E-07	1.09E-03	**1.44E-01**
Arsenic	1.21E-04	2.71E-03	7.22E-06	1.45E-02	**1.73E-02**
Barium	1.62E-03	3.63E-02			**3.63E-02**
Beryllium	3.12E-06	7.00E-05	2.16E-07	4.36E-04	**5.06E-04**
Cadmium	2.74E-03	6.14E-02	1.44E-06	2.91E-03	**6.43E-02**
Chromium	3.88E-03	8.70E-02	2.16E-05	4.36E-02	**1.31E-01**
Copper	6.24E-03	1.40E-01	6.25E-07	1.26E-03	**1.41E-01**
Iron	7.22E-03	1.62E-01			**1.62E-01**
Lead	3.64E-02	8.16E-01	6.01E-09	1.21E-05	**8.16E-01**
Manganese	2.84E-04	6.37E-03	6.01E-06	1.21E-02	**1.85E-02**
Mercury	5.37E-02	1.20E+00			**1.20E+00**

Table 2-4. Estimated Air Emissions from SODV Incinerators During A Typical Expedition

Parameter	**Solid Waste** 22.4 metric tons per expedition[1]		**Fuel/Waste Oil** 2,016 L per expedition[1]		**Total Emissions (kg/expedition)**
	Emission Factor (kg/metric ton combusted)	Emissions (kg)	Emission Factor (kg/L fuel combusted)	Emissions (kg)	
Nickel	2.95E-04	6.61E-03	1.92E-05	3.88E-02	**4.54E-02**
Silver	1.13E-04	2.53E-03			**2.53E-03**
Thallium	5.51E-04	1.24E-02			**1.24E-02**

Note:

[1] A typical expedition comprises 56 days at sea (5 days in transit, 51 days on-site). The SODV incinerator will typically consume 2 m^3 (or 400 kg) of waste and 36 L of used oil or marine gas oil per day.

2.2.6 Hazardous Materials Management

Routine operations onboard the SODV will require the handling and storage of various hazardous materials. A hazardous material is generally considered a substance or mixture exhibiting characteristics such as reactivity, corrosivity, toxicity, flammability, or suspected to be harmful to human health or the environment. Hazardous material use onboard the SODV can be broadly categorized as materials associated with the mechanical operation of the vessel and those used in the laboratories. Hazardous materials will not be intentionally released from the SODV to the environment.

2.2.6.1 Vessel Operations

Hazardous materials that will used in support of the mechanical operation of the SODV include substances such as fuel, lubricants, hydraulic fluids, cleaning agents, solvents, paints, and coatings. Appendix C contains a list of the hazardous materials that were used in the past and are representative of future SODV operations. The storage, use, and handling of these hazardous materials will be guided by information contained in Material Safety Data Sheets and procedures documented in the SODV operator's Environmental Management System (EMS). In addition, the EMS contains procedures which address occupational exposure, environmental preparedness and response, the Shipboard Oil Pollution Emergency Plan (SOPEP), and the Spill Plan.

2.2.6.2 Laboratory Operations

In the SODV's laboratories, various chemical reagents and gases will be used to perform physical and chemical tests on core samples collected during drilling. Appendix C provides a list of the laboratory chemicals that were used in the past and is representative of future use of chemicals in the SODV's laboratories.

2.2.7 Solid and Hazardous Wastes

Various solid and hazardous wastes will be generated onboard the SODV resulting from the operation of the vessel including personnel support services and activities in the laboratories.

2.2.7.1 Vessel Operations

Nonhazardous solid wastes generated during operation of the SODV will include refuse such as cardboard, paper, rags, metal cans, wood, as well as food-related wastes which will not be macerated and discharged as a liquid waste stream. These solid wastes will not be disposed into the sea. Combustible wastes will be segregated from other wastes and destroyed in the SODV's incinerators. Noncombustible waste will be compacted and stored for subsequent offload and disposal onshore. Waste disposal activities will be conducted and recorded consistent with the SODV's Garbage Management Plan. Uncontaminated scrap metal such as steel from damaged or obsolete deck plates, railings, and drill pipe may be periodically disposed of at sea consistent with MARPOL Annex V requirements.

While at sea, the SODV's incinerators are expected to combust on average approximately 2 cubic meters of nonhazardous solid waste each day. Approximately 12 liters of marine gas oil or waste oil will be used per hour to fuel the incinerators. The ash produced by the incinerators will be collected, stored, and offloaded for onshore disposal. During previous ODP operations, a burn basket was used along with an incinerator to dispose of combustible solid wastes at sea. It is anticipated that the burn basket will not be used on the SODV even though it is permissible under MARPOL requirements.

Hazardous wastes produced on the SODV will include used oil, lubricants, hydraulic fluid, and residues resulting from the use of cleaning agents, acids, and other products containing harmful constituents. With the exception of combustible waste oil, all hazardous wastes from vessel operations will be properly containerized and stored for subsequent onshore disposal. Waste lubricating oils from mechanical equipment as well as the organic phase from the oil/water separator will be combusted in the onboard incinerators along with nonhazardous solid waste. The incinerators will have the capacity to burn approximately 50 liters of waste oil per hour. As needed, waste oil that cannot be incinerated will be stored for subsequent disposition in an appropriate onshore facility.

2.2.7.2 Laboratory Operations

The SODV's laboratories will perform various analytical tests to assess various geophysical, geochemical, and biological properties of core samples obtained from drilling. Minor quantities of solid waste will be generated such as residue from samples, plastics, glass, cardboard and other packaging materials, and paper. Combustible solid wastes will be segregated for subsequent combustion in the onboard incinerators while noncombustible wastes will be containerized and stored for onshore disposal.

In general, the onboard laboratories consume relatively small quantities of chemical reagents (see Appendix C) and the resulting wastes may contain trace residues of these materials. Although perfluoro(methylcyclohexane) also appears in Appendix C, it is not specifically consumed in the laboratories but is occasionally injected into the seawater drilling fluid as a tracer to detect if core samples collected for microbiological evaluation have been cross-contaminated by drilling fluid. Inorganic acid wastes generated in the laboratories will be neutralized and discharged to the sea while other wastes including organic liquids will be containerized for subsequent onshore disposal.

2.3 Riserless Drilling Operations and Associated Environmental Outputs

2.3.1 Overview of Riserless Drilling Operations

The SODV is designed to perform riserless drilling and utilize a hollow drill string through which seawater, the drilling fluid, is pumped to lubricate the drill bit and clear cuttings from the borehole. Riserless drilling procedures that will be used on the SODV have evolved over many years of IODP-USIO experience including the ODP and DSDP. Integral with this riserless drilling expertise, the IODP-USIO has developed the guidelines listed in Table 2-5 to define, mitigate, and avoid potential health and safety hazards as well as adverse environmental impacts.

Table 2-5. SODV Riserless Drilling Health, Safety, and Environmental Guidelines

Title	Subjects
Draft Guidelines for Drillsite Selection and Near-Surface Drilling Hazard Surveys. February 2003. Bruce, Robert J., Consulting Geophysicist, and Shipp, R. Craig, Shell International E&P Inc., Interim Pollution Prevention and Safety Panel, Integrated Ocean Drilling Program.	Methods to Identify Potential Seafloor, Man-made, and Subsurface Geologic Hazards: • Scope of Surveys • Recommended Drillsite Survey Types and Density • Standard Data Types and Recommended Parameters • Analysis of Geohazards and Reporting

Table 2-5. SODV Riserless Drilling Health, Safety, and Environmental Guidelines

Title	Subjects
Guidelines for Site Survey and Safety. 2007. Graber, K.K., ODP Tech. Note, 32 [online], available from the World Wide Web: (http://www-odp.tamu.edu/publications/tnotes/tn32/INDEX.HTM) [Cited 2007-08-08]	• Principal hazards • Hydrocarbon flow during drilling • Logging
Hydrogen Sulfide Drilling Contingency Plan. 2006. Mills, W.G., Malone, M.J., and Graber, K., 2006. ODP Tech. Note, 33 [online], available from World Wide Web: (http://www-odp.tamu.edu/publications/tnotes/tn33/INDEX.HTM) [Cited 2007-08-08]	• H_2S hazard conditions • H_2S operation instructions • Special coring procedures for H_2S sites

The SODV will essentially use many of the same drilling and coring tools that were used and refined during the ODP. These tools are identified on Table 2-6 and described in detail in Appendix D. All drilling and coring equipment is intended to be retrieved before the SODV leaves the drilling site. In the event that a drilling tool is lost in a borehole, attempts will be made, if feasible, to retrieve it; however, a possibility exists that some lost equipment cannot be retrieved resulting in a release to the environment.

Table 2-6. Typical SODV Drilling and Coring Equipment

Device	Application
Drillship Tools	
Drill String	Used to deploy and retrieve all coring/drilling devices, reentry structures, completion hardware, and associated equipment. Composed of drill pipe, a bottom hole assembly (BHA), and a bit.
Bottom Hole Assembly (BHA)	Primary drilling system used to advance boreholes of required diameter following collection of continuous cores.
Rig Instrumentation System (RIS)	Data acquisition system that can present real-time data and drilling parameters in digital and graphical formats.
Vibration Isolated Television (VIT)	Used to provide visual observation of the sea floor, primarily during reentry of an existing borehole.
Coring Tools	
Advanced Piston Corer (APC)	Obtains continuous and relatively undisturbed cores from very soft to firm sediments.
Rotary Core Barrel (RCB)	Obtains continuous cores from hard rock formations.
Extended Core Barrel	Obtains continuous cores from soft to moderately hard

Table 2-6. Typical SODV Drilling and Coring Equipment

Device	Application
(XCB)	formations.
Advanced Diamond Core Barrel (ADCB)	Obtains continuous cores from firm to well lithified sedimentary or igneous formations.
Motor Driven Core Barrel (MDCB)	A wireline-retrievable coring system designed to improve core recovery in formations that are difficult to core using the APC or XCB.
Pressure Core Sampler (PCS)	Used to retrieve core samples while maintaining in situ pressures. The primary application of the PCS is to recover in situ hydrates.
Core Bits	The APC/XCB coring system can use three types of bits for coring soft to firm sediments: four roller cone bit with tungsten carbide chisel teeth, "anti-whirl" bits, or tungsten carbide blade "drag" bits.
Reentry Tools	
Drill-In-Casing (DIC)	Drills in a 25 cm casing string simultaneously with the bit to support an unstable sediment zone to prevent hole collapse.
Free Fall Funnel (FFF)	Metal funnel (229 cm dia., 103 cm high), support plate, glass flotation marker balls.
The Hard Rock Base (HRB)	Designed to focus the direction of the drill bit into hard irregular seafloor surfaces otherwise undrillable.
The Hard Rock Reentry System (HRRS)	Metal funnel; 33.9 cm casing. Used to install casing with reentry capability on a sloping or rough hard rock seafloor, where standard installations are not practical.
Reentry Cone and Casing System (RECC)	Metal cone, seafloor support plate, transition pipe, additional casings (various diameters).
Underreamer	Drills an enlarged hole to provide clearance for additional *casing strings and cement.
Downhole Tools	
Advanced Piston Corer Temperature (APCT) Tool	Obtains single measurements of temperature at discrete depths.
The Advance Piston Corer Methane (APCM)	Used to continuously monitor temperature, pressure, and conductivity changes in the core liner to quantify changes that occur in gas-rich cores.
The Davis-Villinger Temperature Probe (DVTP)	Obtains heat-flow measurements in semiconsolidated sediments that are too stiff for the Advanced Piston Corer Temperature (APCT) tool.
The Instrumented Water Sampler (IWS)	Formation fluid sampling tool with a motorized syringe-type sampling piston considered a replacement for the Water Sampler Temperature Probe (WSTP).
Drilling Sensor Sub (DSS)	Used to measure drilling and coring parameters near the bit during operations to improve downhole tool performance by

Table 2-6. Typical SODV Drilling and Coring Equipment

Device	Application
	optimizing control of drilling parameters.
Wireline Tools	
Lockable Float Valve (LFV)	A flapper-type valve used in the APC/XCB when logging is anticipated following or during coring. Allows the crew to continue to core in the same hole or move to a new hole after logging without tripping the pipe.
Mechanical Bit Release (MBR)	Used to remotely release the RCB core bit to allow logging tools to pass through the BHA.

2.3.2 Discharges Associated with Drilling and Coring

Various outputs will occur during riserless drilling that affect the surrounding environment including the release of seawater drilling fluid, the deposition of sediment cuttings on the seafloor, and the periodic use and release of drilling mud [naturally occurring minerals such as sepiolite (http://www.mindat.org/min-3621.html) or attapulgite (also referred as palygorskite, http://www.mindat.org/min-3072.html)] injected into a borehole to enhance the removal of cuttings.

2.3.2.1 Seawater

During drilling, the SODV will pump unaltered saltwater through the drill string and into the borehole to flush the cuttings from the hole. The seawater drilling fluid will force the cuttings up the annular space of the borehole and exit the hole at the seafloor forming a mound. Depending on the characteristics of the strata being drilled, 392 to 1,862 L of seawater drilling fluid may be released each minute.

2.3.2.2 Cuttings

The drill cuttings produced by the SODV represent the release of naturally-occurring geologic materials which will be deposited on the seafloor surrounding the borehole. The volume of cuttings released will depend on the type of strata being penetrated and the size and depth of the borehole. For a typical 25 cm diameter borehole, approximately 6 m^3 of cuttings will be generated for each 100 m of strata drilled. In cases where a larger size borehole is needed to support the installation of casings or an observatory, a 54.5 cm diameter borehole would produce approximately 28 m^3 of cuttings per 100 m drilled.

Over the past 21 years, the USIO has drilled 1,901 riserless boreholes in the seafloor of which 647 (34 percent) penetrated to a depth of 100 m or less, 987 (52 percent) extended from 100 to 500 m deep, and the remainder (14 percent) range from 500 m up to 2,100 m deep. Observatories were installed in 27 boreholes (1.4 percent) while reentry devices and casings were installed in an additional 45 holes (2.3 percent). Although the specific dimensions of each borehole to be advanced by the SODV will be based on specific research objectives accepted by the science community, it is anticipated that the past trends in the number and depth of boreholes as well as the installation of observatories and reentry devices will be representative of future IODP-USIO riserless drilling activities.

Drill cuttings produced by the SODV are expected to range in particle size from 2 μm for fine silt and clay to 30 mm for coarse gravel materials (Neff, 2005). The spatial deposition of drill cuttings will depend on the drilling and coring method used, the particle size and density of the material displaced from the borehole, and bottom currents affecting the transport of these materials. For example, it is expected that a coarse-toothed roller bit would produce a higher percentage of large particles in the cuttings while an Advanced Diamond Core Barrel (ADCB) used in hard rock strata may produce a higher percentage of fine particles. At sites where hydraulic washing (i.e., jetting in) is used to prepare a borehole for the installation of a casing, reentry cone, or observatory, suspended sediment particles may be expelled from the borehole at greater velocity than what would be encountered during typical drilling and coring activities and the sediments would be dispersed over a larger radius.

In general, larger cuttings particles will settle to the seafloor rapidly and within several meters of the borehole while smaller particles will remain in suspension longer and spread farther from the hole (Whitford, 2003; LGL, 2005). Typically, cuttings displaced from a borehole will settle in a conical mound surrounding the hole. The distance that the mound extends from the center of the borehole will be directly related to the volume of displaced material and its angle of repose on the seafloor, which is conservatively assumed to be 35° (Whipple, 2004). For example, a 500 m borehole that generates 30 m^3 of displaced material would result in a 3.5 m high mound extending approximately 2.5 m from borehole. A borehole advanced to a depth of 2,000 m would generate approximately 120 m^3 of material deposited in a conical mound 3.8 m high and extending 5.5 m from the hole. If the upper portion of a borehole is enlarged to a 54.6 cm diameter to accommodate an observatory, an additional 26 m^3 of sediment would be deposited on the seafloor; however this material would be dispersed over a greater area since hydraulic jetting-in techniques would have probably been used to create the larger diameter hole. Visual observations of a limited number of boreholes with a TV camera confirm sediment displaced during drilling will typically form a localized mound around the borehole.

2.3.2.3 Drilling Mud and Cement

Under normal riserless drilling conditions, seawater will be the primary drilling fluid used by the SODV. However, there will be occasions when drilling mud, which has a higher specific gravity than seawater, will be needed to more effectively displace cuttings from the borehole, control formation pressures, seal permeable formations, maintain well bore stability, or assist in formation evaluation via logging equipment. When needed, the SODV will use sepiolite drilling mud, a naturally-occurring mineral, or attapulgite, another natural mineral, which may be used in geographic areas where it may be more readily available or less expensive. The SODV will not use chemical additives to enhance the drilling muds.

In addition to drilling mud, for certain applications the SODV may introduce cement into a borehole for the installation of casings or borehole closure. The amount of cement expected to be used during future expeditions will depend on a number of site-specific factors, such as the planned research application, borehole depth, and formation conditions.

Table 2-7 identifies typical applications which may involve the use of drilling mud and cement by the SODV.

Table 2-7. Typical Riserless Drilling Applications Involving the Use of Drilling Mud and Cement

Application (purpose)	Concentration (grams/L)	Wet Weight of Mixture (seawater + solids)
Drilling Mud Sweep (expel cuttings from a borehole)	66	1.066 kg/L (8.9 lb/gal)
Heavy Drilling Mud Slug (stabilize borehole during drill bit change)	258	1.258 kg/L (10.5 lb/gal)
	737	1.737 kg/L (14.5 lb/gal)
Drilling Mud Plug (seal a borehole)	258	1.25 kg/L (10.5 lb/gal)
Cement (anchor and stabilize a casing)	869	1.869 kg/L (15.6 lb/gal)

In total, approximately 25 percent of all previous boreholes drilled for research purposes by the USIO required the use of drilling mud to remove (sweep) excess cuttings or solids from a borehole (Table 2-8). It is anticipated that drilling mud will be used by the SODV at approximately the same frequency to facilitate the removal of solids from a borehole. For example, approximately 4 percent of all future boreholes are likely to require 10,000 to 25,000 liters of drilling mud to sweep excess solids from each hole.

Table 2-8. Drilling Mud Used by the USIO to Sweep Excess Solids from Boreholes (1996 – 2005)

Number of Boreholes [1]	Number of Sweeps	Range of Mud Used per Borehole (Liters)
39 (4.6%)	52	≤ 5,000
27 (3.2%)	70	5,000 – 10,000

Table 2-8. Drilling Mud Used by the USIO to Sweep Excess Solids from Boreholes (1996 – 2005)

Number of Boreholes [1]	Number of Sweeps	Range of Mud Used per Borehole (Liters)
35 (4.2%)	206	10,000 – 25,000
49 (5.8%)	525	25,000 – 50,000
26 (3.1%)	377	50,000 – 75,000
15 (1.8%)	271	75,000 – 100,000
21 (2.5%)	973	100,000 – 700,000
212 (25.2%)	2,474	

Notes:
[1] A total of 840 boreholes were drilled during the period (number in parenthesis represent the percent of the total)

Periodically, a more concentrated mixture of sepiolite or attapulgite drilling mud will be used to either stabilize a borehole during drilling operations or seal a borehole upon completion. Table 2-9 summarizes the historical use of heavy drilling mud during previous USIO expeditions. Although the frequency and quantity of use will be site and application specific, it is anticipated that the future use of heavy drilling mud by the SODV will follow a similar trend.

Table 2-9. Heavy Drilling Mud Used to Stabilize and Seal Boreholes (1996 - 2005)

Number of Boreholes [1]	Range of Mud Used per Borehole (Liters)
3 (0.4%)	≤ 5,000
11 (1.3%)	5,000 – 10,000
24 (2.8%)	10,000 – 25,000
6 (0.7%)	25,000 – 50,000
2 (0.2%)	615,000 & 700,000 [2]
46 (5.5%)	

Notes:
[1] A total of 840 boreholes were drilled during 1996 – 2005 (number in parenthesis represent the percent of the total)
[2] Two boreholes were drilled in the Gulf of Mexico during Expedition 308 which required 615,000 and 700,000 liters of heavy mud, respectively for stabilization and sealing

Both drilling mud and cement contain fine grain-size particles typically less than 74 μm in diameter (Neff, 2005). Similar to dispersal of drill cuttings, drilling mud particles will be expelled from a borehole when drilling mud is used to sweep the borehole (generally once every 3 or 4 cores) or when the drill string is reintroduced into a borehole displacing a temporary slug of heavy mud. Drilling mud and cement used to plug (seal) a borehole will be isolated below the seafloor and remain in place, although excess particles, spillage, or water soluble components may be released to the surrounding marine environment during installation. Similar to the fate of fine drill cuttings particles, drilling mud and cement particles that are ejected from a borehole will become temporarily suspended in the water column and disperse as controlled by seafloor bottom currents.

2.3.2.4 Drill Pipe and Joint Compounds

Assembly SODV drill pipe mating joints and associated drill string components require various lubricants and anti-seizing compounds to ensure proper connection including:

- Drill pipe - Zinc-based compounds containing at least 50 percent by weight finely-powdered metallic zinc and not more than 0.3 percent active sulfur are used;

- Drill collars, heavy-wall drilling joints, bits, and other BHA components - lead or zinc-based lubricant with approximately 60 percent metallic content are used, typically in fine powdered form, and not more than 0.3 percent active sulfur;

- Non-metallic drill collars - copper-based compounds.

Although these materials are applied to joint threads prior to assembly, trace amounts may squeeze out of the tightened joints and be released to the surrounding seawater when the drill string and coring equipment are deployed.

2.3.2.5 Irretrievable Material and Equipment

A review of past DSDP/ODP/IODP drilling logs suggests that occasionally some drill string components or equipment may be accidentally or deliberately released to the environment for operational reasons. Equipment loss will be considered an environmental release because in many cases it may not be possible or practical to retrieve the items. It should be noted that the rate at which equipment has been lost at sea has decreased significantly each year since the inception of the ODP in 1985 due to improved drilling technologies and practices as well as more efficient recovery methods. It is anticipated that accidental or deliberate equipment losses will occur occasionally during SODV operations.

Sections of drill string including the bottom hole assembly (BHA), which makes up the lower portion of the drill string, may occasionally be lost in and near a borehole particularly when drilling in hard rock, unstable formations, or in rough sea conditions. For example, during a 13-year period from 1985 to 1997, a total of 10,090 m of drill string was lost in six separate years (1989, 1990, 1993, 1994, 1995, and 1996) while no drill string was lost during the other seven years. Although the loss of 10,090 m of drill string is operationally significant, the frequency of drill string losses is very low considering that during the 13-year period, 1,268 boreholes were drilled at 475 sites representing total drilling and coring penetrations of 78,000 and 230,000 m, respectively.

Drill bits and related hardware may accidentally or deliberately be released to the seafloor by the SODV particularly when drilling in hard rock conditions. In addition, expendable bits may be intentionally left on the seafloor to expedite certain types of operations such as downhole logging so that the entire drill string does not have to be tripped (retrieved) back to the ship to remove the drill bit. It can be expected that on average one or two bits may be lost or intentionally released per SODV expedition.

A free fall funnel will be deployed at certain drill sites to facilitate reentering a borehole following a drill bit change or other operation requiring the drill string to be tripped back to the ship. Typically, the free fall funnel is not recovered from the seafloor. On average, it is anticipated that the SODV may deploy one free fall funnel per expedition.

2.3.3 Acoustic Sources

In addition to acoustic sources discussed in Section 2.2.3 associated with SODV propulsion and navigational systems, underwater noise and vibration will be generated by the drilling and coring equipment and transponders temporarily deployed to the seafloor to support drilling operations. It has been estimated that the underwater source sound level generated by drilling operations in the open ocean is approximately 150 dB re 1 μ Pa (Richardson et al., 1995). Another estimate of acoustic outputs from ocean drilling activities on a vessel with operating thrusters indicates that the sounds are primarily in the broadband range (10 Hz -10 kHz range) and may be intermittently as high as 190 dB re 1 μ Pa (Hildebrand, 2004; Whitford, 2006). Sound level measurements from two different drillships were reported to be between 174 and 185 dB re 1 μ Pa (Hurley and Ellis 2004, WDCS, 2004).

In December 2001, the *JOIDES Resolution* began ODP Leg 200 with the primary goal of drilling a suitable borehole for a seismometer at a location approximately halfway between California and Hawaii. Seismic monitoring instrumentation had been previously installed at the site on the seafloor at a depth of 4,979 m and transmitted acoustic data to researchers in Hawaii via an underwater cable. Ambient noise levels were continuously monitored at the underwater observatory during the time the drillship approached the site, drilled a borehole, collected cores, installed casing, and left the area. Quiet periods were noted when cores were being recovered while sound levels increased above background by approximately 40 dB during drilling operations. By comparison, a large container ship which passed within 180 km of the monitoring instrumentation caused the sound level (RMS) in the octave centered at 8 Hz to increase by 50 dB over the ambient noise level. Following completion of drilling activities, the drillship passed directly over the monitoring instrumentation and the measured sound level (rms) in the 8 Hz octave was less than 20 dB above the ambient noise level (Stephen 2003).

During drilling, up to 12 of the SODV's thrusters as well as the vessel's main propellers may be used to dynamically position the vessel at a drill site. As described in Section 2.2.3, sound level measurements of the drillship SEDCO/BP 471, which is now designated the SODV, were made when all 12 thrusters and the vessel's main props were operating simultaneously. Using hull-mounted hydrophones, the average received sound level was 154 dB re 1 μPa. Although this data does not account for the additional underwater sound produced when the drilling equipment onboard the SODV is operating, the data provides a baseline sound level for the SODV's propulsion systems.

Underwater acoustical transponders or beacons such as Datasonics Model UAB 354EM will be deployed to the seafloor to aid in the operation of the SODV's dynamic positioning system. Output from a beacon is adjustable and will be generally set to a source sound level of 199 – 214 dB re 1 μ Pa at a frequency range of 12 to18 kHz. The acoustic output from the beacon radiates upward in a +/- 6 degree cone pattern about the true vertical. The transmit pulse duration is ~3.5 ms with a repetition interval of approximately 1,000 ms. The transponder power level will be set to the minimum needed to avoid multipathing and to prolong battery life. If multiple offset boreholes are to be drilled in an area, generally only one beacon will need to be deployed. The beacon which will be anchored on the seafloor with a weight, can be acoustically turned on or off and released from the weight for recovery.

2.3.4 Physical Disturbances

By the nature of drilling and coring operations, the SODV will physically disturb the seafloor environment surrounding each borehole including the water column and crustal materials in the formation.

2.3.4.1 Seafloor

Sediment cuttings generated during SODV drilling activities will be discharged at the top of the borehole and physically alter the seafloor. Assuming a 25 cm (9 7/8 in) diameter borehole is drilled, approximately 6 m^3 of cuttings will be generated for every 100 m the drilled is advanced. For a 50.7 cm diameter borehole, 20 m^3 of cuttings would be released for every 100 m drilled.

It is estimated that 90 percent of the material ejected from a borehole including drill cuttings and drilling mud will be deposited on the seafloor within several meters of the hole forming a conical mound. The remaining fine grain-size material will be temporarily suspended in the water column near the seafloor and transported by local currents away from the point of discharge (Neff, 2005).

2.3.4.2 Water Column

Drilling operations will result in the release of drilling fluid (seawater) and drill cuttings to the water column in proximity to the seafloor. Under normal SODV drilling operations, seawater will be pumped through the drill string and exit into a borehole through the drill bit. Drill cuttings will be washed upward in the annular space between the drill string and the borehole walls, and expelled onto the seafloor. Drill cuttings ejected from a borehole will range in particle size from 2 µm to 30 mm (Neff, 2005). The larger particles will quickly settle to the seafloor near the borehole, while the finer particles (typically less than 74 µm in size) may remain in suspension temporarily causing an increase in turbidity in the water column. The cuttings particles are expected to settle out of the water column and onto the seafloor at a rate of 2.6×10^{-1} to 1.3×10^{-6} m/sec (Nedwed, 2004). Depending upon site-specific conditions, between 392 to 1,862 L per minute of seawater drilling fluid will be used to flush the drilling cuttings from the borehole, however the volume of drilling fluid used will be kept to a minimum to prevent erosion of the borehole.

If seawater drilling fluid does not effectively flush cuttings from a borehole, drilling mud consisting of naturally-occurring mineral sepiolite (or attapulgite) mixed with seawater will be periodically used to sweep the excess solids from the hole. In these instances, the drill cuttings as well as the drilling mud will be discharged to the water column near the seafloor. In addition, drilling mud placed in a borehole as a temporary slug will be displaced to water column when the drill string reenters the borehole. The fine grain-size particles from the drilling mud will be suspended in the water column near the borehole and settle out onto the seafloor at a rate of 1.1×10^{-2} to 2.7×10^{-5} m/sec (Brandsma and Smith, 1996).

2.3.4.3 Crustal Materials

During drilling operations, it is anticipated that the SODV will encounter crustal materials including stratified deposits, interstitial water, gas hydrates, and possibly other hydrocarbon expressions. Because drilling and coring operations provide a potential conduit for the mixing, fluid exchange may occur between layers. Fluid movement in the seacrust may potentially rise to the seafloor and disperse in the water column. Additionally, drilling fluid (seawater and sepiolite) may dilute crustal fluids contained in crustal pore spaces.

2.4 **Representative Research Activities and Associated Environmental Outputs**

2.4.1 Overview of Research Procedures

2.4.1.1 Supplemental Site Characterization

Occasionally, when the SODV approaches a drill site, it may be necessary to collect site characterization data to supplement existing site survey data and verify site conditions before proceeding with drilling operations. Supplemental site characterization activities may include verifying drill site locations using standard geodetic positioning techniques, measuring water currents, or conducting visual surveys of the seafloor in the vicinity of the drill site using a vibration isolation television (VIT) camera system. Under special conditions, a Remotely Operated Vehicle (ROV) or Autonomous Underwater Vehicle (AUV) may be obtained and deployed to survey the seafloor. In addition, it may be necessary to supplement or verify existing geophysical data by conducting a limited single-channel seismic survey. The supplemental seismic survey would involve deploying a small airgun seismic source and a 100-m long oil-filled hydrophone streamer to investigate a limited area and collect sufficient information to correlate with existing geophysical data. The seismic survey would be conducted using procedures designed to incorporate mitigating measures to prevent adverse impacts to the biota as described in the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research and the ODP Airgun Policy and Marine Mammal Strategy (JOIDES, 2003). It should be noted that the hydrophone streamer contains approximately 135 liters of refined mineral oil and could potentially be damaged thereby releasing all or a portion of the oil to the sea.

2.4.1.2 Logging

Based upon the specific scientific objectives for each expedition, the SODV may perform various geophysical measurements of the subsurface using borehole logging techniques. These measurements are intended to augment ocean drilling, core recovery, and analysis, by providing in situ information about the formations below the seafloor. As specified in the approved operating plan for each expedition, borehole logging tools may include formation testers, samplers, borehole seismic monitoring, and imaging tools. In general, these borehole tools are small enough to fit inside the drill string (up to 10 cm in diameter), may be up to 29 meters in length, and are intended to be recovered from the borehole after measurements are made. Table 2-10 identifies common logging tools that may be available on the SODV to support specific research needs although more specialized third-party logging tools may be used occasionally as needed. Additional detail describing these tools is provided in Appendix D.

Table 2-10. Summary of Downhole Logging Tools

Device	Application
Logging Tools Selection	The logging tool selection is typically finalized in the expedition operational plan. Standard tool strings that measure basic formation properties are always on the SODV. Specialty tool use is dictated by the scientific objectives of the expedition.
Triple Combo Tools	
Accelerator Porosity Sonde (APS)	Obtains porosity values that are less influenced by environmental conditions.
Dual Induction Tool (DIT)	Measures spontaneous potential and three different resistivity values: deep induction, medium induction, and shallow spherically focused resistivity.
Hostile Environment Lithodensity Sonde (HLDS)	Obtains density measurements based on interaction of gamma rays emitted by a Cs137 radioactive source with the electrons in the formation.
Hostile Environment Gamma Ray Sonde (HNGS)	Measures the natural gamma ray radiation of the formation.
Temperature/Acceleration/Pressure Tool (TAP)	Obtains borehole temperature, tool acceleration, and hydrostatic pressure data.
Formation MicroScanner/Sonic Tools	
Dipole Sonic Imager (DSI)	Produces a full set of compressional and shear waveforms, cross-dipole shear wave velocities and amplitudes.
Formation MicroScanner Sonde (FMS)	Measures formation acoustic velocity, natural gamma ray, and borehole diameter.
Scintillation Gamma Ray Tool (SGT)	Provide a measurement of the radioactive content of the formation.
Third Party Tools	
Core Barrel - Extended Memory Drill String Accelerometer (CB-DSA-XM)	Measures and records drill string acceleration and ambient pressures during coring.
Core Barrel - Retrievable Memory Module (CB-RMM)	Measures incoming weight-on-bit, torque-on-bit, and pressure data from the Drilling Sensor Sub via a wireless inductive link.
Core Barrel Temperature Tool (CB-TT)	Obtains temperatures while drilling to allow an assessment if conditions are favorable for subsequent wireline or logging-while-drilling operations in hydrothermal environments.
Multi-Sensor Spectral Gamma Ray Tool (MGT)	Obtains data to improve the vertical resolution of natural gamma-ray logs by using an array of short detector modules with approximately 60 cm spacing.

Table 2-10. Summary of Downhole Logging Tools

Device	Application
Ultra-High Temperature Multi-Sensor Memory Tool (UHT-MSM)	A slim-hole memory tool which measures pressure and temperature in hot boreholes.
Specialty Tools	
Azimuthal Resistivity Imager (ARI)	Obtains deep measurements and azimuthal resistivity images around the borehole to provide data characterizing features and details that elude conventional resistivity measurements.
Array Seismic Imager (ASI)	Obtains three-dimension walkaway vertical seismic profile (VSP) data in both vertical and deviated wells using an array of five seismic shuttles.
Dual Laterolog (DLL)	Provides two resistivity measurements with different depths of investigation into the formation (deep, shallow).
Logging-While-Coring Resistivity-at-the-Bit (LWC-RAB8)Tool	Obtains lateral resistivity measurements in an 8-inch (20 cm) tool.
Logging-While-Drilling (LWD) adnVISION Tool	Measures azimuthal borehole compensated formation density and neutron porosity.
Logging-While-Drilling (LWD) arcVISION Tool	Obtains multiple, borehole-compensated phase shift and attenuation resistivity measurements in medium to large boreholes at two frequencies and provides a non-azimuthal gamma ray measurement.
Logging-While-Drilling (LWD) EcoScope Tool	Obtains a complete set of formation evaluation measurements using a pulsed neutron generator (PNG) and optional neutron gamma density measurements without the traditional side-mounted cesium source.
Logging-While-Drilling (LWD) sonicVISION Tool	Used to compute porosity and estimate fracture porosity in carbonate rocks.
Logging-While-Drilling (LWD) proVISION Tool	Obtains magnetic resonance measurements in the borehole and transmits them in real-time to the surface.
Logging-While-Drilling (LWD) geoVISION Tool	Obtains lateralog resistivity measurements in conductive muds.
Monitoring-While-Drilling TeleScope Tool	An in-line drill collar that records at the-bit drilling parameters and telemeters the data as well as data from other LWD tools to the surface in real-time.
SlimXtreme Array Induction Imager Tool (QAIT)	Measures the borehole formation conductivity in open holes. The SlimXtreme version (QAIT) is used in slim holes under severe environmental conditions.

Table 2-10. Summary of Downhole Logging Tools

Device	Application
Inline Checkshot Tool (QSST)	A single-axis seismic checkshot tool (hydrophone) that measures the vertically incident signals at the bottom of the hole.
Ultrasonic Borehole Imager (UBI)	Borehole televiewer.
Versatile Seismic Imager (VSI)	Used in conjunction with a seismic source and records seismic waves. Performs integrated processing for interpretation of borehole and surface seismic data and provides high definition images.
Well Seismic Tool (WST)	Used in conjunction with an airgun seismic source and records acoustic waves in a borehole that provide seismic velocity gradient and depth travel time information for determining in situ velocity profiles; also called a Vertical Seismic Profile (VSP).
3-Axis Well Seismic Tool (WST-3 Axis)	A three axis check shot tool used for both zero offset and offset vertical seismic profiles (VSP).
Stuck Tool Procedure	
Various accepted practices	Strategies: 1. Pulling harder on the cable 2. Adding pipe (if using the CSES) 3. Cutting and stripping 4. Using the Kinley crimper/cutter 5. Additional specialized strategies

2.4.2 Discharges and Materials Released to the Environment

It is anticipated that the following SODV research-related activities will result in the release of various substances to the environment.

2.4.2.1 Irretrievable Equipment

The research-related logging tools identified in Table 2-11 as well as other deployed oceanographic devices (e.g., beacons, buoys) are intended to be recovered by the SODV when drilling-related activities are complete in a particular area. However, occasionally retrieval of a deployed or lost device is not successful. In addition, certain devices such as weights are intended to be expendable and will be deployed with no expectation of recovery. Observatories are permanent borehole completion structures and will be further described in Section 2.8.2.

2.4.2.2 Tracers

Geochemical tracers may be used by the SODV for specific pre-approved applications to help improve understanding of porosity, permeability and diffusivity, and to quantify rates of fluid transport in igneous basement. During microbiological investigations of cores, a tracer, which is not naturally-occurring, may be carefully metered into the seawater drilling fluid to provide an indication if cored samples have been cross-contaminated by the drilling fluid thereby compromising the integrity of the samples.

Perfluoro(methylcyclohexane) is a tracer that may be used by the SODV because it is inert and can be detected with high sensitivity. This tracer has a low solubility in water of ~1 mg/L (Colwell et al., 1992) which facilitates gas phase partitioning and quantitative headspace analysis by gas chromatography. When used, perfluoro(methylcyclohexane) is introduced into the seawater drilling fluid to achieve a final concentration of 1 mg/L. Depending upon the drilling conditions, the seawater drilling fluid containing the tracer will be released from the drill bit into the formation at a rate ranging from 392 – 1,862 liters per minute.

Alternatively, extremely small and inert microsphere particles may be deployed by the SODV during coring and used as a tracer. In this application, a 2.5 ml bag of microspheres would be placed on the shoe of the Advanced Piston Corer (APC) and ruptured when the corer is activated. This process would yield approximately10^{10} microspheres/mL at the point of coring. The presence of the inert microspheres in the cored sample would provide a positive indication that drilling fluid had contacted the core and compromised the quality of the sample.

2.4.3 Acoustic Sources

Vertical seismic profiling (VSP) is the process of recording seismic data within the borehole environment and may be performed by the SODV to meet specific research objectives. During a VSP experiment, the Well Seismic Tool (WST) consisting of a single geophone would be secured successively at different depths in the borehole and an airgun would be fired in the water next to the ship each time the WST was repositioned. The WST would record both the direct, downgoing waves, and up-going waves reflected from changes in acoustic impedance below the receiver. Alternatively, the versatile seismic imager (VSI) may be used in place of the WST.

Typically, the SODV may either perform checkshot VSP which is used to calibrate surface seismic surveys or a zero offset VSP which would be used to derive formation velocities and identify certain features such as faults and overpressure zones. From 2004 through 2006, the USIO performed a total of nine zero offset VSP surveys that were generally less than 7 hours each in duration. The VSP surveys utilized a single 3,441 cc

(210 in^3) generator-injector (GI) airgun configured to operate with generator and injector volumes of 737 cc (45 in^3) and 1,720 cc (105 in^3), respectively, and an acoustical source output up to 191 dB re 1 μPa (see Appendix E). The surveys included up to a total of 300 airgun shots with approximately 15 shots at each WST position. At one deep hole site, the VSP survey was performed with a 1,720 cc (105 in^3) airgun operated in the harmonic mode and firing a total of 900 shots over a 10 hour period.

Depending upon site-specific conditions and research objectives, a parallel cluster of two 4,100 cc (250 in^3) generator airguns (output up to 194 dB re 1 μPa at the source) will be available onboard the SODV to provide additional airgun configuration options. It is anticipated that some of VSP experiments would utilize the two 4,100 cc (250 in^3) generator guns and last up to 12 hours in duration. A detailed description of the airguns, operating parameters associated with VSP, and graphic depictions of the sound exposure levels are included in Appendix E.

Depending on site-specific research objectives, other types of VSP surveys that could potentially be performed by the SODV include offset, vertical incident, walkaway, amplitude versus offset (AVO), and 3D. These VSPs are more complex than the checkshot and zero offset VSPs, may require higher output airguns than is typically carried on the SODV, and would involve the use of more than one vessel. Potential impacts associated with these types of VSPs are beyond the scope of this EIS and would be evaluated on a site by site basis.

As indicated in Section 2.4.1.1, occasionally the SODV may perform a limited scope single-channel seismic survey to confirm existing site characterization geophysical data and drill site conditions. Generally, these surveys will involve the use of a small seismic source operated for a short duration, typically less than 12 hours. It is expected that a single 3,441 cc (210 in^3) GI airgun would be used as the source for future single channel seismic surveys. A description of the airgun, operating parameters, and graphic depictions of the sound exposure levels is included in Appendix E. Additional detail pertaining to the use and assessment of seismic sources is presented in a separate document entitled the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research.

In addition, acoustic outputs will result from the use of several borehole logging instruments including the Dipole Sonic Imager (DSI), Logging-while-drilling (LWD) Tool String, Sonic (Isonic) Tool, and Ultrasonic Borehole Imager will utilize sonic transmitters and receivers. Detailed information on these tools is provided in Appendix D.

2.4.4 Physical Disturbances

Some physical disturbance to the seafloor environment will occur as a result of research-related activities performed by the SODV. These disturbances will be derived from the placement of permanent structures such as reentry devices and observatories on the seafloor (see Section 2.5).

2.4.5 Air Emissions

Air emissions will occur in SODV laboratories as a result of research-related activities such as those identified in Table 2-11.

Table 2-11. Summary of Laboratory Emissions

Emissions Source	Substances Released
Vapors or aerosols from chemical reactions	Acid (HCl, HF, HNO_3) vapors from the digestion solid materials
Vapors from volatile solvents	Acetone, methanol, propanol
Fugitive emissions from compressed or cryogenic gases	Nitrogen, oxygen, inert gases
Fugitive emissions from core samples	Methane and other aliphatic hydrocarbons, hydrogen sulfide

The type and quantity of laboratory chemicals and gases that may be used on the SODV for research applications will depend on the objectives of the expedition. Based upon past usage patterns (Appendix C), the quantity of chemicals that is expected to be used in the SODV's onboard laboratories and contribute to air emissions is quite small. Generally, air emissions from these chemicals will be released in laboratory fume hoods or ducted areas and exhausted outdoors to the ambient air. Because these materials are used in small quantities and on an intermittent basis, it is not reasonable to estimate the frequency and composition of each release.

Fugitive gases containing hydrocarbon and other organic or sulfur compounds may be emitted from samples when cores are opened and processed. The types and concentrations of fugitive gases released will be site dependent and cannot be generalized. These gases will be captured by vents and exhausted outdoors.

2.5 Environmental Outputs Associated With Borehole Completion and Deployed Equipment

2.5.1 Materials Introduced Into the Borehole

When drilling, coring, and logging operations are complete at a particular drill site, all drill equipment and tools will be retrieved by the SODV and the borehole will either be abandoned as-is, sealed, or prepared for continuing use. Items that may be permanently placed in a borehole include substances used to seal the hole (drilling mud, cement) or materials needed for the installation of observatories or reentry devices (casings, cement, instrumentation, supporting hardware).

Heavy Drilling Mud

Consistent with past practices, it is anticipated that most boreholes advanced during IODP riserless drilling activities will be left open when drilling and related measurements are complete. However as indicated in Section 2.3.2.3, if site conditions indicate that subsurface materials could migrate from an open borehole, the hole would be filled or plugged with heavy drilling mud and sealed with cement. The plugging mud would be a more concentrated mixture of sepiolite (or attapulgite) and seawater than occasionally used to sweep excess solids from a borehole during drilling (see Table 2-8). Heavy mud would be injected directly into a borehole and would not be expected to affect the surrounding seafloor or water column.

Based upon site characterization data evaluated during the site selection process, the SODV will have heavy mud available at certain sites to serve as a safety and environmental control measure to fill a borehole quickly, if needed, and provide hydrostatic kick control to prevent the release of pressurized materials. For this application, the hole would be filled to the uppermost competent layer with the heavy mud and sealed with a cement plug.

Cement

As described in Section 2.3.2.3, neat cement slurry may be used by the SODV for the installation of casings and plugging of select boreholes. The primary constituents of cement include calcium silicate and calcium sulfate additives. The cement slurry will be mixed at a concentration of 869 grams of material per liter of water (see Table 2-9) and injected into the borehole. The cement will stabilize the casing in the borehole and prevent open circulation between the ocean bottom water and formation intervals. Progressively smaller casings may be attached to hangers and cemented in place. The amount of cement used will depend on the length of casing and the diameter of the borehole. For example, a casing installed during Expedition 179 required approximately 10,000 kg (22,000 lb) of cement.

Casing

Depending upon site-specific conditions, the SODV will install casings of different diameters and lengths to suit the particular application. When used in conjunction with an observatory, the casing will provide an essential barrier between the measuring devices and crustal layers by preventing fluid exchange between the overlying seawater and the crustal fluids, while logging devices are operating inside the borehole. Casings may also be used to stabilize boreholes or isolate the borehole from formation fluid or pressure, especially for deep boreholes. Casings represent permanent installations and will not be retrieved.

2.5.2 Reentry Devices and Observatories

Consistent with the approved scientific objectives for each expedition, the SODV may install engineered structures at selected drilling sites to facilitate reentry into a borehole at a later time to either continue drilling and coring activities or support the installation of instrumentation in a permanent observatory. These reentry devices are intended to be permanent structures and will not be retrieved. Table 2-12 identifies common reentry and observatory systems that may be deployed by the SODV. Installation of these systems will typically involve deployment of casings and cement to secure the structures and casings. Detailed descriptions of these devices are presented in Appendix D.

Table 2-12. Borehole Research Tools

Device	Typical Components
Observatories	
Circulation Obviation Retrofit Kit (CORK)	Reentry cone and casing system, sensor string (pressure gauges, thermistors), additional scientific instruments as needed
Advanced Circulation Obviation Retrofit Kit (ACORK)	Reentry cone and casing system; instruments (data loggers, samplers), casing screens and packers, sensor string (pressure gauges, thermistors)
Support Tools	
Borehole Packers	An inflatable rubber element that seals the annular space between the drill string and the borehole wall
Borehole Instrument Hanger (BIH)	Provides a flexible system that can be customized to install scientific instruments in permanent boreholes for enhanced long-term downhole measurements. Includes an ROV platform, which serves as a landing pad for submersibles or ROVs to access the data.

2.6 **Environmental Outputs Associated With Accidental Events**

2.6.1 Geologic Sources

With any type of land- or marine-based deep earth drilling activity, there is always a risk of an accidental event resulting from the uncontrolled release of pressurized hydrocarbons in a formation from a borehole to the surrounding environment. This event is commonly called a blowout. In riserless drilling, control features that are inherent in riser drilling and used to prevent the escape of hydrocarbons from a borehole are not available; therefore each SODV expedition will incorporate special safety precautions to prevent a blowout or gas leak from occurring. These features include a comprehensive and conservative site selection process to identify and avoid drilling in conditions where an uncontrolled release hazard may exist, a stringent program of continuous real-time monitoring of hydrocarbon content in recovered sediments, and the immediate availability of heavy mud to seal a borehole and prevent a release. Existing SODV guidelines and contingency plans which describe these features include the Guidelines for Drillsite Selection and Near-Surface Drilling Hazard Surveys (Bruce, Robert J., Shipp, R. Craig, 2003), Guidelines for Site Survey and Safety (Graber, 2007), and Hydrogen Sulfide Drilling Contingency Plan (Mills, et al., 2006).

Although the careful selection of drill sites is the best insurance against blowouts or the accidental penetration of an oil or gas accumulation, a minimal risk remains. This low-level risk is reduced further by carefully planned and thoroughly executed shipboard laboratory procedures. All boreholes will be continuously cored. This means that, as permitted by the physical nature of the material being drilled, a sample of every foot of rock and sediment recovered in a core will be brought into the shipboard laboratory for immediate examination. Thus, any signs of either gas or liquid hydrocarbon will be detected as an early warning that the drill may be approaching a hydrocarbon rich environment.

It is possible in the drilling of relatively deep, open holes in the seafloor to penetrate an undetected, small reservoir of gas, so thin that it might be missed in the coring, or that its laboratory warning signal was so fleeting it was not detected. The gases in such small volume accumulations might then migrate into the open hole and exhaust into the sea. This would cause no particular damage to the seafloor environment and would probably be undetectable at the sea surface. It could, however, conceivably damage an adjacent reservoir formation by water encroachment. Consistent with previous ODP policies and procedures, every hole that penetrates more than approximately 400 meters into the seafloor will be logged. These well logs yield information on formation properties which, when combined with a second look at slight hydrocarbon shows in the cores, may give a clue to thin, leaky reservoirs. The abandonment procedures for such sites call for sealing off the interval with either heavy mud or cement as conditions require, equal to or greater than petroleum exploration industry standards.

Special measures will be performed by the SODV in areas where oil exploration and production facilities are operated. In these areas, boreholes will only be advanced to relatively shallow depths where nearby industry drilling data has confirmed that hydrocarbons were not encountered. In addition, the Measurement While Drilling (MWD) tool will be used in conjunction with Logging While Drilling (LWD) and Pressure While Drilling (PWD) tools to detect potentially pressurized formations and trigger immediate implementation of mitigating measures.

2.6.2 Vessel-related Sources

The risk of an accidental event involving fuel or hazardous materials onboard the SODV will always be present as with any ocean-going ship. The primary concern is the spillage and release of petroleum hydrocarbon substances such as fuel, hydraulic fluid, or liquid hazardous substances. Marine diesel fuel (i.e., marine gas oil), degreasers, solvents, and aerosols will be present on the SODV with diesel fuel being the most abundant (SODV capacity of 3,290 metric tons).

To avoid spills, SODV operations will be conducted consistent with established environmental protection procedures contained in the ship operator's Environmental Management System (EMS) including the Shipboard Oil Pollution Emergency Plan (SOPEP) and Spill Plan. These guidelines combined with in-depth experience of the vessel's operator, will help to minimize the potential risk of vessel-related releases to the environment. However, unpredictable events such as collisions with other vessels or groundings represent a very small but inherent risk.

2.7 Current Regulatory Framework Potentially Affecting the Proposed Action

All marine operations by the SODV including ocean drilling and research activities will be performed within the constraints of the regulations that govern any particular operation. An environmental legislation review was conducted to identify the applicable laws and regulations with respect to vessel and drilling operations applicable to the following representative countries:

- Angola
- Australia (Victoria, New South Wales, South Australia, Northern Territory)
- Brazil
- Canada (Newfoundland, Nova Scotia)
- Egypt
- Equatorial Guinea

- India
- Italy
- Indonesia
- Malaysia
- Thailand
- United States of America
- Venezuela
- Vietnam

The review encompassed international conventions related to pollution prevention as well as national environmental legislation in countries where requirements and responsibilities are clearly defined. Based on this, the study addressed the following objectives:

- Confirm environmental legislation registers for countries included in this study.
- Review license and permit holder's responsibilities and obligations related to national environmental legislation.
- Determine the SODV operator's environmental legislation and regulatory responsibilities versus those of other IODP participants.
- Identify national environmental legislation requirements for the SODV operator to be aware of specific to operating countries.

2.7.1 Flag State Requirements and International Regulations

Flag state requirements cover items such as design and constructions, stability, freeboard, watertight integrity, fire fighting appliances, and lifesaving equipment, pollution prevention, radio installations, manning levels and competence, navigation, normal and emergency operation, mooring and position keeping. These requirements are presented in a series of internationally recognized conventions, protocols and codes, usually sponsored by the International Maritime Organization (IMO), a specialized agency of the United Nations devoted to maritime affairs. The main conventions and protocols affecting mobile offshore units such as the SODV are:

- International Convention for the Prevention of Pollution from Ship Protocol of 1978 (MARPOL 73/78) and subsequent amendments;
- Safety of Life at Sea Convention of 1974 (SOLAS 1974) with 1978 and subsequent amendments;
- IMO Code for the Construction and Equipment of Mobile Offshore Units, 1979 and 1989 (IMO 1979 / 1989 MODU Code) and amendments;
- International Convention on Load Lines, 1966 (ILLC 1966) and amendments;
- Convention on the International Regulations for Prevention of Collision at Sea, 1972 (COLREG 1972) and subsequent amendment;
- International Convention on Tonnage Measurement of Ship, 1969;

- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969;
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LDC), 1972;
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990;
- Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (HNS Protocol);
- International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS), 2001; and
- International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004.

2.7.2 Coastal State or National Legislation and Regulations

Coastal states have generally accepted International Maritime Certificates (SOLAS; MODU Code, ILLC, MARPOL, etc.) issued by or on behalf of recognized maritime administrations. In addition, Coastal States have delegated authority to act or issue documents on their behalf to Classification Societies or other agencies. The extent of acceptance and authorization must be clarified with the Coastal State. Where there exists acceptance of the maritime certificates and/or appointed classification society by the Coastal State, surveys and certificates required to comply with requirements of the Coastal State legislation should, as far as possible, be conducted simultaneously with the maritime certificates and/or appointed classification society surveys.

In addition, the following regulations would be applicable to the SODV when it is operating either within U.S. jurisdiction or at locations outside of U.S. waters since its funding originates from a Federal agency.

<u>Marine Mammal Protection Act (MMPA)</u>

The MMPA of 1972 established, with limited exceptions, a moratorium on the “taking” of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates “takes” of marine mammals in the global commons (i.e., the high seas) by vessels or persons under U.S. jurisdiction. The term “take,” as defined in Section 3 (16 USC 1362) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, which provided two levels of “harassment,” Level A (potential injury) and Level B (potential disturbance).

The proposed action is designed to avoid Level A harassment and minimize potential disturbances to marine mammals (Level B) by avoiding marine mammal migratory routes, consistent feeding grounds, and local breeding grounds that concentrate cetaceans in critical areas.

Endangered Species Act (ESA)

The ESA (16 USC 1531 to 1543) applies to federal actions in two separate respects. First, the ESA requires that Federal agencies, in consultation with the responsible wildlife agency, ensure that proposed actions are not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of critical habitat [16 USC 1536 (a)(2)]. Regulations implementing the ESA expand the consultation requirement to include those actions that "may affect" a listed species or adversely modify critical habitat.

Second, if an agency's proposed action would take a listed species, then the agency must obtain an incidental take statement from the responsible wildlife agency. The ESA defines the term "take" to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt any such conduct" [16 USC 1532(19)].

- Harm is defined by regulation as "an act which actually kills or injures" fish or wildlife (50 CFR 222.102)

- Harass is defined by regulation to mean an "intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering" (50 CFR 17.3)

During various review stages of each proposed expeditions, activities will be undertaken to identify those proposed drilling locations where endangered species may be present. When applicable, IODP-USIO will consult with NOAA Fisheries under section 7(a)(2) of the ESA with respect to planned activities that may affect a listed species, including appropriate documentation of location- and time-specific parameters for the expedition. In response to any biological opinions that may be issued by NMFS for the proposed activities, the IODP-USIO will implement Reasonable and Prudent Measures (RPMs) necessary to prevent the harming or harassing of these organisms, and will comply with related terms and conditions to meet ESA requirements.

Coastal Zone Management Act

The CZMA provides assistance to states, in cooperation with federal and local agencies, for developing land and water use programs for the coastal zone. This includes the protection of natural resources and management of coastal development. The respective state coastal zone management program implements policy.

The CZMA requires that any federal agency activity within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone be carried out in a manner that is consistent, to the maximum extent practicable, with the enforceable policies of NOAA approved state management programs. Hence, under the CZMA, the NSF will determine whether IODP-USIO operations will affect the coastal zone and, if so, whether they are consistent with the enforceable policies of approved state coastal programs.

National Marine Sanctuaries Act

Consistent with the standards set forth by the National Marine Sanctuaries Act, the National Marine Sanctuary Program Regulations (codified at 15 CFR Part 922) prohibit specific kinds of activities, describe and define the boundaries of the designated national marine sanctuaries, and set up a system of permits to allow the conduct of certain types of activities (that would otherwise not be allowed). Each sanctuary has its own set of regulations (subparts) within 15 CFR Part 922.

Although drilling within National Marine Sanctuaries during the proposed action will be avoided unless there is critical scientific value, Subpart E of the regulations is most applicable, and contains provisions for the processing of sanctuary permits, emergency regulations, and appeals. While each Sanctuary has its own unique set of regulations, there are some regulatory prohibitions that are typical for many sanctuaries:

- Discharging material or other matter into the sanctuary,
- Disturbance of, construction on, or alteration of the seabed,
- Disturbance of cultural resources, and
- Exploring for, developing, or producing oil, gas, or minerals (with a grandfather clause for preexisting operations).

In addition, some sanctuaries prohibit other activities, such as the disturbance of marine mammals, seabirds, and sea turtles, operation of aircraft in certain zones, use of personal watercraft, mineral mining and anchoring of vessels.

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Act, enacted to conserve and restore the nation's fisheries, includes a requirement for NMFS and regional fishery councils to describe and identify Essential Fish Habits (EFH) for all species that are federally managed. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. In compliance with the act, the NSF will consult with the Secretary of

Commerce regarding any proposed activity that is authorized, funded, or undertaken by the agency that may adversely affect EFH.

Antarctic Treaty

The Antarctic Treaty will apply to all activities conducted in regions below 60° south latitude. The treaty was signed on 1 December 1959 by the twelve nations that had been active during the International Geophysical Year (IGY): Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, United Kingdom, United States and USSR. The Antarctic Treaty system currently includes 28 consultative parties and 17 acceding states, and encompasses several measures designed to protect the scientific value and the Antarctic environment:

- Agreed Measures for the Conservation of Antarctic Fauna and Flora (1964);
- Convention for the Conservation of Antarctic Seals (1972);
- The Convention on the Conservation of Antarctic Marine Living Resources (1982); and
- Protocol on Environmental Protection to the Antarctic Treaty (1991), including Annex 1-6.

In addition, Antarctica is designated as a Special Area under Annex I, II and IV of the International Convention for the Prevention of Pollution from Ship Protocol of 1978 (MARPOL 73/78).

2.7.3 Local Regulations

The following environmental legislation and regulations generally apply to ocean drilling activities and primarily relate to the petroleum industry for the particular country.

Angola

General Environmental Law (GEL) ascribes responsibility to all persons who, as a result of their actions, cause damage to the environment, degrade, destroy or fail to sustain natural resources. Such persons are compelled to restore them and/or pay compensation for the damage caused. GEL provides that all firms are obligated to protect the environment:

- General Environmental Law 5 of 1998(GEL): Article 16
- General Environmental Law 5 of 1998(GEL): Article 17
- General Environmental Law 5 of 1998(GEL): Article 18

For Petroleum Industry Environmental Protection Decree 39, the following outlines the requirements for a Spill Response Plan and a Spill Prevention Plan:

- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 6
- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 6(5)
- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 10
- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 11
- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 15
- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 16
- Petroleum Industry Environmental Protection Decree 39 of 2000: Article 27

Brazil

- CONAMA 273 of 19/12/97 – National Environmental Council, Installation License
- CONAMA 01 of 23/01/1986 – National Environmental Council, Installation License
- Lei estadual 1356/88 – Installation License
- LEI 9966 of 28/04/02 – Risk Management Program
- CONAMA 293 of 12/12/2001 – National Environmental Council, Environmental Audit
- CONAMA 265 of 27/01/00– National Environmental Council, Environmental Audit
- CONAMA 306 of July, 2002 – National Environmental Council, Environmental Audit
- Lei estadual 3471/2000 – Environmental Audit
- LEI 9966 of 28/04/02 – Liquid Effluent
- CONAMA 20 of 18/06/1986 Liquid Effluent
- Lei estadual 3007/98 Solid Waste
- ABNT rules Solid Waste
- Law Nº 6938, of 08/31/1981 - National Environment Policy Article 14 of this law sets forth that "without prejudice to application of the penalties provided for in this article, the polluter is obliged to indemnify or to remedy any damage caused to the environment or to third parties affected by its activity, regardless of the existence of blame."
- Law Nº 9605, of 12/12/1998. Article 2 of Law Nº 9605 of 12/12/1998 clearly defines who is responsible for compliance with environmental rules, as follows:

  "Article 2 - Everyone who contributes in any way for the crimes foreseen in this law will be subject to the penalties established herein, according to his/her culpability, such as the director, administrator, council or technical body member, auditor, manager, representative or agent of a legal person."

  Law Nº 9605 also establishes penalties for individuals and companies that fail to comply with existing environmental laws. This law allows penalties for companies and individuals that include:
  - Fines of up to US$ 70,000;

  - Cleaning of the contaminated areas and indemnification of the affected persons; and
  - Up to 5 year prison term.
- CONAMA Decision Nº 237 of 12/19/1997. This CONAMA Decision establishes basic rules for the licensing of activities considered to be polluting. This matter is dealt with in detail in Section 3 below, Licensing and Authorization Requirements.
- Law Nº 9966 of 04/28/2000. This law was created as a consequence of two large oil spills and it establishes preventive steps to be taken by companies engaging in activities that handle oil and its derivatives such as oil, diesel, gasoline and fuel oil.
- CONAMA Decision Nº 293 of 12/12/2001. This Decision involves the development of Emergency Plans and outlines the minimum criteria required in a Plan. Emergency Plans must be prepared for ports, port installations, platforms, pipelines and supporting installations.
- Decree Nº 4136 of 02/20/2002 sets forth the penalties to be imposed in the event of violations of Law Nº 9966 of 04/28/2000 (see above).
- ANP Administrative Ruling Nº 03 of 01/10/2003 establishes mandatory reporting of accidents involving oil and its derivatives. Furthermore, it establishes the reporting procedure and fines for failing to report. The Rule does not clearly define "accident" in terms of its size or magnitude, therefore making it potentially applicable to any size accident.
- Legislative Decree Nº 60, of 04/19/1995 approves the text of the International Agreement of 1973 on prevention of pollution by ships.
- Legislative Decree Nº 43, of 05/29/1998 approves the text of the International Agreement (London 11/30/90) on emergency preparation caused by oil pollution.
- Decree Nº 2508, of 03/04/1998 enacts the International Agreement on prevention of pollution by ships, completed in London on 11/02/1973.
- CONAMA Decision Nº 20, of 06/18/1986 regulates the classification of fresh water, brackish water and salt water in the Brazilian territory.
- CONAMA Decision Nº 05, of August 1993 establishes definitions, classifications and minimum procedures for the management of solid wastes resulting from health services, ports and airports.
- CONAMA Decision Nº 265, of 01/27/2000 establishes how to carry out environmental audits in activities that handle oil and its derivatives. The details of this audit appear in CONAMA 306, listed directly below.
- CONAMA Decision Nº 306, of July 2002 establishes minimum requirements for environmental audits. The audit scope is similar to ISO 14001.
- IBAMA Administrative Ruling Nº 10, of 08/17/2001 establishes mandatory registration in the "Cadastro Técnico Federal" (Federal Technical Reference File) for individuals and legal persons engaged in potentially polluting activities.
- Legislative Decree Nº 74, of 09/30/1976 approves the text of the International Agreement on civil liability for any damage caused by oil pollution.

Egypt

The role and responsibilities of Egyptian Ministries & Authorities having an implicit mandate on Environment in Egypt can be summarized as follows:

- Regulation of Environmental protection Law 4/1994
- Petroleum Pipeline Agreements Law 4/1988
- Petroleum Concessions Law 6/1974
- Licensing of wastewater drainage Law 93/1962
- Identifying methods of treating ponds and marshes Law 57/1978
- Observing rules for public cleanliness Law 88/1967
- Urban planning and land use Law 59/1979
- Definition of historical buildings Law 529/1953
- Protection of antiquities Decree 2828/1971
- Regulation of excavation Law 117/1983
- Protecting the River Nile and the waterways from pollution Law 48/1982
- Regulating discharge of wastewater and reuse of drainage Law 12/1984
- Protection of Agricultural Land. Law 53/1966
- Protection of marine life and regulation of fisheries Law 24/1983
- Rules and requirement for industrial projection. Law 21/1958
- Regulating use of chemicals in industry Presidential Decree 116/1965, Law 137/1981
- Specifications of industrial products. Occupational safety and health measure Law 27/1981

India

The following conventions are either directly applicable to India in that it has adopted them or, with varying levels of influence, are considered by the Government of India (GOI) in its deliberations of the expected development of the offshore and onshore oil and gas industry:

Global Conventions on Protection of Marine Environment

- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972), London, 1972;
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), London, 1973 and 1978;
- Convention on the Control of Transboundary Movements of Hazardous (Basel Convention);

- International Convention on Civil Liability for Oil Pollution Damage 1969 (1969 CLC), Brussels, 1969, 1976, and 1984;
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1971 (1971 Fund Convention), Brussels, 1971;
- Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), London, 1996;
- International Convention on Oil Pollution Preparedness, Response, and Co-operation (OPRC), London, 1990;
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Intervention Convention), Brussels, 1969;
- United Nations Convention on the Law of the Sea (UNCLOS), Montego Bay, 1982;
- The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR); 1992; 1996; 2000; Includes CHARM (Chemical Hazard Assessment & Risk Management). Although this convention does not apply directly to India, it is frequently referenced by government agencies and working groups in India when speaking about offshore oil & gas exploration. More significantly, the International Finance Corporation (World Bank Group) specifically references OPSAR as providing guidance to the offshore oil and gas exploration industry.

Indonesia

Control of Water Pollution; Regulation 20/1990 - Surface Water

- Reg/20/1990 Section 17
- Reg/20/1990 Section 20
- Reg/20/1990 Section 19
- Reg/20/1990 Section 21
- Reg/20/1990 Section 32

Air Emission Standards; Regulation 41/1999

- Reg/41/1999 Section 4
- Reg/41/1999 Section 21
- Reg/41/1999 Section 22
- Reg/41/1999 Section 26
- Reg/41/1999 Section 39
- Reg/41/1999 Section 51
- Reg/41/1999 Section 52
- Reg/41/1999 Section 54

Hazardous & Toxic Waste Management; Regulation 18/1999

- Reg/18/1999 Section 3
- Reg/18/1999 Section 7 & Appendix 5A
- Reg/18/1999 Section 8
- Reg/18/1999 Section 9
- Reg/18/1999 Section 10
- Reg/18/1999 Section 11
- Reg/18/1999 Section 27
- Reg/18/1999 Section 28
- Reg/18/1999 Section 40
- Reg/18/1999 Section 47
- Reg/18/1999 Section 48
- Reg/18/1999 Section 55

Oil Gas & Geothermal Industry (Risk Based Approach to Health, Safety and Environment) Regulations (2003)

- Regulation 4, Oil gas Regs 2003
- Schedule 1, 2.2 Oil Gas Regs 2003

Act Number 23/1997; Management of the Living Environment

- 23/1997 Chapter 5, Section 14
- 23/1997 Chapter 6, Section 20
- 23/1997 Chapter 6
- 23/1997 Chapter 7, Part III, Section 34
- 23/1997 Chapter 7, Part III, Section 35
- 23/1997 Chapter 7, Part III, Section 36
- 23/1997 Chapter 7, Part III, Section 37
- 23/1997 Chapter 9, Section 41
- 23/1997 Chapter 9, Section 43
- 23/1997 Chapter 9, Section 44
- 23/1997 Chapter 8, Section 40

Guidelines for the Establishment of Environmental Quality Standards (EQS) - Surface Water & Sea Water

- Decree KEP-02/MENKLH/1/1988

Guidelines for the Establishment of Environmental Quality Standards (EQS) - Air Quality

- Decree KEP-02/MENKLH/1/1988

Odor Level Standards - Air Quality

- Decree KEP-50/MENLH/11/1996

Noise Level Standards - Air Quality

- Decree KEP-48/MENLH/11/1996

Malaysia

- Exclusive Economic Zone Act (1984)
- Environmental Quality Act (1974) & Amendments of (1985) & (1996)
- Malaysia Thailand Joint Authority (Petroleum Regulations) and Procedures (1990)
- Scheduled Waste Regulations (1989): Prescribed Premises
- Clean Air Regulations (1978)
- Environmental Quality (Prohibition on the use of Chlorofluorocarbons and Other Gases as Propellants and Blowing Agents) Order (1993) (CFC's)
- Atomic Energy Licensing Act (1984)
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) (1990)
- Environmental Quality (Clean Air) Regulations (1978) (Clean Air)
- Petroleum (Safety Measures) (Transportation of Petroleum by Water) Regulations (1985) (Water Transport

United States

Mineral Mining Service (MMS)

- Title 30 - Chapter II - MMS - Part 250 - Oil, Gas and Sulphur Operations in the Outer: The installation must be decommissioned in a manner that does not cause undue or serious harm to the human, marine or coastal environment.
- NTL 98-16: Venting of H2S prohibited, except for maintenance and repair operations and where the emission levels do not exceed 15-minute-time-weighted average of 20ppm. NTL 98-16 also addresses guidance on protection against SO2 emissions; approval of flaring systems and other environmental and safety considerations.
- NTL 98-20: Outlines requirements for Shallow Hazard Surveys and Reports designed to prevent blowouts and rig damage.
- NTL 98-26: MMS requires any object installed on the lease (wells, pipelines, platforms, etc) must be properly removed and the site cleared and verified.
- NTL 2000-G20: All leases in greater than 400 meters of water depth in which chemosynthetic communities have been found must adhere to avoidance plan and conduct appropriates surveys.
- NTL 2002-G01: Certain leases in the Gulf of Mexico will have additional lease stipulations requiring the Operator to conduct remote sensing surveys to determine the presence or absence of certain archaeological features.

- NTL 2000-G07: Gives requirements for Marine Riser systems on Floating Rigs to prevent accidental disconnects and resulting safety and environmental danger.
- NTL 2002-G12: Outlines process for implantations of North American Datum 83 surveying / coordinate system for location of wells and facilities.
- NTL 99-G16: Certain leases in the Gulf of Mexico will have additional lease stipulations requiring the Operator to conduct remote sensing surveys to determine the presence or absence of certain biological assemblages (sea grasses, turtles, fish, etc).
- NTL 99-G22: Provides Standardized Guidance and instructions for sub-seabed disposal and offshore storage of oil and gas wastes generated in the OCS and classified as "Exempt" E&P Wastes under RCRA. Also covers the offshore storage of waste which contains NORM above background levels.
- NTL 2003-G06: Provides requirements and instructions for offshore placarding and annual video training of all offshore personnel regarding the prevention of loose items, trash and debris entering the marine environment.
- NTL 2003-G03: Provides guidance on conducting ROV survey for Deepwater operations.
- 30 CFR 250: All leases in greater than 400 meters of water depth in which chemosynthetic communities have been found must adhere to avoidance plan and conduct appropriates surveys.
- 30 CFR 254: Allows Operator to cover more than one facility, operation or location with a single Oil Spill Response Plan (OSRP). Eastern Gulf of Mexico lease must have individual plans.
- 40 CFR – 112: Owners or operators of onshore or offshore facilities which have or could be expected to have a discharge must prepare a written Facility Response Plan. Existing faculties have 6 months to prepare the plan and a further 6 months to implement the plan.
- Oil Pollution Act Places liability for oil pollution incidents on responsible parties. Contains financial penalties for clean-up and damages. OPA Response Planning requirements are administered in the GOM by the MMS.

Clean Water Act/ Federal Water Pollution Control Act

- EPA has authority to set effluent discharge standards for all point source industries including offshore oil and gas E&P. It is unlawful to discharge any pollutants unless a National Pollutant Discharge Elimination System permit is obtained.
- Continental Shelf Region - Code of Federal Regulations NPDES Outer Continental Shelf General Permit for Western Portion of Gulf of Mexico: For Each new lease the Operator must submit a letter signed by an Authorized Manager requesting coverage of lease activities under the existing Gulf of Mexico (GOM) General Permit. Similar General Permits cover the Texas and Louisiana state waters.

- Federal Water Pollution Control Act: 33 U.S.C. 1251 et seq. MARPOL 73/78 sets a standard of 15 ppm for oil contaminated discharges, which must not be exceeded: vessels grater than 400grt must have an oil/water separator and a Shipboard Oil Pollution Emergency Plan (OPEP).
- Oil Pollution Prevention and Response;
- Title 49 CFR - Subtitle III - Chapter 51 - Transportation of Hazardous Material Federal Water Pollution Control Act, as amended by Clean Water Act 1977.

Resource Conservation and Recovery Act (RCRA)

- 40 CFR - Parts 240-299: Waste generators - must determine if waste is hazardous. A waste manifest must be prepared on EPA form 8700-22 and 8700-22A. The manifest must state the permitted facility to which the waste is being transported - establishes requirement for manifest copy distribution and requires retention for 3 years.
- Establishes timescale for accumulation of waste at point of generation (180 days for companies generating between 100 and 1000Kg per month provided the quantity does not exceed 6000 Kg provided specific conditions regarding storage and labeling and emergencies are met or 270 days if the waste must be transported over 200 miles for disposal).
- 40 CFR - Subchapter I - Solid Wastes: State Agencies regulate disposal of oil field wastes, garbage and other waste streams.

Clean Air Act

- Part 55 Outer Continental Shelf Air Regulations: Prior to modification or 18 months prior to application for preconstruction a Notice of Intent must be submitted through the EPA Regional office and the pollution control agency of the nearest onshore area

3.0 ALTERNATIVES

3.1 Introduction

The Earth's surface veneer of seafloor sediment and extrusive volcanic rock represents the most recent snapshot of geologic time. Beneath that veneer, buried in sedimentary sections and the underlying crust, is a rich history of the waxing and waning of glaciers, the creation and aging of oceanic lithosphere, the evolution and extinction of microorganisms and the building and erosion of continents. More than thirty years of scientific ocean drilling by the U.S. have explored this history in increasing detail, revealing the complexity of the processes that control crustal formation, earthquake generation, ocean circulation and chemistry, and global climate change. Drilling has also revealed that deep within marine sediments, rock pore spaces and rock fractures is an active environment where ocean water circulates, microbes thrive and natural resources accumulate.

The IODP's drilling initiatives require the deployment of closely linked drilling platform types simultaneously to achieve specific research objectives. As the subject of this PEIS, the SODV will enable the USIO to reach the ocean's greatest depths using riserless drilling technology, while continuing to expand the global sampling coverage and disciplinary breadth characteristic of the ODP and DSDP. In concert with the IODP-USIO's riserless drilling capability, a riser-equipped drillship operated by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) Center for Deep Earth Exploration (CDEX) will permit the IODP to address deep objectives that require drilling for months to a year or more at a single location. Deep objectives include the "seismogenic zone" experiment, designed to determine the behavior of earthquake-generating faults in subduction zones; the deep crustal and intra-sedimentary biosphere; the three-dimensional structure of oceanic and Large Igneous Province (LIP) crust; and the processes of continental breakup and sedimentary basin formation. Complementing these capabilities, mission-specific platforms implemented by the European Consortium for Ocean Research Drilling (ECORD) Science Operator for the IODP will permit unprecedented examination of the history of sea-level change in critical regions near the shoreline, the recovery of high-resolution climate records from atolls and reefs in shallow water areas, and the exploration of climatically sensitive, ice-covered regions not yet sampled by drilling, such as the Arctic Ocean basin.

Within the scope of these IODP drilling initiatives, the proposed action encompasses the USIO's implementation of riserless ocean drilling techniques that have evolved and been refined for over thirty years. Alternative A of the proposed action represents the performance of riserless drilling activities focusing primarily on achieving specific scientific goals and minimizing health and safety hazards as carried out during the eras of the DSDP and ODP. In Alternative A, riserless drilling would be conducted without the benefit of advisory support obtained through technical reviews by the IODP. Alternative B represents an enhancement of Alternative A and is designed to merge the USIO's expertise in riserless drilling with input provided by the IODP Science Advisory Structure (SAS). The IODP process would include environmental reviews of each proposed drilling expedition which would identify conditions that could be potentially affected by riserless drilling operations and recommend measures to avoid adverse impacts. In Alternative C, the USIO would not conduct riserless ocean drilling.

The following describes each of these alternatives in greater detail and provides a discussion of other research technologies that were identified but eliminated from further consideration in the PEIS.

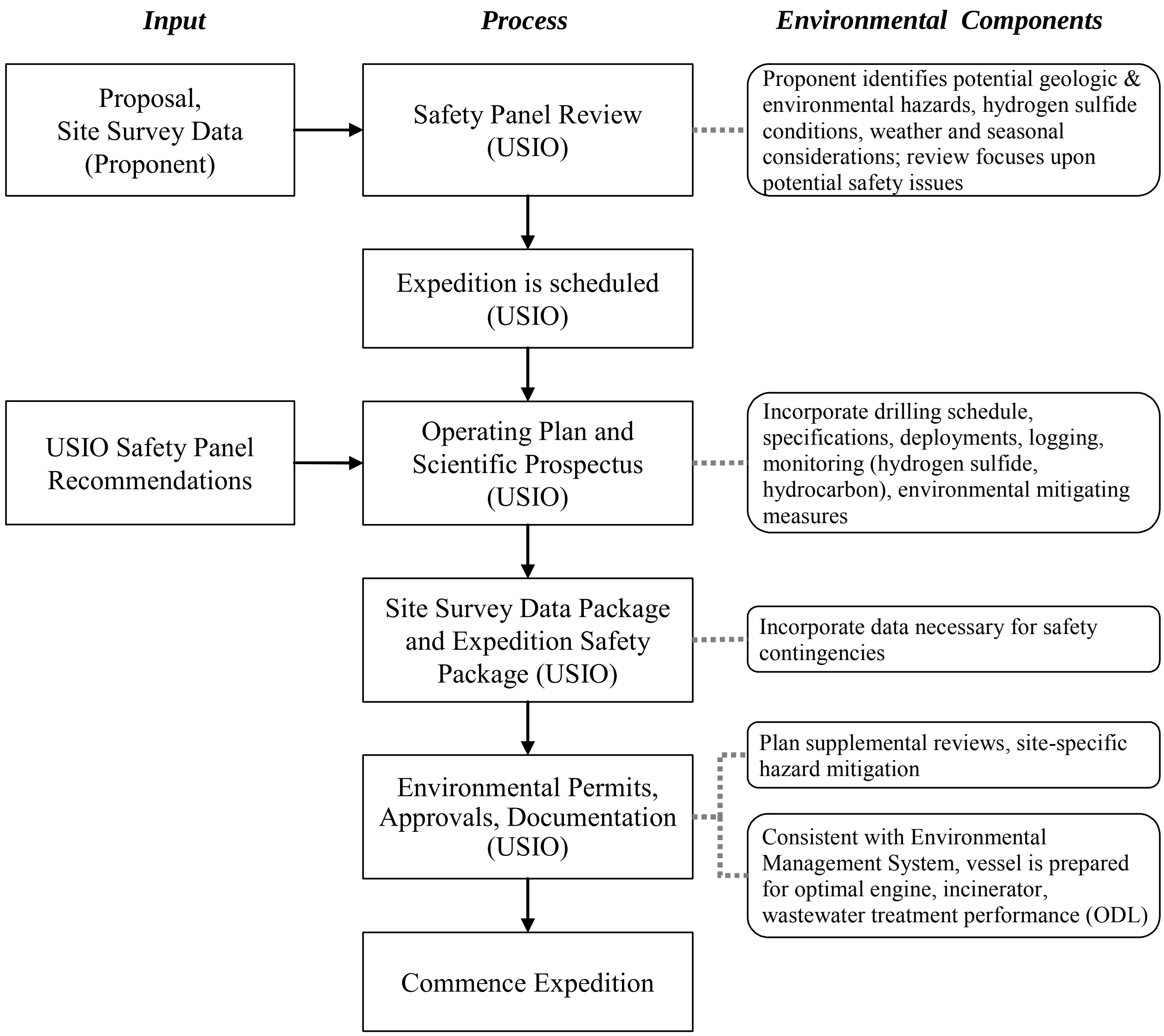
3.2 Alternative A – Conduct Riserless Ocean Drilling Based Solely on Scientific Research Needs

In Alternative A, riserless ocean drilling expeditions would be designed and conducted to meet site-specific scientific objectives as developed by the proponents of the research. In this alternative, the primary focus during the planning and implementation of riserless drilling expeditions would be on achieving the proposed scientific objectives and avoiding unsafe working conditions. Figure 3-1 identifies the process features and the environmental components of this alternative.

Texas A&M University (TAMU) and Lamont-Doherty Earth Observatory (LDEO), the IODP-USIO's science support contractor, would maintain a distinct, independent panel of safety experts (Safety Panel) to advise the IODP-USIO on safety issues and drilling hazards. The IODP-USIO Safety Panel would review all site-specific data pertaining to each expedition and render a final decision regarding site safety. The IODP-USIO Safety Panel would grant approval before an expedition could be scheduled.

TAMU would provide the IODP-USIO management with a preliminary review of a series of expeditions that may be grouped together (leg) for logistical reasons based on operational feasibility, time, cost, location, and environmental factors. The IODP-USIO would assemble a ship schedule and assign key personnel, and the Science Services groups at TAMU and LDEO would formulate a detailed operating plan in concert with the Staff Scientist/Expedition Project Manager, Co-chief Scientists, IODP-USIO staff, and Overseas Drilling Limited/Transocean, the vessel operator and owner.

Figure 3-1. Expedition Review and Planning Process for Alternative A



Legend

ODL Overseas Drilling Limited

USIO United States Implementing Organization

A pre-cruise meeting would be held with the Co-Chiefs at TAMU about 6-12 months prior to the leg, and the IODP-USIO Operations Manager (Ops Mgr), Staff Scientist/Expedition Project Manager (EPM), Lab Officer and other staff would become involved in detailed planning with the Co-Chiefs. A detailed Scientific Prospectus would be prepared at the pre-cruise meeting, reflecting the agreed upon priorities and implementation strategies for each expedition. The Site Survey Package consisting of data required for an expedition would be published in the Scientific Prospectus. The Expedition Safety Package would be prepared which would include a collection of all data and documentation (including the Site Survey Package) necessary to support a safe and environmentally compliant operation. In the event that proposed riserless drilling operations were to take place in regulated or environmentally sensitive areas, applicable permits and authorizations (e.g., Marine Mammal Protection Act) or supplemental environmental review documents would be submitted to the appropriate authorities prior to scheduling the expedition. Both the Site Safety and the Expedition Safety Packages would contain pertinent information on the potential geological or environmental hazards that would be used to determine appropriate contingencies during drilling.

Prior to the vessel departure, the IODP-USIO would obtain necessary approvals for the areas in which the vessel will operate including permits and other regulatory notifications. In parallel, the vessel operator (ODL/Transocean) would ensure that vessel systems such as engines, incinerators, and wastewater treatment devices are functioning properly per regulatory requirements (e.g., MARPOL).

In Alternative A, the comprehensive additional IODP SAS advisory process including the identification and review of the anticipated environmental conditions at each proposed drill site would <u>not</u> be performed. As a result, the IODP SAS would not provide additional advice or feedback to the proponents and the IODP-USIO regarding potential environmental impacts and mitigating measures that could be incorporated into the operating plan for each riserless drilling expedition. Without input from the IODP advisory process, the nature and extent of proposed drilling and coring activities will be less optimized to minimize possible adverse effects in environmentally sensitive areas. If environmentally sensitive conditions are not recognized during the planning process for each expedition, opportunities to identify and implement effective mitigating measures to prevent or minimize adverse environmental impacts may not be realized.

3.3 Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless ocean drilling expeditions would be designed and conducted to meet site-specific scientific objectives as presented by the proponents of the research and would incorporate advisory input and support from the IODP. The IODP would provide a mechanism for the efficient and effective integration and selection of multiple drilling platforms, exploratory tools, and diverse strategies in resolving outstanding research questions as discussed in the IODP ISP.

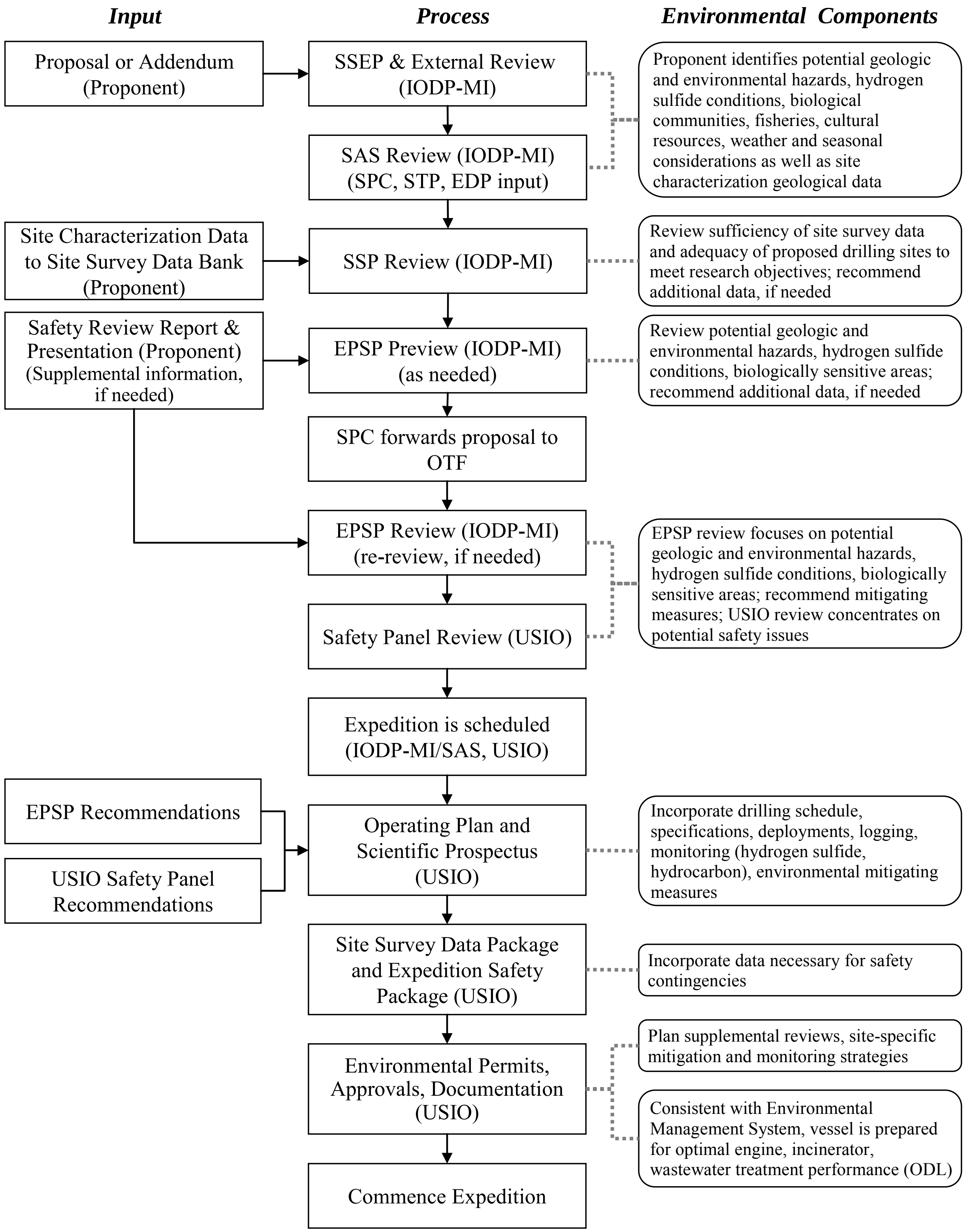
The need to effectively prevent or minimize safety and environmental risks during drilling has been recognized throughout the history of the DSDP, ODP, and IODP. Policies to minimize drilling hazards originally developed during DSDP and ODP would continue to be updated during the USIO's participation in the IODP. The value of the potential scientific results of any drilling proposal would be balanced against the possible hazards so that IODP-USIO riserless operations can achieve valuable scientific results without jeopardizing the health of individuals, the environment, or the future of the program. Figure 3-2 depicts the combined IODP and USIO review processes which would be used to select safe drilling locations and methods, and identify site-specific environmental conditions that could be adversely affected by riserless drilling activities before an expedition is included in the drilling program.

At the IODP level (see Appendix B), the Central Management Office of IODP-MI would provide scientific direction and planning advice to the USIO represented by the Consortium for Ocean Leadership, Inc formerly the Joint Oceanographic Institutions (JOI) and its science services subcontractors at TAMU and at LDEO. There are two main committees in the IODP, the SASEC (SAS Executive Committee), which oversees all policies and procedures, and the SPC which oversees the science. These committees and their associate subgroups would forward recommendations to the USIO and IODP-MI for action, who would in-turn notify Consortium for Ocean Leadership, Inc, TAMU, and LDEO. A responsibility of the SPC would be to prioritize recommendations for the drilling sites and consider recommendations from the various SAS technical panels including the SSP, EPSP, STP, and EDP.

The SSP provides advice to IODP-MI through the SPC on the adequacy of, and need for, site survey information relating to proposed drilling target sites. On notification from the IODP-MI Science Advisory Structure Office, proponents of proposals that have been highly ranked by the SSEP would submit supporting site survey data to the IODP Site Survey Data Bank for archiving. The information contained in these data packages would be derived from previous geophysical research efforts (e.g., seismic surveys) and would characterize the area in the immediate vicinity (within 1 km) of each proposed drill site for the purpose of evaluating seafloor conditions (water depth, seafloor topography and stability) and identifying potential hazards and environmental concerns.

A site survey data package for a particular expedition would include geological characteristics of each proposed drill site as well as information pertaining to environmental or man-made hazards, the presence of sensitive biological communities, and cultural resources. The data package, along with the proposal would be evaluated by the SSP to determine if (1) regional and site-specific survey data are of sufficient quality and quantity to properly image the sites and that the selected sites adequately address the scientific questions posed in the proposal, (2) proposed sites are in feasible places for the riserless drilling vessel to core, and (3) the regional and site-specific survey data are of sufficient quality and quantity that it is possible to extrapolate the results from this borehole over a usefully broad portion of the ocean and/or to apply the results from this borehole to related questions and analogous sites worldwide. The SSP would provide comments on this evaluation to the SPC and also provide advice to proponents on how to improve their data packages.

Figure 3-2. Expedition Review and Planning Process for Alternative B



(continued)

Legend			
EDP	Engineering Development Panel	OTF	Operations Task Force
EMS	Environmental Management System	SAS	Science Advisory Structure
EPSP	Environmental Protection and Safety Panel	SPC	Science Planning Committee
IODP-	Integrated Ocean Drilling Program -	SSEP	Science Steering and Evaluation Panel
MI	Management International	SSP	Site Survey Panel
ODL	Overseas Drilling Limited	STP	Science and Technology Panel
		USIO	United States Implementing Organization

During the review, the SSP would examine the potential hazards and other environmental issues described in the proposal and included in the data package. The SSP would identify a proposal that may have potential safety or environmental concern and pass this information along to the EPSP for preview and analysis. A proposal proponent may be asked to present additional environmental data, as needed.

The EPSP is an essential component in the review of drilling proposals to identify unacceptable operational hazards and adverse environmental impacts. The EPSP advisory panel currently consists of 18 multi-disciplinary experts drawn from industry, government, and academia with diverse backgrounds including the specialties shown in Table 3-1.

Table 3-1. Current EPSP Member Specialties

Member	Specialty	Member	Specialty
1	Geophysics, geopressure, drilling technology & methods	10	Geophysical exploration
2	Exploration geophysics	11	Gas hydrates, structural geology
3	Mining engineering, offshore drilling operation	12	Deep-sea exploration, hydrothermal system, gas hydrates
4	Seismic, methane hydrate exploration	13	Marine ecology, biodiversity
5	Marine drilling operations	14	Petroleum engineering
6	Downhole measurements	15	Deepwater riser drilling, geohazards
7	Petroleum geochemistry, exploration & development	16	Petroleum geology and geophysics
8	Petroleum geology, deepwater carbonate	17	Geophysics, seismic data
9	Marine biology, ecology	18	Gas hydrates, geotechnology

Following the EPSP preview, if needed, the SPC would rank all the proposals and send them to IODP-MI for operational evaluation by OTF. A full review by the EPSP would occur next, including evaluation of supplemental data provided by the proponent(s) as the result of the EPSP preliminary review. As indicated above, the EPSP would provide independent advice to IODP-MI through the SPC regarding potential safety and environmental hazards that may exist because of general or specific geology of the seafloor, as a consequence of human activities, or the potential impact on the marine life and their environment.

During the EPSP review process, a representative proponent would make a presentation consisting of a project overview followed by an appraisal of each proposed drill site and a description of the key safety and environmental issues. The purpose of the presentation would be to provide the panel with information on the proposed drilling activities, environmental conditions at each drill site, and other site-specific features that would allow the panel to identify operational hazards and potential environmental impacts. Consistent with Guidelines for the EPSP Safety Review Report and Presentation, and Expedition Safety Package (Appendix F), the proponent would prepare and present a report containing maps and data which provide the following information:

- A summary of the scientific objectives and environmental issues of the proposed expedition.
- Completed site summary forms.
- A contoured seafloor bathymetry map with an appropriate contour interval to illustrate the topography.
- Multibeam maps (contours at 50-100 m intervals or finer).
- Track chart of available seismic data. This map should also identify any known hazards, communication cables, and/or protected areas, as well as any prior commercial wells or scientific drilling sites.
- An uninterpreted section with the drill site annotation.

Specific issues that may be identified by the EPSP include the need for additional data such as shallow hazard survey, other special surveys, or a drilling protocol document. In some instances this may also include a request for interpretation of hazards survey data by an independent entity. Following examination of the data package, the EPSP would provide guidance on site selection and data processing to improve imaging of the sites, and on modification of site locations, so that the proposed sites would be safe to drill and will meet the scientific objectives. Typically, the site survey data would characterize the area in the immediate vicinity (within 1 km) of each proposed drill site for the purpose of evaluating seafloor conditions (water depth, seafloor topography and stability) and identifying potential hazards and environmental concerns while allowing flexibility in the use of alternate drill sites if unexpected field conditions prevent drilling at primary locations.

Some frequently asked questions posed by the EPSP to the proponent(s) related to environmental issues include:

- Are there are any reasons to suspect that an over-pressured section will be encountered?
- Are there any indications of active (or previously active) vent systems or hydrocarbon seeps in the area of proposed drilling?
- Is there a probability of encountering H2S (hydrogen sulfide) or hydrates during coring or core recovery?
- Are there any biological communities within 100 meters of any proposed drill sites, what are they (e.g., vents, deep-water reefs, etc.), and what is the evidence for their existence (e.g., sampling, visual, etc.)?
- Is the proposed drilling location in the vicinity of a fishery (species, typical gear), known local breeding ground, consistent feeding area, migration route, or habitat to threatened or endangered species?
- Have alternative sites been prepared if weather, currents, ice, sensitive biological communities, etc. prevent drilling or in the event additional time is available during the planned expedition?

Supplemental EPSP review may be necessary if sites are moved or new sites are added. In the event that proposed riserless drilling operations were to take place in regulated or environmentally sensitive areas, the EPSP would acknowledge the need to submit applicable permits and authorizations (e.g., Marine Mammal Protection Act) or supplemental environmental review documents to the appropriate authorities prior to scheduling the expedition. In some instances, EPSP approval may be contingent on additional data or reports requested. Following the final EPSP review, the panel will make recommendations for each site which will then be forwarded to the SPC, IODP OTF, and the IO. Possible site recommendations may be:

- Approve as requested
- Approve to a specified depth other than that originally requested
- Approve at a new site based on discussions between panel members, proponents, and operator
- Approve with the recommendation of a specific drilling order and/or specific monitoring requirements
- Defer any recommendation until additional specified information is provided
- Not approve

Separate from the IODP structure, TAMU would maintain a distinct, independent panel of safety experts (Safety Panel) to advise the IODP-USIO on safety issues and drilling hazards. In concert with EPSP advice, the IODP-USIO Safety Panel would review all site-specific data pertaining to a particular expedition and render a final decision regarding site safety. The IODP-USIO Safety Panel would grant approval before an expedition can be scheduled.

Responding to input from IODP-MI, including EPSP guidance, TAMU would provide IODP-USIO management with a preliminary review of a series of expeditions that may be grouped together for logistical reasons (leg) and the IODP-USIO advises OTF accordingly on operational feasibility, time, cost, location, and environmental factors. SPC would review and approve the proposed drilling schedule recommended by OTF for use in Annual Program Plan preparation by IODP-MI and the implementing organizations. The IODP-USIO would assemble a ship schedule and assign key personnel, and the IODP-USIO Science Services groups at TAMU and LDEO would formulate a detailed operating plan in concert with the Staff Scientist/Expedition Project Manager, Co-chief Scientists, IODP-USIO staff, and ODL/Transocean, the vessel operator and owner.

A pre-cruise meeting would be held with the Co-Chiefs at TAMU about 6-12 months prior to the leg, and the IODP-USIO Operations Manager (Ops Mgr), Staff Scientist/Expedition Project Manager (EPM), Lab Officer and other staff would become involved in detailed planning with the Co-Chiefs. A detailed Scientific Prospectus would be prepared at the pre-cruise meeting, which reflects the agreed upon priorities and implementation strategies for each expedition. The Site Survey Package consisting of data required for an expedition would be published in the Scientific Prospectus. The Expedition Safety Package would then be prepared which would be a collection of all data and documentation (including the Site Survey Package) necessary to support a safe and environmentally compliant operation. Both the Site Safety and the Expedition Safety Packages would contain pertinent information on the potential geological or environmental hazards that would be used to determine appropriate contingencies during drilling.

Prior to the vessel departure, the IODP-USIO would obtain necessary approvals for the areas in which the vessel would operate including permits and other regulatory notifications. If necessary, site-specific environmental assessments, Incidental Harassment Authorization (IHA), mitigating measures, monitoring strategies, and contingencies for alternate drill sites, would have been developed, reviewed by the appropriate authorities, and incorporated into the operating plan. In parallel, the vessel operator (ODL/Transocean) would ensure that vessel systems such as engines, incinerators, and wastewater treatment devices are functioning properly per regulatory requirements (e.g., MARPOL).

Benefits resulting from the collaboration of USIO riserless drilling planning efforts and IODP SAS review processes that contribute to the minimization of adverse environmental impacts include:

- Selection of the optimum drilling platform based upon site-specific conditions and research objectives;

- Ensuring that site characterization data is adequate to support the proposed research objectives and identify potentially sensitive environmental conditions for protection;

- Selection of the most appropriate drilling locations and minimal number of boreholes to be drilled based on research needs and local environmental conditions;

- Developing plans and procedures to limit vessel and drilling related discharges in environmentally sensitive areas to the minimum needed to support the intended research; and

- Minimizing the use of acoustic sources (e.g., transducer-based equipment, seismic sources) in environments containing organisms sensitive to outputs from these sources.

3.4 Alternative C - Do Not Conduct Ocean Drilling (No Action Alternative)

In Alternative C, the IODP-USIO would not operate the SODV and would not provide the riserless ocean drilling capability to the IODP. Unless the riserless drilling resources are realized from other sources, the IODP's goal to integrate multiple drilling platforms, exploratory tools, and diverse strategies to resolve outstanding research questions as identified in the ISP may not be achieved. The long-term U.S. commitment and expertise to support earth sciences research using riserless ocean drilling technologies would be lost.

3.5 Alternatives Not Considered

Riserless drilling is a central pillar in the IODP's strategy to integrate multiple drilling platforms and exploratory tools along with riser-equipped drilling and mission-specific platforms. The IODP recognizes that for specific types of geologic conditions, environmental settings, and research applications, riserless ocean drilling is the most efficient and effective technology available. In these instances, there are no equivalent-performing alternatives to riserless ocean drilling. Although riser-equipped drilling resources and mission-specific platforms may be configured to perform riserless drilling, they are not optimally suited to conduct riserless drilling for applications and in environments that the SODV is intended to operate. As a result, riser-equipped drilling resources and mission-specific platforms were not considered as viable alternatives to riserless drilling.

Other technologies may be used to access earth materials below the seafloor such as very large piston coring devices. Although large piston coring and similar devices are effective in certain types of seafloor strata, penetration depths are limited (typically <50

m) and sampling of hard rock substrates is not possible. As such, these types of devices were not considered as suitable alternatives to riserless drilling.

Compared to riserless drilling and coring technologies, the extent of disturbance to the seafloor can be reduced by the use of narrow-kerf (i.e., small diameter) diamond coring devices. Diamond coring bits are effective in recovering cores from friable, laminated hard/soft, and crystalline formations. Because of the narrow-kerf design, these coring devices result in less drill cuttings released to the seafloor than other riserless drilling and coring techniques. However, narrow-kerf coring has depth limitations, cannot sample certain types of unconsolidated sediment substrates, and the resulting cores are smaller than conventional cores thereby potentially limiting the types of analyses that can be performed on the cores. Although a narrow-kerf coring device may slightly reduce the extent of seafloor disturbance, its use is not equivalent to SODV riserless drilling and coring technologies and was not considered an alternative.

The strata below the seafloor may also be investigated remotely using seismic surveying techniques. Marine seismic surveys are conducted using one or more airguns which are towed behind a vessel and activated by compressed air to generate a pressure pulse that travels downwards into the seabed. The pulses, reflected back from the seabed and underlying strata, are detected by one or more hydrophone streamers also towed by the ship, recorded, interpreted, and plotted. As the survey of a specific area proceeds, the airguns are continually fired and recharged with compressed air at several second intervals depending on site-specific conditions and the objectives of the survey. This remote sensing technology is very effective and widely used to explore oil and gas reserves as well as for scientific research purposes. In fact, seismic surveying data is a required precursor for scientific ocean drilling to identify locations of unique research interest. Seismic surveying data alone fails to provide the types of physical and chemical data obtained from the recovery and analysis of core samples, in situ logging measurements, and borehole observatories needed to address many complex scientific objectives. As a result, seismic surveying is a highly important foundation to support ocean drilling but is not an equivalent alternative for drilling and coring.

4.0 ENVIRONMENTAL ANALYSIS

4.1 Introduction

As indicated in Section 1, the proposed action involves the continuation of ocean drilling activities for scientific research purposes by the United States using the modernized riserless drilling vessel and research platform, the SODV. The direct effects of the proposed action relate to the outputs of each riserless drilling activity which interact with the environment. Section 2 of the PEIS identified the SODV processes and activities that would result in physical changes, or entities imposed on or released, to the environment as the result of these actions. The outputs also include by-products of a process or activity such as air emissions, wastewater discharges, noise, or fuel spills. The following section identifies the environmental media or receptors that may be affected by the proposed action and a discussion of potential impacts for each of the alternative.

4.2 Marine Water Quality

The operation of the SODV including riserless drilling, coring, and related research activities will result in the discharge of substances to the sea and create disturbances on the seafloor that may potentially impact water quality. Sanitary wastewater (consisting of human waste) and non-sanitary wastewater (washwater or greywater), desalination brinewater, and victual (food-related) wastes will be discharged as the vessel operates on the open sea. Intermittent discharges of deck drainage, bilge and engine room drainage, noncontact cooling water, and ballast water will also occur. Ocean drilling activities will also result in the release of fine grain-size particles from the borehole which will disperse in the water column near the seafloor.

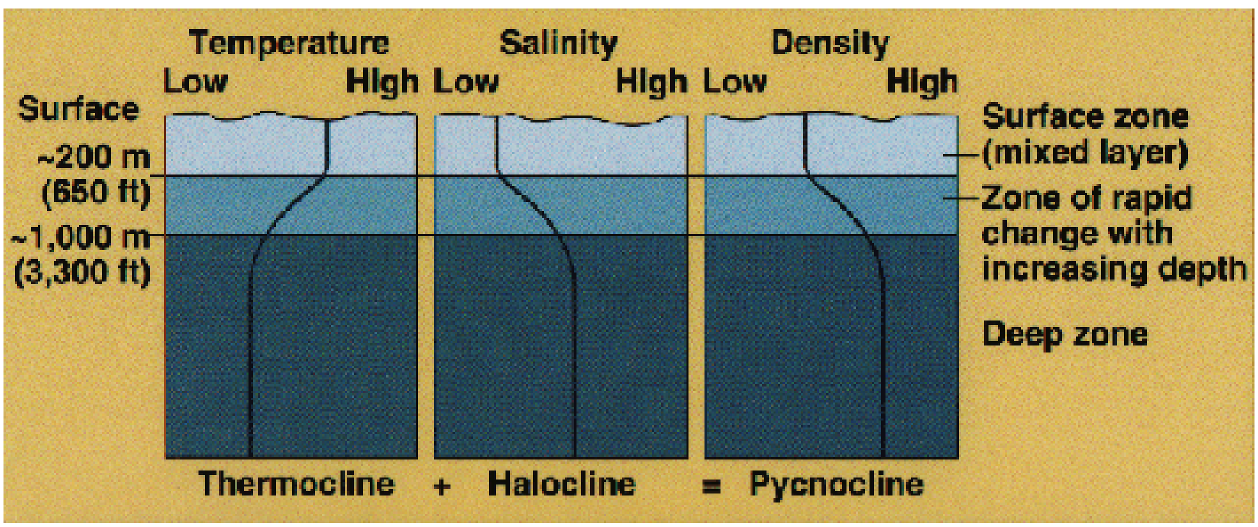
4.2.1 Environmental Settings

Seawater is a solution of salts of nearly constant composition, dissolved in variable amounts of water. There are more than 70 elements dissolved in seawater but only six make up greater than 99 percent of all the dissolved salts. These dissolved salts occur as ions. The resulting average salinity in the open ocean is approximately 35 parts per thousand (ppt or ‰); however, the concentration of dissolved material changes with the addition or removal of water, i.e., salinity variations can result from differences in local rates of evaporation and precipitation over the ocean and from the volume of freshwater discharged into a particular basin. The salinity of the Red (40‰) and Mediterranean (38‰) Seas is high because of low rainfall and high evaporation, whereas the Black (18‰) and Baltic (8‰) Seas have a low salinity due to a large influx of freshwater and a low rate of evaporation.

The chemical constituents of seawater originate from the (1) degassing (releasing of volatile chemicals) of Earth's mass that began after the planet's formation and continues today during volcanic activity, (2) erosion of sediments and basalts on land by weathering, (3) seawater reactions with basalt extruded under the sea that release chemicals to seawater, (4) biological processes that produce organic chemicals and cycle bioreactive elements, (5) photochemical reactions that occur in the upper pelagic waters, and (6) radioactive decay of elements that yield other elements.

Seawater salinity varies with depth. Surface layers of water are generally well-mixed by waves, winds, and tides and their salinities and temperatures are generally uniform (though can exhibit seasonal changes due to increased rainfall, evaporation, etc.). Beneath the surface can be a zone called the halocline, which is characterized by rapid salinity changes with increasing depth. Below the halocline, deep water is relatively uniform in salinity and temperature. Where there is both a thermocline and a halocline, the density of water changes dramatically called a pycnocline. These variations of temperature, density and salinity are shown in Figure 4-1 and represent the water quality environment in which drilling operations occur.

Figure 4-1. Thermocline, Halocline and Pycnocline in Seawater



4.2.2 Regulatory Settings

Broadly speaking several international laws and treaties apply to marine pollution on the open sea (beyond territorial waters or other waters under jurisdiction of a nation or state), including those regulating discharges from marine vessels. The following water quality requirements are applicable to the discharges from the SODV or related to drilling operations.

International Convention for the Prevention of Pollution from Ships (1973) as modified by the Protocol of 1978 (MARPOL 73/78)

Annex IV of MARPOL 73/78 contains a set of regulations regarding the discharge of sewage into the sea, ships' equipment and systems for the control of sewage discharge, the provision of facilities at ports and terminals for the reception of sewage, and requirements for survey and certification. The regulations in Annex IV of MARPOL 73/78 prohibit the discharge of sewage into the sea, except when the ship has in operation an approved sewage treatment plant and is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; or is discharging sewage which is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land. Ships without these approved systems must retain sewage in a holding tank, and governments are required to ensure the provision of adequate facilities at ports and terminals for the reception of sewage.

Regulations for the Prevention of Pollution by garbage from ships are contained in Annex V of MARPOL 73/78. Under Annex V, garbage includes all kinds of food (excluding fresh fish), domestic and operational waste generated during the normal operation of the vessel and liable to be disposed of continuously or periodically. Annex V totally prohibits the disposal of plastics anywhere into the sea, and severely restricts discharges of other garbage from ships into coastal waters and "Special Areas". The Annex also obliges Governments to ensure the provision of facilities at ports and terminals for the reception of garbage. Special areas established under the Annex include the Mediterranean Sea, Baltic Sea area, Black Sea area, the Red Sea area, the Gulfs area (Gulf of Oman/Arabian Sea), the North Sea, the wider Caribbean Region, and the Antarctic area. These are areas which have particular problems because of heavy maritime traffic or low water exchange caused by the land-locked nature of the sea concerned. Although the Annex was optional, the Annex did receive sufficient number of ratifications to enter into force on 31 December 1988.

In accordance with regulation 9 of Annex V, all ships of 400 gross tonnage and above and every ship certified to carry 15 persons or more, and every fixed or floating platform engaged in exploration and exploitation of the seabed must provide a Garbage Record Book, to record all disposal and incineration operations. The date, time, position of ship, description of the garbage and the estimated amount incinerated or discharged must be logged and signed. The books must be kept for a period of two years after the date of the last entry. The Garbage Management Plan should designate the person responsible for carrying out the plan and should be in the working language of the crew. This regulation makes it easier to check that the requirements on garbage are being adhered to because ship personnel must keep track of the garbage and what happens to it. It may also prove an advantage to a ship when local officials are checking the origin of improperly disposed garbage. Administrations may exempt fixed or floating platforms while engaged in exploration and exploitation of the seabed from providing a Garbage Record Book.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention or LDC)

The Inter-Governmental Conference on the Convention on the Dumping of Wastes at Sea, which met in London in November 1972 at the invitation of the United Kingdom, adopted this instrument, generally known as the London Convention. The Convention contributes to the international control and prevention of marine pollution. It prohibits the dumping of certain hazardous materials, requires a prior special permit for the dumping of a number of other identified materials and a prior general permit for other wastes or matter. "Dumping" has been defined as the deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures, as well as the deliberate disposal of these vessels or platforms themselves. Article 4 states that Contracting Parties "shall prohibit the dumping of any wastes or other matter with the exception of those listed in Annex 1" including: (1) dredged material, (2) sewage sludge, (3) fish waste, or material resulting from industrial fish processing operations, (4) vessels and platforms or other man-made structures at sea, (5) inert, inorganic geological material, (6) organic material of natural origin, and (7) bulky items primarily comprising iron, steel, concrete and similar unharmful materials for which the concern is physical impact and limited to those circumstances, where such wastes are generated at locations, such as small islands with isolated communities, having no practicable access to disposal options other than dumping. The only exceptions to this are contained in Article 8 which permits dumping to be carried out "in cases of force majeure caused by stress of weather, or in any case which constitutes a danger to human life or a real threat to vessels..."

The 1996 Protocol, adopted on 7 November 1996, and effective on 24 March 2006, is intended to replace the 1972 Convention. It represents a major change of approach to the question of how to regulate the use of the sea as a depository for waste materials. One of the most important innovations was to introduce (in Article 3) what is known as the "precautionary approach". This requires that "appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects."

International Convention for the Control and Management of Ships' Ballast Water and Sediments

This Convention was adopted on 13 February, 2004, and it will enter into force 12 months after ratification by 30 States, representing 35 percent of world merchant shipping tonnage. The Convention is divided into Articles; and an Annex which includes technical standards and requirements in the Regulations for the control and management of ships' ballast water and sediments. The main features of the ballast water Convention that apply to the SODV are outlined below.

Annex - Section B Management and Control Requirements for Ships

Ships are required to have onboard and implement a Ballast Water Management Plan approved by the Administration (Regulation B-1). The Ballast Water Management Plan is specific to each ship and includes a detailed description of the actions to be taken to implement the Ballast Water Management requirements and supplemental Ballast Water Management practices.

Ships must have a Ballast Water Record Book (Regulation B-2) to record when ballast water is taken on board, circulated or treated for Ballast Water Management purposes, and discharged into the sea. It should also record when Ballast Water is discharged to a reception facility and accidental or other exceptional discharges of Ballast Water. Additional requirements pertaining to Ballast Water Management are contained in regulation B-4 and include the following provisions:

- Whenever possible, conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 m in depth, taking into account Guidelines developed by IMO.

- In cases where the ship is unable to conduct ballast water exchange as above, this should be as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 m in depth.

- When these requirements cannot be met, areas may be designated where ships can conduct ballast water exchange. All ships shall remove and dispose of sediments from spaces designated to carry ballast water in accordance with the provisions of the ships' ballast water management plan.

Annex - Section D Standards for Ballast Water Management

There is a ballast water exchange standard and a ballast water performance standard. Ballast water exchange could be used to meet the performance standard:

> **Regulation D-1 Ballast Water Exchange Standard** – Ships performing Ballast Water exchange shall do so with an efficiency of 95 percent volumetric exchange of Ballast Water. For ships exchanging ballast water by the pumping-through method, pumping through three times the volume of each ballast water tank shall be considered to meet the standard described. Pumping through less than three

times the volume may be accepted provided the ship can demonstrate that at least 95 percent volumetric exchange is met.

Regulation D-2 Ballast Water Performance Standard – Ships conducting Ballast Water Management shall discharge less than 10 viable organisms per cubic meter greater than or equal to 50 micrometers in minimum dimension and less than 10 viable organisms per milliliter less than 50 micrometers in minimum dimension and greater than or equal to 10 micrometers in minimum dimension; and discharge of the indicator microbes shall not exceed the specified concentrations.

a. The indicator microbes, as a human health standard, include, but are not be limited to: Toxicogenic Vibrio cholerae (O1 and O139) with less than 1 colony forming unit (cfu) per 100 milliliters or less than 1 cfu per 1 gram (wet weight) zooplankton samples;
b. Escherichia coli less than 250 cfu per 100 milliliters;
c. Intestinal Enterococci less than 100 cfu per 100 milliliters.

Ballast Water Management systems must be approved by the Administration in accordance with IMO Guidelines. These include systems which make use of chemicals or biocides; make use of organisms or biological mechanisms; or which alter the chemical or physical characteristics of the Ballast Water.

Convention for the Protection of the Marine Environment of the North Atlantic (OSPAR 1992)

An international water quality agreement pertaining to the North Atlantic was prepared by 14 signatory states to the Oslo and Paris Conventions and is known as the Convention for the Protection of the Marine Environment of the North Atlantic (OSPAR 1992). The goal of OSPAR is to take all possible steps to prevent and eliminate pollution, take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. OSPAR contains five annexes two of which may be relevant to drilling activities including Annex IV - Assessment of the quality of the marine environment and Annex V - Protection and conservation of the ecosystem and biological diversity of the maritime area.

National Laws and Regulations

In addition to the international conventions identified above, some countries have specific regulations and guidelines regarding marine water quality within their territorial waters. Some of these regulations are more stringent than the international conventions. These national regulations generally exist to protect endangered habitats, fishery and allied industries, and aquaculture. Some of these regulations address regional initiatives, such as the European Union's Thematic Strategy on the Protection and Conservation of the Marine Environment. In preparation for each expedition (see Section 2.10), the vessel operator (ODL/Transocean) and the science support contractor (TAMU) will identify specific territorial marine water quality guidelines, regulations, and permitting requirements relevant to the countries where vessel and drilling operations will take place.

4.2.3 Significance Criteria

Water quality impacts associated with SODV operations may be considered significant if any of the following criteria are exceeded:

- Release of visible indications of oil or grease, spilled petroleum products, garbage that has not been macerated, plastics, organics, or any other substances that are prohibited;

- Effects of turbidity, pH, and other chemical indicators that are persistent at the location of discharge and not reversed by natural attenuation processes over a short-term period;

- Physical/chemical changes that extend beyond the immediate area of discharge resulting in exceedance of water quality parameters stipulated by international, national, regional, or local laws and regulations;

- Alteration of local sea currents to an extent that the mixing and assimilating processes of the discharges are compromised; or

- Release and dispersal of drilling fluids and other drilling-related substances beyond expected fate and transport characteristics or loss of equipment that would cause leaching of toxic or harmful constituents into the seawater.

4.2.4 Impact Source Characterization

Based on recent USIO riserless drilling experience and for the purpose of this PEIS, it is assumed that each typical SODV expedition may be up to 61 days in duration including five days in port and 56 days at sea either in transit or performing riserless drilling operations. While at sea during each expedition, the SODV will discharge various liquids to the sea, including treated sanitary wastewater, non-sanitary wastewater, bilge water, noncontact cooling water, deck drainage, ballast water, desalination brinewater, and treated laboratory wastewater. These discharges will be compliant with applicable laws and treaties and the resulting impacts are not expected to be significantly different than water quality impacts from similar size and class vessels. When the SODV is in an area where national or international regulations prohibit a certain type of discharge, the liquid wastes will be retained onboard in storage tanks or transferred to a temporary holding facility. Upon leaving a regulated area, the SODV will release treated and untreated liquid wastes to the sea consistent with international conventions. Similarly, when the vessel is docked and port facilities are not available for the conveyance and disposal of sanitary wastewater, the SODV will temporarily hold wastewater until transfer or treatment and discharge is possible. The SODV will be capable of storing approximately 16 days of wastewater at typical generation rates.

Sanitary wastewater generated onboard the SODV will be collected using a vacuum conveyance system, treated via an activated sludge/suspended aeration process, and disinfected by chlorination prior to discharge. The wastewater treatment system is capable of processing and discharging up to 15,800 liters per day and meeting MARPOL standards yielding effluent containing less than 50 mg/L for total suspended solids (TSS), 50 mg/L for 5-day biological oxygen demand (BOD_5), and 250 MPN colonies/100mL for fecal coliform bacteria. Table 4-1 summarizes the projected wastewater discharge volumes and maximum pollutant loadings for a typical 61-day SODV expedition.

Table 4-1. Projected SODV Liquid Waste Discharge

Source	**Liters Per Expedition [1]** (per day)
Sanitary Wastewater [2]	963,800 (15,800)
Non-sanitary Wastewater [3]	3,355,000 (55,000)
Desalination Brinewater	132,929,000 (2,179,000)
Bilge Water	Unquantifiable (intermittent and variable) [4]
Deck Drainage	Unquantifiable (intermittent and variable) [4]
Noncontact Cooling Water	2,092,300,000 (34,300,000)
Ballast Water	Unquantifiable (intermittent and variable)
Laboratory Wastewater	Minimal (intermittent and variable)
TOTAL	2,229,547,800 (36,549,800)
TOTAL (excluding noncontact cooling water)	137,247,800 (2,249,800)

Notes:

[1] Typical expedition duration is 61 days including 5 days in port and 56 days at sea (5 days in transit and 51 days drilling on-site).

[2] Sanitary wastewater will be treated to meet or exceed MARPOL requirements for TSS, BOD_5, and fecal coliform bacteria. Assuming a 61-day expedition and treatment to MARPOL requirements, pollutant loadings for both TSS and BOD_5 would be 54.9 kg.

[3] Includes approximately 200 liters per day of macerated victual (food-related) wastes.

[4] Deck drainage containing oil or other residues will be collected and treated before discharge using an oil/water separator (capacity of 120,000 liters per day).

Unlike sanitary wastewater which contains a high organic load and pathogens, the SODV's non-sanitary wastewater (greywater) consists primarily of domestic washwater which will rapidly assimilate in the sea even without treatment. Based on anticipated water consumption rates, it is estimated that the SODV will generate and discharge 55,000 liters of greywater per day during a typical expedition. If necessary, the SODV can store several days of greywater at the typical generation rate.

It is estimated that up to 132,929,000 liters of brinewater, obtained as a by-product from the production of potable water in flash evaporator desalination units, will be released to the sea during a typical expedition. The flash evaporators, which use waste heat from the SODV's main engines, produce potable water and the brinewater byproduct which has a salinity concentration approximately 25 percent higher than ambient seawater. The brinewater discharge will disperse and dilute rapidly in the sea.

Bilge water will be collected in holding tanks and processed in an IMO-approved oil/water separator to remove oil to a concentration level less than 15 parts per million (ppm). Generally, if the decks are free of residues, drainage will be discharged directly to the sea through scuppers. However, if oil or other residues are present on the deck or the ship is operating in an area where the discharge of deck drainage is prohibited, the scuppers will be sealed and the deck drainage conveyed to a settling tank for processing through an oil/water separator. Up to 120,000 liters of water may be processed in the oil/water separator and discharged each day.

Untreated seawater will be used as a heat exchange media for onboard engines, pumps and other mechanical components on the drillship. The cooling water will only come in contact with heat exchange coils, pumps, and piping and therefore will not be contaminated with combustion residues, oil, sludge, metal shavings, or chemicals. Ballast water, comprised of seawater will also be discharged periodically consistent with the SODV's Ballast Water Management Plan.

Liquid discharges from the SODV will also include wash and rinse water from the vessel's laboratories that may contain inorganic chemical residues (e.g., acids). Wastewater from the laboratories will be neutralized prior to discharge. Liquid organic wastes will be segregated in the laboratories and containerized for subsequent onshore disposal.

Physical characteristics of the sea in the immediate vicinity of the SODV may be affected by the ship's propulsion systems. When the SODV is dynamically positioned at drill site, the vessel's main propellers and up to 12 thrusters may be needed to hold position. The turbulence created by the propulsion units will agitate the water column and potentially cause stratified seawater within approximately 100 m of the ship to mix.

Water quality near the seafloor will be affected by residues from riserless drilling operations including seawater drilling fluid used to flush sediment and rock drill cuttings from the borehole, drilling mud (sepiolite), and cement slurry. When ejected from a borehole, fine grain-size particles may become temporarily suspended in the water column and will be transported by bottom currents, if present, until the material settles out on the seafloor.

Based on video observations of ODP boreholes, larger grain-size particles released from a borehole during drilling tend to form a conical mound on the seafloor surrounding the borehole. These observations also indicate that the turbidity plume from the borehole usually rises several meters above the seafloor and dissipates rapidly after the injection of the seawater drilling fluid into the borehole ceases.

As indicated in Section 2.3.2, during a ten-year period of the ODP, drilling mud was used in 25 percent of the boreholes to clean (sweep) excess drill cuttings from the borehole, or to stabilize and plug the hole. When used to clean a borehole, drilling mud was typically introduced at a concentration of 60 grams per liter of seawater. Drilling mud used to stabilize or seal a borehole was more concentrated at 250 grams to 730 grams per liter of seawater. The volume of drilling mud injected into a hole varied ranging from 795 liters to 700,000 liters. These drilling mud usage characteristics are expected to be representative of future SODV operations. With the exception of drilling mud used to permanently seal a borehole, residual mud along with the drill cuttings will be ejected from the borehole and dissipate. It is estimated that approximately 90 percent of the drill cuttings consisting of large grain-size particles will rapidly settle to the seafloor while the suspended fine particles (less than 74 µm in diameter) will be transported by the prevailing currents away from the borehole (Neff, 2005). The settling rate of fine silt and clay particles is estimated to be 1.1×10^{-2} to 3.0×10^{-5} m/sec (Brandsma and Smith, 1999).

The results of two studies of a drill site in the North Atlantic provide additional insights into the fate and transport of the drilling mud discharged to the sea. A sediment transport model was used to predict that a plume of drilling mud released from a drilling platform in relatively shallow water (30-70 m) could potentially extend up to several hundred meters from the drill site and remain suspended in the water column for several days to a week or more before settling on the seafloor (Hannah et al., 2003, 2005). In addition, several other studies have been conducted to evaluate the dispersal rate and patterns of drilling muds discharged to the water column from offshore drilling platforms. For example, the concentration of drilling mud in the water column 100 m down-gradient of a drilling platform in the Cook Inlet was diluted by 10,000 compared to the concentration at the source (Houghton et al., 1980). In a more comprehensive study, the concentration of suspended solids resulting from the use of drilling mud at seven offshore drilling platforms was evaluated by USGS using samples collected in currents ranging from 24 to

44 cm/s. The sampling data indicated that the plume of suspended solids from each platform typically dispersed to a concentration below control or background levels at distance of 96 m or less from the source (Shinn et al., 1980).

When mud is used by the SODV, the spatial extent that fine grain-size drilling mud particles travel in the water column is expected to be minimal since most SODV drill sites will be located in relatively deep water and may not be significantly affected by strong bottom currents or wave action. Under these relatively quiescent conditions, the fine grain-size particles will settle out of the water column quickly and near the borehole. Because drilling mud, if needed for a particular borehole will only be used intermittently during drilling, the inert fine grain-size particles will only be released to the water column for relatively short periods of time.

Occasionally small quantities of an inert material such as perfluro(methoxycyclohexane) may be injected into a borehole to act as a tracer when collecting cores samples for microbiological analysis. In this application, the SODV will meter the tracer liquid into the seawater drilling fluid to produce a final concentration of 1 mg/L. Assuming drilling fluid is typically injected into a borehole at a rate of 392 – 1,862 liters/minute, approximately 0.4 – 1.9 grams of tracer may be introduced into the borehole each minute. Occasionally, inert microsphere particles may be used as a tracer instead of perfluro(methoxycyclohexane) and introduced into the drilling fluid to yield a concentration of 10^{10} spheres/mL at the point of drilling. Based on past experience, chemical tracers or microspheres will only be used occasionally, and then will be introduced into the marine environment at extremely low concentrations.

Damage or loss of the 100-m long oil-filled hydrophone streamer used during occasional single-channel seismic surveys could potentially result in a water quality impact. The streamer is typically towed behind the vessel during a survey and contains approximately 135 liters of light aromatic hydrocarbon oil. Unless the streamer is severely damaged, baffles and bulkheads would prevent a sudden loss of the oil. In addition, loss of signal or added noise would be readily apparent to technicians monitoring the instrument and would result in the streamer's immediate retrieval, thereby minimizing the quantity of oil released.

4.2.5 Impact Analysis

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

Similar to most marine shipping vessels, the treated and untreated liquid wastes discharged from the SODV are not expected to adversely affect water quality due to the lack of toxic constituents in the waste streams, rapid mixing once discharged, and the assimilative capacity of the sea. In addition, treated wastewater streams are not expected to result in visual indicators of oil, grease, or un-macerated solid materials. The environmental effects of these discharges will be localized in extent and short-term in duration.

Operation of the SODV's propellers and thrusters when the SODV is at a drill site will create turbulence that may potentially affect surrounding seawater. It is estimated that the effects of this turbulence will be limited to within approximately a 100 m of the vessel for the amount of time the vessel is positioned at a drill site. The resulting mixing is not expected to alter currents, surface wave conditions or assimilative properties of the surrounding water column.

The effects of turbidity resulting from riserless drilling activities on the seafloor are generally not expected to affect water quality on a large scale or regional basis. The release of fine grain-size particles in the water column would be confined to an area within several hundred meters of the borehole site. Impacts, if any, will be minimal and will be highly localized and dependent on site-specific factors affecting the transport of fine grain particles from a borehole during drilling.

The scope of drilling and coring activities that may be performed in Alternative A may slightly increase the spatial or temporal extent of any resulting water quality impacts. For example, if more boreholes were advanced in an area or the boreholes were drilled deeper than needed to support specific research objectives, or drilling mud was used continuously, the increased turbidity plume could affect water quality over a greater area and for a longer period of time. Drilling and coring activities also have the potential to occur within sensitive environments that would not be adequately identified in advance. In these instances, the discharges and resulting water quality impacts would have a greater potential to impact sensitive biota.

Impacts to marine water quality resulting from the occasional use of inert tracers are not expected to occur due to the generally small quantities that may be typically introduced into the surrounding seawater and the low tracer concentrations. It is possible that light hydrocarbon oil could potentially be released from the occasional use of hydrophone streamer. The highly refined oil which is less dense than seawater, would disperse on the surface and rapidly evaporate (<24 hours) (UNEP-GPA, 2006).

Overall, the impacts to water quality from riserless drilling activities, including discharges from the SODV, thruster turbulence, and riserless drilling operations will be minimal. Additionally, impacts to water quality originating from the occasional use of inert tracers or in the event of an accidental release of oil from the hydrophone streamer would be expected to be minimal.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS. The intensity, extent, and duration of potential impacts to water quality resulting from the mechanical operation of the SODV are not expected to change as compared to Alternative A. The impacts to water quality resulting from SODV operations will include:

- Localized, short-term impacts resulting from SODV discharges of treated wastewater, greywater, treated bilgewater, deck drainage, ballast water, and treated lab discharges; and

- Localized disturbances resulting from mixing of the water column surrounding the SODV during thruster operation.

Discharges associated with drilling and coring operations, including seawater drilling fluid, sediment displaced from the borehole, drilling mud, cement, and tracers in Alternative B would also have localized affect near a borehole. However, through the IODP SAS review and advisory process, site-specific best management practices or mitigating measures may be identified to reduce environmental outputs associated with drilling and coring operations. As a result, the duration and extent of water quality impacts may be reduced compared to Alternative A.

In addition, potentially sensitive environments would be identified during the environmental review and planning processes for Alternative B. In response to these concerns, drilling operations would be modified or avoided to prevent conditions where water quality issues from drilling discharges could produce potentially adverse environmental effects.

Overall, water quality impacts resulting from riserless drilling activities in Alternative B are expected to be minimal. Similar to Alternative A, impacts from the occasional use of inert tracers or accidental release of petroleum hydrocarbon oils from the hydrophone streamer are also expected to be minimal.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), no discharges resulting from SODV operations would occur and marine water quality would be unaffected.

4.3 Sea Bottom and Sediment Quality

4.3.1 Environmental Settings

Most SODV riserless drilling operations are expected to occur in deep water areas where the seafloor has not been disturbed by other activities such as commercial fishing (e.g., bottom trawling) or mineral exploration. In general, the seafloor may contain a mixture of one or more naturally occurring sediments:

- Lithogenous sediment - derived from the weathering of continental rocks and volcanic eruptions

- Biogenous sediment - comprised of the remains of organisms. When the sediment contains 30 percent or more organic material it is termed ooze. Oozes are further subdivided into calcareous oozes, which are only found in water depths less than 3,000 m, and siliceous ooze that occur throughout the deeper portions of the ocean basin.

- Hydrogenous sediment - precipitated directly from seawater. The most common hydrogenous sediment is manganese nodules. How and why they form remains something of a mystery, but probably requires a contribution from hydrothermal waters generated by heat from subsea volcanoes.

Mixing of bottom sediments occurs naturally as a result of current and wave motion. Seismic events, turbidity currents, storm events or excessive loading may also contribute to sedimentation patterns. Storms can drive wave, current, and river runoff, which can then transport sediments great distances alongshore and offshore.

Sediment mixing events may occur on an intermittent basis and produce suspended particle concentrations up to several tens of milligrams per liter. However, these concentrations would be expected to decrease rapidly as the suspended particles settle and are redeposited on the seafloor. The frequency and magnitude of these events are expected to decrease in deeper water due to the weaker influence of turbulence associated with the currents and surface waves. At depths exceeding approximately 153 m (500 ft), the frequency of mixing events is low. The SODV will typically be drilling in water depths much greater than this and thus natural sediment mixing events affecting these areas will be minimal.

The vast seafloor ocean environment may contain features that are characterized as biologically sensitive environments such as chemosynthetic communities, coral reefs, and seamounts. These areas are described in Section 4.7 and Appendix G.

4.3.2 Regulatory Settings

Few laws exist to govern drilling-related outputs to the sea bottom and changes in marine sediment quality. In U.S. territorial waters, the Clean Water Act prohibits discharge of oil or hazardous substances and regulates the disposal of dredged or fill material. Although the release of materials into the water column may affect sediment water quality, the Clean Water Act does not specifically address sediment quality in the marine environment. However, it does generally prohibit the use of surfactants or other dispersing agents that may be used to dissipate oil on the surface and cause petroleum hydrocarbons to agglomerate, sink in the water column, and mix with sediments.

The *Convention for the Protection of the Marine Environment of the North Atlantic* (OSPAR convention 1992) is a major international agreement which may be applicable to SODV operations that affect the seafloor. The OSPAR convention is a general water quality agreement pertaining to the North Atlantic. The goal of OSPAR is to take all possible steps to prevent and eliminate pollution, take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. OSPAR contains five annexes including Annex IV which pertains to the assessment of the quality of the marine environment and Annex V related to the protection and conservation of the ecosystem and biological diversity of the maritime area.

The convention is administered by the OSPAR Commission, which prepares Decisions and Recommendations to address specific issues such as the following which may relate to drilling activities, SODV outputs, and sediment quality:

Decision 2000-03	Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings
Agreement 2004-10	OSPAR List of Substances / Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR)
Agreement 2005-06	Background Concentrations for Contaminants in Seawater, Biota and Sediments

4.3.3 Significance Criteria

Impacts to the sea bottom and sediment quality are considered significant if any one of the following actions occur:

- Drilling operations permanently alter the seafloor to an extent greater than the area influenced by natural transport and deposition of the displaced material;

- Turbidity or suspended sediment concentrations are persistent and are not reversed by natural dispersion processes over a period of several weeks;

- Materials and irretrievable equipment accumulate in quantities sufficient to degrade sediment quality, or create a hazard to fisheries; or

- The advancement of boreholes significantly increase hydrothermal circulation of fluids in oceanic crust or penetrate into active magma chambers.

4.3.4 Impact Source Characterization

Drilling operations will result in the displacement and subsequent deposition of cuttings on the seafloor consisting of sediment and geological basement materials. For uncased 25 cm diameter boreholes, approximately 6 m^3 of material will be displaced for each 100 m drilled. For larger 56 cm diameter boreholes used to accommodate casings or observatory installations, 28 m^3 of material would be displaced for each 100 m drilled. Table 4-2 summarizes the volume of material displaced for boreholes of varying depth. During drilling, the cuttings will be swept from the borehole by seawater drilling fluid pumped through the drill string and discharged from the drill bit.

Table 4-2. Volume of Displaced Material

Borehole Depth (m)	Sediment Displaced (m^3)	
	25 cm dia.	56 cm dia.
100	6	28
200	12	55
500	30	138
800	48	221
1,000	60	276
2,000	120	552

The size and density of the particles in the displaced material will depend upon the physical characteristics of the seafloor sediments, underlying crustal layers, and the drilling/coring methods used. However, drill cuttings will generally range in size from 2 µm for fine silt and clay particles to 30 mm for coarse gravel materials (Neff, 2005). Because particle size rather than density controls the particle settling rate, it is estimated that approximately 90 percent of the mass of cuttings will be deposited on the seafloor near the borehole (Neff, 2005). The remaining 10 percent, mostly composed of fine suspended particles, will disperse in the water column near the seafloor by local bottom currents. In general, cuttings particles are expected to settle on the seafloor at a rate of 2.6×10^{-1} to 1.3×10^{-6} m/sec (Nedwed, 2004)

Because the SODV will normally operate in deep water, the effect of wind and surface currents will be minimal, thereby limiting the transport of fine grain-size cuttings by these mechanisms. Video observations made at several ODP borehole sites indicate that drill cuttings tend to form a conical mound around a borehole. These mounds were typically circular and rapidly decreased in height with distance from the borehole. At sites where there was a distinct color contrast between the cuttings and seafloor sediment, the finer particles appeared to extend up to 30 m from the borehole.

Drilling muds may be used occasionally during riserless drilling to facilitate the removal of excess cuttings from a borehole (i.e., sweep). When used for this purpose in the past, the drilling mud was introduced into a borehole at a concentration of 66 grams of solids per liter of seawater (Table 2-17) and at a rate of 392-1,862 L/min. Based on historical trends (Table 2-18), it is anticipated the SODV will use drilling mud in 25 percent of the boreholes to be drilled and then only when needed based on site-specific conditions and research needs. Depending on these factors, the number and volume of drilling mud sweeps per borehole may range from one or two, representing less than 5,000 liters of drilling mud, to dozens of sweeps totaling 100,000 to 700,000 liters of mud.

Drilling mud used to sweep a borehole will be discharged from the borehole along with drill cuttings. Drilling mud consists of fine grain-size particles generally less than 74 μm in diameter that will become temporarily suspended in the water column before settling to the seafloor (Neff, 2005). The height that a plume of drilling mud particles extends above the seafloor will be affected by the frequency, duration, and volume of drilling mud sweeps, while the distance the suspended solids travel will depend on the velocity of the bottom currents and settling rate of the particles. Under relatively calm conditions, the settling rate for fine silt and clay drilling mud particles is estimated to be 1.1×10^{-3} to 3.0×10^{-5} m/sec (Brandsma and Smith, 1999).

Based on site-specific conditions, the SODV may periodically deploy heavy drilling mud to stabilize a borehole (i.e., prevent it from caving in on itself) or to seal it for closure. In these instances, the drilling mud will be mixed at a concentration ranging from 258 to 737 grams of solids per liter of seawater (Table 2-17). Based on historical trends, it is anticipated that the SODV will deploy heavy drilling muds in 5.5 percent of the boreholes to be drilled (Table 2-19). The volume of heavy drilling mud to be used for these applications will depend on the depth of the borehole but is generally expected to be less than 50,000 liters per borehole. Heavy drilling mud used for this application as a temporary slug will be expelled from the borehole when the drill string is reintroduced into the borehole to resume drilling operations. Heavy drilling mud which is intended to fill a borehole for permanent closure will remain in the borehole and will not disperse or be displaced to the marine environment.

Most studies focusing upon the fate and transport of drilling muds have been derived from drilling operations performed on offshore platforms involving the continuous large scale use and discharge of drilling mud. As indicated in the discussion on water quality impacts (section 4.2.4), a sediment transport model was used to predict that a plume of drilling mud released from a platform in relatively shallow water (30-70 m) could potentially extend up to several hundred meters from the source and could remain suspended in the water column for several days to a week or more before settling to the seafloor (Hannah et al., 2003, 2005). These results are consistent with another dispersion model study for an offshore drilling operation in Russia which predicted rapid dilution of drilling mud within of several hundred meters of the discharge point (Ayers, 1994).

While these studies of the transport of fine grain-size particles discharged from oil drilling platforms provide an indication of the underwater fate of drilling mud in the marine environment, it is anticipated that the spatial extent of drilling mud particles released during SODV operations will be less extensive. The release of drilling mud particles from riserless drilling operations will occur at the seafloor, not from a platform and the transport of these particles will be less affected, if at all, by surface currents and wave action. Drilling mud will not be used by the SODV continuously nor in every borehole drilled, and therefore the releases will be intermittent and relatively short in duration. As a result, not every drill site will be impacted by drilling mud particles. For the sites where drilling mud is used, fine grain-size particles may extend several hundred meters down-current, however the thickness of the material deposited on the seafloor will be minimal since the amount of drilling mud used will be limited.

Cement may be used in conjunction with heavy drilling mud to plug and permanently seal certain boreholes and may also be used in select boreholes to secure casings, reentry cones, or observatories. These permanent structures and associated scientific equipment will be installed at pre-determined drill sites (see Section 2.8.3) and will not be retrieved. Occasionally a drill string, drill bits, coring equipment, or anchoring weights may be accidentally or intentionally released to the seafloor or in a borehole to facilitate operations (see Section 2.6.3). Uncontaminated scrap metal from the SODV may also be disposed of at sea and deposited on the seafloor.

When a borehole is advanced into the seafloor, fluids may flow into the hole until pressure equalization is achieved. However, intercommunication of fluids between formations is unlikely, limiting the total volume that may be released. During previous ocean drilling expeditions, temperatures as high as 260° C were recorded when penetrating certain oceanic crustal areas. After abandonment, thermal convection may warm seawater and mix between convective cells that could develop from the thermal gradient in the rock. Dissolved gases may also be present. Evidence exists for hydrothermal circulation of fluids in oceanic crust for some distance out from spreading centers where heat flow is high. These migrations probably occur through fissures and voids. Because holes will be filled with weighted mud or cemented to inhibit hydrothermal circulation through the hole, the presence of a borehole is not expected to contribute to this natural process.

4.3.5 Impact Analysis

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

The impacts to the seafloor resulting from the dispersal of sediment, rock cuttings, and drilling mud used during riserless drilling activities in Alternative A will be extremely localized and will include slight alterations in the seafloor topography. The extent of these impacts will depend on the volume of borehole cuttings displaced, amount of drilling muds used, if any, and local oceanographic factors affecting the dispersion of the fine grain-size particles. Benthic biota in the vicinity of a borehole may be displaced, partially covered, or smothered by deposited materials. The extent of these effects near a borehole will vary from site to site depending on the degree of endemism of the benthic community. Benthic impacts are discussed in greater detail in Section 4.6.

Without the benefit of an independent review of a proposed riserless drilling expedition in Alternative A, drilling and coring activities may be more extensive both in the number of boreholes advanced and the use of drilling mud than absolutely needed to support the intended research, thereby increasing seafloor impacts. In addition, sensitive environments or cultural resources may not be adequately identified in advance in Alternative A, thereby limiting the application of effective mitigating measures or the avoidance of the critical habits. In sensitive environments, adverse effects caused by seafloor disturbances may be more pronounced and persistent.

A recent review of the effects of drill cuttings and drilling mud discharges from offshore rigs on marine biota concluded that short duration ocean drilling operations, such as those which would be performed by the SODV would not have a significant effect on the marine environment (Whitford, 2006). Although the use of drilling mud by the SODV will be occasional and variable depending on site-specific conditions, impacts resulting from the deposition of inert sepiolite or attapulgite drilling mud on the seafloor are expected to be localized to the immediate area surrounding the borehole.

Seafloor impacts resulting from the deployment of heavy drilling mud plugs and cement in a borehole will be minimal because these materials will be permanently emplaced in the hole, thereby not adversely affecting the surrounding seafloor. In addition, natural transport and sedimentation processes will eventually restore the seafloor terrain to its original contour. The presence of permanent structures such as a reentry device or observatory in a borehole, and on the seafloor will disturb the sediment during installation but will not extensively or adversely affect the seafloor environment or benthic communities.

Overall, no significant changes to the seafloor or ocean sediment quality are expected to occur as a result of drilling operations performed in Alternative A. Impacts from the deposition of cuttings or drilling mud particles on the seafloor, the localized alteration of the seafloor topography, and the deployment of equipment or materials on the seafloor will be minimal.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, proposed riserless drilling activities would be subject to the comprehensive review process by the IODP SAS during the planning for each expedition. The nature and extent of impacts to the seafloor environment and sediment quality resulting from Alternative B expeditions are expected to be similar to those described for Alternative A, including:

- Localized disturbances to the seafloor derived from the installation of boreholes and the introduction of naturally-occurring drilling muds and cement;

- Localized deposition of drill cuttings and drilling mud particles, and alteration of seafloor topography;

- Displacement or smothering of benthic organisms in the immediate vicinity of the borehole; and

- Localized disturbances to the seafloor derived from the installation of permanent structures.

The review process conducted in Alternative B will examine data characterizing the environmental setting and resources which may be present at each proposed drill site. For example, potentially sensitive environments will be identified during the planning process for each expedition (see Section 3.3) and may prompt the performance of a supplemental environmental review, implementation of site-specific mitigating measures, or the avoidance of critical areas completely. As needed, drilling operations may be modified to avoid creating significant adverse effects to sensitive environments or resources. The resulting impacts to seafloor and sediment quality in these settings may be reduced as compared to Alternative A since measures would be taken to avoid adversely affecting sensitive environments. Overall, impacts to the seafloor and sediment quality from riserless drilling activities in Alternative B are expected to be minimal.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), the seafloor would not be disturbed by SODV operations and sediment quality would be unaffected.

4.4 Air Quality

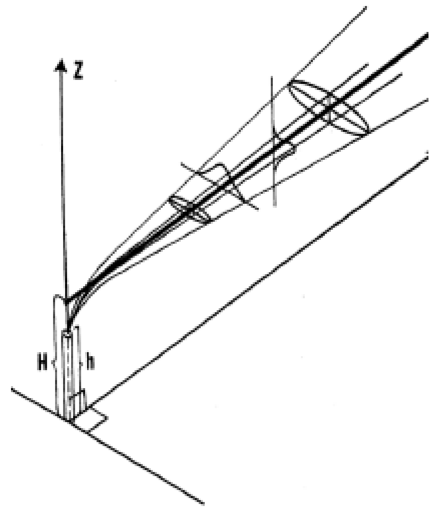
4.4.1 Environmental Settings

The fate and transport of air emissions from the SODV will depend on the following physical and chemical factors which define atmospheric dispersion:

- Meteorological conditions such as wind speed and direction, the amount of atmospheric turbulence (as characterized by what is called the "stability class"), the ambient air temperature and the height to the bottom of any inversion aloft that may be present.
- Emissions parameters such as source location and height, source vent stack diameter and exit velocity, exit temperature and mass flow rate.
- Terrain elevations at the source location and at the receptor location.
- The location, height and width of any obstructions (such as buildings or other structures) in the path of the emitted gaseous plume.

The Gaussian Plume model (Draxler, 1981) or the Briggs Plume Rise model (Briggs, 1969) will be used to qualitatively describe the fate of air emissions from SODV operations. For example, the Gaussian plume (Figure 4-2) takes the shape of an inverted cone exiting from the source (e.g., SODV engine exhaust outlet) and is continually mixing and interacting with air constituents. Movement of the SODV, wind, temperature variations in both lateral and vertical directions, will affect the shape of this cone of dispersal. Some of this mixing may be temporary and upon encountering precipitation, exhaust emissions constituents may eventually return to land or sea.

Figure 4-2. Gaussian Plume Model Used to Characterize Dispersion from a Point Source



LEGEND

h = stack height
H = effective stack height, including rise of hot plume near source
Z = distribution of mass in vertical dimension

4.4.2 Regulatory Settings

<u>MARPOL – Annex VI</u>

Annex VI of MARPOL 73/78 contains requirements issued in a series of 19 regulations and one Technical Code to control the air pollution from ships, including the emission of ozone-depleting substances, nitrogen oxides (NO_x), sulfur oxides (SO_x), volatile organic compounds (VOCs) and shipboard incineration. It also establishes requirements for reception facilities for wastes from exhaust gas cleaning systems, fuel oil quality, and for the establishment of SO_x Emission Control Areas (SECAs). This Annex entered into force on 19 May 2005 by the signatory parties but the United States has not yet ratified it. Although the provisions of Annex VI are not binding to the U.S. at the current time, the Annex's requirements provide a benchmark for comparison.

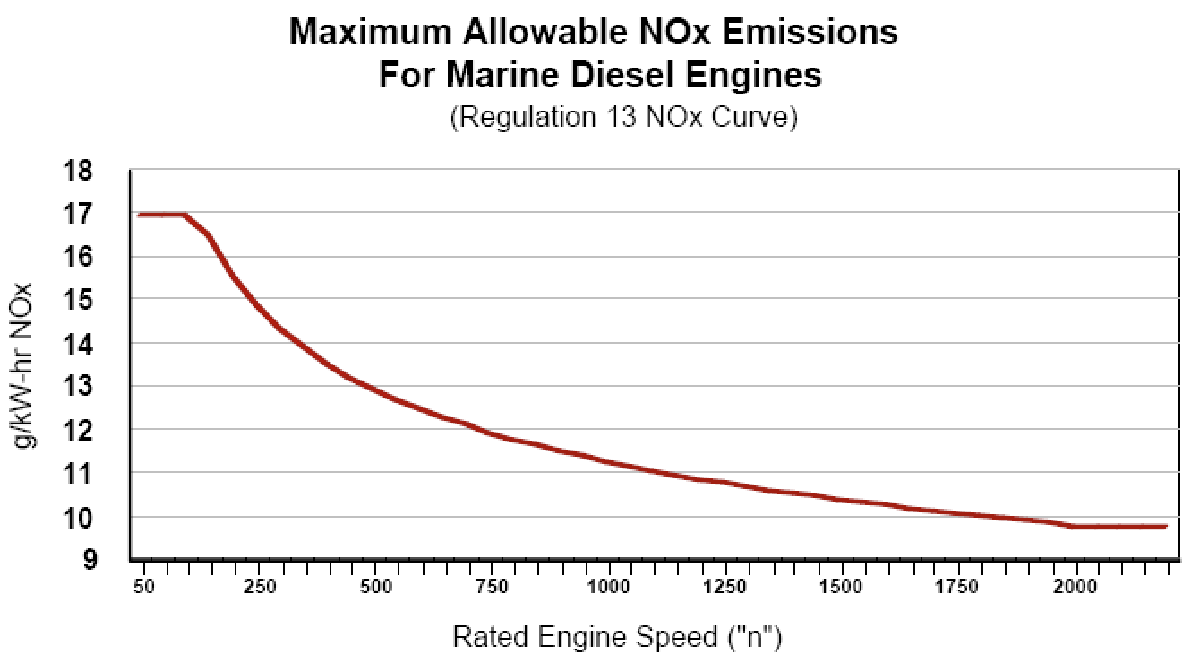
Air Pollution Prevention (IAPP) certificate

All ships greater than 400 gross tons must obtain an International Air Pollution Prevention (IAPP) certificate after the owner demonstrates that the vessel complies with all relevant requirements under MARPOL Annex VI. Before a certificate is issued, an initial survey will be conducted to ensure that the equipment, systems, fitting arrangements and material used onboard fully comply with the requirements of Annex VI. The IAPP is valid for five years, at which point the vessel will be subject to successful completion of periodic surveys. These surveys confirm that no actions or modifications have been made to the ship's equipment that would take it out of compliance.

Nitrogen Oxide Emissions

This Annex VI requirement applies to each diesel engine with a power output of more that 130 kW installed on a ship constructed on or after 1 January 2000, and each diesel engine with a power output of more that 130 kW which undergoes a major conversion on or after that date. However, the regulation does not apply to emergency diesel engines, engines installed in lifeboats or from any equipment intended to be used solely in case of emergency. Figure 4-3 depicts the Annex VI NO_x emission limits for marine diesel engines rated above 130 kW expressed in grams per kilowatt-hour for a particular rated engine speed (in rpm).

Figure 4-3. Annex VI NOx Requirements



Engines are to be certified that they comply with the Annex VI NOx emissions limits, to be documented through a verification process, including either a new engine certification or one of three onboard certification processes for existing engines such as the engine parameter method, simplified measurement method, or the direct measurement and monitoring method

Ozone Depleting Substances

New installations which contain ozone-depleting substances are prohibited on all ships after the entry into force date, except new installations containing hydrochlorofluorocarbons (HCFCs), which will be permitted until 1 January 2020.

Sulfur Oxide Emissions

Under Annex VI, the sulfur content of any fuel oil used onboard ships is not to exceed 4.5 percent. For those ships operating within SECAs, the sulfur content is not to exceed 1.5 percent. Alternatively, a scrubber can be used to treat emissions below 6 g SO_x/kw-hr.

The first SECA designated area was the Baltic Sea, which came into force on 19 May 2006. The second SECA designated is the North Sea, which is expected to come into force during 2007. Actions to ensure fuel oil quality consistent with Annex VI requirements include (1) retention of bunker delivery notes documenting the lack of contaminants in fuel oils, (2) signed declaration from the fuel supplier documenting the 4.5 percent maximum sulfur levels, and (3) retention of fuel samples onboard for a period of 12 months.

Use of Incinerators

Annex VI specifies that after 1 January 2000, only incinerators approved under IMO Resolution MEPC 76(40) are allowed, and onboard combustion of waste using other methods (e.g., open burning) is prohibited. The operating manual and the approval certificate for such incinerators must be maintained onboard and the crew trained and capable of operating the incinerators in accordance with the manual. Flue gas temperatures shall be monitored and maintained at not less than 850° C for continuous feed and reach 600° C within 5 minutes for batch feed. In addition, PCBs and fuel containing halogens are prohibited from incineration, as are PVC's (polyvinyl chlorides) except in approved shipboard incinerators consistent with specifications in resolutions MEPC 59(33) or MEPC 76(40).

Other International Agreements

OSPAR 1992 contains several provisions applicable to air emission sources. The agreement contains five annexes of which Annex II, Prevention and Elimination of Pollution by Dumping or Incineration, pertains to air emissions. Specifically, incineration is prohibited in the territorial seas of the signatory states.

National Laws and Regulations

Besides the international conventions identified above, some countries have specific regulations and guidelines regarding air quality within their territorial waters. These regulations exist with the intent to protect regional air quality or regulate emissions within their ports. In preparation for each expedition (see Section 2.10), the vessel operator (UDL/Transocean) and the science support contractor (TAMU) will identify specific territorial air quality guidelines, regulations, and permitting requirements relevant to the countries where vessel and drilling operations will take place.

U.S. Environmental Protection Agency Regulations

(40 CFR part 50) National Ambient Air Quality Standards

Should the vessel be operating in a port or the territorial waters of the U.S., it may be subject to the NAAQS (National Ambient Air Quality Standards). Areas of the U.S. where air pollution levels persistently exceed the national ambient air quality standards may be designated "nonattainment areas". Sources operating within these nonattainment areas, including marine vessels, may be subject to limitation in emissions for VOCs, NO_x, and other parameters.

(40 CFR Part 94) Control of Emissions from Marine Compression-Ignition Engines

The emission standards regulations issued by the USEPA apply only to U.S. flagged vessels with newer engines but can also be used as a baseline for comparison to evaluate estimated emissions from the SODV. The EPA standards include two tiers with different implementation schedules. Tier 1 standards, effective in 2004, adopted the MARPOL Annex VI standards for NO_x emissions, using the Regulation 13 NO_x curve (Figure 4-3). Tier 2 standards will be promulgated in 2007 and include more stringent standards for total hydrocarbons (HC), NO_x, carbon monoxide (CO), and particulate matter (PM). Tier 2 standards are derived from type and size of engine. The Tier 2 standards that would apply to engines comparable to those used onboard the SODV are presented in Table 4-3.

Based on the EPA Tier 2 emission standards presented in Table 4-3 and assuming the SODV conducts a typical 61-day expedition SODV (5 days in port, 5 days in transit, 51 days on-site), the resulting emissions would be equal to 37,200 kg exhaust hydrocarbons and nitrogen oxides (HC + NOx$_)$, 1,264 kg PM, and 23,280 kg of CO.

Table 4-3. USEPA Marine Engine Tier 2 Exhaust Emission Standards (5.0 to 15 Liter per Cylinder Engines)

Power	Displacement (see note)	Exhaust Hydrocarbons + Nitrogen Oxides (g/kW-hr)	Particulate Matter (g/kW-hr)	Carbon Monoxide (g/kW-hr)
All ranges	5.0 ≤ L/cy < 15	7.8	0.27	5.0

Note: the SODV's 16-cylinder EMD 645 series engines have a displacement of 10.57 L per cylinder and a rated engine speed of 900 rpm.

4.4.3 Significance Criteria

An impact to air quality is considered significant if any one of the following occur:

- Release of NOx or SOx emissions that exceed the MARPOL Annex VI requirements;
- Release of VOCs, NOx, or other emissions that exceed NAAQS parameters while the vessel is operating in U.S. waters;
- Incineration of any substances that are prohibited by MARPOL Annex VI requirements;
- Release of visible plumes of particulates, soot, or uncombusted material that do not disperse under natural wind conditions; or
- Loss and dispersal of oil or other volatile organic compounds (VOCs) that would cause the uncontrolled release of contaminants into the atmosphere

4.4.4 Impact Source Characterization

The SODV will generate emissions to the atmosphere from the vessel's engines, incinerators, fuel storage and transfer operations, maintenance functions, and research activities in the vessel's laboratories. Fuel combustion byproducts (exhaust emissions) will be produced by the vessel's diesel-electric engines. The composition and quantity of exhaust emissions that will be released from the vessel during typical expedition were estimated (Table 4-4) using air emissions factors developed by EPA.

Table 4-4. Estimated Exhaust Emissions During a Typical 61-day SODV Expedition

SODV Operational Phase	In Port	Transit	On-site	Total
No. of Days	5	5	51	61
No. of Engines in Use	1	4	3	N/A
Fuel Use (liters)	34,000	227,000	1,061,000	1,322,000
Parameter	**Emissions (kg)**			
Sulfur Oxides	69	459	210	738
Nitric Oxide	1,409	8,123	36,141	45,672
Nitrogen Dioxide	2,299	13,250	58,966	74,515
Nitrogen Oxides	1,547	8,917	39,674	50,138
Carbon Monoxide	212	848	6,153	7,212
Carbon Dioxide	104,539	589,455	2,705,530	3,399,524
Particulate Matter	39	221	998	1,258
Total Hydrocarbons	22	74	693	789

Note: N/A = Not applicable

The estimated NO_x emission rate of 10.8 g/kW-hr would comply with the MARPOL Annex VI requirements for NOx. Because the SODV will utilize low-sulfur fuel (<0.5 percent) which is well below the MARPOL requirement of 4.5 percent, the SODV will comply with the Annex VI SOx emissions requirement. Although the EPA Tier 2 standards will not be applicable to the SODV, the total estimated exhaust emissions that would occur during a typical 61-day expedition would be within the Tier 2 guidelines for PM and CO but would exceed the combined standard for exhaust HC + NO_x.

Exhaust emissions will be generated while the SODV is in-port, transiting between ports and drilling sites, and while dynamically positioned at each drill site. Over 95 percent of the total emissions from a typical 61-day expedition would be generated offshore as the vessel transits and while it is drilling. Exhaust emissions (e.g., particulates, water vapor) which may be visible exiting the vessel's stacks will rapidly disperse in the atmosphere. Exhaust emissions will also be released to the atmosphere from operation of the SODV's incinerators used to combust nonhazardous solid waste and waste lubricating oil. The SODV's main fuel, marine gas oil (i.e., diesel) will also be used to fuel the incinerators. The incinerators will be operated consistent with the MARPOL Annex VI requirements and national or international regulations applicable to the area where the vessel is operating. In areas where incinerators exhaust emissions are prohibited, combustible wastes will be retained onboard and will be combusted when the vessel sails into an area where incineration is allowed.

On average, the SODV's two incinerators are expected to combust 2 m^3 of solid waste and 36 liters of marine gas oil diesel fuel or waste lubricating oil each day the vessel is at sea. Exhaust emissions from the incinerators were estimated (Table 4-5) using emissions factors developed by EPA. Analogous to the fate of the SODV's engine exhaust emissions, the incinerators may produce emissions which are visible near the exhaust stack outlet however they will rapidly disperse.

Table 4-5. Estimated Air Emissions from SODV Incinerators During A Typical Expedition

Amount Combusted	Solid Waste 22.4 metric tons [1]	Fuel/Waste Oil 2,016 L [1]	Total Emissions (kg/expedition)
Parameter	Emissions (kg)	Emissions (kg)	
Characteristic Air Pollutants			
Carbon Monoxide	33	0.4	**34**
Nitrogen Oxides	40	3.0	**44**
Particulate Matter	52	12	**68**
Sulfur Oxides	24	20	**50**
Total Organic Carbon (TOC)	3.36	0.2	**3.61**
Metals			
Aluminum	1.17E-01		**1.17E-01**
Antimony	1.43E-01	1.09E-03	**1.44E-01**
Arsenic	2.71E-03	1.45E-02	**1.73E-02**
Barium	3.63E-02		**3.63E-02**
Beryllium	7.00E-05	4.36E-04	**5.06E-04**
Cadmium	6.14E-02	2.91E-03	**6.43E-02**
Chromium	8.70E-02	4.36E-02	**1.31E-01**
Copper	1.40E-01	1.26E-03	**1.41E-01**
Iron	1.62E-01		**1.62E-01**
Lead	8.16E-01	1.21E-05	**8.16E-01**
Manganese	6.37E-03	1.21E-02	**1.85E-02**
Mercury	1.20E+00		**1.20E+00**
Nickel	6.61E-03	3.88E-02	**4.54E-02**
Silver	2.53E-03		**2.53E-03**
Thallium	1.24E-02		**1.24E-02**

Note:
[1] During a typical expedition, it is anticipated that the SODV will spend 56 days at sea (5 days in transit, 51 days on site). During this time, it is assumed the incinerators will combust 2 m^3 (or 600 kg) of solid waste and 36 L of marine gas oil fuel or used oil per day.

Since petroleum hydrocarbon fuels, such as marine gas oil, contain volatile organic constituents, the SODV will be a source of such fuel evaporative emissions. During a typical 61-day expedition, the total evaporative losses were estimated to be 10.87 kg of petroleum hydrocarbons (178 grams per day). These hydrocarbon emissions will disperse in the air and degrade with sunlight.

In addition to fuel evaporative losses, various volatile or gaseous chemicals will be used onboard the SODV for various operational and maintenance processes. These materials may include volatile components in cleaners, degreasers, solvents, paints, refrigerants, and aerosols. Typically these substances will be used intermittently and in small quantities. The volumes of resulting air emissions are not expected to be significant. Refrigerants present onboard the SODV will be contained in closed systems and recovered to prevent release to the environment when maintenance is performed on the equipment. In addition, the use of hydrocholorofluorocarbon (HCFC) compounds in new refrigerant systems will be avoided wherever possible, even though these compounds are presently allowed under MARPOL Annex VI requirements.

Volatile constituents or gases will also be emitted to the atmosphere from the SODV's research laboratories from the use of chemical reagents and compressed gases. The types of chemicals that may be used in the laboratories are provided in Appendix C and include acids, alcohols, and organic solvents. The resulting emissions will be exhausted outdoors via laboratory fume hoods and exhaust ducts. In addition, when seafloor cores are opened, the cored material may release gaseous constituents (e.g., methane, hydrogen sulfide) which will be exhausted outside.

4.4.5 Impact Analysis

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

The emissions resulting from SODV operations during expeditions performed in Alternative A, including engine exhaust and incinerator combustion byproducts, are expected to be transitory and will not adversely impair local air quality. Fuel evaporative emissions resulting from SODV operations are not expected to be detectable or adversely affect local air quality.

Similarly, emissions from volatile or gaseous chemicals used onboard the SODV for operations or in the laboratories are expected to be minimal. Because the chemicals are used on an intermittent basis and in small quantities, the resulting air emissions are expected to be minimal.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, the duration of each expedition as well as operating conditions on the SODV which result in the release of air emissions are expected to be the same as in Alternative A. Therefore, the resulting emissions would be transitory and would not be expected to adversely affect or degrade the local air quality.

Alternative C – No Action

If the IODP-USIO did not conduct IODP riserless drilling activities (No Action Alternative), there would be no air emissions from the operation of the SODV.

4.5 Acoustic Environment

Various mechanical systems and equipment onboard the SODV such as the engines, pumps propulsion devices, drilling equipment, and certain types of instrumentation will produce noise which will be emitted to the underwater marine environment. In addition, the SODV may occasionally perform research activities such as single-channel seismic surveys and vertical seismic profiling (VSP) which by design involve the use of small underwater seismic sources. The evaluation of all acoustical outputs and impacts associated with SODV operations is discussed in this section. Further information pertaining to the effects of acoustic sources on marine organisms is provided in Section 4.6. Additional detail pertaining to the use and assessment of seismic sources is presented in a separate document entitled the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research.

4.5.1 Environmental Settings

Acoustical and vibrational outputs to the environment will occur during most stages of SODV operations including transiting between ports and drilling sites, while dynamically positioned (DP) at drill sites, and during drilling or coring activities. Noise has the potential to travel distances from the source in air and water, depending on the intensity of the source and environmental conditions tending to attenuate the propagation of the sound energy. At sea there are few, if any, potential receptors subject to airborne noises and the sound is generally expected to attenuate below ambient levels within 3.2 km of the source (Minerals Management Service 1983). Therefore, the primary focus of this acoustical impact analysis is related to the underwater environment.

Natural Sound Sources

Ambient noise is a critical component in evaluating potential adverse impacts resulting from SODV acoustical outputs. In general, ambient noise in the ocean environment is produced by the action of waves and currents and in the absence of anthropogenic sources may approach sound levels of about 60 dB re 1 μPa (Hurley and Ellis, 2004). Wind, rain, volcanic, and natural seismic events may increase sound levels significantly (WDCS, 2004). In polar regions, the movement of ice (melting glaciers, ice sheets, icebergs, sea ice) may contribute as much as 90 dB to the ambient noise level.

Various biological sources also contribute noise to the ambient ocean environment. Most whale species produce sounds for communication as well as dolphins which also use sound for echolocation and to locate prey. Fin whales have been known to produce noise levels of 160-186 dB re 1 µPa at 20 Hz (Richardson et al, 1995), which is considered to be representative of many whale species. Fish are known to produce sounds such as grunts, grinds, and scrapes to mark territory, bonding, and hunting. Sounds made by barnacles when they open and close their shells and move appendages have been detected many miles from barnacle beds (Frings, 1977). In tropical and semitropical coastal regions, the crackle and hiss of certain types of shrimp is a dominant biological source of sound. In general, background noise levels attributed to organisms can exceed 70 dB (Urick, 1983).

Anthropogenic Sound Sources

Anthropogenic sources of noise in the sea include marine shipping traffic, construction activities, and petroleum/mineral exploration and production facilities. Table 4-6 provides examples of typical sound levels from these types of sources (IOSEA, 2006).

Table 4-6. Sound Sources from Various Maritime Activities (adapted from Evans and Nice, 1996; Richardson et al, 1995)

Source	Frequency (kHz)	Source Level (dB re 1µPa)	Received sound levels (dB) at different ranges [1]			
			0.1 km	1 km	10 km	100 km
Oceanographic measurement tools [2]	10 to 200	<230	190	169	144	69
Geophysical (seismic) measurement tools [3]	0.008 to 0.2	248	210 [4]	144 [4]	118 [4]	102 [5]
			208	187	162	87
Production drilling platforms	0.25	163	123	102	77	2
Jack-up drilling rig	0.005 to 1.2	85 to 127	45 to 87	24 to 66	<41	0
Semi-submersible drilling rig	0.016 to 0.2	167 to 171	127 to 131	106 to 110	81 to 85	6 to 10
Drillship	0.01 to 10 45 to 7,070 [6]	179 to 191 174 to 185 [6]	139 to 151	118 to 130	93 to 105	18 to 30
Large merchant vessel	0.005 to 0.9	160 to 190	120 to 150	99 to 129	74 to 104	<29
Supertanker	0.02 to 0.1	187 to 232	147 to 192	126 to 171	101 to 146	26 to 71

Notes:
[1] Based on spherical spreading model
[2] Pinger, side-scan sonar, fathometer, etc.
[3] It is estimated that 170 ships routinely perform seismic surveys including 90 ships operated for the oil and gas exploration while the other conduct seismic measurements for other purposes including scientific research (MMC, 2007).

[4]Actual measurements in St. George's Channel, Irish Sea
[5] Extrapolated figure as presented by Evans & Nice, 1996
[6] Moored (anchored) drillship [Hurley and Ellis (2004)]

4.5.2 Regulatory Settings

The regulatory requirements that apply to acoustic outputs from the SODV depend on the vessel's location and distance from coastal nations, territories, or specially protected areas. In addition, the SODV will be subject to U.S. regulations applicable to federal actions abroad or on the high seas. The major U.S. regulations that address the effects of acoustic disturbances on the high seas are the Marine Mammal Protection Act administered by the National Marine Fisheries Services and the Endangered Species Act (ESA), requiring conservation of endangered and threatened species and their habitats. Many countries have similar laws governing their territorial waters and the open sea.

The MMPA regulates activities that have the potential to result in the "take" of marine mammals, including activities that may expose marine mammals to acoustic stimuli above certain levels. A "take" is defined in section 3(13) as, "*to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal*." The MMPA further clarifies the types of activities that constitute harassment. Any activity having the potential to injure a marine mammal or marine mammal stock in the wild is defined as "Level A" harassment. Behavioral changes resulting from acoustic outputs may be considered "Level B" harassment of certain marine mammals in the terminology of the 1994 amendments to the MMPA. Level B harassment is defined as "*harassment having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering*."

The NMFS clarified the definition of Level B harassment by stating "*…a simple change in a marine mammal's actions does not always rise to the level of disruption of its behavioral patterns. … If the only reaction to the [human] activity on the part of the marine mammal is within the normal repertoire of actions that are required to carry out that behavioral pattern, NMFS considers [the human] activity not to have caused a disruption of the behavioral pattern, provided the animal's reaction is not otherwise significant enough to be considered disruptive due to length or severity. Therefore, for example, a short-term change in breathing rates or a somewhat shortened or lengthened dive sequence that are within the animal's normal range and that do not have any biological significance (i.e., do no disrupt the animal's overall behavioral pattern of breathing under the circumstances), do not rise to a level requiring a small take authorization*." The definition of "harassment" in the MMPA was expanded in the reauthorization bill passed by the U.S. House of Representatives in July 2006 to define both Level A or B harassment to originate from "any act" likely to cause those effects.

Currently, NMFS uses received underwater sound pressure levels of 180 dB re 1 μPa (rms) (cetaceans) and 190 dB re 1 μPa (rms) (pinnipeds) as the Level A Harassment thresholds, which means that NMFS assumes, for the sake of their analysis, that all animals exposed to these levels or above will respond in a way that NMFS classifies as Level A Harassment. Similarly, NMFS considers 160 dB re 1 μPa (rms) the Level B Harassment Threshold, and assumes that all animals exposed to these levels or above (but below 180 or 190 dB) will respond in a way that NMFS classifies as Level A Harassment. These guidelines take into consideration the sound pressure level exposure as well as other attributes, such as duration, frequency, or repetition rate, all of which are critical for assessing impacts on marine mammals. For continuously-produced sounds such as those generated by marine construction operations, NMFS considers 120 dB re 1 μPa (rms) the received sound pressure level above which some marine mammals will respond to in a way that NMFS classifies as Level B Harassment..

Based on this guidance, NMFS acknowledges that simple exposure to sound or brief reactions by an organism that does not disrupt the animal's behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". The phrase "potentially significant" is commonly meant "*in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations*".

Even with this guidance, there are difficulties in evaluating if a marine mammal has been "taken by harassment". For many species and situations, there is little detailed information about their reactions to noise. Behavioral reactions of marine mammals to sound are difficult to predict. Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be significant to the individual let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, the impacts on the animals could be significant. Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate the number mammals that may be present within a particular distance of sound source. In relation to SODV operations, this approach would likely overestimate the number of marine mammals that may be affected in some biologically important manner.

The MMPA enables the NMFS to authorize "incidental takes" for non-fishery maritime activities, provided the takings are of small numbers and have no more than a "negligible impact" on those marine mammal species not listed as depleted under the MMPA. The "incidental take" authorizations require that notice be published in the Federal Register for the specified activity and geographical region. Authorization for incidental takes of small numbers of marine mammals by "harassment" are issued through an expedited process known as Incidental Harassment Authorization. Based on the nature and intensity of the sound sources used in typical riserless drilling expeditions (including both the small seismic sources and the thrusters used to hold the SODV in place during drilling) and the locations of typical operations, NSF does not anticipate that the generated sounds will result in the incidental taking of marine mammals by harassment and therefore warrant NMFS MMPA authorization. However, an evaluation will be conducted for each event, paying special attention to sensitive areas, such as NM Sanctuaries, shallower areas, or areas with known concentrations of marine mammals breeding, feeding, or migrating. In the event that a proposed expedition has the potential to incidentally disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns (Level B harassment), including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering, then an IHA may be appropriate.

4.5.3 Significance Criteria

Impacts to biological receptors are considered significant under the following conditions:

- Acoustic outputs strong (intense) enough and over a sufficient duration to cause death of a marine species or otherwise cause injuries involving:
    - ◊ a Permanent Threshold Shift (PTS), that will cause permanent hearing impairment;
    - ◊ neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. Using the NMFS guidelines, acoustic outputs exceeding 180 dB re 1 μPa (rms), for cetaceans and 190 dB re 1 μPa (rms) for pinnipeds may cause this type of adverse impact to marine mammals.
- Acoustic outputs of sufficient intensity and duration which initiate behavioral changes that severely disrupt an organism’s health by interfering with migration, breathing, nursing, breeding, feeding, or sheltering; or
- Acoustic outputs of sufficient intensity and duration to displace marine organisms from critical feeding or breeding areas for prolonged periods.

4.5.4 Impact Source Characterization

In general, acoustic outputs to the marine environment may elicit various responses by marine mammals and other aquatic animals ranging from avoidance, no reaction or interest, to physical injury or mortality. The following provides additional detail on the nature of these responses.

Disturbance Reactions

An organism's reaction to underwater sounds depends on a combination of factors including the species, state of maturity, experience of the animal to unfamiliar sounds, type of activity, reproductive state, time of day, and sea conditions. If a marine mammal reacts briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant. Some individual marine mammals may exhibit behavioral responses at received levels below 160 dB re 1μPa levels while others may tolerate higher sound levels without reacting in any substantial manner. For example, recent research indicates that some species of baleen whales display avoidance reactions at sound levels slightly below 160 dB re 1μPa while pinnipeds are generally less responsive (Stone 2003; Gordon et al. 2004). In fish, behavioral response to underwater sounds primarily include avoidance, typically stimulated at noise levels above 160 to 180 dB re 1 μPa, (Evans and Nice, 1996, Gordon et al, 2004).

Masking

Sounds used by numerous cetaceans and pinnipeds for communication and echolocation typically involve lower frequencies (<150 kHz). Intense background sounds at lower frequencies may mask or degrade an organism's ability to communicate or echolocate effectively.

Hearing Impairment

Temporary or permanent hearing impairment is possible when marine mammals are exposed to sounds generally above 210 dB re 1 μPa. TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends.

For toothed whales exposed to single short pulses, the TTS threshold appears to be a function of the energy content of the pulse (Finneran et al. 2002). Given the available data, the received level of a single acoustic pulse might need to be on the order of 210 dB re 1 μPa in order to produce brief, mild TTS. Exposure to several acoustical pulses at received levels near 200–205 dB might result in slight TTS in a small odontocete, assuming the TTS threshold is a function of the total received pulse energy.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. However, no cases of TTS are expected given the types of the sources, and the strong likelihood that baleen whales would avoid the area before being exposed to levels high enough for there to be any possibility of TTS. Many cetaceans are likely to show some avoidance of either the approaching or stationary vessel and the associated levels of sound. In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid any possibility of hearing impairment.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) have not been measured. However, prolonged exposures show that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999; Ketten et al. 2001; cf. Au et al. 2000).

Permanent Threshold Shift (PTS) is a more intense form of hearing impairment, in which there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges. Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level of 20 dB or more above that inducing mild TTS if the animal were exposed to the strong sound for an extended period or to a strong sound with very rapid rise time.

Physiological Effects

Physiological damage or mortality in fish exposed to underwater sounds generally occurs at sound levels in excess of 220 dB re 1 μPa. Injuries and other non-auditory physiological effects that may occur in marine mammals exposed to underwater sound in excess of 180 dB re 1 μPa may include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. These types of effects are generally caused by exposure to strong acoustic pulses at close range for a long period of time.

Based on this general understanding of the range of possible effects that underwater noise may have on marine organisms, the following describes the potential range of noise-related impacts that may occur specific to the acoustic outputs resulting from SODV operations, research-related drilling and coring processes, and the use of small seismic sources. Additional details describing the potential impacts of acoustic outputs to specific marine organisms are presented in Section 4.6.

Generally, a dynamically positioned drillship which uses thrusters to maintain a fixed position over a drill site will generate more underwater noise than other commonly used types of commercial drilling rigs (R.A. Buchanan et al., 2003). Based upon underwater sound level measurements, it is expected that the SODV's engines and thrusters exclusive of drilling activities will generate approximately 154 dB re 1 μPa of noise. Drilling and coring operations will add to the underwater noise and vibrational output from the vessel however some of the noise will emanate from the drill string extending from the SODV's moonpool, through the water column, and into the seafloor. As shown in Table 4-6, underwater sound levels attributed to moored oil exploration drillships typically may range from 174 to 185 dB re 1μPa (Hurley & Ellis, 2004). In comparison, a supertanker may emit up to 232 dB re 1μPa while military sonar equipment may emit 235 dB re 1μPa.

Using an underwater hydrophone, sound measurements were made while the *JOIDES Resolution* was drilling in the Pacific Ocean in December 2001. The monitoring data identified a 40 dB shift (increase) over ambient sound levels when the vessel was drilling with quiet periods occurring when core samples were being recovered. During the monitoring event, the increase in noise created by the passage of a container ship 180 km away from the hydrophone was more than twice the level produced by the drillship as it transited directly over the monitoring equipment (Stephen, 2003).

The SODV's transducer-based instruments will also generate acoustical outputs, primarily while the vessel is in transit, but also when the vessel is at a drill site prior to commencement of drilling. Because these sources are highly directional and aimed toward the seafloor, peak sound levels would only be received directly beneath the vessel. The peak sounds produced by the single beam echo sounder typically range from 200 to 230 dB re 1μPa emitting two pulses per second in a 30° beam. Sub-bottom profilers generally produce a peak sound level of 204 dB re 1μPa at 50 millisecond intervals and emit a 45° beam from the bottom of the ship. The estimated acoustic source level for the ADCP unit is ≤ 224 dB re 1μPa which is emitted in a 30° conically shaped beam. Using the ADCP as an example, sound levels of 160 and 180 dB re 1μPa would be realized approximately 1,514 and 151 m beneath the source, respectively. Sound levels produced by the single beam echo sounder and sub-bottom profiler are expected to propagate and attenuate similarly.

The underwater acoustic transponder beacons deployed on the seafloor to be used in conjunction with the vessel's dynamic positioning system have an acoustic source output of 199 to 214 dB re 1μPa with a frequency range of 12 to18 kHz. Because the beacons are often deployed in very deep water, relatively few species, if any, would be capable of diving deep enough to be exposed to peak sound levels.

Following drilling and coring operations, certain downhole instruments which exhibit acoustical outputs may be deployed into a borehole using a wireline that passes through the drill string. The outputs will be short duration events and will be significantly attenuated within the borehole.

Occasionally a single-channel seismic survey or vertical seismic profiling measurement may be performed using a small seismic source (1 or 2 airguns). The pulsed acoustic outputs from the airguns that may be occasionally used by the SODV generate underwater sounds at frequencies below 250 Hz. The acoustic energy from the single or double airgun configuration would travel underwater in a circular spreading pattern and attenuate with distance from the source. Table 4-7 presents the predicted maximum lateral distances from the source for 160 dB re 1 μPa (rms) and 180 dB re 1 μPa (rms) sound levels. Graphs depicting the predicted received sound levels are presented in Appendix E.

Table 4-7. Estimated Sound Level Distances from SODV Seismic Sources

Airgun Configuration	Airgun Depth (meters)	Distance from Source (meters)	
		180 dB re 1 μPa (rms) [1]	160 dB re 1 μPa (rms) [2]
Single GI gun, 737 cc (45 cu in) injector volume	3	23	230
	5	30	300
	6	35	350
	10	38	385
Single 4,100 cc (250 cu in) G Gun,	3	44	440
	5	56	560
	6	63	630
Double 4,100 cc (250 cu in) G gun parallel cluster	3	66	665
	5	100	1,000
	6	100	1,000

Notes:
[1] 180 dB re 1 μPa (rms) ≈ sound exposure level (SEL) of 170 dB re $(1\ \mu Pa)^2 \cdot s$
[2] 160 dB re 1 μPa (rms) ≈ 150 dB re $(1\ \mu Pa)^2 \cdot s$ SEL

A recent study of sound propagation from marine seismic survey sources indicated that sound energy produced by airguns traveled longer distances laterally than predicted in shallow water (< 300 m depth) but less in deeper water (Tolstoy et al., 2004). Since the water depths where the SODV will typically operate are expected to be greater than 300 m, the actual distance that the seismic source sound levels may travel may be less than the values shown in Table 4-7. Additional detail pertaining to the use and assessment of seismic sources is presented in a separate document entitled the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research.

4.5.5 Impact Analysis

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

During transit, sound and vibration produced by the SODV engines, propulsion systems, and transducer-based instruments may be noticeable to nearby marine organisms. It is expected that many potential receptors will perceive the continuous noise produced by the approaching vessel and will deviate from the path of the vessel thereby avoiding exposure to peak and potentially harmful noise levels. It is unlikely that the transducer-based equipment on the SODV would cause a marine organism to be exposed to sound levels greater than the 180 dB re 1 μPa (rms) level which the NMFS considers to be potentially harmful for several reasons. First, the sound would be produced in narrowly focused beams directed toward the seafloor and would only affect organisms directly beneath the vessel. Second, at a typical cruising speed of 11 knots (20 km/hr), it is expected that if an organism were exposed to noise from the vessel, it would only be for a short period of time. Finally, the short pulse duration from the transducer devices reduces the risk of hearing impairment or other injury to exposed organisms. Therefore, potential impacts to organisms exposed to sounds and vibrations from the transiting SODV would be expected to be minimal.

The noise created by the SODV while it is dynamically positioned over a drill site and the physical turbulence in the water caused by the vessel's thrusters are likely to deter many marine organisms from approaching the drillship and becoming exposed to potentially intense sound levels. Because most drill sites will be located in deep open ocean areas that are not densely populated by marine organisms, the potential that an individual or a population of animals may be exposed to continuous noise levels that could cause behavioral changes is very low.

Similarly, the short-term increase in the ambient noise created by vessel operations or drilling and coring may deter some organisms from a particular area, resulting in temporary displacement and possible disturbance to an animals' feeding or spawning behavior. In general, the SODV will only occupy a drill site for a relatively short period of time (i.e., hours or days), thereby allowing displaced organisms to repopulate the area when drilling ceases and the vessel departs. Therefore, the resulting behavioral effects to marine organisms would be minimal, short-term, and reversible.

In most areas where the SODV is expected to operate, the range of potential effects to biological receptors resulting from riserless ocean drilling operations and related research activities are expected to be minimal. However, in Alternative A, drilling and research activities could proceed in sensitive marine environments such as native hunting areas, migratory routes, consistent feeding grounds, or local breeding grounds that concentrate cetaceans or other sensitive species in critical areas. Without effective mitigating measures or avoidance of critical areas when sensitive species are expected to be present, certain marine organisms may be at greater risk of exposure to acoustical outputs from the SODV operations if the plans to conduct the riserless drilling and related research activities did not take into consideration the possible presence of these animals.

Similarly in Alternative A, although a seismic survey or VSP experiment may be performed in an area without consideration of the marine organisms that may be present, these research activities will consistently incorporate best management practices to prevent marine biota from being exposed to sound levels that could result in injury (≥ 180 dB re 1 μPa rms) or significant behavioral changes (≥ 160 dB re 1 μPa rms). Resulting behavioral effects, if any, would be minimal and short-term. Additional detail pertaining to the impact assessment of seismic sources is presented in a separate document entitled the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, the acoustical outputs and range of potential impacts resulting from IODP-USIO riserless drilling expeditions are expected to be minimal and similar to those described in Alternative A. However, in Alternative B, USIO ocean drilling and research activities will be planned and implemented based upon input received through the IODP SAS review and advisory process. As such, proposed drill sites where potentially sensitive marine organisms may be present during drilling operations would be identified and suitable mitigating measures would be incorporated into the Operating Plan and Scientific Prospectus for each expedition. These measures may include modifying the schedule for an expedition or limiting the types of activities performed to avoid or minimize exposing sensitive marine organisms to potentially disturbing or harmful acoustic levels. At drill sites where marine organisms that are potentially sensitive to acoustic sources may be densely populated or the proposed research activities may result in more intense or prolonged acoustic exposures, a supplemental environmental review may be prepared to evaluate the site-specific risks and develop recommendations for additional mitigating measures. Therefore, the extent of acoustical source impacts in Alternative B for all receptors including cetaceans and other sensitive organisms would be expected to be minimal for IODP-USIO ocean drilling expeditions.

Alternative C – No Action

If the IODP-USIO did not conduct IODP riserless drilling activities (No Action Alternative), there would be no acoustic outputs resulting from the operation of the SODV and ocean drilling activities.

4.6 **Marine Biological Resources (Near-Coastal and Deep Sea)**

4.6.1 Environmental Settings

This section addresses the seven major communities found in the marine environment, and provides the context from which the potential impacts of the IODP-USIO riserless drilling operations can be assessed. Plankton (4.6.1.1) is the collective term for a variety of marine (and freshwater) organisms that drift through the water. By definition, plankton are unable to resist ocean currents. This is in contrast to nektonic organisms that can swim against the ambient flow of the water environment and control their position, such as fish (4.6.1.2), cephalopods (4.6.1.3), marine mammals (4.6.1.5), and marine reptiles (4.6.1.6). Benthos (4.6.1.4) is another collective term used to describe organisms associated with the seabed, including those living in, on, or near the bottom substrate. Finally, seabirds (4.6.1.7) are those birds that travel varying distances across the sea and typically breed on offshore islands or coastal areas (Levinton, 1995). The environmental settings section concludes with a discussion of threatened species (4.6.1.8).

4.6.1.1 Plankton

Plankton are primarily divided into broad functional (or trophic) groups. Depending on whether a planktonic organism is a protist, plant, or animal, a distinction is made between phytoplankton and zooplankton. Phytoplankton are autotrophic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, and dinoflagellates. Zooplankton are small protozoans or metazoans (e.g. crustaceans and other animals) that feed on other plankton; zooplankton include some of the eggs and larvae of larger animals, such as sea urchins, sea stars, fish, crustaceans, and annelids. Bacterioplankton, of which many phytoplankton are a subset, play an important role in remineralizing organic material down the water column (Omari, 1992).

Plankton are found throughout the oceans of the Earth. Plankton abundance and distribution are strongly dependent on factors such as ambient nutrient concentrations, the physical state of the water column, and the abundance of other plankton. The local abundance of plankton varies horizontally, vertically, and seasonally. The primary source of this variability is the availability of light. Nearly all plankton ecosystems are driven by the input of solar energy (with the exception of chemosynthetic organisms), and this confines primary production to surface waters and to geographic regions where, and seasons when, light is abundant. Planktonic organisms usually depend upon the surface waters for their survival. Phytoplankton will die unless they are near a source of sunlight for photosynthesis. They will be unviable if they sink below a depth of 50 to

100 m in the open seas, but will be unable to photosynthesize even in much shallower depths in estuaries and inshore waters. A secondary source of variability is that of nutrient availability. Although large areas of the tropical and sub-tropical oceans have abundant light, they experience relatively low primary production because of the poor availability of nutrients such as nitrate, phosphate, and silicate.

While plankton are found in the greatest abundance in surface waters, they occur throughout the water column. At depths where no primary production occurs, zooplankton and bacterioplankton make use of organic material sinking from the more productive surface waters above. This flux of sinking material can be especially high following the termination of spring blooms. Many planktonic organisms undergo diurnal vertical migrations; i.e. they move toward the surface during the night and descend during the day. Diurnal vertical migrations are common in surface waters, but they also have been observed to depths of greater than 1,000 m, where light from above is no longer detectable. Some animals such as copepods and jellyfish can migrate 400-800 m in a single day (Levinton, 1995).

4.6.1.2 Fish

Fish constitute the largest and most diverse group of marine vertebrates. They are taxonomically separated into three classes. Class Agnatha encompasses approximately 50 species of the most primitive of living fish, the jawless lampreys and hagfish. Class Chondrichthyes comprises approximately 300 species of sharks, skates, and rays; they are characterized by having a cartilaginous skeleton and lacking scales. Skates and rays have flattened bodies, and most are adapted to a bottom-dwelling habitat. While many skates and rays live in coastal waters; only a few species, like manta rays, live in the open sea (FishBase, 2006). Class Osteichthyes (teleost fish), comprising the majority of living fish, with over 20,000 marine species, includes those fish which have a bony skeleton.

As with most other animal groups, the largest fish populations are found in temperate waters, but species diversity is much higher in tropical and subtropical waters (Lalli & Parsons, 2002). Food supplies for oceanic fish vary in abundance due to physical factors. Some species respond to predictable seasonal variability in food concentration by migrating to certain feeding sites when prey becomes particularly abundant. For example, tuna in the Pacific migrate to areas where swarms of pelagic crabs are seasonally available. Other fish, such as those associated with special benthic habitats (e.g., coral reefs) are themselves specialized to feed on corals or resident plants and animals (Lalli & Parsons, 2002).

The "pelagic zone" refers to the open waters of the ocean, and fish that live in this region are typically mobile and/or migratory species that are not closely associated with permanent structures such as coral reefs. The largest of the pelagic teleosts are piscivorous species such as tuna, jackfish, and barracuda. Some fish, such as cod, haddock (both family Gadidae), and hake (family Lotidae), feed in both mid-water and on the sea bottom and are capable of catching fish or benthic invertebrates. True demersal fish spend all their lives on or near the sea bottom, where some (e.g. sole) feed exclusively on benthos (e.g. clams, worms, crustaceans) and others (e.g. halibut, turbot) eat smaller fish (Lalli & Parsons, 2002).

Fish residing in deeper waters (>200 m) are not as numerous as epipelagic species (i.e. those occurring within the illuminated surface zone where there is sufficient light for photosynthesis), and they are not commercially exploited. Mesopelagic fishes live in depths between 150 and 2000 m. Most mesopelagic species undergo vertical migrations often moving into the epipelagic zone at night to prey on plankton and other fish. The most diverse of the roughly 1000 mesopelagic fish species, both in numbers of species and individuals, are the 300+ species of stomiatoids and the 200-250 species of lantern-fish (family Myctophidae). The majority of mesopelagic fish are small, ranging from about 25-70 mm in length at maturity; the largest mesopelagic species are about 2 m long. The best known stomiatoid genus, *Cyclothone*, contains many species, and these fish live between 200 and 2000 m in depth in large schools. The shallower-living species are silvery or partly transparent; the deeper residents are typically black. The lantern-fish perform diurnal vertical migrations, some rising to the very surface to feed on planktonic crustaceans, and this group comprises a major food source for tuna (family Scombridae), squid (family Teuthida), and porpoises (family Phocoenidae). In bathypelagic waters (1000 to 4000 m deep), there are about six times fewer fish species (Lalli & Parsons, 2002). In contrast to mesopelagic fish, bathypelagic species are largely adapted for a sedentary existence in a habitat with low levels of food and no light. Some of the species occupying the bathypelagic zone also cross into the mesopelagic zone during vertical migrations.

The swimming abilities of most fish make them independent of ocean currents, and they are able to migrate from one area to another, selecting favorable conditions in terms of food availability or reproductive sites and associated physical parameters. Whereas many species may undertake oceanic migrations ranging from several hundred to several thousand kilometers between, for example, feeding and spawning areas, other fish may undertake migrations between the sea and freshwater. Anadramous fish, such as salmon (family Salmonidae), sturgeon (family Acipenseridae), shad (family Clupeidae), smelt (family Osmeridae), and sea lampreys (family Petromyzontidae), breed in freshwater; the young then migrate to sea, where they spend most of their adult life, with the adults eventually returning to their specific freshwater sites to breed and spawn. Catadromous species are those that breed in the sea, but spend the majority of their adult life in freshwater. Some of the longest migrations are undertaken by the catadromous American and European eels (*Anguilla* sp.), of which the adults migrate from rivers in Europe and eastern North America to breeding sites in the Sargasso Sea where they spawn and die (Lalli & Parsons, 2002).

4.6.1.3 Cephalopods

Species within the class Cephalopoda, the largest of the invertebrates, belong to the phylum Mollusca, and include squids, cuttlefish, pearly nautilus (*Nautilus* sp.), and octopus. Cephalopods are the most mobile of the mollusks, and their greater nervous organization facilitates their advanced locomotion. While many other mollusks have hard external shells, most cephalopods do not. Nautilus has a coiled external shell, while squids and cuttlefish have a smaller internal skeleton, and the octopus has no hard skeleton at all (Levinton, 1995).

There are approximately 786 distinct living species of cephalopods, which are found in all the oceans of the world and at all depths. Because they are elusive creatures, the habits and ecological details of most species of cephalopods are not well known. The cephalopods all have two well-developed eyes used in hunting prey. The octopus spends most of its time scurrying along the seafloor, feeding on other bottom dwellers such as crabs. In contrast, nautilus and squids are active swimmers and also can prey on fish.

4.6.1.4 Benthos

Benthic communities are strongly structured by sediments, which are mainly composed of detritus in the form of dead phytoplankton and zooplankton. Relative to the pelagic zone, the seafloor presents a greater variety of physically diverse habitats that differ from each other in terms of depth, temperature, light availability, and type of substrate. Hard, rocky substrates provide sites of attachment for sessile species like barnacles and mussels which remain in one place throughout their adult life. Soft-bottom substrates (e.g. mud, clay, sand) offer both food and protection for burrowing animals. At least partly owing to the greater variety of benthic habitats, the number of species of benthic animals (estimated at >1 million) is much greater than the combined number of pelagic species of larger zooplankton, fish, and marine mammals (Lalli & Parsons, 2002).

As in the pelagic environment, vertical gradients of temperature, light, and salinity are important in establishing distinctly different living regimes for benthic organisms. Some of the ecological-depth divisions have well-defined boundaries, while others are more arbitrary zones. The animals that inhabit different zones are generally of different species, each uniquely adapted to the particular environment where it is found. A variety of marine plants attach to the seabed or live within sediments in shallow depths. All marine plants are restricted to the epipelagic zone; which extends from the surface down to about 100-150 m (NHM, 2005).

Benthic animals (zoobenthos) are separated into two ecological categories based on where they live relative to the substrate. Infauna are those species which live wholly or partly within the substrate; this category includes many clams and worms (polychaetes) as well as other invertebrates. Infaunal species usually dominate communities in soft substrates, and they are most diverse and abundant in subtidal regions. Epifauna are those animals living on or attached to the seafloor. A few common examples of epifauna include corals, barnacles, mussels, many starfish, and sponges. Epifauna are present on all substrate types, but they are particularly richly developed on hard substrates. A third category includes those animals that live in association with the seafloor but also swim temporarily above it; animals such as prawns and crabs, or flatfish such as sole (family Soleidae), form the epibenthos (Lalli & Parsons, 2002).

Benthic communities contain an extremely diverse assemblage of zoobenthos. Some of the dominant types of animals in benthic communities are described below. Xenophyophores, the largest of all protozoans, are especially abundant in the hadal zone (the deepest part of the oceans); they extend their pseudopodia to form tangled masses on the seafloor, which collect organic matter from surface sediments. Ciliates, many of which are adapted to attach to sand grains or to live freely within the interstitial spaces of sediments, provide a link between bacteria and deposit-feeding invertebrates. The most primitive multicellular animals are the sponges, whose many cavities provide protective refuge for myriads of small animals such as worms and crustaceans. Polychaetes are a class of over 10,000 species of segmented worms with multiple appendages. Molluscs include over 50,000 marine species, among them familiar snails, sea slugs, bivalved clams and mussels. Echinoderms comprise over 5,600 species within several classes, including starfish, sea stars, sea urchins, and sea cucumbers. Benthic decapod crustaceans include the familiar crabs, lobsters, and shrimp; the group has both epifaunal and infaunal representatives. Decapods show their greatest diversity in shallower water, but a few species live at depths of 5,000 to 6,000 m. Many decapods are economically important as human food, and those species along with mollusks constitute the shellfish industry (Lalli & Parsons, 2002).

4.6.1.5 Marine Mammals

Three orders of mammals have evolved from different terrestrial ancestors and are independently adapted to life in the sea including Cetacea, Pinnipeds, and Sirenia.

The order Cetacea comprises approximately 75 species of marine mammals known as whales, porpoises, and dolphins. The largest of these marine mammals are the baleen whales; these include the biggest animals that have ever lived, the blue whales (*Balaenoptera* sp.), which can attain a length of 31 m. Baleen whales form a separate suborder of about ten species; most of these immense whales feed primarily on zooplankton. Some of the large baleen whales (e.g. greys, humpbacks) make extensive seasonal migrations, usually breeding in winter in tropical waters and moving poleward to feed in summer. Grey whales spend the summer in the Bering Sea and in the Arctic Ocean and winter in breeding grounds in bays on the Pacific Coast off Baja California and off Korea and Japan. Humpback whales (*Megaptera novaeangliae*) consist of several independent migrating populations; one, for example, winters in the Hawaiian Islands and spends the summers in Alaskan waters, while another population divides its time between waters offshore of California and those of Mexico.

Smaller cetaceans do not undertake long migrations, but move in response to changing food supplies or physical changes. The odontocetes, equipped with teeth and characterized by having a single blowhole rather than two, are not reliant on surface-living prey, and may undertake dives to depths of several hundred meters. Sperm whales (*Physeter macrocephalus*) can routinely dive to depths of 1,000 m, and hold the record among marine mammals for deepest dives; this species is believed to descend to over 2,200 m in search of giant squid (Levinton, 1995). Many odontocetes are capable of sophisticated communication and can generate a series of sonic and ultrasonic clicking signals. In killer whales, pods (groups of whales) often use sounds different from other pods. The clicks are also used while hunting prey as a means of echolocation, in which they emit pulses of sound and monitor the returning echoes (Levinton, 1995).

Seals, sea lions (both of the family Otariidae), and walruses (*Odobenus rosmarus* sp.) are known taxonomically as pinnipeds, meaning 'feather-footed' to describe their four swimming flippers. In contrast to whales, these animals spend part of their time on land or on ice floes, where they congregate for breeding and resting. The 32 species of pinnipeds are found in all the seas of the world, but the majority of the species and the largest populations are found in the cold waters of the Arctic and Antarctic (Lalli & Parsons, 2002). Most feed primarily on fish or squid, but walruses also use their tusks to dig mollusks and other benthic animals from the sea bottom. Sea otters often dive tens of meters to pull abalones (*Haliotis* sp.) and urchins from hard bottoms; whereas male elephant seals have been traced to depths of over 1,500 m. Pinnipeds typically live and travel in herds, and some may undertake long migrations at sea (Levinton, 1995).

Manatees (*Trichechus* sp.) and dugongs (*Dugong dugon*) belong to the order Sirenia. They are the only herbivorous aquatic mammals, and they rely on larger plants, not algae, for nourishment. Their food requirements restrict them to living in shallow coastal waters, estuaries, and rivers. All four species of this order reside in warm waters and do not come onto land. The sirenians have been particularly vulnerable to hunting pressure because of their inshore habitats and their slow, placid behavior. At one time, dugongs had a widespread distribution which included Atlantic waters; today, they are restricted to shallow waters of the Indian and Pacific Oceans. All three species of manatees are found only in tropical Atlantic waters (Lalli & Parsons, 2002).

4.6.1.6 Marine Reptiles

There are comparatively few reptiles that have adapted to a marine life (Lalli & Parsons, 2002). The best known are the eight species of marine turtles, but there are also more than six times as many species of sea snakes (family Hydrophiidae), and there is one marine lizard, a large seaweed-eating iguana of the Galapagos Islands.

Sea turtles are integral components of the ocean environment and have been shown to have beneficial impacts on coral reefs, seagrass meadows, and coastal dune ecosystems. Marine turtles are usually found in tropical waters, but some migrate or are carried by currents to temperate shores. All undertake long migrations to return to land in order to lay their eggs at specific nesting sites on sandy shores.

Sea snakes breathe air by means of nostrils and lungs, but they are truly marine animals that inhabit coastal estuaries, coral reefs, or open tropical water. Most of the approximately 60 species remain at sea to bear their young. They school in large numbers and feed on small fish or squid which they kill with venom injected by fangs. Sea snakes are presently restricted to warm waters of the Indian and Pacific Oceans (Lalli & Parsons, 2002).

4.6.1.7 Birds

Seabirds live throughout the oceans and consist of a diverse array of adaptive types. They vary from the flightless cormorant to the frigate-bird, which is completely dependent upon long-term flight. They range from those species feeding upon small zooplankton to those, such as pelicans, that feed on large muscular fish. Some are limited to a relatively small feeding and breeding area, whereas others migrate for thousands of miles, such as the Arctic tern (*Sterna paradisaea*), a seabird in the gull family (Terres, 1996). Approximately 95 percent of seabirds are colonial.

Seabirds include penguins, petrels, pelicans (*Pelecanus* sp.), and auks. Penguins live only in cold Antarctic and sub-Antarctic waters in colonies that vary from a few pairs to thousands. Petrels have modified tubes on their bills, which they use to drink salt water and dispose of the salt. Pelican and their relatives (the boobies, gannets, and cormorants) are often heavy and include many brightly colored and ornamented species. They are mainly tropical, but some species nest in the Arctic and Antarctic. While some, such as the frigate-birds (*Fregata* sp.), fly far out to sea, most of this group stays closer to land. Gulls (family Laridae), terns (family Sternidae), and auks comprise the most diverse group of seabirds. Various gull species extend over vast areas of the northern hemisphere and can be found breeding in a wide variety of shoreline and island habitats (Levinton, 1995). Terns are smaller and more oceanic than gulls, and are most abundant in diversity in the tropics (Levinton, 1995). Auks are usually black and white, have chunky bodies, and are excellent swimmers and divers (Terres, 2006). Puffins (*Fratercula* sp.) , members of the auk family, include four species that are found in the North Atlantic and North Pacific oceans, with a large percentage of puffins breeding on the coast of Iceland. There are approximately 12 to 15 million puffins in the world (Project Puffin, 2006).

The many species of oceanic birds have developed diverse methods of feeding and take different types of prey; this is reflected in species differences in structure of the bill and wings. However, the majority of seabirds are essentially dependent on the uppermost layers of the sea for their food (Lalli & Parsons, 2002). Although seabirds are found world-wide, the largest colonies are located adjacent to highly productive ocean areas where food is plentiful and concentrated. At sea, birds frequently form feeding aggregations along oceanic fronts which, like upwelling regions, have relatively high biological productivity. Far fewer birds are present in low-productivity tropical regions. Seasonal changes in the marine environment can be reflected in the distribution of birds, and some species undertake long annual migrations in response to seasonal food availability and suitable weather for breeding. Seabirds also exhibit natural fluctuations in population densities which can be caused by climate change and subsequent fluctuations in prey availability (Lalli & Parsons, 2002).

Migration pathways over the ocean include routes over the Atlantic Ocean from Labrador and Nova Scotia to the mainland of South America (Bird Nature, 2001) and the East Asian-Australasian flyway, which extends from Siberia and Alaska in the north, to Australia and New Zealand in the south.

4.6.1.8 Threatened Species

The populations of many marine species are decreasing to unsustainable levels (MarineBio, 2006). Key threats, primarily due to human activities, include accidental capture in fishing gear, habitat destruction, overharvest, and ship strikes (NOAA, 2006a). Other possible causes of marine mortality include the introduction of new diseases, ecosystem changes such as algal blooms, and indirect effects of climate change. Although pollution rarely kills marine creatures directly (with the exception of catastrophic events), it can impair their health, harm their reproductive potential, and eventually lead to their death. Ingestion of marine debris and entanglement in plastic trash can be significant additional sources of mortality (Ocean Commission, 2004). In the past few decades, there has been a considerable increase in the number of species listed as threatened from marine life families such as whales, dolphins, manatees and dugongs, salmon, seabirds, sea turtles, and sharks.

The International Union for Conservation of Nature and Natural Resources (IUCN), through its Species Survival Commission (SSC) assesses the conservation status of numerous global species in order to highlight taxa threatened with extinction, and therefore promote their conservation. The IUCN Red List of Threatened Species provides taxonomic, conservation status, and distribution information on taxa that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalog and highlight those taxa that are facing a higher risk of global extinction (i.e. those listed as critically endangered, endangered, and vulnerable). The IUCN Red List currently tallies over 16,000 threatened species, including both terrestrial and aquatic species, and primarily plants and animals. The Red List is available at: http://www.iucnredlist.org.

Marine animals teetering above extinction on the critically endangered list are the coelacanth, southern bluefin tuna (*Thunnus maccoyii*), as well as the hawksbill and leatherback turtles. Marine endangered animals include: loggerhead, green and olive ridley (*Lepidochelys olivacea*) turtles, various species of saw fish (family Pristidae), and the blue whale. Among a large list of marine animals that could go extinct if nothing changes (i.e. threatened) are the dugong, humphead wrasse (*Cheilinus undulatus*), whale shark (*Rhincodon typus*), humpback whale, grey nurse shark (*Carcharias taurus*), and great white shark (*Carcharodon carcharias*).

4.6.2 Regulatory Settings

The oceans of the world are subject to a number of international conservation efforts. Among several institutions with an interest in sponsoring efforts to protect and manage the habitats of marine organisms are the United Nations Environment Program (UNEP), the United Nations' Educational, Scientific and Cultural Organization (UNESCO) Intergovernmental Oceanographic Commission, the International Ocean Institute, the International Maritime Organization, and the World Conservation Union Global Marine Program. As part of the global effort to protect the planet's biodiversity, the UNEP administers one of the world's largest conservation agreements – the Convention on International Trade in Endangered Species of Wild Fauna and Flora, known as CITES. More than 150 governments have ratified the treaty, which offers varying protection to more than 35,000 species of animals and plants. CITES bans international commercial trade in species threatened with extinction. It also protects other species, which are not threatened, but may be at serious risk unless international trade is strictly regulated (CITES, 2006).

Among other international treaties to protect marine life are the International Convention for the Prevention of Pollution from Ships (MARPOL) and the International Convention on the Regulation of Whales. Conservation of the natural resources within the ocean environment also constitutes part of several other broad agreements, such as the Convention Concerning the Protection of the World Cultural and Natural Heritage

(World Heritage Convention) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

There are also numerous agreements focused on specific reaches of water. These are too numerous to list, but include agreements such as the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region and the Convention of the Conservation of Antarctic Marine Living Resources (CCAMLR). UNEP's Regional Seas Program consists of several regional agreements, making it one of the most globally comprehensive initiatives for the protection of marine and coastal environments, including: Arctic, Antarctic, Baltic, Caspian, Atlantic Coast of West and Central Africa (Abidjan Convention), Eastern Africa, North-East Pacific (Antigua Convention), Mediterranean (Barcelona Convention), North-East Atlantic, South-East Pacific (Loma Convention), South Pacific (Noumea Convention), North-West Pacific, east African seaboard (Nairobi Convention), Kuwait region (Kuwait Convention), and Red Sea and Gulf of Aden (Jeddah Convention). All of these agreements share the underlying principle of pursuing the conservation of biological diversity and the sustainable use of its components; some also address issues ranging from chemical wastes to coastal development (UNEP, 2006)

Within the United States, the early 1970s witnessed the passage of several landmark environmental laws; many of these statutes affected marine species indirectly but two were focused specifically on the conservation and protection of these organisms. The Endangered Species Act (ESA) was enacted to conserve endangered and threatened species and the ecosystems upon which they depend. The ESA works in two stages. First, the government protects a species from possible extinction, and then it takes steps to restore the species' numbers to the point where it is no longer threatened (HSUS, 2006). The law includes powerful prohibitions against any action that harms a listed animal. The law, with limited exceptions, prohibits federal agencies from authorizing, funding, or carrying out any action that would jeopardize a member of a listed species or destroy its critical habitat. Table 4-8 summarizes the marine mammal and sea turtle species that are listed in the Endangered Species Act of 1973.

Table 4-8. Marine Mammals and Reptiles Listed in the Endangered Species Act

Species		Year Listed	Status
Cetaceans			
Dolphin, Chinese River	*(Lipotes vexillifer)*	1989	E (F)
Dolphin, Indus River	*(Platanista minor)*	1991	E (F)
Porpoise, Gulf of California harbor/vaquita	*(Phocoena sinus)*	1985	E (F)
Whale, blue	*(Balaenoptera musculus)*	1970	E
Whale, bowhead	*(Balaena mysticetus)*	1970	E
Whale, fin	*(Balaenoptera physalus)*	1970	E
Whale, gray (1 listed DPS)	*(Eschrichtius robustus)*		

Table 4-8. Marine Mammals and Reptiles Listed in the Endangered Species Act

Species		Year Listed	Status
- Western North Pacific		1970	E
Whale, humpback	*(Megaptera novaeangliae)*	1970	E
Whale, killer (1 listed DPS)			
- Southern Resident	*(Orcinus orca)*	2005	E
Whale, Northern right	*(Eubalaena glacialis)*	1970	E
Whale, sei	*(Balaenoptera borealis)*	1970	E
Whale, Southern right	*(Eubalaena australis)*	1970	E (F)
Whale, sperm	*(Physeter macrocephalus)*	1970	E
Pinnipeds			
Seal, Caribbean monk	*(Monachus tropicalis)*	1967	E
Seal, Guadalupe fur	*(Arctocephalus townsendi)*	1985	T (F)
Seal, Hawaiian monk	*(Monachus schauinslandi)*	1976	E
Seal, Mediterranean monk	*(Monachus schauinslandi)*	1970	E (F)
Seal, Saimaa	*(Phoca hispida saimensis)*	1993	E (F)
Sea Lion, Steller (2 listed DPSs)	*(Eumetopias jubatus)*		
- Eastern		1990	T
- Western		1997	E
Sirenia			
Manatee, Amazonian	*(Trichechus inunguis)*		E (F)
Manatee, West African	*(Trichechus senegalensis)*		T (F)
Manatee, West Indian	*(Trichechus manatus)*		E
Sea Turtles			
Turtle, green (2 listed populations)	(*Chelonia mydas*)		
- Florida & Mexico's Pacific coast		1978	E
- all other areas		1978	T
Turtle, hawksbill	(*Eretmochelys imbricata*)	1970	E
Turtle, Kemp's ridley	(*Lepidochelys kempii*)	1970	E
Turtle, leatherback	(*Dermochelys coriacea*)	1970	E
Turtle, loggerhead	(*Caretta caretta*)	1978	T
Turtle, Olive ridley (2 listed populations)	(*Lepidochelys olivacea*)		
- Mexico's Pacific coast breeding colonies		1978	E
- all other areas		1978	T

Notes:
E = endangered; F = foreign; T = threatened DPS = Distinct population segment

The Marine Mammal Protection Act was passed in response to public concerns about the incidental deaths of hundreds of thousands of dolphins each year associated with tuna fisheries, the hunting of seals for fur, and the continuing commercial harvest of whales despite controls by the International Whaling Commission. The MMPA, with limited exceptions, prohibits the hunting, killing, or harassment of marine mammals. The MMPA also established the independent Marine Mammal Commission, which is charged with reviewing and making recommendations on domestic and international actions and policies of all federal agencies with respect to marine mammal protection and conservation.

In addition to the international conventions and U.S. laws identified above, some countries have specific regulations and guidelines regarding protection of marine resources within their territorial waters. Some of these regulations are more stringent than the international conventions. These national regulations generally exist to protect endangered habitats, fishery and allied industries, and aquaculture. In preparation for each expedition, the vessel operator (ODL/Transocean) and the science support contractor (TAMU) will identify specific territorial guidelines, regulations, and permitting requirements relevant to the countries where vessel and drilling operations will take place.

4.6.3 Significance Criteria

An impact on marine and near-coastal biological resources is considered significant if any of the following apply:

- Any substantial loss or degradation to biological populations or communities or a functional habitat value that cannot recover within a reasonable period of time;

- Any substantial impedance of fish or wildlife migration or passage routes; or

- Any loss of a population of a threatened, endangered, or candidate species or its habitat, for example, by reduction of numbers, substantial alteration in behavior, reproduction, or survival, or loss or disturbance of habitat.

4.6.4 Impact Source Characterization

Discharges, physical disturbances, and acoustic sources resulting from SODV drilling and related research operations may affect marine organisms present in the vicinity of the vessel as it transits or operates at a particular drill site. The following provides detail on the nature of these sources.

4.6.4.1 Discharges and Physical Disturbances from SODV Operations

As described in Section 2.2.2, the SODV will discharge liquid wastes consisting of treated sanitary, untreated domestic (grey water) wastewater including victual (food-contaminated) wastes, desalination brine water, deck drainage, and treated drainage from bilge and engine room sources, non-contact cooling water, and ballast water. In addition, wash and rinse water from the vessel's laboratories will be treated to neutralize inorganic chemical residues (acids) before being discharged.

Sanitary wastewater will be processed in a marine sewage treatment plant prior to discharge. Under normal conditions, approximately 15,800 liters of sanitary wastewater will be treated per day and the resulting effluent will contain less than 50 mg/L suspended solids, 50 mg/L BOD_5, and fewer than 250 total coliform bacteria colonies per 100 ml. Untreated non-sanitary wastewater (greywater) will also be discharged to the sea. It is estimated that approximately 55,000 liters of greywater per day will be discharged from the SODV during a typical expedition. In addition, up to 120,000 liters of drainage containing oily residues may be processed in an oil/water separator to a concentration level less than 15 parts per million (ppm) and discharged per day. It is expected that wastewater discharges will be subject to rapid dilution and assimilation in the sea.

Other than the noncontact cooling water comprising unprocessed seawater, the largest discharge volume from the drillship will occur as a result of the potable water production/desalination process. It is estimated that the SODV would discharge approximately 132.9 million liters of waste brinewater per typical expedition. Because desalination will be performed by evaporation, the resulting brinewater discharge will only include constituents naturally contained in seawater. As described in Section 2.2.2, it is anticipated that the salinity level of the brinewater will be approximately 25 percent stronger than ambient seawater. The brinewater discharge will disperse and dilute rapidly in the sea.

Operation of the SODV's propulsion equipment will create physical disturbances to the water column in proximity to the ship. When the SODV is dynamically positioned at a drill site, the ship's main propellers and up to 12 thrusters will cause turbulence and mixing that may affect the water column up to a distance of about 100 m from the ship.

4.6.4.2 Acoustic Outputs from SODV Operations

Noise produced by SODV operations has the potential to impact many marine organisms particularly cetaceans exposed to the underwater sounds. Operations of the SODV will generate noise and vibration created by the ship's engines, propellers, thrusters, mechanical systems, and transducer-based instruments such as sonar, ADCP, and transponder beacons. It is expected that the SODV's engines and thrusters exclusive of drilling activities will generate approximately 154 dB re 1 μPa of noise. The pulsed sounds from the transducer-based instruments will be emitted in narrow beams directed beneath the vessel, including the single-beam echo sounder (200 to 230 dB re 1μPa within a 30° beam), the sub-bottom profilers (up to 204 dB re 1μPa within a 45° beam), and the ADCP (up to 224 dB re 1μPa over a 30° beam). The underwater acoustic transponder beacons deployed on the seafloor typically have an acoustic output of 199 -

214 dB re 1 μPa at the source. The energy emitted by these transducer-based sources is highly directional and will attenuate with distance from the source.

Additional sound will be produced drilling operations. As previously summarized (Table 4-6), moored drillships (production drilling) typically produce sounds in the range of 174 - 185 dB re 1μPa (Hurley and Ellis (2004).

Single-channel seismic surveys or VSP operations, which may be occasionally performed by the SODV at selected sites, represent an additional source of underwater acoustic energy from the ship. These activities are typically performed using a small seismic source (1 or 2 airguns) having a typical maximum acoustic output of 194 dB re 1 μPa at the source operated for short durations of time (less than 12 hours). The acoustic energy from the relatively small seismic source airguns travel underwater in a circular spreading pattern and rapidly attenuate with distance from the source (Table 4-7).

As described in Section 4.5.5, the potential range of effects from acoustical sources on various marine organisms encompasses various physiological effects, hearing impairment, and disturbance reactions. These effects are often species specific and may also involve minor changes in behavior, interference with vocalization, or temporary displacement of individual animals. The following provides more detailed information on how certain types of marine mammals may react to acoustic stimuli such as the acoustic sources on the SODV.

Baleen Whales

Based on available literature, Richardson (1995) concluded that whales seem to react to lower frequency echo sounders, sometimes showing avoidance reactions. Baleen whales appear to react to frequencies up to 28 kHz but generally do not react to transducer-based equipment at 36 kHz and above. One observation of baleen whale's reaction to a transponder beacon occurred during ODP Leg 188 in January to March 2000 (SCAR, 2002). In this case, pods of humpback whales were observed swimming around and under the vessel for about two hours while the vessel was drilling. In addition, several individuals raised their heads above the water (spy hopping) within 30 m of the vessel and commenced breaching displays before departing.

Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the acoustic pulses remain well above ambient noise levels. However, baleen whales exposed to strong noise pulses often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the case of the migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees but within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 μPa range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. Subtle behavioral changes sometimes become evident at somewhat lower received levels.

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades (Malme et al. 1984). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987).

Toothed Whales

Little systematic information is available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale studies have been reported for toothed whales. However, systematic work on sperm whales is underway.

Some observations of toothed whale reactions to transducers were documented by Richardson et al. (1995) particularly for equipment producing sound in the animals' optimum hearing range. For example, in one study, sperm whales ceased calling when exposed to sounds in the 6-13 kHz range. Reaction thresholds in deplhinid species were also found to be as low as 110-130 dB re 1 μPa but response times for higher levels may vary due to habituation or other behavioral effects, as seems to occur with baleen whales. Some observations of killer whales approaching and accompanying vessels operating echo sounders in transit have also been documented suggesting that these animals are not adversely affected by this type of acoustic source (SCAR, 2002).

Although dolphins and small toothed whales may be observed near vessels producing high acoustical output sound levels (e.g., seismic surveys), there is a general tendency for most delphinids to show some limited avoidance to acoustic sources. There have been indications that small toothed whales sometimes tend to head away, or to maintain a somewhat greater distance from the vessel, when a large array of seismic airguns is operating than when it is silent (e.g., Goold 1996; Calambokidis and Osmek 1998; Stone 2003). Similarly, captive bottlenose dolphins and beluga whales exhibit changes in behavior when exposed to strong pulsed sounds (Finneran et al. 2000, 2002). However, the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 μPa) before exhibiting aversive behaviors.

There are no specific data on the behavioral reactions of beaked whales exposed to acoustical sources. A few beaked whale sightings have been reported from seismic vessels (Stone 2003). However, most beaked whales tend to avoid approaching vessels even without the added noise (e.g., Kasuya 1986; Würsig et al. 1998). Beaked whales have been reported to show avoidance reactions to standard vessels and it is to be expected that they would similarly avoid the SODV.

Pinnipeds

Pinnipeds are not likely to show a strong avoidance reaction to the acoustical outputs from the SODV. There is very little published data on the response of seals to transducer-generated sound, although Richardson et al. (1995) reviewed three related studies. One study documented altered swimming patterns in harp seals in response to a 200 kHz echo sounder being operating nearby. Other studies noted the absence of reactions from 60-69 kHz acoustic tags attached to ringed and Weddell seals.

Visual monitoring data taken onboard vessels emitting high acoustical outputs such as those conducting seismic surveys have shown that pinnipeds only slightly avoid acoustical sources and exhibit only minor changes in behavior. Those observations suggest that pinnipeds frequently avoid coming within a few hundred meters of the acoustic source. However, initial telemetry work suggests that avoidance and other behavioral reactions to small acoustical sources may be stronger than pinniped reactions to intense sources (Thompson et al. 1998b).

4.6.4.3 Discharges from Drilling, Coring and Borehole Completion Activities

Drilling operations will result in the displacement and subsequent deposition of cuttings on the seafloor consisting of sediment and geological basement materials. As shown in Table 4-2, for uncased 25 cm diameter boreholes, approximately 6 m^3 of material will be displaced for each 100 m drilled while 28 m^3 of material would be displaced for each 100 m drilled of larger 56 cm diameter boreholes. Occasionally, drilling muds consisting of naturally occurring minerals (sepiolite or attapulgite) mixed with seawater may also be used to remove (sweep) excess cuttings from a borehole at a typical concentration of 66 grams of solids per liter of seawater. Generally, the larger grain-size particles originating from drill cuttings will settle out within several meters of the borehole forming a mound, while smaller particles from drilling fines or drilling mud are expected to remain in suspension and eventually settle on the seafloor within several hundred meters of the borehole.

In addition to drilling mud used to clean boreholes, heavy drilling muds mixed to more dense concentrations or cement may be used to plug and permanently seal certain boreholes. Cement will also be used to also be used in select boreholes to secure casings, reentry cones, or observatories. In some applications where heavy drilling mud is used as a temporary slug, it will be expelled from the borehole when the drill string is reintroduced into the borehole to resume drilling operations. Heavy drilling mud and cement which is intended to seal a borehole for permanent closure or install casings or permanent structures will remain in the borehole and will not disperse or be displaced to the marine environment.

4.6.4.4 Physical Disturbances Drilling, Coring and Borehole Completion Activities

Drilling and coring operations will also result in physical disturbances to the seafloor environment. These disturbances will be derived from the installation of boreholes, including the displacement and deposition of drill cuttings and naturally-occurring drilling muds that may be introduced into the borehole during the drilling process.

Localized disturbances to the seafloor environment will also occur as a result of the installation of permanent structures such as reentry cones and observatories at selected drill sites. The extent of the disturbances created by the presence of these structures will be limited to the immediate vicinity surrounding the borehole.

Occasionally a drill string, drill bits, coring equipment, or anchoring weights may be accidentally or intentionally released to the seafloor or in a borehole to facilitate operations (see Section 2.3.2). Uncontaminated scrap metal from the SODV may also be disposed of at sea and deposited on the seafloor. These materials will not be retrieved and will create localized disturbances on the seafloor.

4.6.5 Impact Analysis

Potential impacts to marine biological resources resulting from the operation of the SODV and riserless ocean drilling activities are discussed below. It should be noted that since the scope of this PEIS focuses on a general assessment of IODP-USIO riserless drilling and related research activities independent of specific geographic locations and time periods, it is only possible to make qualitative statements regarding the potential range of effects on these biological resources and their anticipated significance.

4.6.5.1 Plankton

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

The nutrients in the treated and untreated liquid wastes released from the SODV in Alternative A will be rapidly diluted and assimilated into the sea upon discharge. Because of these conditions, SODV wastewater discharges are not expected to enhance phytoplankton growth or reproduction. Therefore, no appreciable change in phytoplankton abundance in the vicinity of the drillship is expected.

Zooplankton may be indirectly affected by the discharge of liquid wastes from the SODV due to their dependence on the phytoplankton community. Because phytoplankton are not expected to be adversely affected by SODV discharges, there should be no collateral effect on zooplankton. Zooplankton could potentially experience a direct effect from the discharge of suspended solids causing an interference with respiratory activities. This effect, if present at all, would be short term and the resulting impacts would be minimal. Because sanitary wastewater would always be treated prior to discharge, the effluent is not anticipated to affect the dissolved oxygen concentration of the receiving seawater beyond a very small area at the discharge point known as the zone of initial dilution. Therefore, no adverse impacts to zooplankton and phytoplankton resulting from dissolved oxygen deficiencies are expected.

Increased salinity resulting from brinewater discharges may also affect plankton populations. Recent studies on zooplankton salinity tolerance indicate that increased salinity can affect distribution and abundance of zooplankton species (Hall & Burns, 2003). However, due to the rapid dilution of the brinewater discharge in the sea, the resulting salinity concentrations are expected to quickly equilibrate to local levels. Any increased salinity effects on zooplankton community structure would be short term and localized to the immediate discharge area.

Finally, the treated drainage discharges from the SODV bilge, engine room, and portions of the deck will only occur periodically and are anticipated to mix quickly in the sea and will be dispersed by surface currents. Thus, impacts to zooplankton and phytoplankton from this source are anticipated to be minimal.

Mixing of the water column caused by operation of the vessel's thrusters when the SODV is in the dynamically positioned mode will potentially influence local plankton communities. Increased turbulence may potentially redistribute phytoplankton and zooplankton within communities within approximately 100 m of the vessel. These localized effects would be short term, reversible, and would occur only while the vessel is positioned at a drilling site.

IODP-USIO drilling activities are expected to occur at depths exceeding 200 m and therefore in areas where no light penetrates to the seafloor. In general, all active photosynthetic activity occurs above 200 m; therefore, no impacts to phytoplankton due to drilling operations are anticipated. Drill activities that occur at shallower depths are also anticipated to have minimal impacts to phytoplankton, because the quantity of fine grain-size particles released would only have a localized effect on turbidity and would not significantly reduce the effective photosynthetic zone.

In general, the distribution and abundance of zooplankton decrease with depth. The exact distribution of zooplankton communities is driven by the presence of phytoplankton and oxygen. Below 1,000 m, oxygen concentrations are, in general, too low to support zooplankton populations. Regardless of depth, the impacts to zooplankton from drilling activities will likely be negligible; however, some regions of the world's deep oceans do contain hydrothermal vents, which support overlaying zooplankton communities (see Section 4.7.1.1). In general it is anticipated that the large grain-size particles originating from drilling discharges will settle out within a few meters of the borehole and will likely not impact any zooplankton communities present. However, the smaller particles are expected to remain in suspension slightly above the seafloor and dissipate down current of the borehole. The resulting turbidity is expected to dissipate rapidly with distance from the borehole. Although localized plumes of elevated turbidity may occur, they are generally expected to be limited to within several hundred meters of the borehole.

There is very little known about most of these deepwater zooplankton communities, and therefore their sensitivity to the effects of turbidity is difficult to assess. However, it can be expected that zooplankton in the vicinity of a borehole may experience interference with feeding and respiratory activities due to the increased suspended solids concentrations. The turbidity plume associated with the riserless drilling will be composed of particles of native rock, clay, silt, and other naturally-occurring minerals used by the SODV in drilling mud, which are all relatively inert materials. Therefore, no toxicity impacts are expected as a result of the localized turbidity plumes. In addition, these relatively inert drilling muds are not expected to bioaccumulate through the food chain.

Phytoplankton and zooplankton impacts in the areas where riserless drilling activities will occur are expected to be very similar. Slight differences in magnitude of impact may occur due to timing and duration of each expedition. Expeditions that occur during warm weather seasons may have slightly greater, although still minimal, impacts on phytoplankton and zooplankton in surface waters, as blooms typically occur during these months. Impacts are not expected to be significant, as no substantial loss or degradation to biological populations or communities or the functional habitat value is expected. However, as indicated above, there is some potential for localized smothering impacts on zooplankton in areas near hydrothermal vents, if present in the immediate vicinity of the borehole (see Section 4.7).

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS. The intensity, extent, and duration of potential impacts to plankton communities resulting from the discharges from SODV operations are not expected to differ significantly as compared to Alternative A. The potential impacts to plankton communities that may result from SODV operations in Alternative B include:

- Localized, short-term impacts to zooplankton respiration resulting from increased turbidity associated with SODV discharges of treated wastewater, greywater, and other liquid wastes;

- Localized, short-term impacts to phytoplankton and zooplankton community structure due to increased salinity from brinewater discharges;

- Localized, short term, and reversible redistribution of phytoplankton and zooplankton communities within 100 m of the SODV as a result of turbulence created by thruster operations;

- Interference with shallow or deepwater zooplankton feeding and respiratory activities due to the increased suspended solids concentrations within several hundred meters of the borehole.

Alternative C – No Action

If the IODP-USIO did not conduct IODP riserless drilling activities (No Action Alternative), there would be no discharges resulting from SODV operations or drilling and sampling activities to affect plankton communities.

4.6.5.2 Fish

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

Treated and untreated wastewater discharged from the SODV in Alternative A is expected to be rapidly diluted in the ambient seawater. It is anticipated that rapid dilution and dispersion will minimize contact with and impacts to fish.

Some fish may be exposed to the turbulence created by the thrusters when the SODV is dynamically positioned over a drill site. The resulting turbulence is generally expected to be limited to within 100 m of the vessel. Combined with the noise produced by the vessel operations, the turbulence created by the thrusters will effectively deter most species of fish from approaching the vessel. Behavioral changes that fish may experience, if any, would be limited to the immediate area surrounding the vessel and short term in duration.

Potential effects to fish may result from riserless drilling activities and exposure to acoustic sources generated by SODV operations. In general, potential impacts caused by acoustic sources to marine species from drilling activities are not well understood (ANZECC, 2000). Because most drilling will occur in deep water occupied by mesopelagic and bathypelagic fish species in relatively limited numbers, the potential for exposure to environmental outputs and adverse effects is minimal.

In general, riserless drilling activities will not directly affect most fish species inhabiting the water column. A number of fish species deposit demersal eggs on the seafloor and therefore it is possible that some eggs may be present in the vicinity of a drill site. To survive under normal conditions, fish eggs require oxygen to respire and transpire waste through the cell membrane. In situations where eggs are smothered, this process would be blocked causing mortality or deformities. The greatest potential impacts to fish eggs would occur over the continental slope and upper continental slopes where fish are more likely to spawn. Since the geographic area of each drill site is small and most pelagic fish are highly fecund (producing millions of eggs), the possible mortality associated with smothering is likely to be minimal compared to the natural mortality rate associated with demersal eggs. Given the temporary nature of drilling activity and the small area of impact at each drilling site, no impacts to demersal eggs as a result of drilling operations are expected.

During riserless drilling, acoustical outputs will include the noise produced by the vessel, operation of the drill string, and the underwater acoustic transponders deployed on the seafloor. Generally, physiological damage or mortality in fish may occur at sound levels in excess of 220 dB re 1 μPa (Turnpenny & Nedwell, 1994). Fish deterrence is typically stimulated at noise levels above 160 to 180 dB re 1 μPa (IOSEA, 2006, Evans and Nice, 1996, Gordon et al, 2004). Because adult and juvenile fish have the ability to move away from acoustical sources, exposure to peak sounds will be limited and it is unlikely that physiological effects will result. It is expected that most fish will avoid the area and the continuous output of noise generated by drilling/coring operations, the transponder beacon deployed near the drill site, and the turbulence created by the vessel's thrusters. The impacts associated with this deterrence may include a temporary disturbance in feeding and spawning behavior in the general vicinity of the vessel. It is anticipated that these disturbances would be short term and not significant because fish will rapidly reoccupy the area once drilling is complete and the vessel has left the area.

Overall, impacts to fish associated with IODP-USIO riserless drilling activities are expected to be minimal. Expeditions with longer durations will have the potential for greater cumulative noise and vibration impacts on fish species than those with shorter durations, but no significant behavioral changes or long-term loss or degradation to biological populations or communities or functional habitat value is expected.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS which would take into consideration biological resources present at specific drill sites. However, the intensity, extent, and duration of potential impacts to fish communities resulting from the discharges from SODV operations and drilling activities expected to be the same as those realized for Alternative A, including:

- Localized, short-term disturbances to fish resulting from turbulence created by the thrusters when the vessel is dynamically positioned at a drill site; and

- Localized, short-term disturbances to fish derived from the acoustic outputs generated by the vessel's thrusters, drilling/coring operations, and transponder beacons deployed near the drill site.

Alternative C – No Action

If the IODP-USIO did not conduct IODP riserless drilling activities (No Action Alternative), there would be no discharges resulting from SODV operations to affect fish.

4.6.5.3 Cephalopods

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

The potential impacts to cephalopods relating to SODV operations in Alternative A are very similar to those described above for fish. Thus, it is expected that the discharge of liquids from the SODV will rapidly disperse minimizing contact and impact to cephalopods.

The level of information that is available on underwater noise impacts is generally inconclusive with regard to effects on cephalopods (as it is for fish). Thus, it is possible that some cephalopods may be deterred from an area by incidental noise from the SODV. The impacts associated with this deterrence may include a temporary disturbance in feeding and spawning behavior in the general vicinity of the vessel. It is anticipated that the impacts resulting from these disturbances would be minimal.

As noted previously, the impacts of riserless drilling operations will occur primarily near the seafloor. Therefore, no impacts are anticipated as a result of the release of the drill cuttings or drilling mud on most cephalopod species, due to their mobility and ability to temporarily leave an affected area. Significant impacts to cephalopod eggs, whether on the substrate or suspended in the water column, are not expected, because of the limited dispersal area of material discharged focused around the borehole (section 4.3.4).

In general, impacts to cephalopod organisms in areas where IODP drilling activities will occur are expected to be minimal. Expeditions with longer durations at one particular drill site will have the potential for greater cumulative noise impacts on cephalopod species than those with shorter durations at each drill site. No significant long-term loss or degradation to biological populations or communities or functional habitat value is expected.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS. The potential impact to cephalopods resulting from SODV discharges and drilling activities would be the same as those realized for Alternative A, and would be limited to localized, short term disturbances primarily derived from acoustic outputs generated by the vessel and drilling and coring operations.

<u>Alternative C – No Action</u>

If the IODP-USIO did not conduct riserless drilling activities (No Action Alternative), there would be no discharges from SODV operations to affect cephalopods.

4.6.5.4 Benthos

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

Due to the large water depths in which the SODV will typically operate, it is expected that wastewater discharges from the SODV will have little or no effect on seafloor benthic communities in Alternative A. Similarly, noise generated from the drillship is not expected to have an effect on the benthos.

Impacts to deep sea benthic communities in proximity to a borehole may include disturbance (displacement) or physical contact by the release of materials from the borehole to the surrounding area. The primary direct impacts to the benthic community are associated with turbidity and smothering. Indirect effects include substrate changes in the vicinity of a borehole which may enhance or diminish habitat sites. For example, the permanent installation of borehole completion devices will alter the seafloor and may provide a substrate for further benthic development. Impacts to the benthos from these inert materials would be localized in extent and minimal.

As the plume of suspended particles of drilling fines and drilling mud are transported by bottom currents, it can be expected that some benthic organisms in the vicinity of the borehole may be partially covered by deposition of these fine particles and experience interference with feeding and respiratory activities. It is not anticipated these particles (composed of inert clay, silt, and minerals) would cause acute or chronic toxicity impacts to the benthic community. In addition, these discharges are not expected to bioaccumulate through the food chain.

Because the greatest concentration of drill cuttings and drilling mud particles are expected to be deposited within a few meters of the borehole (Section 4.3.4), smothering of the benthic biota, if present in the immediate vicinity of the borehole, is expected. Smothering would be caused by low oxygen concentrations in the sediment, physical effects of burial beneath deposited solids, or the physical change in sediment composition (Neff, 2005). The low oxygen levels affecting the benthic communities would be expected to eventually increase through biodegradation, in a process known as organic enrichment, resulting in the recovery of the benthic community (Pearson and Rosenberg, 1978). Additionally, the presence of organic matter in deposited sediments may retard development of the benthic community (Hartley et al., 2003).

One study in the Bass Strait and Otway Basin in Australia, determined that the smothering effects of drilling in deep waters were generally short lived, with most benthic organisms recovering within 4 months (Terrens et al., 1998). Based on these findings, it is expected that for most of the regions, impacts to benthic organisms from riserless ocean drilling will be minimal. However, the negative effects associated with smothering will vary depending on the degree of endemism of the benthic community. In some regions of the world's oceans, the distribution of deep sea benthic communities appears to be patchy and the specific species assemblages differ at various sites, between year, and among season. In regions where the benthic community has a wide distribution of species and heterogeneity of benthic habitat, the isolated drilling activities are unlikely to disturb any unique benthic communities, and the community is expected to recover in a relatively short time period. On the other hand, in areas where endemic communities exist, the effects of smothering may be more significant, although localized in extent.

In general, impacts to benthos in Alternative A are not expected to be significant, as most expeditions would not result in loss or degradation to biological populations, communities, or functional habitat value. However, should unique populations be present near a drill site, localized effects could be significant, as this impact would affect a greater percentage of the extant population. For example, if hydrothermal vent communities are present, their very unique species assemblages may not recover rapidly from smothering or indirect impacts resulting from sediment changes. Additional information pertaining to biologically sensitive areas is provided in Section 4.7.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS which would take into consideration biological resources present at specific drill sites. In general, the resulting impacts to benthos from riserless drilling expeditions in Alternative B are expected to be minimal, and may include:

- Localized alteration of benthic communities caused by physical changes in the substrate;

- Localized interference with benthic organism feeding and respiration due to suspended particles of drill cuttings and drilling mud; and

- Localized impacts to the benthic community derived from smothering effects of drill cuttings and drilling mud particles deposited on the seafloor.

However, in Alternative B, potentially sensitive benthic communities unique to a particular area would be identified during the IODP SAS planning and review process. As needed, drill site locations or particular operations may be modified to avoid significant adverse effects to these sensitive benthic organisms. For perspective drill sites where benthic organisms that are especially sensitive to the deposition of sediment from a borehole are densely populated, or the proposed research activities may result in more intense or prolonged exposure, a supplemental environmental review may be prepared to evaluate the site-specific risks and develop recommendations for additional mitigating measures. Overall, impacts to benthic organisms resulting from riserless drilling activities in Alternative B are not expected to be significant.

Alternative C – No Action

If the IODP-USIO did not conduct IODP riserless drilling activities (No Action Alternative), there would be no discharges resulting from drilling and coring operations on the seafloor to affect benthic organisms.

4.6.5.5 Marine Mammals

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

In Alternative A, the physical presence of the drillship, whether in transit or at a drill site, is unlikely to significantly interfere with the movement of marine mammals. Close approaches of the vessel to marine mammals (or vice versa) are expected to be rare, considering that the proposed action will only involve one vessel and that the average density of marine mammals in the open ocean is very low. When close approaches occur, the mobility of marine animals and their ability to detect the ship would permit them to easily avoid contact, especially since the cruise speed of the ship is generally 11 knots or less. Therefore, collisions between the drilling ship and marine mammals are not expected to occur. Detours made by marine animals to avoid the ship will be a temporary response. When approached by boat or aircraft, bowhead whales have been observed to change behavior, including changing breathing rates, surfacing intervals, and time spent on the surface (LGL, 2006). The distances at which gray whales showed a 50 percent probability of exhibiting avoidance response (change in direction, reduction in speed) were 1.1 km for drillships and only 80 m for helicopter overflight (Malme et al., 1984).

Discharges from the drillship could potentially disturb marine mammals or their food sources. Effects on water quality from drillship discharges are expected to be minimal and localized near the ship. Wake and disturbance effects such as turbulence created by the dynamic positioning thrusters are likely to deter most mammals from approaching the vessel, and instead will likely remain outside the small area where an adverse effect from discharges might occur. Direct physical or toxicological effects of various vessel discharges on marine mammals are therefore unlikely and few animals would be affected.

Acoustic outputs from SODV operations have the potential to affect marine mammals exposed to the underwater sounds. The SODV will generate noise and vibration created by the ship's engines, propellers, thrusters, mechanical systems, and transducer-based instruments such as sonar, ADCP, and transponder beacons. Additional sound will be produced drilling operations on the seafloor. As previously summarized (Table 4-6), moored drillships typically produce sounds in the range of 174 - 185 dB re 1μPa (Hurley and Ellis, 2004). Based upon underwater sound level measurements, it is expected that the SODV's engines and thrusters exclusive of drilling activities will generate approximately 154 dB re 1 μPa of noise. Because the transducer based sources emit narrow beams of energy directed toward the seafloor and mostly during transit, marine mammals, if present beneath the vessel, are not expected to be exposed to peak sound levels (200-230 dB re 1μPa) for prolonged periods.

The potential range of effects of acoustical outputs to marine organisms encompasses physiological effects, hearing impairment, and disturbance reactions (Section 4.5.5). Marine mammal reactions to underwater sounds may include cessation of feeding, resting, socializing, and an onset of alertness or avoidance. These disturbances may not be biologically significant if they only cause a temporary change in behavior or habitat use. In contrast, the disturbance may be biologically significant if it causes animals to avoid critical habitat for an extended time period, or hinders foraging or mating.

It is expected that marine mammals like many marine organisms will perceive the continuous noise produced by the SODV operations and avoid approaching the vessel, thereby avoiding exposure to peak noise levels. Some species or individual animals may not be deterred by the presence of the SODV and may potentially be exposed to the vessel's acoustical sources. However, it is generally expected that marine mammals will not be exposed to potentially harmful levels of noise (≥ 180 dB re 1 μPa), including the SODV's transducer-based equipment. Similarly, few species of marine mammals would be capable of diving deep enough at active drill sites to approach a transponder beacon deployed on the seafloor and become exposed to a peak sound level from that devices. Generally, no significant physiological effects to individual animals or marine mammal populations are expected as a result of the proposed drilling activities.

Single-channel seismic surveys or VSP operations, which may be occasionally performed by the SODV at selected sites, represent an additional noise source. These activities will generally involve small seismic sources (1 or 2 airguns) operated for short duration (less than 12 hours). Resulting effects to marine mammals, if any, would be minimal and short-term due to the consistent implementation of mitigating measures during these surveys to prevent exposure to harmful sound levels (≥ 180 dB re 1 μPa rms) or sound levels that may initiate adverse behavioral effects (≥ 160 dB re 1 μPa). Additional detail pertaining to the impact assessment of seismic sources is presented in a separate document, the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research.

Helicopter operations also represent a noise source during SODV operations. Helicopter overflights will be infrequent and will temporarily affect the surface environment at a given location. The noise from helicopter operations can cause a startle response and interrupt whales and dolphins while resting, feeding, breeding, or migrating. Both the noise and shadow cast by the helicopter can elicit a response from nearby cetaceans (Richardson et al. 1995). These occurrences would be temporary and would pass within seconds, having no long-term impact on cetaceans. The greatest potential effect from helicopters is disturbance of pinnipeds breeding rookeries. Although the infrequent nature of helicopter operations used to support the SODV suggests that the likelihood of flights occurring in a region containing pinniped rookeries is minimal, overflights in these sensitive areas will be prohibited through the use of mitigating measures.

The continuous underwater sounds generated by SODV operations may produce species specific effects involving minor changes in behavior, interference with vocalization, or temporary displacement of individual animals from the vicinity of the SODV during transit or when the vessel is on station at a drill site. However, these effects will be short term and therefore not anticipated to be significant.

Impacts to marine mammals may vary from place to place, depending on the species present and their particular sensitivity to noise, or their density. General observations made during previous DSDP, ODP, and IODP expeditions, suggest that the underwater noise generated by the ship and riserless drilling activities do not significantly interfere with animal population densities, communities, habitats, migration, breeding, or feeding behaviors.

In Alternative A, drilling operations could potentially be conducted at drill sites containing resident or sensitive marine mammal populations or within areas characterized as critical habitats, native hunting areas, feeding, or breeding grounds. As a result, behavioral disturbances caused by acoustic outputs in these areas could potentially have a more pronounced affect on the population. Similarly, seasonal considerations such as marine mammal migrational patterns may not be taken into consideration in the selection of perspective drill sites.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

The range of potential impacts to marine mammals caused by SODV operations including acoustic sources in Alternative B are expected to be similar to those describes for Alternative A and would primarily include short-term behavioral effects and disturbance reactions. In Alternative B, the comprehensive IODP SAS review process would identify proposed drill sites where rare or biologically sensitive marine mammal species may be present and, if so, prompt the selection of suitable mitigating measures or the recommendation to avoid critical areas to prevent adverse impacts. As needed, these mitigating measures may include recommendations to modify proposed activities to reduce the intensity of acoustic outputs, change the timing of an expedition, or select alternate sites to avoid critical habitats, native hunting areas, breeding, feeding grounds, or migration pathways.

Prompted by the IODP SAS review and planning process for each expedition, the IODP-USIO would obtain necessary approvals for the areas in which the vessel would operate including permits and other regulatory notifications. As necessary, the IODP-USIO would consult with National Marine Fisheries Service with respect to rare or endangered species (e.g., North Atlantic right whale, Northeast Atlantic bowhead whale) listed in the Endangered Species Act to prevent harassment or interference to those species. In the event that a proposed expedition that has the potential to cause significant adverse behavioral effects or disturbances to marine mammals, the IODP-USIO would apply for an IHA as required by the Marine Mammal Protection Act. Mitigating measures and operating conditions developed in response to these requirements and notifications would be incorporated into the Operating Plan and Scientific Prospectus for the expedition accordingly.

Additionally, a supplemental environmental review may be prepared to address potential impacts from a proposed expedition in areas containing sensitive marine mammal species, dense concentrations of marine mammals, including resident populations, or to address drilling activities that may result in more intense or prolonged acoustical outputs. A supplemental review will evaluate site-specific risks to potentially affected marine mammals species and may include additional strategies to mitigate risks from acoustical sources.

As a result of the IODP SAS comprehensive review and planning process and associated mitigating measures, the extent of impacts to marine mammals would be expected to be minimal for all IODP-USIO expeditions conducted in Alternative B.

Alternative C – No Action

If the IODP-USIO did not conduct IODP riserless drilling activities (No Action Alternative), there would be no discharges or acoustic outputs from SODV operations or drilling and coring operations to affect marine mammals.

4.6.5.6 Marine Reptiles

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

The potential for exposure of marine reptiles to SODV wastewater discharges in Alternative A is expected to be minimal since water column disturbances (e.g., turbulence) caused by the SODV's presence at a drill site is likely to deter the animals from approaching the vessel and coming in contact with discharged wastewater.

Although sea turtles are generally not sufficiently mobile to avoid a moving ship in case of an imminent collision, such situations are expected to be relatively rare because the density of turtles in the open ocean is very low. Therefore, very few, if any, sea turtles are likely to be involved in collisions with the drillship, and the resulting effects on turtle populations would be minimal. Sea snakes, because of their greater mobility, are unlikely to be victims of a collision.

Unlike marine mammals, sea turtles are not known to be acoustically sensitive or depend heavily on acoustic cues for communication, navigation, or feeding. The limited available data on sea turtles indicate that sea turtles are capable of hearing low frequency sound. Their hearing sensitivity extends from roughly 250–300 Hz to 500–700 Hz, but their hearing threshold appears to be high. There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz. The effects of sounds from acoustic sources may primarily include behavioral disturbance, and, at least in theory, temporary or permanent hearing impairment or non-auditory physical effects if exposed to peak sound levels (Richardson et al. 1995).

There are few data on temporary hearing loss and no data on permanent hearing loss in sea turtles exposed to acoustic outputs. The apparent occurrence of TTS in loggerhead turtles exposed to intense acoustical sources such as airgun pulses at a distance of 65 m suggests that sounds could cause temporary hearing impairment. In three studies involving the exposure of sea turtles in enclosures to acoustical sounds originating from seismic airguns, behavioral responses were observed to include increase in swimming speed, increase in activity, change of swimming direction, and avoidance. It is not anticipated that the small seismic source airguns occasionally used by the SODV would emit sufficient acoustic energy to create these concerns.

Based on available data, it is unlikely that sea turtles will exhibit behavioral changes as a result of acoustic outputs from SODV operations in Alternative A. If a sea turtle approaches the SODV during drilling, it is likely the animal will exhibit an avoidance reaction. Any effects on sea turtles will generally be short-term, reversible, and would not be expected to displace the animals from their preferred habitats, foraging, or breeding areas.

Noise from helicopter operation can elicit a startle response and can interrupt sea turtles while resting, feeding, breeding, or migrating. Sea turtles spend more than 70 percent of their time underwater, but it is assumed that sea turtles can hear helicopter noise at or near the surface, and that unexpected noise may causes animals to alter their activity (Advanced Research Projects Agency, 1995). It is unlikely that sea turtles or sea snakes would be adversely affected by infrequent helicopter traffic to and from the SODV.

Unless the SODV is operating in a concentrated area used by sea turtles for breeding, it is unlikely that sea turtles will be encountered during riserless drilling expeditions. Overall, the resulting impacts to marine reptiles in Alternative A would be expected to be minimal, with no significant loss or degradation of marine reptile communities or functional habitats, or seasonal migration patterns.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS which would help to identify rare or sensitive biological resources such as sea turtles that may be present at specific drill sites. Based on IODP SAS advice and guidance, mitigating measures would be developed to prevent significant adverse effects to marine reptiles by addressing site-specific factors or seasonal variations that could affect the organisms near proposed drill sites.

The resulting impacts to marine reptiles in Alternative B would be expected to be minimal, and because proposed activities will have been designed to account for the possible presence of these organisms, the intensity, extent, and duration of effects would be reduced as compared to Alternative A. No significant loss or degradation of marine reptile communities or functional habitat value are expected as a result of SODV activities in Alternative B, nor are SODV activities expected to impede seasonal migrations.

Alternative C – No Action

If the IODP-USIO did not conduct riserless drilling activities (No Action Alternative), there would be no discharge or acoustic outputs from SODV operations or drilling and coring activities to affect marine reptiles.

4.6.5.7 Birds

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

As described in Section 4.4.4 (Impact Source Characterization), operation of the SODV will result in the continuous release of fuel combustion byproducts to the atmosphere when the vessel is in transit and at drill sites. Additional air emissions will be generated by the intermittent use of the SODV's incinerators and the periodic release of vapors and gases from the vessels laboratories. However, since the emissions from all sources are expected to disperse rapidly in the surrounding atmosphere, no impacts to birds are expected.

The SODV operations will result in discharge of wastewater and victual wastes each day the vessel is at sea. These discharges could potentially affect marine birds either directly while the birds are in the water or indirectly through the ingestion of fish or plankton. Since the points of discharge for liquid wastes from the drillship will occur very close to the vessel, there should be no significant direct physical or toxicological effects on marine bird populations. The effects of drillship discharges on fish and zooplankton are also expected to be minimal and localized in extent. Therefore, resulting indirect effects on marine birds will also be minimal.

The SODV contains numerous sources of noise including the ship's diesel-electric engines, mechanical equipment, and various transducer-based devices. The sounds from these sources will propagate in air and be transmitted through the vessel and into the water. It is anticipated that the impacts to bird communities as a result of the drillship and associated equipment operation would be minimal. SODV activities could affect marine birds through disturbances caused by helicopter overflights. However, these disturbances are expected to be very infrequent and temporary. Therefore, only minimal, short-term impacts on bird populations and their flying patterns are expected.

Overall, the resulting impacts to birds in Alternative A would be expected to be minimal. The SODV activities are not anticipated to result in a substantial loss or degradation of marine bird populations or their functional habitat, nor present a substantial impedance of migration routes.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS which would identify rare or sensitive bird species that may be present at specific drill sites. Based on IODP SAS advice and guidance, mitigating measures would be developed to prevent significant adverse effects to birds by addressing site-specific factors or seasonal variations that could affect the organisms near proposed drill sites.

The resulting impacts to bird populations in Alternative B would be expected to be minimal. No significant loss or degradation of bird communities, functional habitat, or interference with seasonal migrations are expected.

<u>Alternative C – No Action</u>

If the IODP-USIO did not conduct riserless drilling activities (No Action Alternative), there would be no discharges or acoustical outputs from SODV operations to affect bird species.

4.6.5.8 Threatened and Endangered Species

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

As indicated above, the proposed expeditions will have minimal impacts on all marine organisms including plankton, cephalopods, fish, marine mammals, marine reptiles, and birds. This conclusion would also generally apply to endangered and threatened species of those groups; however, any impacts to diminished populations or limited ranges of threatened or endangered species would be greater than impacts to non-endangered species. In Alternative A, it is assumed that the SODV would comply with all regulatory requirements pertaining to threatened species such as the Endangered Species Act.

SODV activities are generally not expected to result in substantial loss or degradation of the functional habitats that may be used by threatened and endangered species, nor are IODP riserless drilling activities expected to result in the impedance of fish or wildlife migration routes. Because of the sensitivity of some endangered populations to the loss of even just one individual, if endangered species, habitats or other critical breeding, feeding, or migratory areas are not identified in advance, some impacts resulting from the riserless drilling expeditions may have the potential to be significant. For example, in Alternative A, drilling may proceed at locations where outputs such as wastewater discharges, seafloor alteration, or acoustical outputs have a greater potential to adversely impact local biota, habitats, or disrupt behavior. Without the benefit of a thorough environmental planning process to review site-specific conditions at each proposed drill site, Alternative A ocean drilling expeditions may potentially proceed in habits occupied by threatened or endangered species where adverse impacts may otherwise be avoided.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, the IODP SAS will evaluate each drilling proposal presented by the principal investigators to identify site conditions where threatened or endangered species may be adversely affected by the proposed drilling activities. The comprehensive review process will ensure that sufficient data is available to identify critical species near the proposed drill sites and recommend for implementation measures to mitigate potentially adverse impacts. If a riserless drilling expedition were planned in an area where endangered or threatened species may be adversely impacted or harmed, a supplemental site-specific environmental review would be performed to evaluate the risks of proceeding with the proposed action and to develop recommendations to mitigate unacceptable risks.

As a result of the comprehensive review and planning process and associated mitigating measures, the extent of impacts to threatened and endangered species is expected to be minimal for all IODP-USIO expeditions conducted in Alternative B.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), the threatened and endangered species present on the seafloor and within the water column would not be disturbed by SODV operations.

4.7 **Biologically Sensitive Areas**

4.7.1 Environmental Settings

Many areas of the world's oceans are considered biologically sensitive areas for a variety of reasons. The primary basis would be the presence of unique or vulnerable communities or ecosystems such as those found in coral reefs or kelp forests. Other areas may be considered sensitive because of their overall function, such as critical breeding, feeding, or migratory habitat for fish, marine mammals, sea turtles, or seabirds. This section will focus on representative sensitive areas that are known to exist throughout the world.

4.7.1.1 Sensitive Communities and Ecosystems

Although there are many different types of biologically sensitive areas that may be present in the world's oceans, this section will focus on four prominent examples that include (1) chemosynthetic communities, (2) coral reefs, (3) seamounts, and (4) kelp forests. Since kelp forests typically only exist in relatively shallow waters (15 to 40 m) which are unsuitable for SODV operations, this type of sensitive environment will be eliminated from further consideration in this assessment. A summary of the characteristics of the remaining sensitive communities is presented below, while detailed information on each of these communities is included in Appendix G.

Chemosynthetic Communities

Chemosynthetic communities are unique habitats which support species endemic to hydrothermal vents or cold seeps. In the deep ocean below the photic zone, at depths below 300 m, photosynthesis is not possible and low nutrient concentrations sharply constrain the possibilities for complex community structure. Where venting of hydrothermal fluids, seepage of hydrocarbons, or other geological processes supply abundant reduced compounds, chemosynthesis becomes the dominant process of the ecosystem. Chemosynthesis is a mode of life practiced by numerous groups of bacteria that are able to oxidize simple compounds such as hydrogen sulfide (H_2S) and methane (CH_4) as the energy source (Jannasch, 1989).

Chemosynthetic microbes thrive around areas such as hydrothermal vents, which emit plumes of hot water that can reach 400°C and contain high concentrations of hydrogen sulfide, or at cold seeps, where methane and hydrogen sulfide seep from the seafloor at the same temperature as the surrounding water. Hydrothermal vent and cold seep communities are considered biologically sensitive areas due to their limited range, large variety of endemic species, and scientific value.

Hydrothermal vent ecosystems can be unique, with over three hundred species documented, some of which thrive only at certain vents (endemic species) (WWF, 2006a). Hundreds of hydrothermal vents have been discovered around the world, typically in clusters called fields.

Species live much longer in the vicinity of cold seeps than hydrothermal vents. The deepest cold seep ecosystem known is 5,000 to 6,000 m deep in the Sea of Japan. Other places where cold seeps have been discovered include the Gulf of Mexico and off the coasts of California and Alaska (WWF, 2006a).

Coral Reefs

Coral reefs are among the most biologically diverse and productive ecosystems of the world and can exist for thousands of years. Although coral reefs occupy less than one percent of the marine environment, they are known for their extensive biodiversity, providing feeding grounds, shelter, and breeding habitat for 25 percent of the world's marine life (WWF, 2006b). Coral reefs are formed by colonies of stony coral polyps which attach to hard surfaces and produce calcium carbonate to form exoskeletons.

There are many types of coral reefs, including fringing reefs, barrier reefs, and atolls. Coral reefs occur in both warm and cold water regions. The Great Barrier Reef off the northeast coast of Australia is an example of a large barrier reef, extending 150 km wide by 2000 km long. Barrier reefs are also found off the coasts of Belize, Honduras, and around islands in the west Atlantic and Pacific Oceans, including Tahiti.

Although shallow water tropical coral reefs are reasonably well mapped globally, regions of deeper water corals are less well located. Deep sea coral reefs grow between 5 and 25 mm per year and some may be over 8,000 years old. Deepwater coral reefs are generally found near chemosynthetic communities. In fact, coral reefs and other potential hard-bottom communities not associated with chemosynthetic communities appear to be very rare in deep water. Atolls develop on underwater islands, most of which are sinking volcanoes. They are usually circular or irregular shapes and surround a lagoon that is no more than 30 to 50 m deep (WWF, 2006b).

Seamounts

Seamounts are underwater hills, mountains, or volcanoes and are typically found rising from the seafloor in ocean depths of 1,000 to 4,000 m. There may be an estimated 30,000 to 100,000 seamounts in the world (DSCC, 2004), which are often found grouped together in long chains while isolated seamounts are less common. Similar to chemosynthetic communities, many species found are endemic, only thriving in the vicinity of seamounts. In addition, the biodiversity of seamounts is comparable to coral reefs. Strong currents which attract plankton are associated with seamounts. Due to the plethora of plankton as a food source, seamounts serve as breeding/spawning and feeding grounds for marine mammals and fish species, as feeding areas for seabirds, and as habitats for sponge communities. Fish species in these areas are slow to reach maturity but have long lifespans, therefore, they are vulnerable to fishing and environmental changes (DSCC, 2004).

4.7.1.2 Designated Areas

In addition to the sensitive communities described above, many nations throughout the world have recognized that marine resources in selected coastal areas warrant specific measures to preserve and protect their economic and environmental value. These areas may be afforded international, national, or local protection due to the fragility of an ecosystem or the resources an ecosystem provides. While the nomenclature for areas so designated may vary widely, to include terms such as marine sanctuaries, marine protected areas, or marine ecological reserves, for the purposes of this section, the phrase Marine Protected Areas (MPA) will be used to characterize these areas.

An MPA is further defined by the World Conservation Union (WCU) as "*any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment*" (IUCN, 1992). This designation allows enforceable regulations to protect an area and its marine organisms, while encouraging continued scientific study and research of a unique ecosystem. Designated MPAs are vital to protecting water quality, habitat, biodiversity, and fisheries, and some MPAs may include biologically sensitive communities and ecosystems. Some nations have defined very restrictive standards for MPAs, prohibiting most uses while others have placed few restrictions on activities that are deemed compatible with economic interests and the environment. In some instances, graduated restrictions are applied, consistent with the vulnerability and uniqueness of a particular area or ecosystem.

There are currently over one thousand MPAs worldwide, ranging in size from several square kilometers to several thousand square kilometers, such as the Great Barrier Reef Marine Park (Gubbay 1995). MPAs cover less than one percent of the world's oceans (Kelleher et al., 1995 as cited in Pomeroy et al., 2004) and, with few exceptions are all located in relatively shallow territorial waters. A searchable database of worldwide MPAs is provided by MPA Global and based on the World Database of Protected Areas (MPA Global, 2006).

Almost all MPAs are within state or country territorial waters. There is only one MPA that currently exists within the high-seas. The International Ligurian Sea Cetacean Sanctuary, which covers 84,000 km^2 off the coast of Italy and France, became an international MPA in 1999. Efforts are currently underway to create additional high-sea MPAs (MPA News, 2003). There are many international groups involved in MPA establishment and management, including the World Commission on Protected Areas (WCPA), a commission within the WCU, and the World Wildlife Fund (WWF).

In territorial waters of the United States, MPAs include sites within the National Marine Sanctuary Program, administered by the National Oceanic and Atmospheric Administration (NOAA), to manage and protect specially designated areas of the nation's oceans and Great Lakes for their cultural or natural marine features (see Section 2.10.2). A total of 13 national marine sanctuaries and one Marine National Monument encompassing more than 388,000 square kilometers of marine and Great Lakes waters are designated. The sanctuaries range in size from less than 1 km^2 to over 13,700 square kilometers in Monterey Bay, with the Northwestern Hawaiian Islands Marine National Monument, over 362,000 square kilometers in size, representing the largest marine protected area in the world.

4.7.2 Regulatory Settings

Several existing treaties and agreements, with the goal of protecting and preserving biodiversity in the world's ocean, were summarized in Section 4.6.2. Many of the provisions of these international treaties encompass biologically sensitive areas described in Section 4.7.1.1. For example, in Alaska bottom trawling is banned on more than 370,000 square miles off Alaska's Aleutian Islands to protect coral beds and other sensitive fish habitat. Several local provisions aimed at protecting specific areas have been promulgated by other nations. Recently several countries have made the protection of deep sea corals and seamounts a priority. Most of these regulations involve the banning of bottom trawling in the vicinity of known areas in territorial waters. Indonesia has implemented a trawl ban since 1980 in the Malacca Strait and Northern Coast of Java, and bottom trawls do not operate in areas where seamounts are found (Oceana, 2005). Other examples of regulations designed to protect these areas include the following (Oceana, 2005):

- Norway banned bottom trawling on six deep sea coral reefs, covering over 2,000 km2, creating Europe's largest deep coral protected area;
- Canada permanently closed 2,300 km^2 of corals in "the Gully" off Nova Scotia;
- EU permanently closed Darwin Mounds (100 km^2) off Scotland
- Australia created a network of 15 seamounts, covering 370 km^2, which ban bottom trawling;
- New Zealand has protected 19 seamounts, comprising 40,000 km^2.

Management and regulations applicable to MPAs depend on the nature and size of the site, the location, the climate, local community, state and national government, and funding; therefore, there are many variations in the regulations that are enforced at individual MPAs.

Within territorial waters of the United States, each designated National Marine Sanctuary has its own unique set of regulations, although there are some regulatory prohibitions that are typical for many sanctuaries (NOAA, 2006b) including:

- Discharging material or other matter into the sanctuary;
- Disturbance of, construction on, or alteration of the seabed;
- Disturbance of cultural resources; and
- Exploring for, developing, or producing oil, gas, or minerals

Depending on the site, certain activities such as fishing, mining, or recreation activities may or may not be permitted, and drilling activity in these areas is usually highly regulated. For example, National Marine Sanctuary regulations in the U.S. restrict drilling or coring in the seabed, and access is generally limited to scientific research conducted under a permit issued by NOAA.

Activities conducted in regions below 60° south latitude will be subject to requirements of Antarctic Treaty. The Antarctic Treaty system currently includes 28 consultative parties and 17 acceding states, and encompasses measures designed to protect the scientific value and the Antarctic environment including:

- Agreed Measures for the Conservation of Antarctic Fauna and Flora (1964);
- Convention for the Conservation of Antarctic Seals (1972);
- The Convention on the Conservation of Antarctic Marine Living Resources (1982); and
- Protocol on Environmental Protection to the Antarctic Treaty (1991), including Annex 1-6.

Antarctica is also designated as a Special Area under Annex I, II and V of the International Convention for the Prevention of Pollution from Ship Protocol of 1978 (MARPOL 73/78). Certain discharges are prohibited in these Special Areas (see Section 4.2.2).

In addition, a voluntary Code of Conduct for the Scientific Study of Marine Hydrothermal Vent Sites has been adopted by InterRIDGE, a loosely affiliated group of hydrothermal-vent researchers. In general, the code applies to marine scientific research and submarine-based tourism activities at hydrothermal vents located within and beyond the limits of national jurisdiction and are viewed as an interim measure until regulations are developed. The code goals are to maximize efficiency of necessary research, minimize or eliminate adverse environmental impacts through all stages of an activity, reduce the impact of sampling at heavy use sites by encouraging the development of micro-analytical procedures, and alternatives to sampling. The code also encourages participants to minimize or eliminate actual or potential conflicts or interference with existing or planned marine scientific research activities, and monitor, evaluate, report on activities.

4.7.3 Significance Criteria

An impact to a biologically sensitive area is considered significant if any of the following apply:

- Any substantial alteration or destruction of habitat that prevents reestablishment of biologically significant communities that inhabited the area prior to the proposed action;

- Alteration or loss of biota in high-quality habitat, such as chemosynthetic communities; and

- Outputs occurring within specific MPAs that result in a prohibited action, exceeding applicable permit requirements or limits, or creating impacts greater than identified in site-specific supplemental environmental reviews.

4.7.4 Impact Source Characterization

Various outputs associated with SODV operations and related research activities may affect marine organisms in critical habits near drill sites. These outputs include:

- Discharge on liquids from the SODV;

- Turbulent mixing of the sea in proximity to the vessel;

- Use of acoustical sources; or

- Disturbances on the seafloor from riserless drilling operations and the release of drill cuttings, and use of drilling mud and cement.

The source and nature of these outputs were described in detail in Section 2 and were summarized in Section 4.6.4.

4.7.5 Impact Analysis

In general, the outputs resulting from SODV operations and impacts to biological resources in sensitive environments will be similar to those discussed in Section 4.6, however, since the receptors may represent unique individuals or communities, the resulting degree of one or more effects may be more severe than realized in more common marine environments. The following describes the potential impacts that may occur as result of SODV operations for each alternative.

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

Given the deep locations that the SODV will operate, outputs from vessel operations will occur near the surface hundreds of meters from sensitive communities and structures associated with the seafloor. Therefore, few of these outputs would be expected to result in significant impacts to these resources. For example, SODV wastewater discharges containing nutrients and pathogens would experience rapid dilution and dispersion in the water column, minimizing the potential for contact with marine biota on these structures or causing other conditions (e.g., macro-algae growth) that would smother organisms or otherwise impede their growth.

Noise and vibrations generated by the operation of the SODV and created by the ship's engines, propellers, thrusters, mechanical systems, and transducer-based instruments will propagate from the vessel and spread depending upon the intensity of the source and the oceanographic conditions. Sound levels are expected to attenuate sufficiently with distance from the source to prevent most aquatic organisms from being exposed to noise levels that would result in adverse physiological effects. It is possible that some sounds received by an organism in a sensitive community could exceed the 160 dB re 1 μPa rms guidance level established by NMFS that would be expected to cause avoidance reactions in some aquatic animals. However as previously described, it is anticipated that these effects would last for the relatively short period of time the vessel is on-site and drilling. Because affected organisms in biologically sensitive areas would be expected to return once the vessel leaves the area, the resulting behavioral effects would be considered minimal and short-term in duration.

In Alternative A, if riserless drilling proceeded in biologically sensitive areas characterized by unique species assemblages, the range of impacts could be significant, particularly if drilling mud were introduced to the habitats. Hydrothermal vent (chemosynthetic) communities may be unlikely to recover rapidly from drilling mud deposition, increased turbidity, or changes to substrates in the localized area surrounding the borehole. It can be expected that the greatest area of smothering impact will be close to the borehole. Resulting impacts to these deepwater chemosynthetic communities may potentially be long-term, because activities may prevent re-establishment of the community and potentially result in the loss or diminishment of unique species. In some cases, recovery times could be as long as 200 years for mature tube worm communities.

Under Alternative A, it is possible that riserless drilling could proceed in coral reefs and the obvious initial impact would be the mechanical damage resulting from the borehole itself, including the impact of the drilling tools and the installation of casings, if used. The internal circulation of reefs is complex and poorly understood and, due to the presence of voids and its high permeability, it is unclear what overall effect a borehole may have on the internal circulation of the reef itself. There is some evidence from field studies that in addition to damaging the internal structure of the coral, a borehole can allow the introduction of organisms harmful to long-term growth. However, recent observations of scientific drilling conducted in coral reef areas has indicated that controlled advancement of the borehole in the reef structure did not significantly impact the coral cover (ESO, 2005).

Although laboratory and field studies indicate that corals can tolerate some drilling mud and natural sediment (ESO, 2005), they are particularly susceptible to prolonged periods of increased turbidity and sediment buildup which can inhibit their ability to feed and photosynthesize. At shallower depths, wave action and local currents may disperse only a portion of the cuttings and mud in the vicinity of the borehole. For deeper ocean coral communities, where currents may be very strong, the deposition of drilling material may be less pronounced. For example, in a study evaluating impacts of exploratory drilling efforts in Florida, it was concluded that drilling in coral reef habitats subject to currents and storms resulted in short-term alteration that was essentially undetectable within several months due to the effects of currents and storms (Dustan et al, 1991). Nonetheless, prolonged exposure of coral to sediment build-up, at any depth, will have a negative impact on growth and long-term survival.

Due to the diverse characteristics associated with seamounts, the potential impacts from the drilling operation in or near these structures could vary quite widely. Certain portions of the seamount would likely be less susceptible to severe impacts from the drilling of a borehole. For example, seamounts are extremely steep (sometimes with slopes up to 60^o), with limited extent at the summit, and while the tops of many seamounts are hundreds of meters below sea-level, they can also be shallow enough to support plant life such as kelp and warm water corals. The potential impacts associated with drilling on or near seamounts are very similar to those described for benthic organisms (Section 4.6.5.4). Nonetheless, because seamounts represent such a diverse and in many cases slow growing ecosystem, the drilling impacts could be significant if they result in substantial alteration or destruction of habitat that prevents re-establishment of biologically significant communities.

In Alternative A, requirements to notify appropriate authorities necessary to perform drilling in specific MPAs may not be thoroughly identified in advance to allow sufficient time or resources to acquire appropriate authorizations. For example, if site-specific restrictions are not incorporated into expedition planning, potential delays or other operational changes may be necessary to address pertinent MPA regulations or permitting. Consequently, certain modifications may inhibit collection of data necessary to achieve scientific objectives

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, the IODP SAS will evaluate each drilling proposal and site characterization data package presented by the principal investigators to identify site conditions such as biological resources in sensitive ecosystems that may be adversely affected by the proposed drilling activities. The comprehensive review process will ensure that sufficient data is available to identify these critical areas and recommend appropriate best management practices. If a riserless drilling expedition were planned in an area where biologically sensitive organisms may be adversely impacted or harmed, a supplemental site-specific environmental review would be performed to evaluate the risks of proceeding with the proposed action and develop recommendations to mitigate unacceptable risks or select alternate sites.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), SODV operations including riserless drilling activities would not affect biological sensitive areas.

4.8 Commercial and Native Fisheries and Aquaculture

4.8.1 Environmental Settings

Marine fisheries constitute a multi-billion dollar industry supplying about 20 percent of the animal protein consumed by humans, and also producing animal feeds for domestic livestock and poultry, fish oils for paints and drugs, pet foods, and some food additives (FAO, 2004). It is particularly important for many island nations and coastal communities that rely on fishing either as a commercial activity or as a means of subsistence. The health of the world's fisheries is, therefore, a critical concern. As the human population continues to expand, the increasing demand for high-quality protein and other marine resources has focused attention on the present stocks of commercial marine species and on the feasibility of increasing, or at least maintaining, the present harvest.

Most marine fishery catches take place in coastal waters. However, the share of landings from the open ocean has increased in recent decades and in 2002 reached 11 percent of all marine catches. Between 1993 and 2003, the reported landings of marine capture fisheries fluctuated between 80 and 86 million metric tons, a slight increase over the preceding decade where the average was 77 million tons. Between the two periods, the quantity of marine fish caught and discarded has fallen by several million tons (FAO, 2004). This is the result, in part, of improved gear selectivity and fishing practices (that reduced incidental catch), fisheries management that decreased access to some stocks (by reducing allowable catches and including the closure of some fisheries), no-discard policies in some countries (that forced landings of all catches), and growing demand for fish combined with improved technologies and opportunities for using the incidental catch.

Marine capture fisheries production in 2002 was 84.5 million tons, while preliminary estimates for 2003 indicate a drop in production to 81.3 million tons. The top ten capture fishery producing countries have not changed since 1992 (Table 4-9) (FAO, 2004). In 2002, their cumulative catches represented 60 percent of the world total, with China and

Peru leading the ranking in both 2001 and 2002. Marine fishery capture production reported by China has remained fairly stable since 1998, while trends in Peruvian total capture production are always strongly influenced by the variability of local environmental conditions. The value of open ocean marine catches was approximately US$6 billion in 2002. This represented roughly eight percent of the total value for marine capture fisheries (US$75 billion).

Table 4-9. Marine Capture Fisheries: Top Ten Producer Countries in 2002

Country	*Catch (million tons)*
China	14.4
Peru	8.8
United States	4.9
Indonesia	4.2
Japan	4.4
Chile	4.3
India	3.0
Russian Fed.	3.2
Thailand	2.9
Norway	2.7

The largest fraction (64 percent) of the global marine catch comes from the Pacific Ocean, with 28 percent from the Atlantic, and eight percent from the Indian Ocean. The top ten species captured in marine waters worldwide are listed in Table 4-10. While the production numbers of some species have remained fairly stable, others are in decline. For example, overall catches of the Gadiformes group of species (e.g. cod, hake, and haddock) continue to decrease and by 2002 had reached their lowest levels since 1967. According to the Food and Agriculture Organization of the United Nations (FAO), the percentages of stocks exploited at or beyond their maximum sustainable levels currently vary widely among fishing regions. However, available information continues to confirm that despite local differences, the global potential for marine capture fisheries has been reached and more rigorous plans are needed to rebuild depleted stocks and prevent the decline of those being exploited at or close to their maximum potential (FAO, 2004).

Table 4-10. Marine Capture Fisheries Production: Top Ten species in 2002

Species	*Catch (million tons)*
Peruvian Anchoveta	9.7
Alaska Pollock	2.7
Skipjack tuna	2.0
Capelin	2.0
Atlantic herring	1.9
Japanese anchovy	1.9
Chilean jack mackerel	1.8
Blue whiting	1.6
Chub mackerel	1.5
Largehead hairtail	1.5

Depending on the salinity of the water environment, aquaculture is divided into freshwater culture, brackish-water culture, and mariculture (the cultivation of marine animals and plants in the open sea). In 2004, mariculture contributed 36 percent (16.3 million tons) of total global aquaculture production and 34 percent ($21.3 billion) of total value. By contrast, production in coastal brackish-water communities represented only four percent (two million tons) of total quantity produced but 12 percent ($7.6 billion) of the total value, reflecting the prominence of high-value crustaceans and finfish (FAO, 2004; FAO, 2006).

In less than a decade, marine aquaculture (mariculture and brackish-water combined) production has increased significantly, from 12 million tons in 1998 to a preliminary estimate of 18.3 million tons in 2004. 90 percent of aquaculture fish production comes from Asia, with China and Japan the largest producers. Reported Chinese marine aquaculture production increased at an average annual rate of 10.9 percent compared with 5.5 percent for rest of the world. Table 4-11 presents the top marine aquaculture species in 2000 by country. In 2004, the value of marine aquaculture production was approximately $29 billion.

Table 4-11. Top Marine Aquaculture Species in 2000 by Country (CBD, 2004)

Species	**Annual Production (million tons)**	**Top Two Producing Countries**
Japanese kelp[2]	4.58	China, Japan
Pacific cupped oyster[1]	3.94	China, Japan
Japanese carpet shell[1]	1.69	China, Italy
Yesso scallop[2]	1.13	China, Japan
Laver/Nori[2]	1.01	China, Japan
Atlantic salmon[1]	0.88	Norway, Chile

Table 4-11. Top Marine Aquaculture Species in 2000 by Country (CBD, 2004)

Species	Annual Production (million tons)	Top Two Producing Countries
Tambalang/Elkhorn/Spinosum[2]	0.60	Philippines
Giant tiger prawn[1]	0.57	Thailand, Indonesia
Blue mussel[2]	0.46	Spain, Netherlands
Blood cockle[2]	0.32	China, Malaysia
Wakame[2]	0.31	Japan, Rep. of Korea
Fleshy prawn[1]	0.22	China, Rep. of Korea
Red seaweeds[2]	0.21	Indonesia
Rainbow trout[1]	0.15	Chile, Norway
Whiteleg shrimp[1]	0.14	Ecuador, Mexico
Japanese amberjack[2]	0.14	Japan, Rep. of Korea
Mediterranean mussel[1]	0.12	Italy, France
Coho salmon[2]	0.11	Chile, Japan
Green mussel[2]	0.09	Thailand, Philippines
Gilthead seabream[1]	0.09	Greece, Turkey

Notes:
[1] mariculture or brackish-water culture environment
[2] mariculture culture environment only

Fishing in marine waters is often a part-time occupation, due to the variations in seasonal resource availability and also because fishing is generally regulated through a series of measures that limit year-round activity. These include: closures of selected fisheries at certain times of the year; limits on total annual catches of selected species so that commercial fishermen may fish for only a few days of each month until the quota is reached; or limiting the number of commercial licenses and the number of fish caught per trip. According to the FAO (2004), it is apparent that as the share of employment in marine capture fisheries continues to stagnate, and in some regions decline, increased opportunities are being provided by aquaculture.

Socioeconomic as well as environmental stresses on near-shore marine fisheries appear increasingly evident. Almost 50 percent of total marine fishery landings are estimated to come from small-scale or artisanal fisheries in developing countries. This type of fishing is not fully commercial in nature and while the technology may in some cases be very sophisticated, it is not highly dependent on outside sources of capital and materials. Most of this fish goes to direct human consumption, and in many coastal regions of the world small-scale artisanal fisheries provide most of the protein and jobs for adjacent communities. However, in many developing countries the need to generate hard currency to reduce national dept is most easily accomplished by either selling fishing rights to countries willing to pay relatively high prices or by exporting high-value fish. This practice has resulted in many coastal areas being overfished by so called distance water fleets, leaving less fish for small-scale and subsistence fishermen, as seen for example in many African countries (Pauly et al., 2005).

4.8.2 Regulatory Settings

The dominant issue underlying the regulation of the global marine fisheries industry is overfishing. However, management of the world's fishing industry is very complicated because it involves not only biological and ecological knowledge of many species, but must also take into account economic considerations, competition between nations for finite (and in some cases rapidly dwindling) fish stocks in the open ocean, labor unions, and public marketing strategies. There have been a number of important international treaties and initiatives that seek to regulate the exploitation of the world's fisheries. Enforcement of these treaties, however, remains a challenge.

Traditionally, international interaction and collaboration on fisheries issues has relied on a large number of regional fishery bodies (RFBs). In addition to international cooperation, these groups have historically been responsible for data collection and research, as well as providing advice on fisheries management. The third UN Law of the Sea conference (UNCLOS), which concluded in 1982, advocated a greater role for RFBs in protecting fish stocks, resolving disputes, and implementing standards and regulations. Following the 1992 United Nations Conference on Environment and Development (UNCED), and with a growing awareness of the scarcity of global fish resources, the international community adopted several provisions including the 1993 FAO Compliance Agreement, the 1995 UN Fish Stocks Agreement, and FAO Code of Conduct for Responsible Fisheries. The overall subsequent result has been a gradual strengthening of the role played by RFBs in local fisheries conservation and management (FAO, 2004).

Currently, many RFBs have real management powers and make decisions on allowable catches, quota allocations, and technical management measures (on mesh size, fishing seasons, closed areas, etc.). However, recent assessments also indicate that in many cases RFBs are constrained by a lack of willingness on the part of member countries to delegate sufficient decision-making power and responsibilities to the agency.

UNCLOS set the limit of territorial waters to 12 nautical miles where the coastal state is free to set laws, regulate any use, and use any resource. It also established exclusive economic zones which extended the exploitation rights of coastal nations to 200 nautical miles from shore, covering all natural resources. Because the populations of many fish species are migratory, much of the world's fishing is carried out in international waters (i.e. outside the national 200-mile economic zone). The UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks (1995) focused on fishing on the high seas and elaborated on the fundamental principle established by UNCLOS that countries should cooperate to ensure conservation and promote sustainable management of fish resources. It has been in force since December 2001, and permits state parties access to selected fishing regions, and regulates the sanctions for infringements (UN, 2006).

With the realization that traditional fishing areas were becoming genuinely threatened, several other measures to conserve and better manage the global marine fisheries have taken effect. For example, in 1989 the UN General Assembly adopted a resolution banning driftnet fishing in the high seas by 1992. A driftnet typically stretches as wide as 40 miles and traps many species, many unintended such as whale, dolphin, porpoise, fur seal, and other sea animals such as sea turtle and even sea birds. Driftnet fishing (principally by Japan) is believed to have contributed to a decrease in the population of such economically valuable fish as tuna, marlin, swordfish, and salmon in the North Pacific Ocean. The principal fishing nations of the world, including Japan, have either banned or strictly regulate the use of driftnets by their fleets (Paul, 1994; TED, 1997). In addition, gear modifications, such as turtle excluder devices, used in the shrimp trawl fishery since the late 1980s, have saved tens of thousands of sea turtles in US waters and other areas where gear is required, such as Australia. Nevertheless, sea turtle bycatch in global shrimp fleets remains very high.

There is no internationally binding legislation, agreement, or convention on aquaculture. However, several major importing regions and countries have begun to set standards and regulations to ensure quality and safety and to reduce the social and environmental impacts of production. These include labeling for origin, reducing the use of veterinary drugs, and improving management practices to limit the spread of disease from cultured to wild stocks.

4.8.3 Significance Criteria

An impact to commercial or recreational fishing or to aquaculture is considered significant if any of the following apply:

- Short or long-term interference to commercial, recreational, or native (subsistence) fishing operators resulting in economic loss in areas where the SODV operates; or

- Long-term exclusion from fishing areas that have historically been important to the local commercial, recreational, or native (subsistence) resources resulting in economic loss.

4.8.4 Impact Source Characterization

Various outputs associated with SODV operations and related research activities may affect fisheries near ocean drill sites. These outputs include:

- Discharge on liquids from the SODV;
- Turbulent mixing of the sea in proximity to the vessel;
- Use of acoustical sources; or
- Disturbances on the seafloor from riserless drilling operations and the release of drill cuttings, and use of drilling mud and cement.

The source and nature of these outputs were described in detail in Section 2 and were summarized in Section 4.6.4.

4.8.5 Impact Analysis

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

Impacts to marine fish species resulting from the proposed riserless drilling operations were described in Section 4.6.5.2. To the extent that those impacts affect the subsistence value of fish used by individuals as a food source or the commercial harvesting of important species, there would be an impact to fisheries and aquaculture. As noted in Section 4.6.5 however, the potential for impacts to open ocean and near-coastal marine fish resulting from the both the presence of the SODV and the riserless drilling activities are not expected to be significant regardless of location.

Due to the mobility of fish and thus their ability to avoid disturbances in their habits, impact to fisheries would be limited primarily to impacts such as disturbances to schooling fish or the smothering of food sources (e.g. plankton) or demersal eggs with drilling sediments. Considering the temporary nature of the drilling activity and the small area of the sea affected, overall impacts to marine fisheries and aquaculture are expected to be minimal.

Permanent structures such as observatories installed on the seafloor may snag and damage fishing nets in areas where extensive bottom trawling occurs. In Alternative A, significant trawl fishing areas may not be identified and therefore the use of specially-designed reentry cones and covers to prevent damage to trawling nets may not be installed.

The proposed drilling and related research activities in Alternative A are not expected to adversely affect access to known commercial and recreational fishing grounds, areas used by individuals for subsistence fishing, or result in a loss of economic livelihood. However, fishing vessels as well as other marine traffic may have to alter course while cruising since the SODV must maintain a fixed position while drilling. In Alternative A, critical fisheries areas may not adequately identified and therefore riserless drilling operations have greater potential to interfere with some fisheries activities or disrupt fish behavior thereby potentially affecting fish catches.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, the IODP SAS will evaluate each drilling proposal and site characterization data package presented by the principal investigators to identify site conditions such as critical fishery areas that may be adversely affected by the proposed drilling activities. The comprehensive review process will ensure that sufficient data is available to identify these areas and recommend appropriate best management practices. If a riserless drilling expedition were planned in an area where fisheries or aquaculture may be adversely impacted or harmed, a supplemental site-specific environmental review would be performed to evaluate the risks and develop recommendations to mitigate unacceptable risks or select alternate sites.

Because of the comprehensive review and planning process and associated mitigating measures, the extent of impacts to fisheries would be expected to be minimal for all IODP-USIO expeditions conducted in Alternative B.

<u>Alternative C – No Action</u>

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), the SODV would not operate in any of the world's oceans and would not affect marine fisheries resources.

4.9 Marine Vessel Transport & Trade Routes

4.9.1 Environmental Settings

Today's world fleet of propelled seagoing merchant ships comprises approximately 92,000 large ships, registered in more than 150 nations and manned by over a million seafarers of virtually every nationality (IMO, 2006). The world's cargo carrying fleet is greater than 46,000 ships, with a combined tonnage of 597,709,000 gross tons. The vast bulk of the fleet consists of: general cargo ships (18,150), tankers (11,356), bulk carriers (6,139), passenger ships (5,679), containerships (3,165), and others (1,733) (IMO, 2006).

The latest full year estimate of total maritime shipping volume is over 27 thousand billion ton-miles in 2004 (IMO, 2006). Maritime transport remains the most inexpensive means of transporting bulk goods; consequently over 80 percent of the world's trade involves ocean transit (IWCO, 1998). In the United States, more than 95 percent of all foreign commerce is maritime, flowing though more than 300 deep draft ports. Vessel traffic is not uniformly distributed. The major commercial shipping lanes follow great circle routes, or follow coastlines to minimize the distance traveled. Dozens of major ports and "megaports" handle the majority of traffic, but in addition, hundreds of small harbors and ports host smaller volumes of traffic. The U.S. Navy defines 521 ports and 3,762 traffic lanes in its catalog of commercial and transportation marine traffic (Emery et al. 2001). Vessels found in areas outside major shipping lanes include fishing vessels, military ships, scientific research ships, and recreational craft – the last typically found near shore (MMC, 2004).

International trade routes are generally transient and largely dependent upon global economic factors. World market variables are very important in terms of determining transoceanic vessel routing and densities. While the coastal routes for large commercial vessels are relatively well defined, offshore routes are much less predictable and dependent on a variety of environmental and economic factors. Densities along existing coastal routes are expected to increase to varying degrees both domestically and internationally. New routes are expected to develop as new ports are opened and existing ports expanded (NOAA, 2004).

Today, most of the world's shipping travels a relatively small number of major ocean routes: the North Atlantic, between Europe and eastern North America; the Mediterranean-Asian route via the Suez Canal; the Panama Canal route connecting Europe and the eastern American coasts with the western American coasts and Asia; the South African route linking Europe and America with Africa; the South American route from Europe and North America to South America; the North Pacific route linking western America with Japan and China; and the South Pacific route from western America to Australia, New Zealand, Indonesia, and southern Asia. The old Cape of Good Hope route shortened by the Suez Canal has returned to use for giant oil tankers plying between the Persian Gulf and Europe and America.

The current standard for estimating vehicle traffic in specific regions of the ocean is the Historical Temporal Shipping (HITS) database. Sea lanes with a high density of shipping include: Straights of Malacca and Singapore, Black Sea and Bosphorus, the Baltic Sea, the North Sea and English Channel, the River Plate, the Red Sea, and the approaches to the Panama Canal and St. Lawrence Seaway (GEF, 2006).

Despite the technological advances in transportation systems, prevailing winds, as well as ocean currents and predominant weather patterns, still determine the safest and most efficient trade routes. Certain parts of the oceans are off-limits during certain times of the year due to the threat of waves of severe destructive force. Zones of violent wave activity exist in the Atlantic and North Pacific during the winter, primarily between latitudes 50° and 60° N (including the British Isles and North Sea countries), and in the corresponding latitudes during the summer in the Southern Ocean (affecting the increasingly used Cape Horn and Strait of Magellan routes). Similarly, ships transiting the Indian Ocean, the tropical southwest Pacific, the West Indies, and the China Sea during the monsoon season may encounter waves of destructive forces sufficient to damage or sink even a modern merchant vessel (NDU, 2002).

4.9.2 Regulatory Settings

It has always been recognized that the best way of improving safety at sea is by developing international regulations that are followed by all shipping nations. From the mid-19th century onwards, a number of international maritime agreements were adopted. The practice of following predetermined routes for shipping originated in 1898 and was adopted, for reasons of safety, by shipping companies operating passenger ships across the North Atlantic. The infamous Titanic disaster of 1912 spawned the first Safety of Life at Sea (SOLAS) convention, which, albeit completely modified and updated, is still the most important international instrument addressing maritime safety today, covering, among others, safety of navigation (IMO, 2006).

Traffic separation schemes (TSS) and other ship routing systems have now been established in most of the major congested shipping areas of the world, and the number of collisions and groundings has often been dramatically reduced (IMO, 2006). A traffic separation scheme is an internationally recognized vessel routing designation which separates opposing flows of vessel traffic into lanes, including a zone between lanes where traffic is to be avoided. Vessels are not required to use any designated TSS, but failure to use one, if available, would be a major factor for determining liability in the event of a collision. Other routing measures to improve safety at sea include two-way routes, recommended tracks, deep water routes (for the benefit primarily of ships whose ability to maneuver is constrained by their draft), precautionary areas, and areas to be avoided (for reasons of exceptional danger or especially sensitive ecological and environmental factors) (IMO, 2006). Precautionary areas are designated in congested areas near harbor entrances to set speed limits, prescribe vessel routing (e.g. recommend direction of traffic flow), or establish other safety precautions.

Regulating the maritime industry to promote safety and security (as well as prevention of pollution from ships) worldwide is the function of the International Maritime Organization (IMO, 2006). Since the inception of the IMO in 1959, a series of measures have been introduced, in the form of conventions, recommendations, and other instruments. The best known and most important of these measures are the International Convention for the Safety of Life at Sea, 1974 (SOLAS); the Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREG); and the International Convention on Standards of Training, Certification, and Watch-keeping for

Seafarers, 1978 (STCW) (IMO, 2006). Ships routing systems and traffic separation schemes that have been approved by IMO are contained in pertinent IMO Publications (IMO, 2004).

SOLAS covers various aspects of ship safety, including construction, fire protection, life-saving appliances, radio communications, safety of navigation, the carriage of cargoes, and safety measures for high-speed craft. SOLAS states that littoral nations may establish Vessel Traffic Information Services (VTIS) or Vessel Traffic Service (VTS) when, in their opinion, the volume of traffic or the degree of risk justifies such services. VTS are shore-side systems that use radar, radio, and visual inputs to gather real time vessel traffic information and broadcast traffic advisories and summaries to assist mariners. VTS can range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway. Generally, ships entering a VTS area report to the authorities, usually by radio, and may be tracked by the VTS control center. Ships must keep watch on a specific frequency for navigational or other warnings, while they may be contacted directly by the VTS operator if there is risk of an incident or, in areas where traffic flow is regulated, to be given advice on when to proceed.

Additionally, the littoral nation may establish Regulated Navigation Areas (RNA). RNAs increase navigational safety by organizing traffic flow patterns; reducing meeting, crossing, and overtaking situations between large vessels in constricted channels; and limiting vessel speed. When navigating within RNAs, large vessels must have their engines ready for immediate maneuvering, operate their engines in a control mode and on fuel that allows for an immediate response to any engine order, and not exceed a posted speed limit. Vessels navigating in and around near-shore areas are generally governed by navigational rules established by the littoral nation. Vessels navigating in open bodies of water in which foreign shipping traffic is possible are governed by Rule 10 of the COLREGS. The boundaries between the areas where these rules apply are shown as the COLREGS Demarcation Lines on navigational charts. Statutory navigation rules also define the responsibilities of vessels restricted in their ability to maneuver, such as cable-laying vessels or drill rigs like the SODV, and of other vessels operating in their vicinity, all aimed at preventing collisions or other incidents.

4.9.3 Significance Criteria

An impact on marine vessel transport and trade routes is considered significant if any of the following apply:

- IODP SODV activities were to result in an unreasonable delay to commercial, military, or recreational marine traffic; or

- IODP SODV activities cause a increased risk to vessels involving accidents or collisions.

4.9.4 Impact Source Characterization

The potential impacts to marine vessel transportation and trade routes would be derived from the presence of the vessel during transit and when positioned at a drill site. The cruise speed of the SODV is 11 knots (20 km/hr) which is relatively slow compared to many marine transport vessels. When stationed at drill site, the SODV will use thrusters to maintain a fixed position and will therefore be unable to change positions unless the drillstring is retrieved from the seafloor.

4.9.5 Impact Analysis

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

As noted above, ship traffic within a geographic area is generally related to the region's proximity to trade routes between the world's major ports. Thus, potential impacts associated with SODV operations will be variable and dependent on the drilling location.

When transiting or stationary at a drill site, the SODV would comply with all international conventions and regulations pertaining to navigational safety. When dynamically positioned at a drill site, the SODV, by nature of the activity, will be required to remain stationary and essentially "tethered" to the seafloor by the drilling equipment. All approaching large maritime vessels would be able to establish radar and/or visual contact with the SODV well in advance of any potential collision. When the SODV is positioned at a drill site, it would be the responsibility of the approaching vessel to choose a course which avoids a collision. However, the SODV will maintain visual and radar vigilance of pending traffic conflicts and communicate accordingly via radio and other means. In addition, the SODV will display universally-recognized maritime signal flags while drilling, indicating the vessel has restricted ability to maneuver. Thus, the proposed drilling activities are not expected to adversely affect shipping traffic.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, the duration of each expedition as well as operating conditions on the SODV which result in potential interferences with marine transportation are expected to be the same as in Alternative A. Therefore through normal expedition planning or vessel operations at any given site are expected to be minimal.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), the SODV would not operate in any of the world's oceans and would not affect marine vessel traffic.

4.10 Cultural Resources

4.10.1 Environmental Settings

Generally speaking, cultural resources can be defined as sites, structures, landscapes, and objects of some importance to a culture or community for scientific, traditional, historic, religious, or other reasons. More specifically, underwater cultural heritage (UCH) as defined under the United Nations' Educational, Scientific and Cultural Organization (UNESCO) 2001 Convention refers to all traces of human existence having a cultural, historical or archaeological character which have been partially or totally under water, periodically or continuously, for at least 100 years (UNESCO, 2001a). By contrast, under the U.S. National Historic Preservation Act (NHPA) while some exceptions exist, a criterion of 50 years has developed as a matter of practice and policy for determining historical significance.

Marine archaeological and cultural sites can vary widely, ranging from individual artifacts, old harbors, landing places, and historic shipwrecks, to coastal communities inundated by rising sea levels such as Jamaica's Port Royal, a victim of an earthquake in 1692. However, the vast majority of the world's marine cultural resources are shipwrecks, often holding the remains of a historically significant cargo. These wrecks are the outcome of thousands of years of travel and trade by sea, following both coastal and transcontinental routes.

The majority of known shipwrecks lie in relatively shallow coastal waters, the victims of such factors as bad weather, poor navigation, inaccurate charts, or ocean warfare. For example, it has been estimated that there are over 100,000 shipwrecks in U.S. waters alone, most within waters under state jurisdiction (MPA, 2006). These underwater resources, many of great historical significance, are being located with increasing frequency due in part to rapidly improving exploration techniques such as high resolution side scan sonar and remotely operated vehicles. These technological advances combined with knowledge of historic shipping routes have allowed many coastal marine resources with cultural significance to be mapped and researched.

While the majority of known marine cultural sites are found in relatively shallow coastal waters, some lie in much deeper waters. For example, the Minerals Management Service

(MMS) of the U.S. Department of the Interior estimates that based on historical records, of the 4,000 historic shipwrecks in the Gulf of Mexico at least 35 are in water greater than 1,000 feet deep (Irion, 2002). Not surprisingly, in most cases these vessels were simply lost at sea with no survivors and therefore with no knowledge of even an approximate location. It has been estimated that there are over three million undiscovered shipwrecks spread across the world's ocean floor (Hocking, 1989 cited in UNESCO, 2001b). Because so many of these vessels are in very deep water, most will never be found unless specifically targeted for exploration.

Globally, the documentation regarding known UCH sites varies widely. The records of marine resources of historical significance in North American and European waters appear to be quite extensive. For example, a recent survey compiled in Ireland by the Department of the Environment's underwater archaeology unit listed 11,000 shipwrecks in coastal waters, including dugouts, Viking longships, sailing vessels, steamers, and great liners (Underwater Times, 2006). The Australian Department of Environment and Heritage in a joint project with the states, territories, and the Australasian Institute for Maritime Archaeology has developed a database of more than 6,500 wrecks all within Australian territorial waters.

The rapid progress made in exploration techniques has made the seabed more accessible and resulted in an increased knowledge of marine archaeological sites worldwide, particularly those found in shallow coastal waters. However, this increased accessibility has also resulted in leaving many marine archaeological and cultural sites vulnerable to treasure hunters. As early as 1974, studies indicated that all known wrecks off the Turkish coast had already been looted. It is estimated only five percent of the approximately six hundred known antique shipwrecks submerged off the cost of France (dating from the sixth century B.C. to the seventh century A.D) remain untouched. In some cases these wrecks have been pillaged despite the fact that they lie in water more then 100 m deep (UNESCO, 2001b).

4.10.2 Regulatory Settings

The dominant issue underlying international and national regulations targeting the protection of underwater cultural heritage sites is the increased vulnerability of these sites to looting by treasure hunters. The trade in objects found in ship wrecks, and in other underwater sites of historical and cultural significance, has become a common and highly lucrative activity that often results in the loss and destruction of valuable scientific and cultural materials. Currently, there is no international law in place to provide significant legal protection to underwater cultural heritage. Although many nations possess laws to provide protection in their own territorial waters, others do not and this has led to confusion about the rights of a nation to protect its cultural heritage, whether submerged in its own waters or another nation's, or on the high seas (MPA News , 2001).

The third UN Law of the Sea conference (UNCLOS) was drafted with a view to providing general provisions for the law of the sea and to regulate the sea's economic resources; it does not include any provisions to specifically protect underwater cultural resources. As a result, the UNESCO 2001 Convention on the protection of Underwater Cultural Heritage represented the first comprehensive global attempt to protect the world's underwater historically significant resources. Many nations with significant maritime interests supported the primary purpose of the Convention, to prevent looting and unwanted salvage, as well as most of its archaeological and historic preservation provisions. However, there were two major obstacles that prevented the U.S., UK and many other nations from supporting the Convention as a whole. First, there was concern related to the so-called "creeping coastal State jurisdiction" over UCH on the continental shelf and Exclusive Economic Zone seaward of the 24 nm limit of the contiguous zone (Varmer, 2005). In the opinion of the U.S., the provisions of the convention would create new rights for coastal nations in a manner that could alter the delicate balance of rights and interests set up under UNCLOS (Blumberg, 2001). The second issue dealt with the treatment of foreign sunken warships and other sunken State craft landward of the 12 nm limit of the territorial sea. In particular, they were concerned about diluting the principle of sovereign immunity as it applies to all sovereign vessels and equipment (Varmer, 2005). As of July 2006 only nine of the required twenty nations had ratified the convention.

There is no U.S. program or statute providing comprehensive protection of UCH. The Abandoned Shipwreck Act (1988) gives ownership of abandoned shipwrecks embedded in, or resting on state submerged lands that are of historical significance, to the states. This legislation directs states to establish a multiple use management regime for the protection of shipwrecks that also incorporates the protection of natural resources. Florida, for example, has accomplished this objective by establishing a series of Underwater Archaeological Preserves.

The National Marine Sanctuary Act (NMSA) provides the strongest protection to UCH beyond state submerged lands. The NMSA authorizes the Secretary of Commerce, through the National Oceanic and Atmospheric Administration (NOAA), to set aside discrete marine areas of special national (and sometimes international) significance. Under UNCLOS, sanctuaries may be established within the national 200-mile economic zone. NOAA protects and manages these areas of the marine environment possessing conservation, recreational, ecological, historical, research, education, or aesthetic qualities which give them special national significance. While most of the sanctuaries focus on protecting ecosystems and natural resources, the first sanctuary established in 1973 was actually to protect the *USS Monitor* from looting and unwanted salvage.

In addition, oil industry exploration and activity in U.S. waters is regulated by the Department of the Interior Minerals Management Service (MMS). The MMS defines archaeological resources as any material remains of human life or activity that are at least 50 years old and are of archaeological interest, and its objective is to ensure that regulated outer continental shelf activities do not adversely affect significant archaeological resources on the seabed.

4.10.3 Significance Criteria

The following four evaluation criteria are based on those used by U.S. and International agencies to determine what properties should be considered for protection from destruction or impairment resulting from SODV activities:

- Resources that are associated with events that have made an important contribution to the broad patterns of history;
- Resources that are associated with the lives of persons important in our past;
- Resources that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent an important and distinguishable entity whose components may lack individual distinction; or
- Resources that have yielded, or may be likely to yield, information important in prehistory or history.

In general, the SODV activities may have a significant impact on UCH if the resource would be (1) physically damaged or altered, (2) isolated from the context considered important, and (3) affected by SODV activities that would be out of character with the important resource or its setting.

4.10.4 Impact Source Characterization

Drilling operations will result in the physical disturbances to the seafloor environment surrounding the borehole site caused by the advancement of drill string and displacement and subsequent deposition of cuttings on the seafloor consisting of sediment and geological basement materials. Table 4-2 summarizes the volume of material displaced for boreholes of varying depth.

During drilling, the cuttings will be swept from the borehole by seawater drilling fluid pumped through the drill string and discharged from the drill bit. It is expected that the larger drill cutting particles will be deposited near the borehole, forming a relatively small conical mound. The fine suspended particles of drill cutting and drilling mud, if used, will disperse in the water column near the seafloor by local bottom currents and will eventually settle on the seafloor within several hundred meters of the borehole.

At selected drill sites, permanent structures such as reentry cones and observatories may be installed. These structures and associated scientific equipment will not be retrieved, and the presence of these devices or equipment may affect cultural resources that may be in the vicinity of the drill site.

4.10.5 Impact Analysis

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

A majority of IODP-USIO riserless drilling activities will be conducted in water depths greater than 500 m. Therefore, most of the mapped historical and cultural resources, which are generally located in relatively shallow coastal waters, will in all likelihood not be affected by the proposed activity in Alternative A. However, as described in Section 4.10.1, there are undoubtedly untold numbers of undiscovered shipwrecks and other culturally significant artifacts lying at great depth throughout the world's oceans, particularly along historic trade routes.

Although unlikely, it is possible that a cultural resource may not be adequately identified prior to drilling resulting in physical disturbance of the resource.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, the IODP SAS will evaluate each drilling proposal and site characterization data package presented by the principal investigators for each proposed riserless drilling expedition. The site characterization data will include information on known (mapped) cultural resources. The site survey data packages will be reviewed by the EPSP as well as other review panels. If proposed drill sites are located near known or suspected cultural resource sites, recommendations will be made to either select alternate drill sites or implement mitigating measures to prevent damaging or destroying the cultural resources.

Because the comprehensive review and planning process are expected to identify known cultural resources at proposed drill sites and will involve incorporating mitigating measures to prevent physical disturbances to these features, the extent of impacts to cultural resources would be expected to be minimal for all IODP-USIO expeditions conducted in Alternative B. As in Alternative A however, it is possible that an unmapped and undiscovered cultural resource may not be adequately identified prior to drilling resulting in physical disturbance of the resource.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), riserless drilling activities by the SODV would not occur and no risk to cultural resources would be realized.

4.11 **Catastrophic Events**

Catastrophic events represent accidents or mishaps which may involve the SODV and could result in major environmental outputs. Broadly speaking, there are two types of catastrophes that could involve the SODV, vessel-based events and those originating from geologic sources.

Vessel-related accidents may involve fuel spills or the release of other hazardous substances, the unexpected loss of equipment, or under extreme circumstances, loss of the SODV including the 3,290 metric tons (3.8 million liters) of marine gas oil fuel which it carries. Potential causes of these incidents may include severe weather, equipment failure, or human error. An event of this nature could occur while the vessel is in transit or operating at a drill site.

Since the proposed action involves drilling into the earth, an accidental release of gaseous or liquid hydrocarbons (blowout) from a geological source could occur. In this case, pressurized hydrocarbons in the formation being penetrated could be uncontrollably released from the borehole and discharged into the marine environment. However, based on the past history and experience gained by the USIO during previous riserless drilling programs (ODP and DSDP) and the consistent use of rigorous mitigating measures to prevent these types of events, the probability of a major or catastrophic release of petroleum from a geological source is extremely low.

4.11.1 Environmental Settings

Background sources of petroleum in the sea are diverse and can be categorized into four major groups: petroleum consumption, extraction, transportation, and natural seeps. Petroleum consumption (use) is responsible for the majority of oil released into the marine environment from anthropogenic sources each year (NOAI, 2006). Releases derived from spills, wastewater, and stormwater sources into rivers represent the most significant source of petroleum to the ocean environment. Releases from these sources, particularly those occurring on land or coastal areas, typically occur as slow chronic releases over a period of years.

The accidental release of petroleum from geologic sources may occur during exploration and extraction operations and could be associated with blowouts or equipment malfunctions. However, blowouts are considered rare because they only occur approximately once in 25,500 wells (NOAI, 2006).

The transportation (including refining and distribution) of crude oil and refined products results in the average annual release of 10.2 million liters (2,700,000 gallons) of petroleum to North American waters and 166 million liters (44,000,000 gallons) worldwide. The majority of these spills are associated with large tanker vessels (NOAI, 2006).

Natural seeps occur when crude oil is released from the geologic strata beneath the seafloor to the overlying water column. Recognized by geologists as an indicator of the potentially economic reserves of petroleum, these seeps are believed to release large amounts of crude oil annually. Yet the petroleum released from these potentially large volume seeps is generally released at a rate low enough that the surrounding ecosystem can adapt and thrive. On an annual basis, natural seepage of crude oil from geologic formations below the seafloor to the marine environment off the coast of North America is estimated to exceed 178 million liters (47,000,000 gallons) and 680 million liters (180,000,000 gallons) globally (NOIA, 2006). In North America, the largest and best known natural seeps appear to be in the Gulf of Mexico and the waters off of southern California, regions that also have extensive oil and gas production.

4.11.2 Regulatory Settings

As described in detail in Section 2.9, vessel operations, drilling, and scientific research performed by the SODV may be subject to U.S. regulations, requirements of host nations, and international laws and treaties in which the United States is a signatory party. In general, these regulations only address catastrophic events from vessel-related sources and may not be applicable for releases from geologic sources. The specific laws or guidelines that apply will depend on the location of the vessel and the associated distance from coastal nations or other special areas.

Specific regulations or guidelines may apply to SODV operations performed within the following range of distances from a coastal nation: territorial seas (within 12 nm), an Economic Exclusion Zone (within 200 nm), and the open seas (beyond 200 nm). Additional requirements will apply to activities conducted within certain regions as defined by the IMO International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78), and the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) 1990.

4.11.3 Significance Criteria

Using the USEPA Oil Pollution Prevention Spill Prevention, Control, and Countermeasure (SPCC) Plan Requirements (40 CFR 112) as a benchmark, discharges to the marine environment from catastrophic events may be categorized as follows:

- Minor Oil Discharge - A discharge of less than 3,800 liters (1,000 gallons);
- Medium Oil Discharge - A discharge of 3,800 to 38,000 liters (1,000 to 10,000 gallons);
- Major Oil Discharge - A discharge of more than 38,000 liters (10,000 gallons); or
- Hazardous Substance Discharge - An element or compound, or mixture, (other than petroleum) which, when discharged in any quantity into or upon navigable or coastal waters, presents an imminent and substantial danger to the public health or welfare, including fish, shellfish, wildlife, shorelines, and beaches. Examples include acids, bases, other laboratory chemicals, radioisotopes, or other bulk chemicals.

Significant water quality impacts resulting from catastrophic releases may include the following range of effects:

- Visible release of petroleum products and the subsequent creation of an oil slick;
- Physical changes caused by the presence of petroleum hydrocarbons on water surfaces, such as reduced dissolved oxygen levels;
- Exceedance of water quality parameters stipulated by international, national, regional, or local laws and regulations; or
- Loss of chemicals, radioisotopes, or other drilling- or research-related substances or equipment that would cause leaching of toxic contaminants into the seawater.

Significant impacts to the marine biota derived from catastrophic releases may encompass the following range of effects:

- Death caused by lethal toxic effects from oil or hazardous substances;
- Altered physiology, growth, behavior, and reproduction caused by sublethal toxic effects of oil;
- Tainting due to uptake of oil;
- Bioaccumulation or biomagnification in a specific species;
- Smothering and suffocation due to heavy oil spill;
- Habitat damage including loss of food sources;
- Disruption of detritus processing;
- Selective elimination of species or functional groups that provide the resource base for higher trophic levels; or
- Selective elimination or depression of keystone predators or foundation species that control or dominate competitive interaction.

4.11.4 Impact Source Characterization

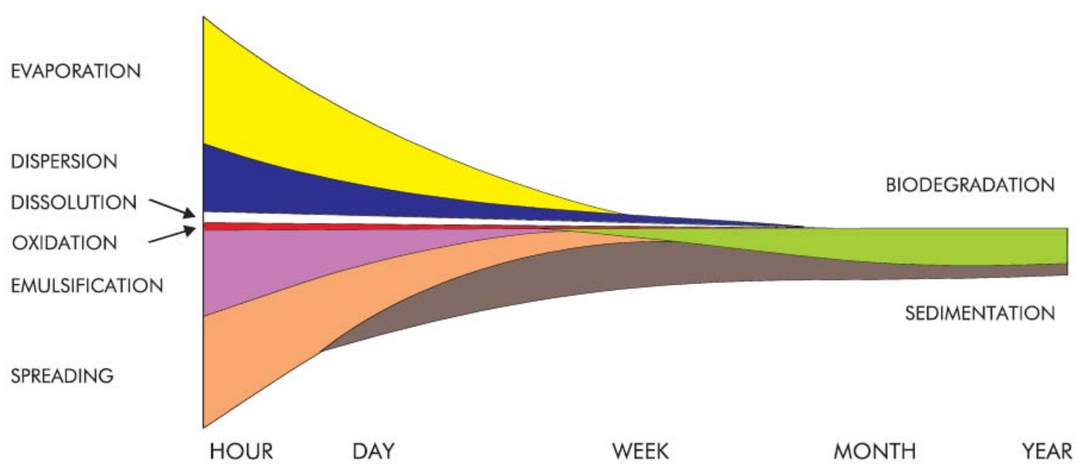
The following is derived from information published by the International Tanker Owners Pollution Federation Limited (ITOPF, 2002) and describes the fate and environmental effects of petroleum hydrocarbons released to the marine environment from major spill events.

Fate and Transport of Petroleum in the Marine Environment

When crude oil or a refined petroleum product is spilled into the sea, it undergoes a number of physical and chemical changes, some of which lead to its removal from the sea surface, while others cause it to persist. Although spilled oil is eventually assimilated by the marine environment, the time involved depends upon factors such as the amount of oil spilled, its initial physical and chemical characteristics, the prevailing climatic and sea conditions and whether the oil remains at sea or is washed ashore.

The physical and chemical changes that spilled oil undergoes are collectively known as ‘weathering’. Although the individual processes causing these changes may act simultaneously, their relative importance varies with time. Together they affect the behavior of the oil and determine its ultimate fate, as shown in Figure 4-4.

Figure 4-4. Fate of Crude Oil Spill – Schematic Representation



As soon as oil is spilled, it starts to spread over the sea surface. The speed at which this takes place depends to a great extent on the viscosity of the oil and the volume spilled. Fluid, low viscosity oils spread more quickly than those with a high viscosity. Liquid oils initially spread as a coherent slick but quickly begin to break up. Solid or highly viscous oils fragment rather than spreading to thin layers. At temperatures below their pour point, oils rapidly solidify and hardly spread at all and may remain many centimeters thick. Winds, wave action and water turbulence tend to cause oil to form narrow bands or 'windrows' parallel to the wind direction. At this stage the properties of the oil become less important in determining slick movement.

The rate at which oil spreads or fragments is also affected by tidal streams and currents - the stronger the combined forces, the faster the process. There are many examples of spills spreading over several square kilometers in just a few hours and over several hundreds of square kilometers within a few days, thus seriously limiting the possibility of effective clean-up at sea. It should also be appreciated that, except in the case of small spills of low viscosity oils, spreading is not uniform and large variations of oil thickness from less than a micrometer to several millimeters can occur.

The more volatile components of petroleum will evaporate to the atmosphere. The rate of evaporation will depend on ambient temperatures and wind speed. In general, those petroleum components with a boiling point below 200°C will evaporate within a period of 24 hours in temperate conditions. The greater the proportion of components with low boiling points, the greater the degree of evaporation. The initial spreading rate of the oil affects evaporation since the larger the surface area, the faster light components will evaporate. Rough seas, high wind speeds and warm temperatures will also increase the rate of evaporation. Any residue of oil remaining after evaporation will have an increased density and viscosity, which affects subsequent weathering processes and the effectiveness of clean-up techniques.

Spills of highly refined products, such as kerosene and gasoline may evaporate completely within a few hours and light crudes can lose up to 40 percent of their volume during the first day. In contrast, heavy fuel oils undergo little, if any, evaporation. When extremely volatile oils are spilled in confined areas, there may be a risk of fire and explosion or human health hazards.

Waves and turbulence at the sea surface can cause all or part of a slick to break up into droplets of varying sizes which become mixed into the upper layers of the water column. While some of the smaller droplets may remain in suspension, the larger ones rise back to the surface, where they either coalesce with other droplets to reform a slick or spread out in a very thin film, often referred to as 'sheen'. Droplets which are small enough are kept in suspension by the turbulent motion of the sea, which mixes the oil into ever greater volumes of seawater, so reducing its concentration. The increased surface area presented by dispersed oil can promote processes such as biodegradation, dissolution and sedimentation.

The rate of dispersion is largely dependent upon the nature of the oil and the sea state, proceeding most rapidly with low viscosity oils in the presence of breaking waves. Oils that remain fluid and spread unhindered by other weathering processes may disperse completely in moderate sea conditions within a few days. The application of dispersant chemicals can speed up this natural process. Conversely, viscous oils and oils at temperatures below their pour point, or oils that form stable water-in-oil emulsions, tend to form thick lenses on the water surface that show little tendency to disperse, even with the addition of dispersant chemicals. Such oils can persist for weeks and on reaching the shore may eventually form hard asphalt pavements if not removed.

The rate and extent to which petroleum dissolves depends upon its composition, spreading, water temperature, turbulence and degree of dispersion. The heavy components of crude oil are virtually insoluble in seawater whereas lighter compounds, particularly aromatic hydrocarbons such as benzene and toluene, are slightly soluble. However, these compounds are also the most volatile and are lost very rapidly by evaporation, typically 10 to 1,000 times faster than by dissolution. Concentrations of dissolved hydrocarbons in seawater thus rarely exceed 1 ppm and dissolution does not make a significant contribution to the removal of oil from the sea surface.

In moderate to rough seas, most oils will take up water droplets and form water-in-oil emulsions under the turbulent action of waves on the sea surface. This can increase the volume of pollutant by a factor of up to four times. Emulsions form most readily in oils which have a combined nickel/vanadium concentration greater than 15 ppm or an asphaltene content in excess of 0.5 percent when they are fresh. The presence of these compounds and the sea state determine the rate at which emulsions form. Oils which readily emulsify do so rapidly in sea states greater than Beaufort Force 3 (wind speed 7 - 10 knots). Very viscous oils tend to take up water more slowly than more liquid oils. As the emulsion develops, the movement of the oil in the waves causes the droplets of water which have been taken up in the oil to become smaller and smaller, making the emulsion progressively more viscous and stable. As the amount of water absorbed increases, the density of the emulsion approaches that of seawater. Stable emulsions may contain as much as 70 - 80 percent water and are often semi-solid and have a strong red/brown, orange or yellow color. They are highly persistent and may remain emulsified indefinitely. Less stable emulsions may separate out into oil and water if heated by sunlight under calm conditions or when stranded on shorelines.

Hydrocarbons can react with oxygen, which may either lead to the formation of soluble products or persistent tars. Oxidation is promoted by sunlight and although it occurs throughout the existence of a slick, its overall effect on dissipation is minor compared to that of other weathering processes. Even under intense sunlight, thin oil films break down only slowly, and usually less than 0.1 percent per day. Thick layers of very viscous oils or water-in-oil emulsions tend to oxidize to persistent residues rather than degrade, as higher molecular weight compounds are formed that create a protective surface layer. This can be seen in tar balls which sometimes strand on shorelines and which usually consist of a solid outer crust of oxidized oil and sediment particles, surrounding a softer, less weathered interior.

A few heavier residual oils have specific gravities greater than seawater (more than 1.025), causing them to sink once spilled. Most crude and fuel oils have sufficiently low specific gravities to remain afloat unless they interact with and attach to more dense sediment or organic particles. Dispersed oil droplets can interact with sediment particles suspended in the water column, thus becoming heavier and sinking. However, adhesion to heavier particles most often takes place when oils strand or become buried on beaches. On exposed, high energy beaches, large amounts of sediment can be incorporated and the oil can form dense tar mats. Seasonal cycles of sediment build-up and erosion may cause oil layers to be successively buried and uncovered. Even on less exposed sandy beaches, stranded oil can become covered by windblown sand. Once oil has been mixed with beach sediment, it will sink if washed back out to sea by storms, tides or currents. On sheltered shorelines, where wave action and currents are weak, muddy sediments and marshes are common. If oil becomes incorporated into such fine grained sediments, it is likely to remain there for a considerable time.

Shallow coastal areas and the waters of river mouths and estuaries are often laden with suspended solids that can bind with dispersed oil droplets, thereby providing favorable conditions for sedimentation of oily particles to the sea bed. Like some heavy crudes, most heavy fuel oils and water-in-oil emulsions have specific gravities close to that of seawater, and even minimal interaction with sediment can be sufficient to cause sinking. Freshwater from rivers also lowers the salinity of seawater, and therefore its specific gravity, and can encourage neutrally buoyant droplets to sink. Oil may also be ingested by planktonic organisms and incorporated into fecal pellets, subsequently falling to the seabed.

When oil droplets in the water column adhere to very fine sediment particles or particles of organic matter they can form flocculates, which may be widely dispersed by currents or turbulence. Small quantities of oil in sea bed sediments or on beaches may also become attached to such particles and become suspended in the water as flocculates as a result of storms, turbulence or tidal rise and fall. This process sometimes referred to as clay-oil flocculation, can result over a period of time in the removal of oil from beaches.

Seawater contains a range of marine microorganisms capable of metabolizing oil compounds. They include bacteria, moulds, yeasts, fungi, unicellular algae and protozoa which can utilize oil as a source of carbon and energy. Such organisms are distributed widely throughout the world's oceans although they tend to be more abundant in chronically polluted coastal waters, such as those with regular vessel traffic or which receive industrial discharges and untreated sewage.

The main factors affecting the rate and extent of biodegradation are the characteristics of the oil, the availability of oxygen and nutrients (principally compounds of nitrogen and phosphorus) and temperature. Each type of microorganism involved in the process tends to degrade a specific group of hydrocarbons and thus a wide range of microorganisms, acting together or in succession, are needed for degradation to occur. As degradation proceeds, a complex community of microorganisms develops. Although the necessary microorganisms are present in relatively small numbers in the open sea, they multiply rapidly when oil is available and degradation will continue until the process is limited by nutrient or oxygen deficiency. While microorganisms are capable of degrading most of the wide variety of compounds in crude oil, some large and complex molecules are resistant to attack.

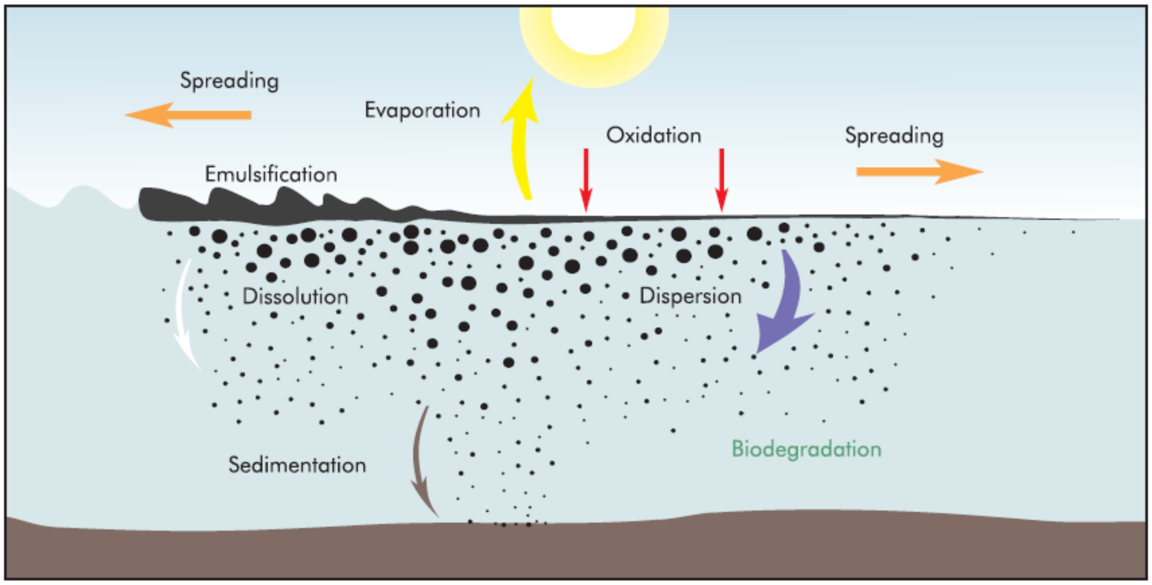
Because the microorganisms live in the water, from which they obtain oxygen and essential nutrients, biodegradation can only take place at an oil/water interface. At sea, the creation of oil droplets, either through natural or chemical dispersion, increases the interfacial area available for biological activity and may enhance degradation.

In contrast, oil stranded in thick layers on shorelines or above the high water mark will have a limited surface area and will be subject to drier conditions which will render degradation extremely slow, resulting in the oil persisting for many years. Similarly, once oils become incorporated into sediments on the shoreline or sea bed, degradation is very much reduced or may stop due to a lack of oxygen and/or nutrients. The variety of factors influencing biodegradation makes it difficult to predict the rate at which oil may be removed. Although biodegradation is clearly not able to remove bulk oil accumulations, it is one of the main mechanisms by which dispersed oil or the final traces of a spill on shorelines are eventually removed.

The processes described previously are summarized in Figure 4-5. All come into play as soon as oil is spilled, although their relative importance varies with time, as shown in Figure 4-4. Spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill while oxidation, sedimentation and biodegradation are longer term processes which determine the ultimate fate of oil.

The movement of an oil slick on the sea surface is due to winds and surface currents, and may be influenced by the combined weathering processes. The actual mechanisms governing spill movement are complex, but experience shows that oil drift can be predicted from a simple vector calculation of wind and surface current direction, based on about three percent of the wind speed and 100 percent of the current velocity.

Figure 4-5. Fate of Oil Spilled at Sea



Predictions of potential changes in oil characteristics with time allow an assessment to be made of the likely persistence of spilled oil and thereby the most appropriate response option. In this latter regard, a distinction is frequently made between nonpersistent oils, which because of their volatile nature and low viscosity tend to disappear rapidly from the sea surface, and persistent oils, which dissipate more slowly and usually require a clean-up response. Examples of the former are gasoline, naphtha and kerosene, whereas most crude oils, intermediate and heavy fuel oils, and bitumen are classed as persistent. However, this simple distinction fails to recognize the wide variation in the properties of different oil types. Better predictions of persistence can be made by using relatively simple empirical calculations based on oil type.

As a general rule, the lower the specific gravity of the oil the less persistent it will be. The concept of a 'half life' is helpful in defining removal rates of less persistent oils. This is the time taken for the removal of 50 percent of the oil from the sea surface so that after six half-lives, little more than one percent of the oil will remain. Half-life calculations are less useful for heavier oils and water-in-oil emulsions. However, it is important to appreciate that some apparently light oils behave more like heavy ones due to the presence of waxes. Oils with wax contents greater than about 10 percent tend to have high pour points and if the ambient temperature is low, the oil will be either a solid or a highly viscous liquid, and natural breakdown processes will be slow.

Environmental Effects of Marine Oil Spills

Oil spills can have a serious economic impact on coastal activities and on those who exploit the resources of the sea. In most cases such damage is temporary and is caused primarily by the physical properties of oil creating nuisance and hazardous conditions. The impact on marine life is compounded by toxicity and tainting effects resulting from the chemical composition of oil, as well as by the diversity and variability of biological systems and their sensitivity to oil pollution.

The effects of a particular oil spill depend upon many factors, not least the properties of the oil. Contamination of coastal amenity areas is a common feature of many spills leading to public disquiet and interference with recreational activities such as bathing, boating, angling and diving. Hotel and restaurant owners and others who gain their livelihood from the tourist trade can also be affected. The disturbance to coastal areas and to recreational pursuits from a single spill is comparatively short-lived and any effect on tourism is largely a question of restoring public confidence once clean-up is completed. Industries that rely on a clean supply of seawater for their normal operations can be adversely affected by oil spills. If substantial quantities of floating or sub-surface oil are drawn through intakes, contamination of the condenser tubes may result, requiring a reduction in output or total shutdown while cleaning is carried out.

Simply, the effects of oil on marine life are caused by either the physical nature of the oil (physical contamination and smothering) or by its chemical components (toxic effects and accumulation leading to tainting). Marine life may also be affected by clean-up operations or indirectly through physical damage to the habitats in which plants and animals live.

The main threat posed to living resources by the persistent residues of spilled oils and water-in-oil emulsions is one of physical smothering. The animals and plants most at risk are those that could come into contact with a contaminated sea surface including marine mammals and reptiles; birds that feed by diving or form flocks on the sea; marine life on shorelines; and animals and plants in mariculture facilities.

The most toxic components in oil tend to be those lost rapidly through evaporation when oil is spilt. Because of this, lethal concentrations of toxic components leading to large scale mortalities of marine life are relatively rare, localized and short-lived. Sublethal effects that impair the ability of individual marine organisms to reproduce, grow, feed or perform other functions can be caused by prolonged exposure to a concentration of oil or oil components far lower than will cause death. Sedentary animals in shallow waters such as oysters, mussels and clams that routinely filter large volumes of seawater to extract food are especially likely to accumulate oil components. While these components may not cause any immediate harm, their presence may render such animals unpalatable if they are consumed by man, due to the presence of an oily taste or smell. This is a temporary problem since the components causing the taint are lost (depurated) when normal conditions are restored.

The ability of plants and animals to survive contamination by oil varies. The effects of an oil spill on a population or habitat must be viewed in relation to the stresses caused by other pollutants or by any exploitation of the resource. In view of the natural variability of animal and plant populations, it is usually extremely difficult to assess the effects of an oil spill and to determine when a habitat has recovered to its pre-spill state.

As described in Section 4.6, plankton are floating plants and animals carried passively by water currents in the upper layers of the sea. Their sensitivity to oil pollution has been demonstrated experimentally. In the open sea, the rapid dilution of naturally dispersed oil and its soluble components, as well as the high natural mortality and patchy, irregular distribution of plankton, make significant effects unlikely.

In coastal areas some marine mammals and reptiles, such as turtles, may be particularly vulnerable to adverse effects from oil contamination because of their need to surface to breathe and to leave the water to breed. Adult fish living in nearshore waters and juveniles in shallow water nursery grounds may be at greater risk to exposure from dispersed or dissolved oil.

The risk of surface oil slicks affecting the sea bed in offshore waters is minimal. However, restrictions on the use of dispersants may be necessary near spawning grounds or in some sheltered, nearshore waters where the dilution capacity is poor.

The impact of oil on shorelines may be particularly great where large areas of rocks, sand and mud are uncovered at low tide. The amenity value of beaches and rocky shores may require the use of rapid and effective clean-up techniques, which may not be compatible with the survival of plants and animals.

Marsh vegetation shows greater sensitivity to fresh light crude or light refined products while weathered oils cause relatively little damage. Oiling of the lower portion of plants and their root systems can be lethal whereas even a severe coating on leaves may be of little consequence especially if it occurs outside the growing season. In tropical regions, mangrove forests are widely distributed and replace salt marshes on sheltered coasts and in estuaries. Mangrove trees have complex breathing roots above the surface of the organically rich and oxygen-depleted muds in which they live. Oil may block the openings of the air breathing roots of mangroves or interfere with the trees' salt balance, causing leaves to drop and the trees to die. The root systems can be damaged by fresh oil entering nearby animal burrows and the effect may persist for some time inhibiting recolonization by mangrove seedlings. Protection of wetlands, by responding to an oil spill at sea, should be a high priority since physical removal of oil from a marsh or from within a mangrove forest is extremely difficult.

Living coral grows on the calcified remains of dead coral colonies which form overhangs, crevices and other irregularities inhabited by a rich variety of fish and other animals. If the living coral is destroyed, the reef itself may be subject to wave erosion. The effects of oil on corals and their associated fauna are largely determined by the proportion of toxic components, the duration of oil exposure as well as the degree of other stresses. The waters over most reefs are shallow and turbulent, and few clean-up techniques can be recommended.

Birds which congregate in large numbers on the sea or shorelines to breed, feed or molt are particularly vulnerable to oil pollution. Although oil ingested by birds during preening may be lethal, the most common cause of death is from drowning, starvation and loss of body heat following damage to the plumage by oil.

An oil spill can directly damage the boats and gear used for catching or cultivating marine species. Floating equipment and fixed traps extending above the sea surface are more likely to become contaminated by floating oil whereas submerged nets, pots, lines and bottom trawls are usually well protected, provided they are not lifted through an oily sea surface. Experience from major spills has shown that the possibility of long-term effects on wild fish stocks is remote because the normal over-production of eggs provides a reservoir to compensate for any localized losses.

Cultivated stocks are more at risk from an oil spill since natural avoidance mechanisms may be prevented in the case of captive species and the oiling of cultivation equipment may provide a source for prolonged input of oil components and contamination of the organisms. An oil spill can cause loss of market confidence since the public may be unwilling to purchase marine products from the region irrespective of whether the seafood is actually tainted. Bans on the fishing and harvesting of marine products may be imposed following a spill, both to maintain market confidence and to protect fishing gear and catches from contamination.

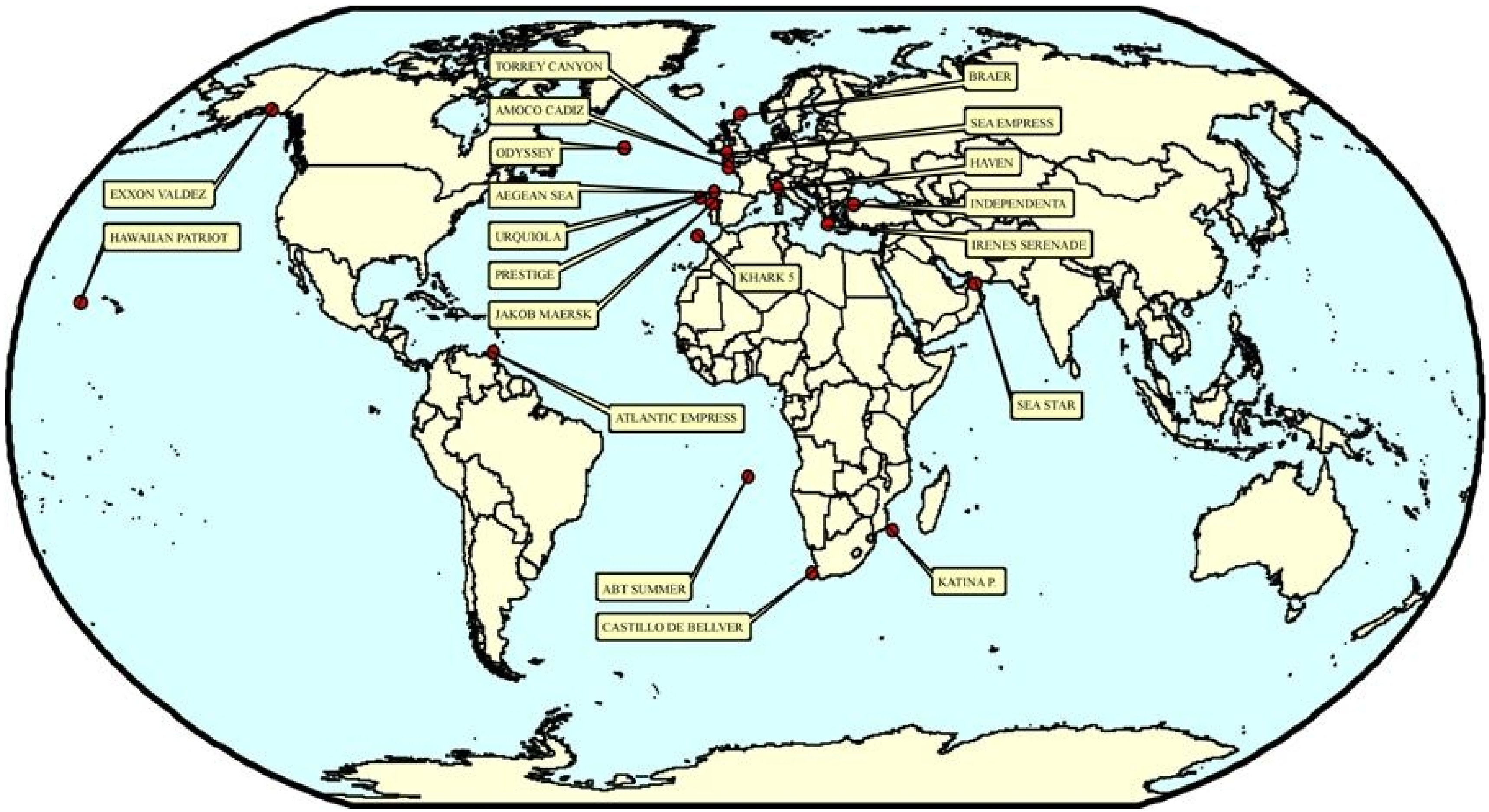
Because major oil spills are accidental events, their location, scope, magnitude, and resulting environmental effects cannot be identified in advance. The effects will be influenced by a variety of physical factors, including weather conditions, ocean currents, water depth, and time of year, and other climatic conditions. Oil spill data compiled by the International Tanker Owners Pollution Federation Limited (ITOPF) was reviewed to broadly characterize the range of region-specific effects that a major release of petroleum could have on the environment. Table 4-12 identifies 20 major oil spills that have occurred since 1967 in different environmental settings with the locations depicted on Figure 4-6. It should be noted that because these spills mostly involved large cargo tankers transporting crude oil and refined petroleum products, the magnitude of the releases are considerably greater than the amount of marine gas oil fuel that could be released from the SODV which has the capacity to carry 3,290 tons of fuel.

Table 4-12. Selected Major Marine Oil Spills 1967-2002

Ship Name	Year	Location (see Figure 4-6)	Spill (tons)
Atlantic Empress	1979	Off Tobago, West Indies	287,000
ABT Summer	1991	700 nautical miles off Angola	260,000
Castillo de Bellver	1983	Off Saldanha Bay, South Africa	252,000
Amoco Cadiz	1978	Off Brittany, France	223,000
Haven	1991	Genoa, Italy	144,000
Odyssey	1988	700 nautical miles off Nova Scotia, Canada	132,000
Torrey Canyon	1967	Scilly Isles, UK	119,000
Sea Star	1972	Gulf of Oman	115,000
Irenes Serenade	1980	Navarino Bay, Greece	100,000
Urquiola	1976	La Coruna, Spain	100,000
Hawaiian Patriot	1977	300 nautical miles off Honolulu	95,000
Independenta	1979	Bosphorus, Turkey	95,000
Jakob Maersk	1975	Oporto, Portugal	88,000
Braer	1993	Shetland Islands, UK	85,000
Khark 5	1989	120 nautical miles off Atlantic coast of Morocco	80,000
Aegean Sea	1992	La Coruna, Spain	74,000
Sea Empress	1996	Milford Haven, UK	72,000
Katina P	1992	Off Maputo, Mozambique	72,000
Nova	1985	Off Kharg Island, Gulf of Iran	70,000
Prestige	2002	Off the Spanish coast	63,000
Exxon Valdez	1989	Prince William Sound, Alaska, USA	37,000

Using the data compiled by ITOPF, the following six case studies represent a range of potential region-specific environmental impacts and response actions that have occurred associated with major oil spill events from ships. It should also be noted that an underwater uncontrolled release of petroleum hydrocarbons from a geologic source may have similar effects.

Figure 4-6. Location of Selected Oil Spills



Metula (Chile, 1974)

Metula grounded in the eastern Strait of Magellan, Chile, on 9 August 1974. About 47,000 tons of light Arabian crude oil and 3,000 to 4,000 tons of heavy fuel oil are estimated to have been lost. Large volumes of water-in-oil emulsion were produced in the rough sea conditions and much of this landed on shores of northern Tierra del Fuego. Most of the shores affected were of mixed sand and gravel, but two small estuaries including salt marshes were also oiled. About 4,000 birds are known to have been killed, including cormorants and penguins.

No cleanup was done because of the remoteness of the area and consequently this remains a distinctive spill site mainly because hard asphalt pavements formed on many shorelines. The long-term fate and effects of heavy oiling have been extensively investigated. One very sheltered marsh received thick deposits of water-in-oil emulsion and, 20 years after the spill, these deposits were still visible on the marsh surface, with the emulsions quite fresh in appearance beneath a weathered surface skin. Little plant recolonization has occurred in the areas with thicker deposits of 4 or more cm, though it is proceeding in more lightly oiled areas. On sand and gravel shores, an asphalt pavement remained in a relatively sheltered area in 1998, but oil deposits had mainly broken up and disappeared from more exposed shores. These remain among the longest-term contaminants recorded for an oil spill, even though they have not resulted in significant impacts on fisheries or the biology of coastal waters.

Argo Merchant (USA, 1976)

The Argo Merchant ran aground on Nantucket Shoals, off Massachusetts, USA, on 15 December 1976, and over the next month spilled her entire cargo (28,000 tons) of Venezuelan No 6 fuel oil and cutter stock. Storms broke up the tanker after grounding, and attempts to pump the oil into another vessel failed. In situ burning was attempted on two occasions, but the slick failed to remain ignited.

Winds during the spill period were offshore from Massachusetts, and as a result no oil from Argo Merchant ever reached the shoreline and no coastal impact was reported. Hydrocarbon contamination of the bottom sediments was restricted to an area immediately around the wreck, and apparently was short-lived. The bulk of the spill formed large 'pancakes' and sheens on the surface; these were carried offshore over the continental shelf and into the prevailing North Atlantic circulation pattern. The cutter stock, which was mixed with the fuel oil to improve handling, entered the water column. Despite its relatively high potential toxicity, there was little evidence of impact on the marine fauna or phytoplankton. The accident occurred at the time when the fewest potential effects on pelagic organisms would be expected; a period of low productivity in the water column, with few fish eggs and larvae present. Oiled birds were seen near the wreck, and though total mortalities are difficult to evaluate, it was concluded that the spill probably had little effect on the coastal and marine bird populations off the New England coast. The outcome of the Argo Merchant oil spill appears to have been fortunate in several respects: (a) the winds were almost continuously offshore, preventing the oil from coming on the beaches; (b) the density of the oil was low enough so that it did not sink and contaminate the bottom; and (c) the spill occurred in the winter when the biological activity, productivity, and fishing activities are relatively low.

Tanio (France, 1980)

On 7 March 1980 Tanio, carrying 26,000 tons of No. 6 fuel oil, broke in two during violent weather conditions off the coast of Brittany, France. As a result approximately 13,500 tons of cargo oil was spilled. The stern section, with about 7,500 tons of cargo oil aboard, remained afloat and was towed to Le Havre; the bow section, carrying 5,000 tons of cargo oil, sank to a depth of 90 m. Strong northwest winds at the time of the incident moved the oil towards the Breton coast (which had already received major oil impacts from the Torrey Canyon spill in 1967 and the Amoco Cadiz in 1978). Due to the high viscosity of the oil and severe weather conditions, neither chemical dispersal nor containment and recovery techniques at sea were possible. The spilled oil began to be washed ashore on 9 March, and eventually contaminated about 200 km of coastline to varying degrees. Many of the worst affected areas could not be boomed effectively because of the nature of the coastline, the extremely large tidal range (9m) and the severity of the weather at the time of the accident.

As tourism is of major importance in Brittany, the main emphasis of the cleanup operation was to return amenity areas to a usable condition as quickly as possible. In severely contaminated areas, bulk oil was removed by the use of tractor-drawn vacuum trucks, but this technique could not be used on cold, cloudy days when the oil became too viscous. Owing to concern that a forthcoming high tide would extend the shoreline contamination, it was decided that a more rapid removal of the bulk oil was required. Heavy earth-moving equipment (bulldozers and front-end loaders) was therefore used despite the well-known detrimental effects of driving heavy equipment over severely oiled beaches. While much oil (and a considerable amount of beach material) was removed within a short time, the underlying sediments at a number of sites were heavily contaminated and required extensive restoration work at a later stage. Where access was difficult or where the deposits of oil were thin or well spread out, men with shovels were employed to pick up the oil and to put it into sacks or tractor-drawn trailers. Oil collected during the cleanup operation was taken to a tanker deballasting station for treatment. The removal of bulk oil was followed by the cleaning of the rocks in the tourist areas, using hot water washing machines and high pressure cold water jets. Released oil was collected using granular mineral sorbents and dispersants were used in cases of severely contaminated rocks. By the time the cleanup operation was completed at the beginning of July most of the beaches and accessible rocks had been restored to something approaching their pre-spill state.

The Tanio spill presented considerable cleanup problems to which there was no easy solution, but the low toxicity of the oil meant that the environmental effects were limited. Approximately 1,700 dead birds, primarily guillemots and other auks, were recovered during the incident, and there were some localized effects such as contaminated oyster beds and disrupted seaweed harvests caused by the smothering of intertidal life and by the extensive cleanup operations at the worst affected areas.

Castillo De Bellver (South Africa, 1983)

Castillo De Bellver, carrying 252,000 tons of light crude oil (Murban and Upper Zakum), caught fire about 70 miles north west of Cape Town, South Africa on 6 August 1983. The blazing ship drifted offshore and broke in two. The stern section possibly with as much as 100,000 tons of oil remaining in its tanks capsized and sank in deep water, 24 miles off the coast. The bow section was towed away from the coast and was eventually sunk with the use of controlled explosive charges. Approximately 50-60,000 tons are estimated to have spilled into the sea or burned. Although the oil initially drifted towards the coast, a wind shift subsequently took it offshore, where it entered the north-west flowing Benguela Current.

Although a considerable amount of oil entered the sea as a result of the Castillo De Bellver incident, there was little requirement for cleanup (there was some dispersant spraying) and environmental effects were minimal. The only visible damage was the oiling of some 1,500 gannets, most of which were collected from an island near the coast where they were gathering for the onset of the breeding season. A number of seals were observed surfacing in the vicinity of the dispersant spraying activities but were not thought to have suffered any adverse effects.

Also of initial concern was the 'black rain' of airborne oil droplets that fell during the first 24 hours of the incident on wheat growing and sheep grazing lands due east of the accident, although no long-term damage was recorded from these residues. The impact on both the rich fishing grounds and the fish stocks of the area was also considered to be negligible.

Exxon Valdez (United States, 1989)

Exxon Valdez grounded on Bligh Reef in Prince William Sound, Alaska, on 24 March 1989. About 37,000 tons of Alaska North Slope crude escaped into the Sound and spread widely. There was some limited dispersant spraying and an experimental in situ burn trial during the early stages of the spill, but at-sea response concentrated on containment and recovery. Despite the utilization of a massive number of vessels, booms and skimmers, less than 10 percent of the original spill volume was recovered from the sea surface. The oil subsequently affected a variety of shores, mainly rock and cobble, to varying degrees over an estimated 1,800 km in Prince William Sound and along Alaska's south coast as far west as Kodiak Island.

This spill attracted an enormous amount of media attention because it was the largest spill to date in U.S. waters (although well down the scale in world terms). Moreover, it happened in a splendidly scenic wilderness area with important fisheries and attractive wildlife such as sea otters and bald eagles. Consequently the response was the most expensive in oil spill history, with over 10,000 workers being employed at the height of the cleanup operations, many of them in shoreline cleanup, often in remote areas. The clean-up cost for the first year alone was over US$2 billion.

Shoreline cleanup techniques included high pressure, hot water washing, which was carried out on a scale never attempted previously or subsequently. This caused substantial impact in intertidal communities and may have delayed their recovery in some areas, although recovery on over 70 percent of oiled shorelines was progressing well one year after the spill. There were also some relatively large scale bioremediation trials that gave mixed results. About 1,000 sea otters are known to have died, and over 35,000 dead birds were retrieved. There were particular efforts to protect fisheries, for example with booming of salmon hatcheries. Oil residues remain trapped in intertidal sediments at a few locations and scientists dispute the evidence of long-term damage to wildlife and fish populations.

Tasman Spirit (Pakistan, 2003)

The Maltese tanker Tasman Spirit (87,584 DWT) grounded at the entrance to Karachi Port, Pakistan in the early hours of Sunday 27 July 2003. The vessel was carrying 67,800 tons of Iranian Light crude oil destined for the national refinery in Karachi. There were also 440 tons of heavy fuel oil in aft bunker tanks. The condition of the grounded tanker deteriorated as she was subjected to continuous stress from the heavy swell of the prevailing south-west monsoon and the vessel subsequently broke in two. In total, it is estimated that some 30,000 tons of oil was spilled from the Tasman Spirit, and the incident ranks as the largest crude oil spill since the Sea Empress incident in February 1996 (72,000 tons).

In the course of inspections onboard the Tasman Spirit, it became apparent that most of the cargo tanks had been ruptured, while the bunker tanks remained intact. The owners appointed salvors and also hired a succession of small tankers and barges for the purpose of shuttling and storing oil lightered from the casualty. During the next few weeks roughly half of the crude oil cargo and most of the bunker fuel was successfully transferred from the casualty.

On 11 August the tanker began to show signs of breaking up and eventually broke in two overnight on 13/14 August, spilling several thousand tons of crude oil. Much of the spilled oil quickly stranded on Clifton Beach, the main tourist beach in Karachi, but significant quantities remained afloat both inside and outside Karachi port. Dispersants were applied offshore from a Hercules C-130 aircraft equipped with an aerial dispersant spraying system (ADDS Pack) in response to two distinct pollution events involving the progressive break-up of the tanker. Approval for large scale dispersant use was given by the Karachi Port Trust (KPT) and the Pakistan Environment Protection Agency. Oil entering the port of Karachi was confined by deploying booms at suitable collection sites, and in total some 140 tons of oil were recovered by skimmers. KPT also deployed vessels to apply dispersant on oil drifting through the port entrance.

The severe pollution of Clifton Beach created very strong oil vapors causing considerable discomfort to local residents and clean-up personnel. Local hospitals reported many cases of headaches, nausea and dizziness and seventeen schools in the vicinity were closed for about a week. The beach was cleaned by a combination of manual and mechanical means, but work was hampered by a lack of suitable disposal sites for collected oily waste. Agreement was eventually reached for disposal at one of the municipal waste sites serving Karachi City. Clifton Beach was reopened to the public in the middle of October.

Given the low persistence of Iranian Light crude oil and the high mixing energy in the many damaged cargo tanks generated by the incessant heavy swell, it is likely that most of the spilled oil dispersed naturally. Field surveys conducted showed little or no impact on mangroves, salt pans and other sensitive resources in the vicinity. The geographical extent of shoreline oiling was limited to a ten-mile radius around the grounded tanker. While there have been few reports of repercussions of the oil on fisheries, a three-month fishing ban was imposed by the Marine Fisheries Department along the coastline directly affected by oil, extending five nautical miles offshore.

4.11.5 Impact Analysis

<u>Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs</u>

The primary output resulting from a catastrophic event related to the SODV itself or drilling into a geological source would be the uncontrolled release of petroleum hydrocarbons to the marine environment. Based on IODP-USIO riserless drilling experience, the probability of a major spill or catastrophic release of petroleum from the

SODV or a geological source is very low. This is readily demonstrated by 21 years of ODP/IODP experience involving riserless drilling of more than 1,900 boreholes without a major spill of fuel from the vessel or accidental release of hydrocarbons from a geologic source. Building further upon this experience, it is anticipated that this record of preventing catastrophic releases will continue with future SODV expeditions.

Severe weather represents a significant condition that could threaten vessel operations and contribute to a catastrophic release or petroleum. For example, if the ship were to be blown off a drill site during a severe storm without ample time to retrieve the drill string, the drill string could be lost and the ship may be severely damaged if it grounded in shallow water or onshore. Through best management practices including the operational planning process for each expedition and continuously monitoring ever-changing weather conditions, the SODV will be able to avoid environmental conditions which could contribute to the catastrophic release of petroleum from the vessel.

The risk of an accidental release of petroleum hydrocarbons from a geologic source exists if riserless drilling intercepts a pressurized formation below the seafloor. In Alternative A, proposed drill sites would undergo rigorous evaluation by the safety panel (IODP-USIO Science Services, TAMU Safety Panel) composed of experienced geologists, engineers, and drilling professionals. This review would ensure that sites exhibiting potentially unsafe conditions would be identified and avoided, thereby preventing boreholes being advanced in areas characterized by geologic sources of petroleum and minimizing the risk of a petroleum release from these sources.

During drilling, if conditions suggesting the possible release of petroleum hydrocarbons or other gasses (e.g., hydrogen sulfide) are detected during SODV operations, drilling will immediately cease and a series of pre-defined control measures will be implemented to stabilize and seal the borehole thereby avoiding an uncontrolled release to the marine environment. It is possible, though unlikely, that riserless drilling may penetrate a thin, relatively undetectable petroleum layer, resulting in its release from the borehole to the marine environment. In this instance, the amount of material released would be minimal.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, the probability of a major spill or catastrophic release of petroleum from the SODV or a geological source would be very low, similar to Alternative A. In Alternative B, the IODP SAS comprehensive review and advisory process combined with the stringent program of continuous real-time monitoring of hydrocarbon potential while drilling would further reduce the risk of an uncontrolled release of hydrocarbons from a geologic source to an extremely low level.

Input from the IODP SAS review process may also include recommendations for site-specific mitigating measures such as additional detection tools (e.g., logging while drilling, measurement while drilling) and the availability of resources to respond to signs of geologic hazards. For example, the IODP SAS may recommend the availability of heavy drilling mud at certain drills sites which could quickly be deployed to abandon a borehole or seal specific stratigraphic intervals, thereby ensuring a maximum level of protection from potential petroleum releases.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), riserless drilling activities by the SODV would not occur and there would be no risk of catastrophic releases from the vessel or drilling operations.

4.12 Temporal Effects

4.12.1 Short-term Effects

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

The majority of the effects resulting from outputs associated with the operation of the SODV and riserless drilling and coring activities will be short term events. These effects are expected to be caused by:

- Wastewater discharges (vessel operations)
- Solid and liquid discharges (drilling)
- Physical disturbances (drilling, research activities)
- Acoustic sources (vessel operations, drilling, and research activities)
- Equipment or material releases (drilling, research activities)
- Air emissions (vessel operations, onboard laboratories)
- Waste and hazardous materials management (vessel operations, onboard laboratories)

Wastewater discharged from the vessel, including treated sanitary wastewater, greywater, and other aqueous wastes (bilgewater, treated deck drainage) will rapidly mix and assimilate into the receiving waters. The resulting effects will be localized and transitory. Fine grain-size particles ejected from a borehole during drilling (cuttings) and the occasional use of drilling mud to condition a borehole may temporarily create turbidity in the water column near the seafloor which will quickly dissipate allowing the local water quality to return to background conditions shortly after drilling operations cease.

It is not expected that the seafloor will be disturbed on the long-term basis beyond the immediate vicinity of a borehole where natural sediment materials (e.g., drill cuttings) will be deposited. Depending on site-specific conditions, the borehole itself will either naturally fill-in with surrounding sediment, be sealed with drilling mud consisting of naturally-occurring minerals, be completed with the installation of a permanent research device (e.g., observatory), or remain as an open hole in the seafloor (long-term effect).

Air emissions including fuel combustion exhaust byproducts and volatile emissions such as fuel vapors or chemicals will be released to the ambient air as a result of the proposed action. In addition, fugitive gases such as methane or hydrogen sulfide may be released when certain types of sediment cores are opened in the laboratory. Notwithstanding health and safety measures that will be implemented to protect the ship's crew and researchers, these emissions will rapidly disperse once vented to the ambient air and yield minor short-term air quality effects.

Acoustic outputs originating from vessel operations and riserless drilling activities will increase the ambient noise level present in the marine environment. Certain noises generated during the proposed action may potentially affect nearby biological receptors. These outputs may elicit avoidance responses in some organisms during the relatively short periods of time when the vessel is drilling at a particular site. Acoustic outputs related to single-channel seismic surveys or VSP measurements will only occur occasionally and for relatively short periods of time. The potential disturbance effects to individual or groups of animals, if any, will be temporary and animals displaced from a particular area are expected to return after drilling ceases and the vessel departs.

Benthic organisms in the immediate vicinity of a drill site may be impacted by the smothering effects of drill cuttings displaced from the borehole. However, benthic organisms which are either capable of moving away from a borehole location before being smothered by drill cuttings or organisms which are beyond the area where cuttings accumulate, will only be disturbed for a relatively short period of time. The effects on benthic organisms will be site-specific depending on factors such as the population density and mobility of the organisms but seafloor conditions existing after drilling is complete are not expected to inhibit recolonization. Effects, if any, to marine mammals, sea turtles, fish, or plankton species, are expected to be short term and cease once the vessel leaves a particular drill site area.

Vessel and drilling operations have the potential to affect marine transport routes, fisheries, and aquaculture. However, if an impact is realized, it would only last for the short period of time that the vessel is present at a particular location. The management of hazardous materials and wastes onboard the SODV may have a short-term effect on vessel operations but is not expected to impact the surrounding marine environment.

Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support

In Alternative B, riserless drilling activities would be planned and performed based on comprehensive review input provided by the IODP SAS. The intensity and extent of short-term impacts caused by typical expedition activities (vessel operations, drilling, and research) are generally not expected to change as compared to Alternative A, including:

- Localized effects to water quality surrounding the vessel and near the seafloor surrounding boreholes;
- Localized disturbances to the seafloor surrounding boreholes and associated deposition of drill cuttings and drilling mud particles;
- Localized smothering of benthic communities in the immediately vicinity of boreholes;
- Temporary displacement or disturbances to biological receptors derived from acoustical outputs;
- Localized interruption of fishery or marine transportation activities.

In Alternative B, the comprehensive review and planning process will ensure that the number and location of boreholes advanced will be kept to the minimum needed to support scientific objectives. As a result, the extent of disturbances to the seafloor and related effects resulting from the discharge of drill cuttings and drilling mud at some drill sites may be reduced as compared to Alternative A.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), the short-term effects identified above will not occur.

4.12.2 Long-term Effects

Alternative A – Conduct Riserless Ocean Drilling Solely Based on Scientific Research Needs

Although a majority of the impacts associated with riserless drilling activities at a particular drill site will cease once the SODV leaves the area, several outputs will exhibit more lasting effects including:

- Localized physical disturbances to the seafloor (drilling);
- Equipment or material releases to the seafloor (drilling, research activities);
- Accidental releases (vessel operations, drilling).

Inherent to the proposed riserless drilling activities, a very small portion of the seafloor will be disturbed at each borehole site as drilling and coring proceeds to support the research objectives. At some drill sites, casing, observatory-related equipment, reentry devices, and certain types of materials used during drilling may be deployed into a borehole or onto the seafloor and may remain in-place indefinitely. Although these items may be permanently left on or below the seafloor, the resulting impacts will be very localized and minimal.

As indicated above, the displacement and deposition of drill cuttings on the seafloor may affect benthic organisms if present in the immediate vicinity of the borehole. In most habitats, displaced benthic organisms would be expected to recover in a relatively short time period once drilling activities cease. However, recovery in sensitive ecosystems such as hydrothermal vents or coral reefs may be inhibited or impossible. In Alternative A, if sensitive resources were not identified during the expedition planning process and effective mitigating measures applied during drilling activities, the resulting environmental effects may be more pronounced and long term.

The catastrophic and uncontrolled release of petroleum hydrocarbons from either vessel related or geologic sources has the potential to effect widespread areas of the environment on a long-term basis. Throughout the site selection process including the application of site-specific mitigating measures to avoid these areas and prevent unsafe conditions, catastrophic release events have been avoided in over two decades of riserless drilling activities by the USIO. These expedition planning and mitigating measures will continue to be refined and applied to further reduce the risk of future catastrophic releases.

<u>Alternative B - Conduct Riserless Ocean Drilling Based on Specific Scientific Research Needs and IODP Support</u>

In Alternative B, long-term impacts resulting from the riserless drilling activities would generally be expected to be similar in intensity and extent to those realized in Alternative A. These impacts would be derived from localized physical disturbances to the seafloor and release of equipment or material to the seafloor.

However, in Alternative B, measures would be taken through the IODP SAS review and advisory process to identify biologically sensitive ecosystems and recommend site-specific mitigating measures that would be designed and implemented to effectively prevent or minimize long-term adverse impacts. Thus, the long-term impacts to these resources would be minimal and would be reduced as compared to Alternative A.

The risk of accidental releases and associated range of long-term impacts that may occur is also expected to be very low (comparable to Alternative A), although during the comprehensive expedition planning and review process in Alternative B, mitigating measures will continue to be refined and applied to further reduce the risk of future catastrophic releases.

Alternative C – No Action

If IODP-USIO riserless drilling activities are not conducted (No Action Alternative), the long-term effects identified above will not occur.

4.13 Unavoidable, Irreversible, and Indirect Effects

Unavoidable effects are those which are inherent to the proposed action and cannot be eliminated if the action proceeds as designed. Irreversible effects are impacts which are permanent and may not be reduced or eliminated by naturally-occurring processes in the foreseeable future. Indirect effects are caused by the proposed action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include effects which are realized at different locations or times but induced by the proposed action. Implementation of Alternatives A or B will result in unavoidable, irreversible, and indirect effects as summarized in Table 4-13.

Table 4-13. Summary of Unavoidable, Irreversible, and Indirect Effects

Affected Environment	Process/ Activity	Environmental Output	Effects		
			Avoidable	Reversible	Indirect
Water Quality	SODV Operations	Releases/Discharges (treated wastewater, greywater, treated bilgewater, deck drainage, ballast water)	No	Yes	No
	Riserless Drilling	Releases/Discharges (seawater drilling fluid, tracers, sediment, drilling mud, cement)	No	Yes	No
	Scientific Research	Releases/Discharges (laboratory wastewater)	Yes [1]	Yes	No
	SODV Operations	Physical Disturbances (operation of vessel's thrusters)	No	Yes	No
Seafloor	Riserless Drilling	Discharges (seawater drilling fluid, tracers, sediment, drilling mud, cement)	No	No	No
	Borehole Completion	Releases/Discharges (heavy drilling mud for closure of select boreholes, cement for casings and plugging select boreholes, casing, reentry devices and instruments)	Yes [1]	No	No

Table 4-13. Summary of Unavoidable, Irreversible, and Indirect Effects

Affected Environment	Process/ Activity	Environmental Output	Effects		
			Avoidable	Reversible	Indirect
	Riserless Drilling	Physical Disturbances (drilling, coring, sediment displacement)	No	No	No [2]
Air Quality	SODV Operations	Air Emissions (exhaust, vapors)	No	Yes	No
	Scientific Research	Air Emissions (laboratory)	Yes[1]	Yes	No
Acoustical Environment	SODV Operations	Underwater Noise (operation of vessel engines, generators, thrusters, mechanical systems, and instruments)	No	Yes	No
	Riserless Drilling	Underwater Noise (operation of drilling/coring equipment)	No	Yes	No
	Scientific Research	Underwater Noise (operation of instruments utilizing sonic transmitters, small seismic sources)	Yes[1]	Yes	No
Biological Resources	SODV Operations	Releases/Discharges (treated wastewater, greywater, treated bilgewater, deck drainage, ballast water)	No	Yes [3]	No
	Riserless Drilling	Releases/Discharges (seawater drilling fluid, tracers, sediment, drilling mud)	No	Yes [3]	No
	Borehole Completion	Releases/Discharges (placement of reentry devices and instruments)	Yes [1]	Yes [3]	No [2]
	Riserless Drilling	Physical Disturbances (operation of drilling, coring equipment, sediment displacement)	No	Yes [3]	No
	SODV Operations	Underwater Noise (operation of vessel engines, generators, thrusters, mechanical systems, and instruments)	No	Yes [3]	No
	Riserless Drilling	Underwater Noise (operation of drilling/coring equipment)	No	Yes [3]	No
	Scientific Research	Underwater Noise (instrument operation, small seismic sources)	Yes [1]	Yes [3]	No
Marine Transportation	SODV Operations	Physical Disturbances (presence of the vessel)	No	Yes	No
	Riserless Drilling	Physical Disturbances (presence of the vessel)	No	Yes	No
Cultural Resources	Riserless Drilling	Discharges (seawater drilling fluid, tracers, sediment, drilling mud, cement)	Yes	No	No
	Riserless Drilling	Physical Disturbances (drilling/coring, sediment displacement)	Yes	No	No
Vessel Crew & Resources	SODV Operations	Hazardous Materials Management	No	No	No

Table 4-13. Summary of Unavoidable, Irreversible, and Indirect Effects

Affected Environment	Process/ Activity	Environmental Output	Effects		
			Avoidable	Reversible	Indirect
	SODV Operations	Solid and Hazardous Waste Management	No	No	No
Marine Ecosystem (water quality, air quality, seafloor, biological resources)	Accidental Events	Spills (major fuel spill from the vessel or blowout caused by drilling into geological source)	No	No	Yes

Notes:
[1] Environmental output can be substantially reduced or eliminated but may result in the failure of the expedition to meet scientific objectives
[2] Research results may prompt follow-on investigation at a particular drill site
[3] Effects on sensitive biological resources may be long term or irreversible in Alternative A

In general, a majority of the unavoidable impacts identified in this impact statement represent localized effects which are minimal in the context of the marine environment and short term in duration. Examples include physical disturbances caused by the presence of the vessel, liquid discharges, and air emissions. Some of the effects resulting from research-related processes may be considered avoidable as indicated on Table 4-13; however, eliminating or altering these activities would likely jeopardize the ability of an expedition to meet its research objectives. Other effects such as those involving the closure or plugging of boreholes, while avoidable, are performed as a mitigating measure to prevent release of geologic materials or fluids to the surrounding environment.

Potential impacts associated with the operation of the SODV and riserless drilling activities in biologically sensitive areas are also considered avoidable, but only if Alternative B were implemented since expedition planning efforts will help to identify these types of environmental settings and prompt the development and implementation of site-specific mitigating measures.

Many of the effects summarized in Table 4-13 are temporary and reversible. These impacts affect air and water quality, behavioral disturbances to biological organisms, noise and vibration outputs, and disturbances to marine transportation routes. The environmental media or receptors that may be affected by these reversible impacts are expected to return to normal conditions shortly after the vessel leaves a particular drill site or completes a transit route. In Alternative A however, impacts to sensitive biological resources or ecosystems may be more significant or prolonged than in Alternative B.

A majority of the effects associated with riserless drilling and borehole completion activities are, by their nature, irreversible disturbances of the seafloor environment and are primarily associated with the deposition of drill cuttings or deployment of equipment on the seafloor. Devices such as reentry cones and observatories are intended to be permanent borehole completion structures and will be used to support long-term research projects.

Few indirect effects are expected to result from riserless drilling expeditions. The operation of the SODV may indirectly affect logistical resources at port facilities needed to support the vessel and crew. These impacts may be related to activities such as cargo handling, vessel maintenance, research staff and crew support, and core sample handling and transportation. The overall environmental impact associated by these support activities is minimal.

The accidental or catastrophic release of a substantial quantity of liquid or gaseous petroleum hydrocarbons to the environment from either a vessel- or geologic-related source is highly unlikely but would result in various unavoidable, irreversible, and indirect effects. The effects would be related to the fate and transport of petroleum into the marine environment and impacts to human and biological receptors. Indirect effects would be realized due to subsequent cleanup or recovery efforts.

4.14 Cumulative Effects

A cumulative impact is an impact on the environment which results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of the source of such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Cumulative effects may include the combination (aggregate) of impacts associated with (1) all individual outputs resulting from an action having the potential to impact an environmental media or receptor, or (2) the effect of a particular process or activity that may combine with the effects of other processes or activities occurring in the same location.

Cumulative impacts that may be realized as a result of SODV operations and riserless drilling activities in either Alternative A or B are described below.

<u>Air Quality</u>

The localized and short-term environmental effects resulting from SODV air emissions are not expected to combine with and magnify air quality impacts from other vessels or sources. Similarly, air emissions from the SODV are not expected to increase the severity of other environmental impacts from SODV operations. Therefore, the SODV operations will not directly or cumulatively contribute to the degradation of local air quality.

Ocean Environment

Treated and untreated liquid wastes originating from SODV operations in Alternative A or B and discharged to the sea are not expected to adversely affect water quality due to the absence of toxic constituents in the liquid waste, rapid mixing once discharged, and the assimilative capacity of the sea. The effect of each liquid discharge will be localized in extent, short term in duration, and additive effects from multiple liquid discharges will not significantly degrade water quality. Similarly, liquid discharges from the SODV are not expected to magnify or increase the severity of other impacts from SODV operations.

The effects of riserless drilling on water quality near the seafloor are generally expected to temporarily increase turbidity in an area within approximately a hundred meters of the borehole. The release of drill cuttings and drilling mud, when used, from a borehole will generally not occur in an area where the local water quality may have already been degraded by other sources, therefore no cumulative effect is expected. At drill sites where multiple offset boreholes are advanced in proximity to each other, turbidity may increase with each successive borehole; however, the overall cumulative effect will be short term and reversible since the suspended particles will tend settle to the seafloor without degrading local water quality significantly.

When the SODV is transiting or dynamically positioned at a drill site, the vessel's engines, propulsion systems, transducer-based equipment, and certain research devices will emit acoustic energy to the marine environment. Even though the SODV has multiple devices that emit acoustic energy underwater, not all sources will emit sound energy simultaneously and transducer-based devices will transmit their energy in narrow beams focused toward the seafloor, thereby minimizing cumulative effects. Generally the source with the highest peak sound level will be the dominant source with little or no cumulative contribution from lesser energetic sources.

Cumulative impacts to marine organisms from SODV acoustic sources may occur from repeated or prolonged exposure to sound sources. It is anticipated that many of the marine organisms that are sensitive to the SODV's acoustic outputs will display avoidance reactions before being exposed to peak sound levels or long-term exposure to continuous sounds. Based on the short-term and intermittent nature of many of the SODV's operations and the mobility of potential receptors, it is highly unlikely that these outputs would disturb marine biota to a degree that would result in chronic disruption of normal behavioral patterns or long-term displacement from preferred feeding or breeding areas. In addition, the relatively short-term nature of the SODV's operations at deep sea drill sites are not expected to significantly combine with acoustical outputs from other vessels and quantitatively increase the background acoustic noise level in the world's oceans.

Seafloor Environment

Analogous to the hundreds of boreholes created for scientific research interests by the IODP's predecessor programs (ODP, DSDP), the proposed drilling and earth sampling activities will, by design, take place over relatively brief periods of time and at select seafloor locations unique for their earth sciences research interests and in water often more than 1,000 m deep. Under these conditions, most of the SODV's riserless drilling activities will take place at sites where the seafloor has not been previously disturbed and therefore minimal risk exists of cumulative impacts to the seafloor or water quality. At sites where multiple offset boreholes will be advanced in proximity to each other, the localized cumulative effect is not expected to adversely impact the seafloor environment or marine biota. Occasionally, an existing borehole may be re-entered to continue coring activities or to support the installation of a completion structure in the borehole. In these cases, the continued activity at the borehole site may result in an additional disturbance to the surrounding environment but the cumulative effect is expected to be minimal.

Benthic organisms are likely to be affected by the deposition of drill cuttings and drilling mud deposited on the seafloor in proximity to a borehole during riserless drilling. Although these benthic organisms may be displaced, partially covered with sediment, or even smothered, the effects will be localized to organisms in the immediate vicinity of the borehole and are not expected to create a cumulative impact on a benthic community or other marine organisms.

There may be a higher probability of a cumulative impact to marine biota if the SODV operates in a biologically sensitive environment. For example, short-term impacts to water quality coupled with deposition of sediment and drilling mud particles on the seafloor may have a greater adverse impact on benthic communities, or other marine biota, than either of the impacts independently. In Alternative A, the resulting cumulative effects could be significant in a sensitive ecosystem. In Alternative B, site-specific will have been identified and mitigating measures designed and incorporated into planned drilling activities to effectively control or prevent disturbances or discharges that may contribute to these types of cumulative effects. In Alternative B, if a riserless drilling expedition were planned in an area where biologically sensitive organisms may be adversely impacted or harmed, a supplemental site-specific environmental review would be performed to evaluate the risks of proceeding with the proposed action and develop recommendations to mitigate unacceptable risks or select alternate sites.

In summary, because the effects to the seafloor environment resulting from riserless drilling activities are relatively unique on spatial and temporal scales of references, no incremental increase to other past, present, and reasonably foreseeable future actions would be expected. Therefore, no significant cumulative effects to the seafloor environment or biological receptors are expected from IODP-USIO riserless drilling activities.

Marine Vessel Transportation and Accidents

The proposed IODP-USIO riserless drilling activities will, by design, take place over relatively brief periods of time and at select marine locations unique for their earth sciences research interests. As the IODP-USIO will utilize just one ship, cumulative impacts to maritime shipping activities are not foreseen in either Alternative A or B. It is highly unlikely that any given commercial or military vessel would be affected by the presence of the SODV multiple times. Regardless, even if there were multiple encounters, each individual encounter is expected to be without conflict. Therefore, no significant cumulative impacts to marine transportation are expected from SODV activities.

Incidents involving the catastrophic release of petroleum hydrocarbons (or other hazardous substances) either from a vessel-related source or a geological source while drilling may also impact maritime shipping operations on a cumulative basis. Based on over 36 years of U.S. scientific riserless drilling, including 21 years experience by the USIO, no major accidental spills have occurred; therefore, there is compelling evidence to suggest that effective procedures have and will continue to be implemented to prevent major accidental spills or releases from the SODV.

The environmental outputs associated with the accidental or catastrophic release of petroleum hydrocarbons from vessel- or geological related sources may be significant and result in major cumulative effects. However, through the use of effective planning, use of best management practices, and mitigating measures, USIO riserless drilling expeditions have avoided these types of events in the past and therefore the probability of major spills or blowouts in the future is extremely low.

4.15 **Impact Summary**

The potential environmental outputs and associated impacts resulting from the proposed operation of the SODV, riserless drilling, and related scientific research activities have been identified and evaluated in this PEIS consistent with National Environmental Policy Act (NEPA) procedures. Table 4-14 identifies the criteria used to evaluate the significance of the potential environmental impacts summarized in Table 4-15.

Table 4-14. Criteria for Assessment of Potential Impacts on the Environment

Impact	Criteria of Assessment			
	Low	**Medium**	**High**	**Very High**
DURATION	*Short term*	*Moderate*	*Long term*	*Permanent*
	Several days to several weeks per drill site; short compared to natural processes	Several months to several years	Decades	Environment will suffer permanent impact
EXTENT	*Local extent*	*Partial extent*	*Major extent*	*Entire extent*
	Action results in an isolated area; impact and confined to the site where the action occurred	Action is isolated but possibly may migrate and affect surrounding area	Initially the action is isolated but likely to migrate and affect surrounding environment	Large-scale impact along the entire transit or study area; migration will cause further impact
INTENSITY	*Minimal Affect*	*Affected*	*High*	*Extensive*
	Natural functions and processes of the environment are not affected	Natural functions or processes of the environment are affected, but on a moderate or short-term basis	Natural functions or processes of the environment are affected and changed	Natural functions or processes of the environment are fully disrupted and adversely impacted
IMPACT PROBABILITY	*Unlikely*	*Possible*	*Likely*	*Certain*
	Impact should not occur under normal operations and conditions	Impact possible but only under certain conditions	Impact likely or probable to occur during vessel operations or drilling activities	Impact inherent to the proposed action and unavoidable
SEVERITY RATING	**0** = No adverse impact; does not exceed threshold criteria or can be eliminated or reduced below threshold criteria	**1** = Short term, local effect that ceases immediately after the vessel leaves a particular drill site **2** = Short term, local effect that continues for a limited period of time after the vessel leaves a particular drill site	**3** = Long term, local effect	**4** = Substantial effects that may be realized on a major (regional) and long-term basis

Note: Affected environment may include water quality, sea bottom and sediment quality, air quality, acoustical environment, biological resources (including sensitive areas and fisheries), marine transportation, and cultural resources

Table 4-15. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
Operate the SODV (vessel in transit and at a drill site using thrusters for dynamic positioning; note: impacts associated with drilling and coring activities are summarized below)	Discharges (treated wastewater, greywater, treated bilgewater, deck drainage, ballast water, treated lab discharges)	Water Quality	Short term	Local	Minimal	Unlikely (A,B)	1
		Seafloor	No environmental impacts				0
		Biological Resources					
		Typical	Short term	Local	Minimal	Unlikely (A,B)	2
		Sensitive Areas	Long term	Local	Minimal	Possible (A)	3
			Short term			Unlikely (B)	2
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
	Physical Disturbances	Water Quality	Short term	Local	Minimal	Unlikely (A,B)	1
		Seafloor	No environmental impacts (A,B)				0
		Marine Traffic	Short term	Local	Minimal	Unlikely (A,B)	1
	Underwater Noise (operation of vessel engines, generators, thrusters, mechanical systems, instruments, transponder beacons)	Acoustical Environment	Short term	Local	Minimal	Unlikely (A,B)	2
		Biological Resources					
		Typical	Short term	Local	Minimal	Unlikely (A,B)	1
		Sensitive Areas	Long term	Local	Minimal	Possible (A)	2
			Short term			Unlikely (B)	1
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
	Air Emissions • exhaust, vapors	Air Quality	Short term	Local	Minimal	Unlikely (A,B)	1
	• laboratory	Air Quality	Short term	Local	Minimal	Unlikely (A,B)	1
	Hazardous Materials (storage & use)	Vessel Crew & Resources	Continuous	(Not Applicable)	Minimal	Unlikely (A,B)	0

Table 4-15. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
	Solid & Hazardous Waste (handling, storage, incineration)	Vessel Crew & Resources	Continuous	(Not Applicable)	Minimal	Unlikely (A,B)	0
Conduct Riserless Drilling and Coring (in addition to impacts associated with the operation of the SODV)	Discharges (seawater drilling fluid, sediment displaced from the borehole, drilling mud, cement, tracers)	Water Quality	Short term	Local; seawater drilling fluid injected into the borehole at ≤ 1,900 L/min; suspended fine grain particles may extend 100^{+} m from the borehole	Minimal	Certain (A,B)	2
		Seafloor	Short term	Local; fine grain particles deposited within 100 m of the borehole	Minimal	Certain (A,B)	2
		Biological Resources					
		Typical	Moderate	Local; benthos & fish eggs/larva may be displaced	Minimal	Possible (A,B)	2
		Sensitive Areas	Long term	Local; habit may be disturbed	Moderate	Possible (A)	3
						Unlikely (B)	3
		Fisheries	Short term	Local; fish may be displaced	Minimal	Possible (A)	2
						Unlikely (B)	2
		Cultural Resources	Long term	Local; sediment deposition	Minimal	Unlikely (A)	3
						Highly Unlikely (B)	3
	Physical Disturbances	Water Quality	No environmental impacts (A,B)				0
		Seafloor	Long term	Local; drill cuttings mound within ~5 m of borehole	Minimal	Certain (A,B)	3
		Biological Resources					

Table 4-15. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
		Typical	Moderate	Local; benthos may be displaced or smothered	Minimal	Possible (A,B)	3
		Sensitive Areas	Moderate	Local; benthos may be displaced or smothered	Moderate	Possible (A)	3
						Unlikely (B)	3
		Fisheries	Moderate	Local	Minimal	Possible (A)	3
						Unlikely (B)	3
		Marine Traffic	Short term	Local	Minimal	Unlikely (A,B)	1
		Cultural Resources	Long term	Local; damage or alteration	Minimal	Unlikely (A)	3
						Highly Unlikely (B)	3
	Underwater Noise (operation of vessel engines, generators, thrusters, mechanical systems, instruments, transponder beacons, drilling/coring)	Acoustical Environment	Short term	Local	Minimal	Unlikely (A,B)	2
		Biological Resources					
		Typical	Short term	Local	Minimal	Unlikely (A,B)	1
		Sensitive Areas	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
Conduct Research Activities (geophysical logging, downhole measurements)	Discharges (none)	Water Quality	No environmental impacts (A,B)				0
		Seafloor	No environmental impacts (A,B)				0
		Biological Resources					
		Typical	No environmental impacts (A,B)				0
		Sensitive Areas	No environmental impacts (A,B)				0
		Fisheries	No environmental impacts (A,B)				0
	Underwater Noise (small seismic sources)	Acoustical Environment	Short term	Local	Minimal	Unlikely (A,B)	2

Table 4-15. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts: Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
		Biological Resources					
		Typical	Short term	Local	Minimal	Possible (A,B)	1
		Sensitive Areas	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
		Fisheries	Short term	Local	Minimal	Possible (A)	2
						Unlikely (B)	1
Complete Boreholes and Install Equipment	Releases/Discharges (heavy drilling mud for borehole closure, cement for casings and borehole seal, deployment of reentry devices, observatories and instruments)	Water Quality	Short term	Local	Minimal	Unlikely (A,B)	2
		Seafloor	Long term	Local	Minimal	Likely (A,B)	3
		Biological Resources					
		Typical	No environmental impacts (A,B)				0
		Sensitive Areas	No environmental impacts (A,B)				0
		Fisheries	No environmental impacts (A,B)				0
Accidental Events	Discharges (petroleum hydrocarbons from major fuel spill from the vessel; liquids and/or gases from blowout caused by drilling into geological source)	Air Quality	Short term	Local (petroleum vapors, geologic gasses)	Severe	Highly Unlikely (A,B)	2
		Water Quality	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Seafloor	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Acoustical Environment	No environmental impacts (A,B)				0
		Biological Resources					
		Typical	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Sensitive Areas	Long term	Major	Severe	Highly Unlikely (A,B)	4

Table 4-15. Summary of Potential Impacts from IODP-USIO Riserless Ocean Drilling

Process/Activity	Output	Affected Environment	Environmental Impacts				
			Duration	Extent	Intensity	Probability of an Impact (Alternative)	Severity Rating
		Fisheries	Long term	Major	Severe	Highly Unlikely (A,B)	4
		Marine Traffic	Long term	Major	Severe	Highly Unlikely (A,B)	4

Notes: **Severity Ratings: 0** = no impact; **1** = minimal local effect that ceases immediately after the vessel leaves a particular drill site; **2** = minimal local effect that continues for a limited period of time after the vessel has left a particular drill site; **3** = minimal local long-term effect; **4** = substantial effects that may be realized on a major (regional) and long-term basis.

In conclusion, the scope of this environmental impact statement focused on the programmatic implementation of riserless ocean drilling activities by the IODP-USIO to support scientific research. The findings indicate that a majority of the outputs associated with the performance of riserless drilling expeditions in either Alternative A or B would have minor and transitory effects on the environment.

Most impacts associated with the proposed action would be highly localized and would disappear once the vessel completes drilling activities at a particular site and leaves the area. Many of the outputs associated with the operation of the modernized *JOIDES Resolution*, exclusive of drilling outputs, such as wastewater discharges, air emissions, noise from propulsion equipment and transducer-based equipment are common to most merchant marine vessels. Some outputs associated with riserless drilling activities (seafloor disturbance, deposition of sediment drill cuttings, deployment of equipment or materials) may remain evident on the seafloor after borehole drilling is complete on a long-term basis; however the effects on the benthic environment would be minor. Using 30 years of riserless drilling experience, the IODP-USIO will continue to refine and implement various best management practices to mitigate adverse impacts to marine organisms and the physical environment.

The potential scientific benefits of the proposed operation of the SODV including riserless drilling and related research activities are known to be substantial. The knowledge that will be gained from the scientific research will far outweigh the relatively localized and minor impacts to the marine environment.

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5.0 OTHER NEPA-RELATED ISSUES

5.1 Environmental Effects of the Proposed Action that Cannot be Mitigated

A detailed analysis of the environmental impacts associated with the proposed action including the operation of the SODV, performance of riserless drilling activities, collection of core samples, and the implementation of associated research activities was presented in Section 4 of this document. The impact analysis concludes that a majority of the environmental effects associated with SODV riserless ocean drilling operations would be minor and transitory. All other potential impacts would be reduced to less than significant levels through the judicious selection of drill sites and the application of proven mitigating measures. Therefore, on a programmatic level, implementation of proposed action, Alternative B, is not expected to cause significant adverse impacts to the marine environment.

The seafloor will definitely be disturbed by the proposed riserless ocean drilling activities resulting from the discharge of borehole drill cuttings and the occasional release of drilling mud and the deployment of research-related devices (e.g., observatories). Although these seafloor disturbances will be unavoidable, in the context of the marine environment, the extent of the disturbances at each drill site will be highly localized, minor, and will not significantly affect the seafloor topography.

The SODV will unavoidably produce various acoustical outputs to the underwater marine environment resulting from the vessel's engines, thrusters, transducer-based equipment, and various research activities. Although the nature and intensity of each acoustical output may change depending upon the operation being performed, collectively the SODV's acoustical outputs will add to the background noise level typically present in the marine environment. However, all marine vessels have acoustical outputs some of which are more intense than the noise produced by SODV operations and yet do not adversely affect the marine environment. Based on the short-term (hours and days) nature of the SODV's acoustic outputs at each drill site and realizing that many potential biological receptors are likely to exhibit avoidance reactions to harmful sound levels, the effects of the SODV's acoustic outputs are expected to be reversible and not significantly expose biological receptors to intense sound levels causing long-term adverse effects.

At each drill site biological receptors, if present in the vicinity of the borehole during drilling will be affected by suspended solids (turbidity) in the water column or the deposition of drill cuttings and drilling mud on the seafloor. In particular, benthic organisms may experience interference with feeding and respiratory activities or may be smothered by the deposition of the drill cutting on the seafloor. These effects are expected to be localized in proximity to the borehole and only affect individual organisms rather than entire populations.

Biological impacts resulting from SODV operations and riserless drilling activities are more pronounced in areas where extremely sensitive biological communities may be present. For example, riserless drilling activities that alter the seafloor substrate, increase turbidity, and deposit sediment cuttings or drilling mud on the seafloor near chemosynthetic communities, coral reefs, or seamounts may impact unique species which may be unable to successfully recover from these outputs. However, measures would be taken during the planning process for each expedition to identify sensitive areas near proposed drill sites and recommend measures including the use of alternate sites to minimize or eliminate potentially adverse and irreversible impacts. Supplemental environmental reviews may be performed if site-specific conditions warrant further evaluation of potential impacts that could be caused by proposed drilling activities. Overall, it is not anticipated that the proposed riserless drilling operations and related research activities will significantly injure or permanently change biological communities in proximity to the drill sites.

Although the risk of a catastrophic release of petroleum hydrocarbons from the drillship or from a geological source while drilling is extremely low, the threat of such an event cannot be eliminated. If a catastrophic release of petroleum hydrocarbons were to occur, water quality, sediment, coastal areas, and biological receptors could be affected on a regional and long-term basis. The planning, procedural, and operational factors which have resulted in the IODP-USIO successfully conducting scientific drilling activities for over 30 years without a major event involving the release of petroleum hydrocarbons will continue during future IODP-USIO drilling expeditions; therefore no significant impacts from catastrophic events are expected.

5.2 Irreversible/Irretrievable Commitment of Resources

Scientific ocean drilling is an essential component of modern geoscience research and education. Its broad use as a scientific tool ranges from investigating the causes of change in the Earth's climate to the rifting and drifting of continents. Drilling is the primary method of sampling sediment and crustal rock from the large percentage of the Earth's surface covered by oceans, and is the only technique for sampling anything more than a few tens of meters below the ocean floor.

The DSDP, which began in 1968 under NSF sponsorship, served as a test of the plate tectonic hypothesis and a basic reconnaissance of deep-sea sediments and crustal rocks. In 1974, the DSDP became an international program, with several European nations, Japan and the USSR entering into an agreement with NSF for providing scientific and financial participation.

The DSDP was followed in 1983 by the ODP which formally ended in 2003 and which focused on examination of earth, ocean and climate processes. Since its inception, approximately 700 U.S. scientists from 150 universities, government agencies, and industrial research laboratories have participated in ODP cruises. Samples and data have been distributed to an additional 700 to 800 U.S. scientists. International participation in planning, research and funding of operations has grown from an initial five countries in DSDP to over 20 nations in ODP.

For both DSDP and ODP, NSF provided the primary facility by contracting and converting an industry drillship for scientific drilling, the *Glomar Challenger* for the former, and the *JOIDES Resolution* for the latter. Both vessels served as facilities to carry out investigations proposed by the scientific community over the course of each program. The proposals, submitted to the ODP international advisory structure, were evaluated and ranked by panels of science experts, and those with the greatest scientific merit were scheduled for drilling operations. The ODP was structured such that formal agreements between NSF and international partners terminated at the end of 2003.

The IODP builds upon the achievements of the predecessor programs and expands on their scientific scope based on the "Earth, Oceans and Life: Scientific Investigations of the Earth System Using Multiple Drilling Platforms and new Technologies; Integrated Ocean Drilling Program Initial Science Plan, 2003 – 2013 (http://www.iodp.org/isp/). The plan identifies the need for two dynamically positioned drillships, the use of "mission specific" drilling platforms, new sampling and downhole measurement technologies, and long-term observatories for borehole experiments and time series studies of active processes.

NSF and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan have agreed to co-lead IODP which began in FY2004. MEXT has finished construction of a heavy drillship with riser capability to address deep drilling objectives in the new program. Their vessel, the *Chikyu*, was launched in January 2002, and will be available for IODP operations in late 2007. European plans are to provide additional "mission specific" drilling capability for shallow water and Arctic objectives and up to one third of program operating costs. NSF will provide a riserless drilling vessel as the U.S. contribution to IODP. The new SODV is expected to be available in 2008.

The drillships, facilities, and operations will be used to address scientific research programs identified in the ISP. The scientific plan for the IODP is the result of an extensive, international collaborative effort, and will encompass three principal scientific themes: (1) the Deep Biosphere and the Subseafloor Ocean, (2) Environmental Change, Processes, and Effects, and (3) Solid Earth Cycles and Geodynamics. Program initiatives and proposals supporting each of these themes will serve as a focus for scientific investigation. Recommendations for specific drilling activity and required science services will be provided by SAS. The SAS is an international committee structure representing the scientific communities in member countries and organizations of the IODP. These recommendations will result in an annual science plan. Progress in the IODP ISP will require access to global samples of sediments, rocks, fluids and biota buried at great depths below the seafloor. The effort will also include in situ geophysical measurements or emplacement of instrumentation for long term monitoring in deep seafloor boreholes. As with ODP, all member countries in IODP will support scientific drilling operations, and each member country will be required to independently provide support for the research effort of its scientists participating in the program. In ODP, elements of this support were provided through the Cooperative Agreement with Consortium for Ocean Leadership, Inc for the U.S. Science Support Program. The U.S. Science Support Program will continue to provide support for U.S. scientists to participate in IODP.

Within this framework, U.S. participation in the IODP includes the following long-term commitment of personnel, equipment, and financial resources.

5.2.1 Consortium for Ocean Leadership

The NSF has awarded a contract to the Consortium for Ocean Leadership, Inc. (formerly the Joint Oceanographic Institutions, Inc.) in alliance with Texas A&M University and the Lamont-Doherty Earth Observatory of Columbia University to operate a scientific drillship as part of the IODP. The contract has an estimated cost of $626 million over 10 years. The contract names the alliance as the system integration contractor, responsible for program management; planning for scientific services and drillship operations; drilling, coring, and logging of seafloor sediments and crustal rock; collecting, analyzing, storing, curating, and disseminating data, samples and results; and science education and outreach.

5.2.2 Integrated Ocean Drilling Program Management International

The NSF has awarded a contract to Integrated Ocean Drilling Program Management International, Inc. (IODP-MI) for central management and planning for the IODP. IODP-MI will also coordinate and support program data archiving, sample archiving, publishing activities, education and outreach. The contract has an estimated cost of $429 million over 10 years. The Japanese Ministry of Education, Culture, Sports, Science, and Technology will consult with NSF in contract management.

This contract represents the final major step in the implementation of the IODP, the largest international earth science program in history. It is the culmination of many years of planning efforts by international scientists to have strong, centralized management and control over science operations in this new drilling program. The IODP will use a variety of drilling platforms to help solve major problems, including the history of global climate change, the origin of damaging earthquakes, and the origin of life and extent of subsurface microbial activity.

IODP-MI is a non-profit, U.S. corporation, recently formed by 15 U.S. and seven Japanese leading institutions in the geosciences. It is expected that an additional eight institutions from Europe will join this corporation shortly. IODP-MI will plan and coordinate the efforts of the IODP science operators and drilling platforms. The core drilling platforms consist of an all-purpose, U.S. light drillship and the 57,500-ton heavy drillship Chikyu, recently constructed by Japan and oriented towards deep crustal drilling in harsh environments. These drillships will be augmented by "mission-specific" platforms, used for drilling in shallow or Arctic waters and sponsored by a consortium of European countries.

IODP is an international program of basic research that succeeds the Deep Sea Drilling Project (1968-1983) and the Ocean Drilling Program (1983-2003). IODP differs from these programs in having multiple drilling platforms and equal partners in program contributions (the United States and Japan). IODP also differs from other large international science programs in that contributions are not "in-kind" but are instead managed centrally under contract.

5.2.3 U.S. Science Support Program Associated with the Integrated Ocean Drilling Program

It is the intent of NSF's Division of Ocean Sciences (NSF-OCE), within available resources, to provide robust and effective participation of the U.S scientific community in all phases of the IODP. The mission of the U.S. Science Support Program (USSSP) is to support involvement of the US scientific community in the IODP. The U.S. Science Support Program is managed by Consortium for Ocean Leadership, Inc for the NSF-OCE under a Cooperative Agreement with $15M projected total funding. Support for the Cooperative Agreement will be for 6.5 years, the duration of the IODP. The U.S. Science Support Program is structured into six broadly defined objectives:

- Support travel and salary for U.S.-based scientists to participate in IODP drilling expeditions and post-expedition activities;

- Support planning activities such as thematic workshops and results symposia to develop concepts for future ocean drilling expeditions, and support US participation in the international SAS of IODP;

- Encourage advanced activities that further the development of ocean drilling proposals and expeditions. Examples of such "pre-drilling" activities are participation in site surveys or analysis of ancillary data sets;

- Development or refinement of unique or innovative instrumentation for core or borehole analysis and downhole experiments;

- Develop educational and community engagement programs that expose the U.S. populace, especially students and educators, to the science arising from ocean drilling research;

- Establishment of an effective national advisory committee to interact with the U.S. and international scientific communities and the NSF, and to disseminate results and encourage wide and multidisciplinary participation of research scientists in IODP.

The support provided through USSSP-IODP is intended to complement the direct support to the scientific community that NSF will provide through its grants program in response to unsolicited proposals. The nature and development of the USSSP-IODP is based, in large part, on the recommendations provided in the report: *"Conference on U.S. Participation in IODP* (CUSP)" (http://www.joi-odp.org/USSSP/Default.html) prepared by the ODP - U.S. Advisory Committee (USAC). The U.S. scientific community has long played a strong leading role in scientific ocean drilling, in terms of planning activities, drilling operations, and producing important scientific results. Responsibility for that success has been in large part due to the effectiveness of the existing U.S. Science Support Program in ODP. USSSP-IODP is intended to further that tradition in IODP. The anticipated funding amount for the cooperative agreement is $65,000,000 for the period FY 2007 through FY 2013, pending availability of funds.

5.3 Scientific Benefits of the Proposed Action

5.3.1 The Deep Biosphere & the Subseafloor Ocean

Extensive Microbial Populations Beneath the Deep Seafloor
Sampling deep within the marine sedimentary section and in basaltic crust has revealed what appears to be a diverse and often very active microbial ecosystem. Recent sampling efforts have demonstrated that uncontaminated samples of these microbes can be recovered for laboratory study.

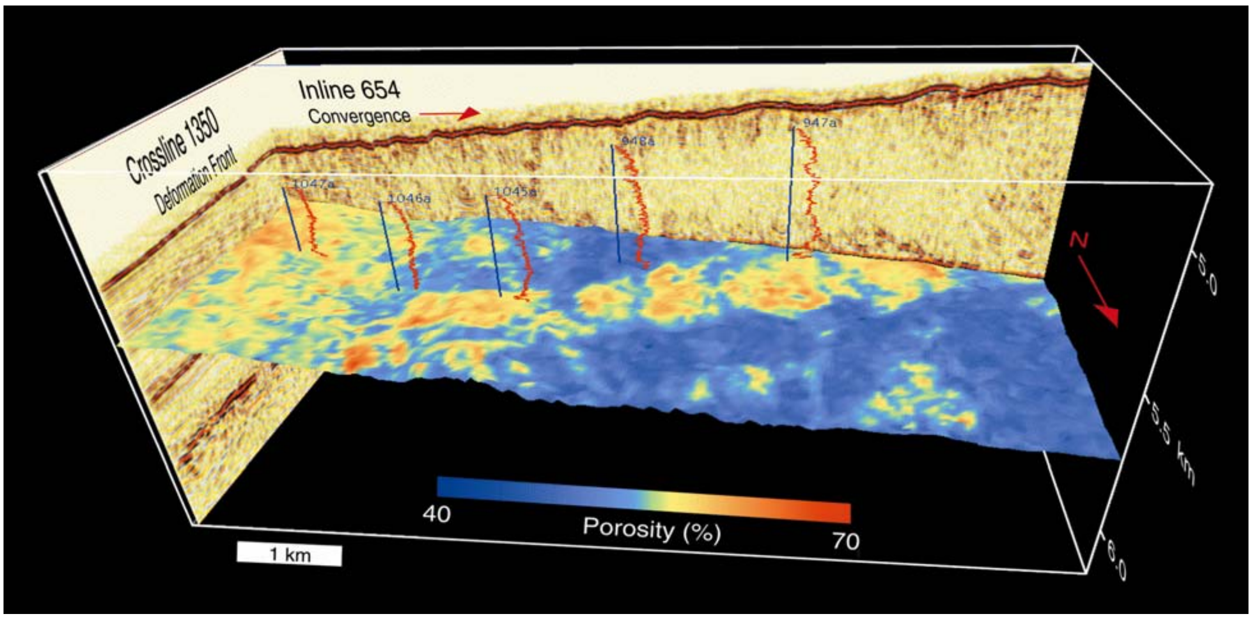
Frozen Methane Reservoir Beneath the Seafloor
Extensive reservoirs of gas hydrates beneath the seafloor have been sampled by ocean drilling, providing valuable information regarding their possible impacts on the global

carbon budget, submarine slope stability and their resource potential. Currently, only IODP technology is capable of retrieving and maintaining gas hydrates samples from the subseafloor marine environment at in situ pressures.

Fluid Pressure and Discharge along Main Thrust Fault Zones

Drilling through the décollement and related thrust faults at convergent plate boundaries has confirmed three-dimensional seismic observations that fluids actively flow along the slip zone. These fluids have distinctive geochemical signatures and are likely involved in the mechanics of thrust faulting (Figure 5-1).

Figure 5-1. Barbados Ridge Three-dimensional Seismic Reflection Data



A perspective view of the Barbados Ridge three-dimensional seismic reflection data volume acquired in 1992. Crossline and inline profiles are shown on the east and south faces of the volume. The décollement surface at the base of the accretionary wedge is also shown, with colors representing porosity estimated from the seismic reflection data and calibrated with ODP Legs 156 and 171A logging-while-drilling logs. Vertical black lines are boreholes and red lines are corresponding density logs. High porosities, and presumably high fluid pressures, extend from the deformation front along a semi-continuous, NE trending zone interpreted to be a major fluid conduit. Figure reprinted from Bangs, N. L., T. H. Shipley, J. C. Moore, and G. F. Moore, Jour. of Geophys. Res., 104, 20,399-20,414, 1999, Plate 4, p. 20,412.)

Hydrothermal Fluid Flux in the Upper Oceanic Crust

Drilling of marine sedimentary and crustal sections is beginning to determine the sources, pathways, compositions and fluxes of fluids associated with mineralization within active submarine hydrothermal systems, and the influence of fluid circulation on ocean chemistry, crustal alteration and the crustal biosphere.

5.3.2 Environmental Change, Processes and Effects

Development of the Field of Paleoceanography
The near-global network of continuous stratigraphic sections obtained by ocean drilling is the foundation of the field of paleoceanography. Paleoceanographers study changes in the life, chemistry and surface, intermediate and deep circulation of the oceans through time. Paleoceanography provides the reference frame for nearly all other investigations of global environmental change.

Orbital Variability during the Cenozoic
By linking the record of climatic variation preserved in deep-sea sediments to calculated variations in Earth's orbital parameters, scientists have demonstrated the role of orbital variability in driving climate change.

Development of High-Resolution Chronology
Complete recovery of fossiliferous marine sedimentary sections has greatly facilitated linking Earth's geomagnetic polarity reversal history to evolutionary biotic changes and to the isotopic composition of the global ocean. Also of great significance is the orbitally tuned determination of time within marine sections, which has resulted in a greatly refined calibration of the Geomagnetic Polarity Time Scale back to 30 Ma. This newly calibrated, globally applicable time scale is crucial for determining rates of processes operating in every aspect of the terrestrial and marine geosciences.

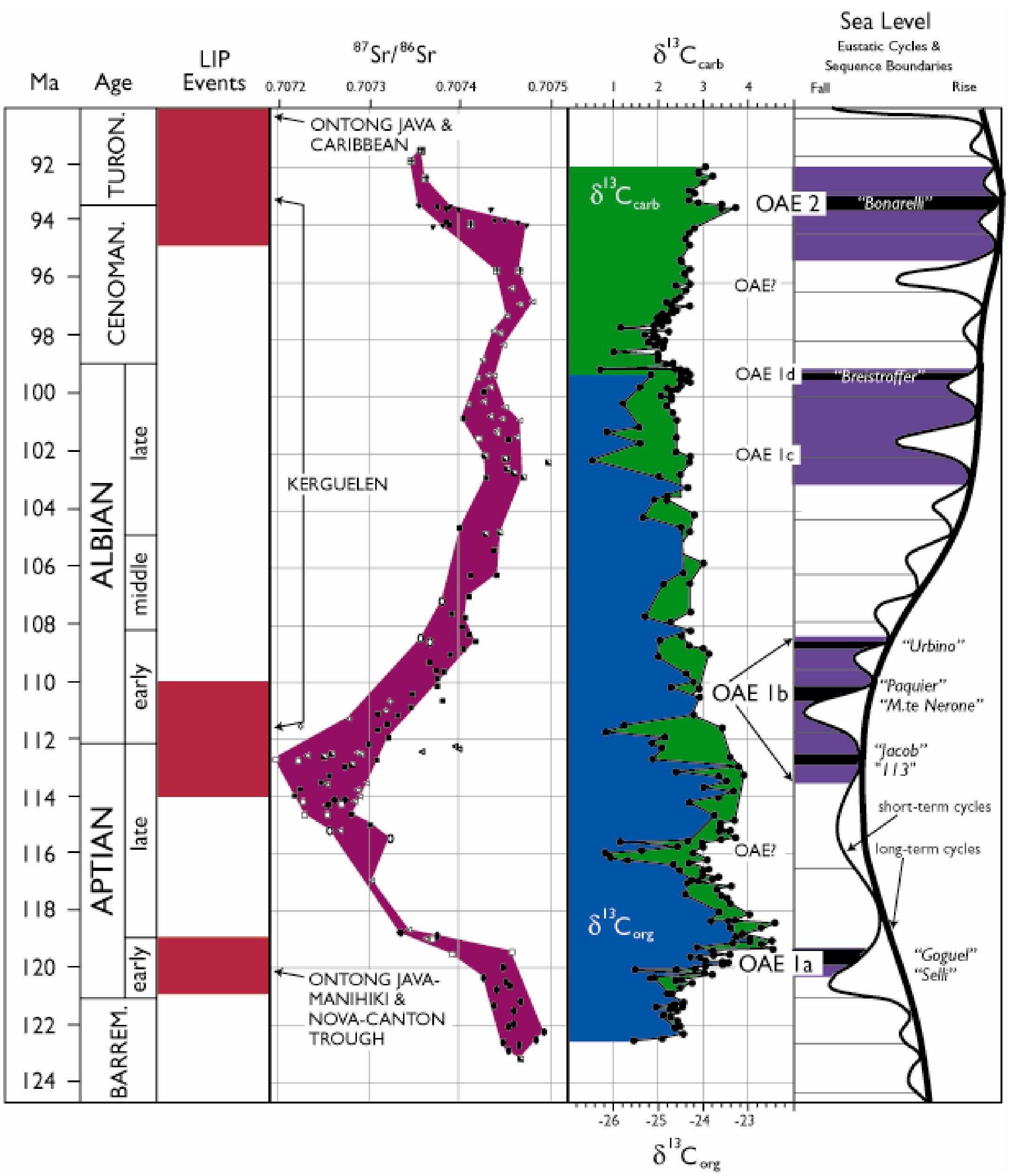
Ocean Circulation Changes on Decadal to Millennial Time Scales
The record preserved in marine sediments and recovered by ocean drilling has clearly demonstrated that deep- and surfaceocean circulation is variable on decadal to millennial time scales, confirming results from ice cores. This body of marine-based data has provided the evidence linking ocean-atmosphere-cryosphere interactions in and around the high-latitude North Atlantic to instabilities in thermohaline circulation, which propagates abrupt climate change to the farthest reaches of the globe.

Ocean Biogeochemical Cycles
The concept of Earth System Science has evolved with detailed analyses of the relatively complete deep-sea sedimentary sections recovered by ocean drilling. These studies have revealed major changes in biogeochemical cycling through time, especially in the complex carbon cycle, resulting from evolutionary changes in the biota, tectonic changes, changes in climate, variations in seafloor hydrothermal activity, and major alterations in ocean circulation.

Global Oceanic Anoxic Events

Deep-sea sediments exhibit specific times when the surface water productivity of large areas of the ocean was unusually high. At these times, the global ocean developed zones of depleted oxygen content, and vast amounts of organic carbon were incorporated and preserved in marine sediments as black shales. Scientific ocean drilling has provided insights into oceanic anoxic events, which are a key to understanding short- and long-term perturbations in global climate and carbon cycling, as well as the timing of significant petroleum source-rock deposition (Figure 5-2).

Figure 5-2. Mid-Cretaceous Record of Major Black Shales and Oceanic Anoxic Events



The mid-Cretaceous record of major black shales and Oceanic Anoxic Events (OAEs) in the context of the carbon isotopic record, changing global sea level and seawater chemistry, and emplacement history of Large Igneous Provinces (LIPs). Data are from both land-based sections and DSDP/ODP deep-sea cores. Organic matter production and preservation during the mid-Cretaceous appears to be closely related to submarine volcanism and hydrothermal activity, which may have stimulated productivity through the input of nutrients, particularly trace elements such as iron. Increased hydrothermal output during LIP emplacement may thus be linked to the three major OAEs. As a result of ocean drilling, the chrono-stratigraphic and biostratigraphic control on deep-sea sections has greatly improved, enabling better temporal resolution of geological processes. Figure compiled by Mark Leckie, University of Massachusetts, Amherst.

Vast Sand Deposits in Deep Water
Drilling has confirmed that the construction of deep-water fan systems, such as that off the Amazon River, are controlled largely by changes in sea level. The hydrocarbon industry is intensively exploring deep-water sand "plays" contained in these fan systems for their proven economic potential.

Timing of Ice-Sheet Development in Antarctica and the Arctic
Drilling has revealed that Earth's entry into its current Ice Age extended over 50 m.y. and involved a complex history of uni-polar, then bi-polar, ice-sheet buildup. Ice streams reached the Antarctic seas as early as 40 Ma, but major ice-sheet formation on Antarctica apparently did not occur until some 25 m.y. later. Northern hemisphere ice sheets did not begin to develop until sometime after 15 Ma, and major northern hemisphere continental glaciations did not start until after 4 Ma. This extended period of climate change appears to have occurred in relatively rapid steps, each associated with major tectonic changes that affected both atmospheric and oceanic circulation.

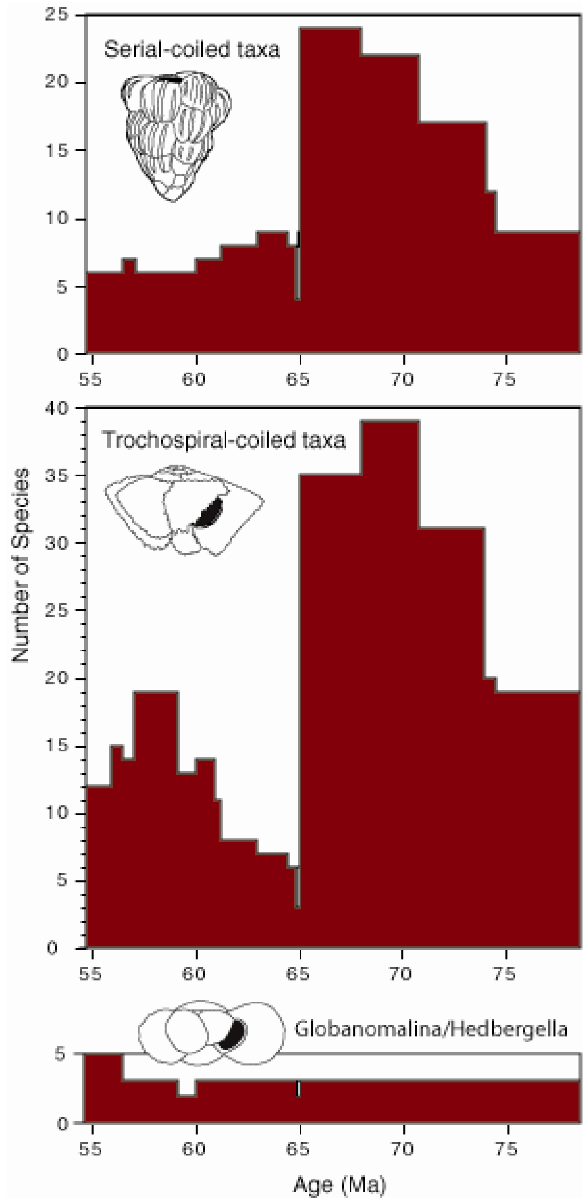
Sea-Level Change and Global Ice Volume
Marine sediments recovered from shallow water areas have shown that important global sea-level changes have occurred synchronously through at least the past 25 m.y., and that these changes can be matched to oxygen isotope records of climate produced from the deep sea. The new understanding of global eustacy has become a primary interpretative tool in unraveling the history of continental margin growth and in the search for hydrocarbons in margin settings.

Uplift of the Himalayas and the Tibetan Plateau
Drilling in both the Indian and Pacific Oceans has helped to establish the timing of the Tibetan Plateau uplift, and to determine change in coastal upwelling, carbon sequestration, and regional and global climate associated with this tectonic event. Drilling results have shown that the onset and development of both the Indian and Asian monsoons are the result of climate change associated with this uplift.

Impact Events and Biological Evolution

Drilling has established the global effects of a major bolide collision with Earth at approximately 65 Ma, including the extinction of as much as 90 percent of all planktonic organisms, and the subsequent repopulation of plankton in the global oceans from a few surviving species (Figure 5-3).

Figure 5-3. Species Diversity Across the Cretaceous-Tertiary Boundary



Species diversity across the Cretaceous-Tertiary boundary for three large groups of planktic foraminifera. Diversity increases rapidly during the ~5-10 m.y. before the boundary then plummets at the extinction. There is a modest rebound of diversity in the first 5 m.y. of the

Paleocene. Species diversity reaches late Cretaceous values about 10-15 m.y. after the impact and mass extinction. Figure courtesy of Richard Norris, Woods Hole Oceanographic Institution.

Desiccation of the Mediterranean Ocean Basin
Drilling demonstrated that the deep Mediterranean basins were sites of salt deposition as recently as ~5 Ma when flow into the basin was restricted and the level of the waters within the basin fell hundreds of meters through evaporation.

Environmental Controls on Growth and Demise of Carbonate Platforms
Drilling has illuminated the development and abrupt demise of large carbonate platforms along with their response to changing climate, sea level, oceanic circulation and gradual movement of the lithospheric plates.

5.3.3 Solid Earth Cycles & Geodynamics

Validation of Plate Tectonic Theory
Dating of igneous basement rocks and overlying sediments recovered by scientific ocean drilling has demonstrated that the age of the oceanic crust increases systematically away from ridge crests, validating a fundamental prediction of plate tectonic theory.

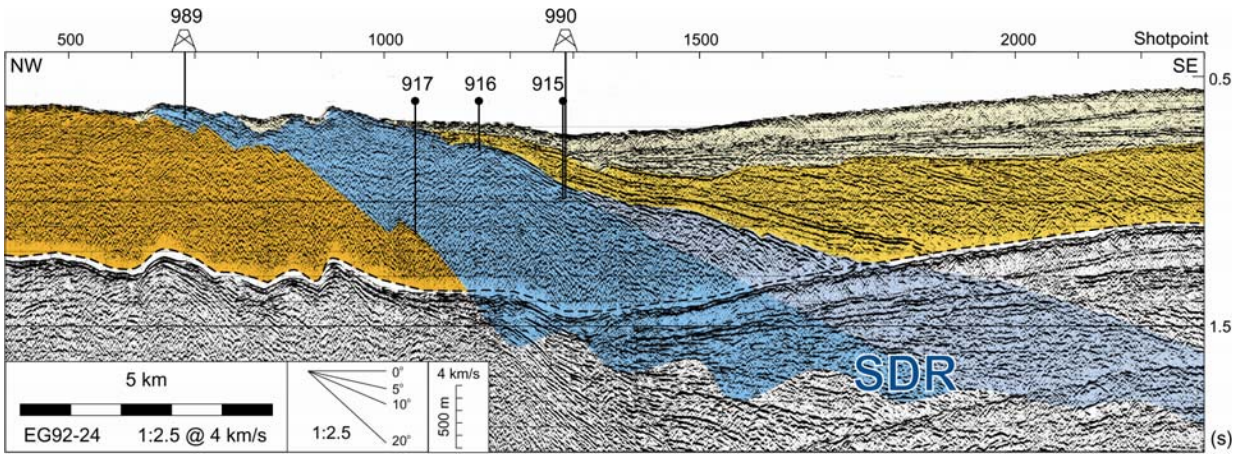
Non-volcanic Passive Margin Evolution and Alpine Geology
Drilling results and seismic data from the Iberian passive rifted margin have facilitated the development of new rifting and extensional deformation models of the continental crust where there is little attendant volcanism. These models imply nearly amagmatic thinning of the crust, with attendant widespread exposure of mantle rocks, a very different process than occurs on magma-rich margins. Rifted margin structure and stratigraphy strikingly similar to those found on the western Iberian margin have been identified in the Alps.

Large Igneous Provinces: Origin of Oceanic Plateaus
Drilling of two oceanic plateaus, which reach diameters of 2000 km and crustal thicknesses of 35 km, has established that their uppermost crust consists of basaltic lava flows with individual thicknesses of up to a few tens of meters. Major portions of these two plateaus were emplaced in geologically short time spans of a few million years or less, and may be the product of rising mantle plume "heads." Accretion of such plateaus to continental margins constitutes a form of continental growth by a mechanism not predicted by standard plate tectonic theory.

Large Igneous Provinces Associated with Continental Breakup: Volcanic Margins
Drilling has established that seaward-dipping reflections identified on multichannel seismic reflection data from many passive continental margins consist of vast subaerial outpourings of lavas rapidly emplaced during the time of final continental separation and

the initial formation of ocean basins. In some instances, enhanced melt production can be related to mantle plume heads thousands of kilometers wide, but other instances appear unrelated to known plumes (Figure 5-4).

Figure 5-4. High Resolution Seismic Image of the SE Greenland Margin



High-resolution seismic image of the inner part of the seaward-dipping reflections (blue) on the SE Greenland Margin. Subaerially emplaced basalts were recovered in five holes drilled during ODP Legs 152 and 163. The entire volcanic sequence was penetrated by Hole 917, bottoming in pre-breakup age sediments (orange). The average P-wave velocity of the basalt pile is 4 km/s, giving a 2.5 times vertical exaggeration of the profile. Figure courtesy of Sverre Planke, Volcanic Basin Petroleum Research, and is based on Planke, S., and E. Alvestad, 1999, Seismic volcanostratigraphy of the extrusive breakup complexes in the northeast Atlantic: Implications from ODP/DSDP drilling, ODP Sci. Res., 163, 3-16.

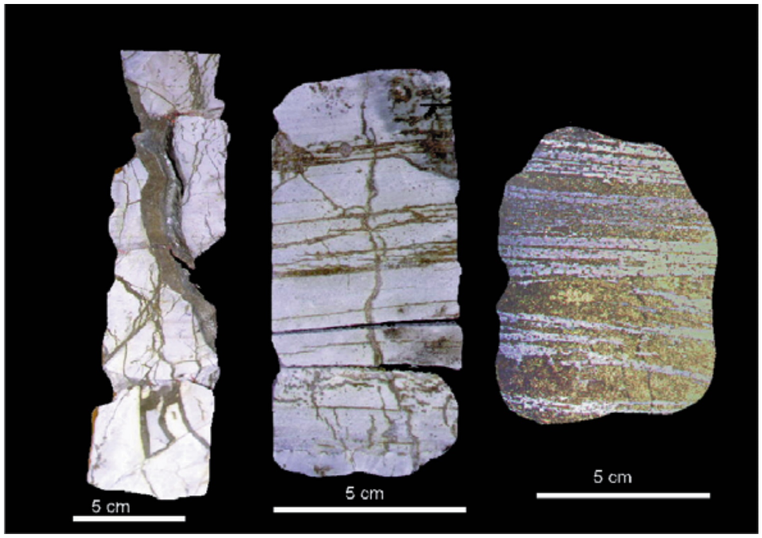
The Oceanic Crust

To date, knowledge of the oceanic crust and shallow mantle has been largely restricted to geophysical observations, seafloor dredge samples and ophiolite studies. Limited ODP drilling into the oceanic mantle and principal crustal layers partly confirms models derived from these earlier studies, but also reveals major discrepancies that will change the estimates of the flux of heat and mass between mantle, crust and oceans over the last 250 million years. ODP drilling results have also challenged the assumption, critical to estimating the composition and volume of the oceanic crust, that seismic structure and igneous stratigraphy can be directly correlated.

Massive Sulfide Deposits

Drilling into two actively forming volcanic- and sediment-hosted metal sulfide deposit sites has established that seafloor sulfide deposits are direct analogs with on-land massive sulfide deposits, in terms of ore-forming process, and with respect to size and grade of mineralizations. New insights gained by ocean drilling may aid in land-based mineral exploration (Figure 5-5).

Figure 5-5. ODP Cores from the Northeast Pacific Ocean



ODP cores recovered in a sedimented ridge crest in the Northeast Pacific Ocean are examples of feeder zone and deep copper zone mineralization below the Bent Hill massive sulfide deposit. Left: Predominantly vertical crack-seal veins filled with pyrrhotite and Cu-Fe sulfide in altered turbiditic mudstone (856H 24R-1 50-70 cm, 134 mbsf). This style of mineralization is characteristic of the upper feeder zone underlying the center of the hydrothermal upflow zone. Center: Less intense feeder zone mineralization underlying the south flank of the Bent Hill massive sulfide deposit. Mineralization consists of simple vertical and horizontal veins filled with pyrrhotite, sphalerite and Cu-Fe sulfide in graded fine sand to silt turbidites. Mineralization also occurs as subhorizontal replacement and disseminations along bedding planes (1035F 12R-2 43-55 cm, 112 mbsf). Right: Deep copper zone mineralization in cross-laminated turbiditic sandstone. Replacement of rock by Cu-Fe sulfide mimics original cross lamination; the matrix is extensively recrystallized to silver-gray colored chlorite and quartz (856H 31R-1, 99-107 cm, 202 mbsf). (Photo courtesy of Robert Zierenberg, University of California, Davis.)

Convergent Margin Tectonics and Subduction Recycling

Strikingly different styles of convergent margin tectonics have been imaged by seismic data and constrained by scientific drilling, ranging from dominantly accretion to the overriding plate, to subduction of most trench sediment, to erosion at the base of the overriding plate. Drilling of down-going slabs and comparison with arc magmatism have provided the beginning of a quantitative understanding of subduction recycling.

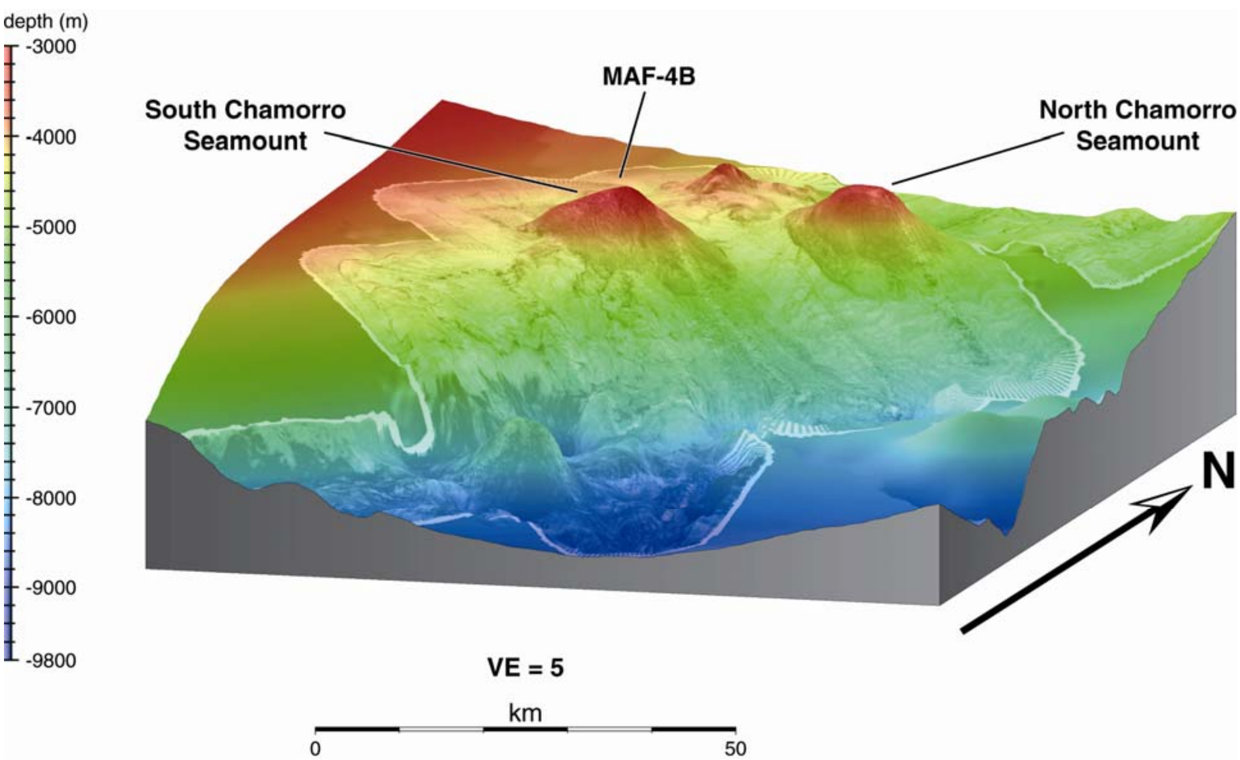
Hot Spot Tracks on the Oceanic Crust

Dating of sediment and basaltic rock recovered by drilling has documented a systematic age progression along several seafloor volcanic chains or ridges, verifying the hypothesis that these features were formed by relatively stable hot spots beneath the moving lithosphere. These drilling samples also provide the main observational evidence that hot spots are generated by deep mantle plumes. In addition, this work has helped establish the absolute movement of lithospheric plates with respect to the lower mantle. Paleomagnetic data from drilled seamounts demonstrate the motion of Atlantic versus Pacific hot spots with respect to each other.

Hydrated Mantle in Many Tectonic Environments

Unexpected mantle-derived serpentinites at shallow crustal levels have been documented by drilling in a variety of tectonic settings from rifted continental margins to fore-arcs to spreading ridges. These results indicate that upper mantle alteration is much more pervasive than previously believed (Figure 5-6).

Figure 5-6. Side-Scan Sonar Image of Several Southern Mariana Seamounts



This side-scan sonar image, draped on bathymetry, shows several southern Mariana seamounts that are approximately 20 km in diameter and 2 km high. Most seamounts are basaltic volcanoes, however, ODP drilling along western Pacific forearcs has shown that edifices similar to ones shown in this image are mud volcanoes composed of fine-grained serpentine muds, fragments of serpentinized mantle derived from the overriding plate, and metamorphosed basalts from the subducted slab — materials derived from depths of up to 29 km. Pore fluids in cores from the active conduits have slab-derived geochemical signatures and support communities of organisms. The seamount in the foreground is currently active, and will be drilled by ODP in 2001; MAF-4B is one proposed drill site. Figure courtesy of Patricia Fryer and Nathan Becker, University of Hawaii.

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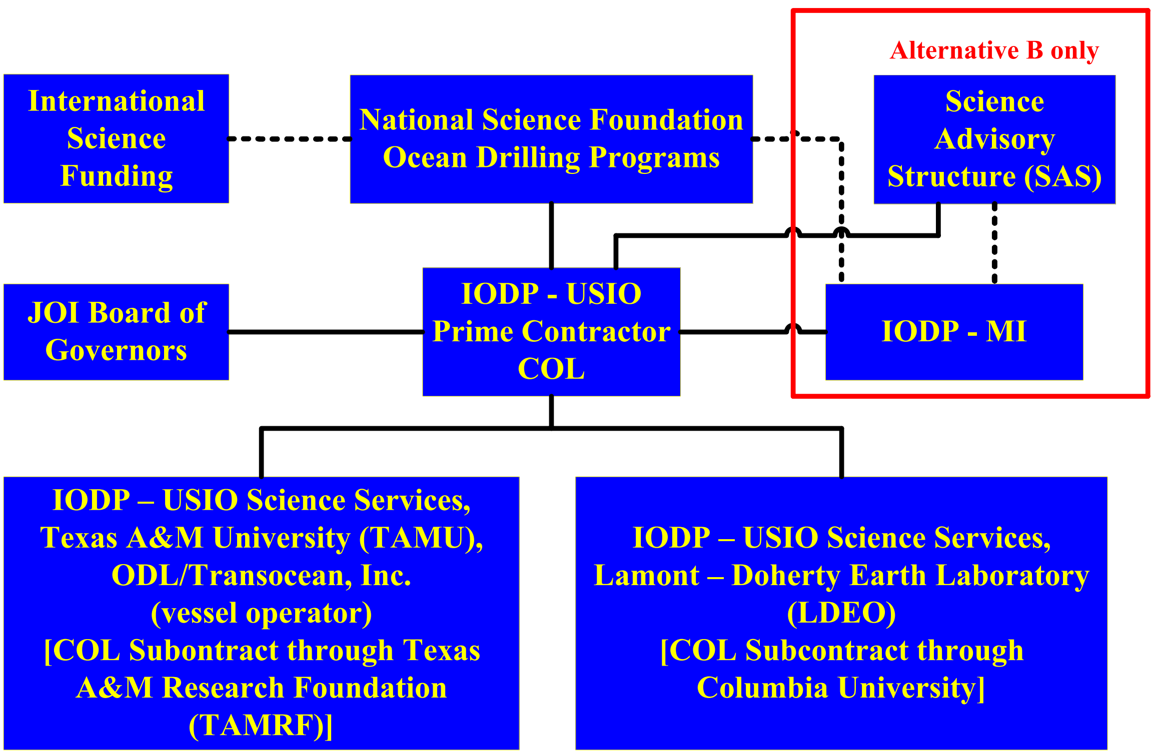
6.0 BEST MANAGEMENT PRACTICES, MITIGATING MEASURES, AND MONITORING

6.1 Responsibilities

The IODP-USIO will be responsible for the successful implementation of all the best management practices and mitigation measures described in this document and assuring compliance with these measures by all applicable IODP-USIO participants (e.g., contractors, field personnel, researchers). Figure 6-1 presents an organizational chart illustrating IODP-USIO participating organizations and depicts how the IODP SAS review process in Alternative B would interface with the USIO. In Alternative A, the USIO management structure would remain the same, however the roles of the IODP SAS and IODP-MI would be absent.

Figure 6-1. IODP-USIO Management Structure for Riserless Drilling Operations



6.2 General Best Management Practices

Best Management Practices (BMPs) represent routine actions that may be performed during riserless drilling expeditions to effectively reduce or avoid impacts to the environment. The BMPs include measures that involve every phase of IODP-USIO operations. Many of the BMPs summarized below have already been incorporated into the operating procedures that will be used by the IODP-USIO including Consortium for

Ocean Leadership, Inc, the science services subcontractors (TAMU, LDEO), and the vessel operator (ODL/Transocean). This BMPs have been designed to complement the IODP's core environmental principles to 1) protect marine life and environment, 2) dispose waste materials consistent with applicable standards, 3) store and transport samples in such a way as to prevent contamination of the environment, and 4) keeping the public informed such as through the dissemination of this impact statement.

The BMPs are applicable to proposed SODV operations, drilling and coring activities, scientific research-related activities, and prevention of accidental releases and are summarized below.

6.2.1 SODV Operations

Mechanical Systems

- Operate vessel to achieve optimal performance (e.g., engine, incinerators, wastewater systems) consistent with regulatory standards and the operator's Environmental Management System; inspect and maintain onboard systems to ensure they operate within these standards.

- Operate SODV engines to meet or exceed MARPOL Annex VI requirements for NOx and SOx emissions using low (<4.5 percent) sulfur content fuel.

- Minimize the number of in-service engines to reduce air emissions; operate engines at peak efficiency consistent with the SODV's Power Management Plan and energy conservation measures.

- Operate the minimum number of thrusters needed and at the minimum speed to hold a specific position given variable wind, current, and sea state conditions to minimize underwater acoustic outputs and turbulent mixing of the water column.

- Minimize the release of ozone-depleting substances such as refrigerants through proper equipment maintenance and refrigerant recovery systems.

Liquid Discharges

- Treat sanitary wastewater prior to discharge using effective, reliable, and well-maintained sanitation system (e.g., suspended aeration, bacterial disinfection) consistent with MARPOL and local requirements.

- Macerate victual wastes prior to discharge to facilitate dispersal and assimilation.

- When oily residues may be present on deck areas, seal scuppers to prevent the discharge of contaminated water and convey drainage to a settling tank for subsequent processing and discharge.

- Treat bilge water and potentially contaminated deck drainage in an oil/water separator to remove oily resides consistent with MARPOL requirements (<15 mg/L).

- Take-on or discharge ballast water consistent with MARPOL requirements, local regulations, and in accordance with the SODV Ballast Water Management Plan.

Waste Management

- Prohibit discharge of plastic wastes consistent with MARPOL requirements; incinerate or retain plastics as well as noncombustible wastes for subsequent disposal onshore.

- Neutralize inorganic liquid wastes from SODV laboratories prior to discharge; containerize and retain organic liquid wastes for subsequent disposal onshore.

- Operate SODV incinerators consistent with MARPOL Annex VI requirements, limited to the combustion of non-hazardous solid waste, diesel fuel and/or waste oil; avoid the use of open combustion devices for the incineration of wastes (i.e., burn basket).

Acoustic Outputs

- Limit the use of transducer-based instruments based on specific operational, navigational, or research requirements.

- Minimize the deployment of multiple transponder beacons, if possible, by utilizing a single transponder when multiple offset boreholes are to be drilled in a particular area.

- Operate transponder locator beacons for dynamic positioning at the minimum power output needed to suit site-specific conditions; deactivate and recover transponder beacons when no longer needed to support drilling activities.

6.2.2 Drilling and Coring Operations

- Reduce discharges of drilling mud particles to the seafloor by using seawater as the primary drilling fluid and only using drilling mud when needed to condition a borehole.

- Minimize drilling fluid pressure to prevent borehole erosion and release of excess solids and associated turbidity in the surrounding water column.

- Avoid the use of oil-based or synthetic materials as drilling mud or to seal or close boreholes; if heavy drilling muds or sealants are required, use naturally-occurring minerals (e.g., sepiolite, attapulgite, cement).

6.2.3 Research-related Activities

- Reduce emissions originating from laboratory operations by properly handling and storing volatile chemicals consistent with the Laboratory Safety and Hazard Communication Compliance Manual.

- During single-channel seismic studies or VSP experiments, conduct airgun operations consistent with NMFS guidelines to protect marine mammals from injury or harassment, as specified in the Airgun Policy and Marine Mammal Strategy (JOIDES, 2003) by:

  - ◊ Establishing an exclusion zone defined by the 160 dB received sound level from the source where airgun operations would cease if a marine mammal or turtle enters
  - ◊ Implementing pre-defined operational procedures (airgun ramp-up, shutdown, course and speed alteration) to protect marine mammals or turtles
  - ◊ Performing visual monitoring to detect the presence of marine mammals or turtles prior to and during operations

- Inspect and maintain the oil-filled hydrophone streamer prior to and after each seismic survey to prevent accidental release of oil.

6.2.4 Accidental Events

- During the site selection and review process, identify site-specific environmental conditions that may require control or avoidance during riserless drilling to prevent the risk of encountering and releasing petroleum hydrocarbons from pressurized formations.

- Avoid spills by adhering to established SODV operating and inspection procedures; should accidental release occur, respond to any spills using procedures described in the Shipboard Oil Pollution Emergency Plan (SOPEP) and Spill Plan.

- Identify hydrogen sulfide (H_2S) hazard conditions and initiate special coring using procedures described in the Hydrogen Sulfide Drilling Contingency Plan (JOI, 2003).

- Obtain information (e.g., weather radar, GPS, satellite data) to help avoid major storms or other situations that may threaten the ship. Respond to severe incidents using procedures described in the Crisis Management Plan for Ocean Drilling Program (JOI, 2003).

6.3 Site-Specific Mitigating Measures

Mitigating measures represent actions that may be taken primarily on a site-specific basis to reduce or avoid potentially adverse impacts to the environment. The mitigating measures focus on achieving certain performance goals often without mandating specific procedures thereby providing flexibility so that the measures may be tailored to suit the environmental and operational conditions that may be encountered.

The mitigating measures will involve every phase of IODP-USIO operations, particularly during the comprehensive planning process for each expedition that would be implemented in coordination with the IODP SAS review process (Alternative B). For example, planning efforts will include a review of each proposed expedition's activities to ensure that science-related objectives can be achieved while minimizing or eliminating adverse environmental impacts. These efforts will involve collecting additional data characterizing the geological, biological, and cultural resources within each proposed drilling area to enable the IODP review panels to adequately assess site conditions and provide recommendations to reduce impacts. In general, these reviews are intended to identify safe drilling locations, environmentally safe drilling methods, site-specific sensitive environments or special conditions warranting site-specific mitigating measures to minimize potential impacts to these resources or supplemental environmental review.

6.3.1 Proposal Review and Expedition Planning

- Identify the biological resources at proposed drill sites, including pertinent information such as presence of sensitive species, threatened or endangered species habitats, known breeding/feeding ground or migration routes, or seasonal distribution patterns.

- Identify known (mapped) or suspected cultural resources at proposed drill sites, including availability of alternate drill sites.

- During pre-cruise planning efforts, avoid planning expedition activities at drill sites:

    ◊ On steep slopes that may impose significant risks to drilling and coring equipment

- ◊ In areas where biologically sensitive species may be present;
- ◊ In areas characterized as critical marine mammal habitats, breeding, or feeding grounds, native hunting areas, or migration pathways;
- ◊ In regions warranting special mitigating measures to protect marine mammals from acoustical outputs, such as areas characterized by the presence of rare or sensitive species (e.g., North Atlantic right whale, Northeast Atlantic bowhead whale), or specific regions where certain species are suspected to concentrate, such as submarine canyons on continental slopes believed to be preferred by beaked whales;
- ◊ In areas containing significant cultural resources;
- ◊ At sites within IMO Traffic Separation Schemes or Precautionary Areas.

- Minimize seafloor terrain alteration by selecting the optimum number of boreholes to be drilled and site conditions needed to meet specific scientific objectives.

- Based on site characterization data or to address observed site conditions, modify proposed activities as needed or develop site-specific mitigating measures to:

  - ◊ Reduce the intensity or duration of discharges from drilling and coring operations to reduce or avoid adverse impacts to known biological resources such as sensitive benthic communities;
  - ◊ Reduce the intensity of acoustic outputs, change the timing of an expedition, or select alternate sites to reduce or avoid impacts to marine mammals in critical habitats, breeding or feeding grounds, native hunting areas, or migration pathways;
  - ◊ Relocate drilling activities to a pre-approved alternate drill sites to avoid adverse impacts to densely populated benthic communities or marine mammal habitats or populations.

- Incorporate modified activities and customized mitigating measures into the Operating Plan and Scientific Prospectus for each expedition.

- Perform supplemental environmental reviews to evaluate site-specific risk and incorporate additional mitigating measures to reduce risks or avoid adverse impacts if any of the following conditions are anticipated at proposed drill sites:

  - ◊ Densely populated benthic communities;
  - ◊ Sensitive benthic communities or ecosystems;
  - ◊ Endangered or threatened species that may be potentially impacted;
  - ◊ Marine organisms potentially sensitive to acoustic sources;
  - ◊ Fisheries or aquaculture resources that may be potentially impacted.

6.3.2 Drilling and Coring Operations

- Minimize the deposition of used material or debris on the seafloor.

- If a primary drill site is unsuitable and an alternate location must be used to achieve research objectives, only move to pre-approved locations.

- If sensitive benthic communities (e.g., chemosynthetic communities, coral reefs) or cultural resources are anticipated at a drill site, inspect or survey the seafloor prior to drilling to identify conditions that may require modifying drilling operations or developing additional mitigating measures to reduce risks or avoid adverse impacts.

6.3.3 Research-related Activities

- During seismic surveys or VSP experiments, shut down airguns if rare, endangered, or sensitive species are sighted.

- Increase marine mammal observer vigilance in areas such as continental slopes or submarine canyons where animals sensitive to acoustic sources (beaked whales) may be present.

- In active fishery areas, use trawl-resistant devices for borehole completion structures (e.g., reentry cones, CORKS) placed on the seafloor.

6.3.4 Accidental Events

- Based on IODP SAS recommendations, develop site-specific procedures and contingencies to avoid geological hazards and prevent or minimize environmental releases; incorporate these procedures into the Operating Plan and Scientific Prospectus for each expedition. Examples of possible recommendations include:

    ◊ Selecting alternate drill sites;
    ◊ Performing a specific drilling order;
    ◊ Limiting drilling depths;
    ◊ Performing additional monitoring to address site-specific conditions.

- Consistent with IODP SAS advice and input, utilize LWD and MWD tools to detect the potential presence of overpressure formations; if monitoring data indicates that an overpressurized formation may be penetrated while drilling, cease drilling operations and plug the borehole with heavy mud or equivalent materials specifically available for that purpose.

- Consistent with IODP SAS advice and input, continuously monitor petroleum hydrocarbon content (e.g., C1-C40 hydrocarbons) in recovered cores to detect potential penetration of an oil or gas accumulation and to distinguish potentially hazardous accumulations of hydrocarbons from the background of the normal increase in hydrocarbon content with depth.

6.4 Mitigation Monitoring

This section describes activities that will be conducted to monitor the application and effectiveness of mitigating measures performed during the planning of each riserless drilling expedition as well as during SODV operations at sea. Mitigation monitoring will involve various IODP-USIO participants including Consortium for Ocean Leadership, Inc, science services subcontractors (TAMU, LDEO), vessel operator (ODL/Transocean), IODP (MI, SAS, review panels, committees), and expedition proponents (researchers).

As part of the IODP SAS in Alternative B, the EPSP would perform a comprehensive review of a proposed riserless drilling expedition during the expedition planning process to assess the adequacy of site characterization data and evaluate potential environmental impacts (see Section 3.3). The EPSP may provide recommendations including site-specific mitigating and monitoring measures that would be incorporated into the expedition's Scientific Prospectus and Operating Plan. Expedition plans will identify needs to obtain required approvals, permits, or special notifications that may involve additional site-specific mitigating measures and monitoring requirements. In some instances, a supplemental site-specific environmental review may be required which could include provisions for additional mitigating measures and monitoring.

For SODV operations, the ship's Captain (vessel master) would have overall responsibility to ensure that vessel operations comply with MARPOL requirements and applicable local regulations. Vessel operations resulting in outputs to the environment (e.g., air emissions, discharges) would incorporate BMPs (Section 6.2), applicable monitoring parameters, and associated recordkeeping. As described in the vessel operator's Environmental Management System, environmental performance indicators (monitoring parameters) would be used to track performance and establish baseline conditions. These criteria would include both leading indicators (preventive measures) and lagging indicators (used to monitor results and impacts).

During drilling operations the Operations Superintendent (OS), the senior IODP-USIO representative onboard the drilling vessel, would be responsible for shipboard functions involving drilling, coring, and reentry operations. The OS will ensure that all drilling is performed consistent with the Operating Plan and optimal drilling conditions are maintained and documented in daily logs. Particular emphasis would be placed on monitoring potential environmental hazards during drilling and coring.

Monitoring observations with an underwater television camera may be performed at select sites to inspect drillstring equipment or the condition of reentry devices and observatories. For example, visual observations obtained during previous ODP and IODP riserless drilling efforts provided information on the deposition of drill cuttings surrounding each borehole and the dispersal of turbidity in the water column.

It is anticipated that some boreholes advanced during previous riserless drilling expeditions may be revisited during future SODV expeditions providing opportunities to monitor and document temporal changes that occur at former drillsites. As shown in Appendix A, over 300 DSDP, ODP, and IODP legacy boreholes may be accessed for future research. In these instances, observations of seafloor conditions collected may allow researchers to monitor and evaluate site-specific changes. These observations may be published such as a recent publication documenting the lack of significant environmental effects following drilling in a coral reef environment (ESO, 2005).

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7.0 PEIS PREPARATION SOURCES

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Higgins, Sean	Associate Director, Ocean Drilling Programs	Consortium for Ocean Leadership
Johnson, Douglas A.	Associate Director (Health, Safety and Environment)	Texas A&M University
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PEIS Preparers (Metcalf & Eddy | AECOM)

Name	Role	Degree(s)	Experience in Subject Field (Yrs)
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Scott, Kevin	Biological Resources, Fisheries, Marine Transportation, Cultural Resources	BS Ocean Engineering	15
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VanGelder, Kurt	Water, Sediment, Air, Acoustics, Biological Resources	MS Oceanography; BS Entomology	24
Weeks, Antoinette	Sediment, Geochemistry	PhD/MS Civil/Enviro. Engineering; BS Civil Engineering	21

8.0 REFERENCES

Advanced Research Projects Agency. 1995. Final Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) for the California Acoustic Thermometry of Ocean Climate (ATOC) Project and its associated Marine Mammal Research Program (MMRP) (Scientific Research Permit Application [P557A]), Vol. 1.

ANZECC. 2000. Australian National Guidelines for Cetacean Observation. Published by Environment Australia. 13 Pages.

Ayers, R.C., Jr. 1994. "The Fate and Effects of Drilling fluid Discharges." In: A. Prodanovic and A.Y. Velikanov, Eds., Mobil and SakhTINRO International Meeting - Theme: Drilling Discharges and Environmental Protection Exploration Drilling Offshore Sakhalin Island. Proceedings of 27-29 Sept 1994 Meeting in Yuzhno-Sakhalinsk, Russia.

Bird Nature. 2001. North American Migration Flyways. http://www.birdnature.com/flyways.html. [Cited August 2006.]

Blumberg, Robert C. 2001. "Statement of R.C. Blumberg, U.S. Observer Delegate to the 31st UNESCO General Conference, to Commission IV of the General Conference, Regarding the U.S. Views on the UNESCO Convention on the Protection of Underwater Cultural Heritage." 29 October 2001, Paris, France.

Brandsma, M.G. and Smith, J.P. 1996. "Dispersion Modeling Perspectives On The Environmental Fate Of Produced Water Discharges." pp 215-224 In: M. Reed and S. Johnsen, Eds., Produced Water 2. Environmental Issues and Mitigation Technologies. Environmental Science Research. Volume 52. Plenum Press, New York.

Briggs, G.A., Plume Rise, USAEC Critical Review Series, 1969.

Bruce, Robert J., Shipp, R. Craig. 2003. Draft Guidelines for Drillsite Selection and Near-Surface Drilling Hazard Surveys. Interim Pollution Prevention and Safety Panel Integrated Ocean Drilling Program (internal document available on request). February 2003.

Buchanan, R.A.; J.A. Cook; and A. Mathieu. 2003. Environmental Effects Monitoring for Exploration Drilling. Prepared by LGL, Ltd., CEF Consultants Ltd., and Oceans Ltd. for Environmental Studies Research Funds. 182 pp.

Calambokidis, J. and S.D. Osmek. 1998. Marine Mammal Research And Mitigation In Conjunction With Air Gun Operation for the USGS `SHIPS' Seismic Surveys in 1998. Draft Rep. from Cascadia Research, Olympia, WA, for U.S. Geol. Surv., Nat. Mar. Fish. Serv., and Minerals Manage. Serv. Var. pag.

Colwell, F.S., Stormberg, G.J., Phelps, T.J., Birnbaum, S.A., McKinley, J., Rawson, S.A., Veverla, C., Goodwin, S., Long, P.E., Russell, B.F., Garland, T., Thompson, D., Skinner, P., and Grover, S. 1992. "Innovative Techniques for Collection of Saturated and Unsaturated Subsurface Basalts and Sediments For Microbiological Characterization." J. Microbiol. Meth., 15:279-292.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 2006. Resolution adopted in 1963 at a meeting of members of IUCN (The World Conservation Union). Agreed to at a meeting of representatives of 80 countries in Washington DC., United States of America, on 3 March 1973, entered in force on 1 July 1975. http://www.cites.org/.

Cummings, Jim. 2003. "Seismic Surveys: What We Don't Know May Hurt." Acoustic Ecology Institute. November 2003.

Deep Sea Conservation Coalition (DSCC). 2004. Mysteries and Mountains of the Deep Sea - Conserving Deep-Sea Biodiversity and Habitats, 4pp.

Draxler, Roland R. Forty-eight Hour Atmospheric Dispersion Forecasts at Selected Locations in the United States. NOAA Technical Memorandum ERL ARL-100,1981.

Dubrovsky, N. A. and S. V. Kosterin. 1993. Noise in the ocean caused by lightning strokes. Pp 697-709 in Natural Physical Sources of Underwater Sound. B. R. Kerman (ed.), Kluwer.

Dustan, P., Lidz, B.H. & Shinn E.A. 1991. "Impact of Exploratory Wells, Offshore Florida – a Biological Assessment." Bulletin of Marine Science, 48 (1), 94-124.

ECORD Science Operator (ESO). 2005. Integrated Ocean Drilling Program Tahiti Sea Level Expedition 310 - Environmental Impact Statement.

Emery, L., M. Bradley and T. Hall. 2001. Data Base Description (DBD) for the Historical Temporal Shipping Data Base (HITS), Version 4.0, PSI Tech. Rep. TRS-301. Planning Systems Incorporated, Slidell, LA 35 pp.

ERT Ltd. 2006. First Strategic Environmental Assessment for Oil and Gas Activity in Ireland's Offshore Atlantic Waters: IOSEA1 Slyne, Erris and Donegal Basins. Report for Petroleum Affairs Division.

Evans, P.G.H. and Nice, H. 1996. "Review Of The Effects Of Underwater Sound Generated By Seismic Surveys" In: Cetaceans. Seawatch Foundation, Oxford, UK.

Faugstadmo, Jan Erik. "Acoustic Positioning in Deep Waters" Dynamic Positioning Conference, October 13-14, 1998.

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, and S.H. Ridgway. 2000. "Auditory and Behavioral Responses of Bottlenose Dolphins (*Tursiops* *truncatus*) and Beluga Whale (*Delphinapterus leucas*) to Impulsive Sounds Resembling Distant Signatures of Underwater Explosions." J. Acoust. Soc. Am. 108(1):417-431.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. "Temporary Shift In Masked Hearing Thresholds In Odontocetes After Exposure To Single Underwater Impulses From A Seismic Watergun." J. Acoust. Soc. Am. 111(6):2929-2940.

FishBase, 2006. World Wide Web electronic publication. Editors: Froese, R. and D. Pauly. www.fishbase.org June 2006 version.

Global Environment Facility (GEF). 2006. Project Document of Two Proposed Grants from the Global Environment Facility Trust Fund to the International Maritime Organization for a Marine Electronic Highway Demonstration Project – Indonesia. April 10, 2006. http://www.gefweb.org/documents/Project_Proposals_for_Endorsem/documents/Regional_MarineElectronicHwy_Demo.pdf

Goold, J.C. 1996. "Acoustic Assessment Of Populations Of Common Dolphins *Delphinus Delphis* in Conjunction With Seismic Surveying. Journal of the Marine Biological Association (UK). 76, 811-820.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift and D. Thompson. 2004. "A Review of the Effects of Seismic Surveys on Marine Mammals." Mar. Technol. Soc. J. 37(4):16-34.

Graber, K.K., 2007. Guidelines for Site Survey and Safety. ODP Tech. Note 32. http://www-odp.tamu.edu/publications/tnotes/tn32/INDEX.HTM. [Cited August 2007].

Gubbay, 1995. Marine Protected Areas: Principles and Techniques for Management. Chapman and Hall, London, 232pp.

Hall, Catherine and Carolyn W. Burns. 2003. "Response of Crustacean Zooplankton to Seasonal and Tidal Salinity Changes in the Coastal Lake Waihola, New Zealand." New Zealand Journal of Marine and Freshwater Research. Vol 37: 31-43.

Hannah, Charles G., Drozdowski, Adam. 2005. Characterizing the Near-bottom Dispersion of Drilling Mud on Three Canadian Offshore Banks July 2005.

Hannah, C.G. Tedford, t. and Drozdowski, A. 2003. Suspended Sediment Drift and Disepersion at Hibernia. Canadian Technical Report of Hydrography and Ocean Sciences, 227 pp.

Hartley, J., R. Trueman, S. Anderson, J. Neff, K. Fucik, and P. Dando. 2003. Drill Cuttings Initiative: Food Chain Effects Literature Review. United Kingdom Offshore Operators Association, Aberdeen, Scotland. 118 pp + Appendices.

Hildebrand, John. 2004. Sources of Anthropogenic Sound in the Marine Environment, Scripps Institution of Oceanography, University of California San Diego

Honeywell Marine Systems Division. 1984. SEDCO B/P 471 Noise Measurement Report. 188-98. June 1984.

Hocking, Charles.1989. "Dictionary of Disasters at Sea during the Age of Steam." London: Lloyd's Shipping Register, vol. 2.

Houghton, J.P., R.P. Britch, R.C. Miller, and A.K. Runchal. 1980b. "Drilling fluid Dispersion Studies at the Lower Cook Inlet, Alaska, C.O.S.T. Well." pp. 285-308 In: Proceedings of Symposium, Research on Environmental Fate and Effects of Drilling Fluids and Cuttings, Vol. I, January 21-24, 1980, Lake Buena Vista, Florida. American Petroleum Institute, Washington, DC.

Frings, Hubert. 1977. Animal Communication. University. of Oklahoma Press.

Humane Society of the United States (HSUS). 2006. Protecting Threatened and Endangered Species. http://www.hsus.org/wildlife

Hurley, Geoffrey and Ellis, Joanne. 2004. "Environmental Effects of Exploratory Drilling Offshore Canada" (pp 29-31). Prepared for Canadian Environmental Assessment Agency, Regulatory Advisory Committee. J. Microbiol. Meth., 15:279–292.

International Maritime Organization (IMO) Publishing. 2004. Ships' Routing on CD. https://www2.imo.org/b2c_imo/b2c/init.do

International Maritime Organization (IMO). 2006. IMO and the Safety of Navigation. http://www.imo.org/safety.

Independent World Commission on the Oceans (IWCO). 1998. The Ocean, Our Future…The Report of the Independent World Commission on the Oceans. Cambridge University Press.

International Union for Conservation of Nature (IUCN). 2006. IUCN Red List of Threatened Species. http://www.iucnredlist.org [Cited August 2006.]

Irion, Jack B. 2002. "Cultural Resource Management of Shipwrecks on the Gulf of Mexico Outer Continental Slope." Paper presented at the 2nd MIT Conference on Technology, Archaeology, and the deep Sea, April 2002.

Irish Offshore Strategic Environmental Assessment (IOSEA) 2006. First Strategic Environmental Assessment for Oil and Gas Activity in Ireland's Offshore Atlantic Waters, IOSEA 1; Slyne, Erris, and Donegal Basins. June 2006.

Jannasch, H. 1989. “The Microbial Basis of Life at Deep-Sea Hydrothermal Vents.” ASM News. 55:413-416.

JOIDES, 2003. Airgun Policy and Marine Mammal Strategy (internal document available on request).

Kelleher, G., Bleakley, C. and Wells, S. (eds.). 1995. A Global Representative System of Marine Protected Areas. The Great Barrier Reef Marine Park Authority, The World Bank, IUCN, Washington, DC, USA.

Lalli, Carol M. and Timothy R. Parsons. 2002. Biological Oceanography: An Introduction. Second Edition, published by Butterworth-Heinemann.

Levinton, Jeffrey S. 1995. Marine Biology: Function, Biodiversity, Ecology. Oxford University Press.

LGL, 2005. Strategic Environmental Assessment, Western Newfoundland and Labrador Offshore Area. December 2005.

LGL Limited, Environmental Research Associates. 2006. Draft Environmental Assessment of a Planned Low-Energy Marine Seismic Survey by the Scripps Institution of Oceanography in the South Pacific Ocean, December 2006–January 2007. July 20, 2006

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations Of The Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior/Phase II: January 1984 Migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. NTIS PB86-218377.

Marine Mammal Commission, 2007. Marine Mammals and Noise, A Sound Approach to Research and Management, March 2007.

Marine Mammal Commission (MMC). 2004. Sources of Anthropogenic Sound in the Marine Environment. By: John Hildebrand, Scripps Institution of Oceanography. http://www.mmc.gov/sound/internationalwrkshp/pdf/hildebrand.pdf.

MarineBio, 2006. http://marinebio.org/Oceans/ThreatenedEndangeredSpecies.asp.

Mills, W.G., Malone, M.J., and Graber, K., 2006. Hydrogen Sulfide Drilling Contingency Plan. ODP Tech. Note 33. http://www-odp.tamu.edu/publications/tnotes/tn33/INDEX.HTM [Cited August 2007].

Mineral Management Service. 1983. Draft environmental impact statement: Proposed Southern California Offshore Lease Offering, U.S. Department of Interior, Los Angeles, CA.

MPA Global, 2006. MPA Global, A Database of the World's Marine Protected Areas. http://www.mpaglobal.org/index.php?action=aboutus.

MPA News, 2003. At World Parks Congress, Target is Set for High-Seas MPAs: Five to be Designated by 2008, Vol. 5, No. 4, October 2003.

National Defense University (NDU). 2002. Sea Lane Security and U.S. Maritime Trade: Chokepoints as Scarce Resources. Institute for National Strategic Studies. http://www.ndu.edu/inss/books/Books_2002/Globalization_and_Maritime_Power_Dec_02/09_ch08.htm

National History Museum (NHM). 2005. Deep Ocean: Vertical Life Zones and Biodiversity. http://www.nhm.ac.uk/nature-online/earth/oceans/fathomseminar-deepocean/session2/no-oceans-fathomseminar-deepocean-session2.html [Cited September 2006].

National Oceanic and Atmospheric Administration (NOAA). 2004. "Trends in the Shipping Industry and Shipping Noise" Shipping Noise & Marine Mammals: A forum for Science, Technology, and Management. May 18-19, 2004. http://www.shippingnoiseandmarinemammals.com/NOAAMaterials.cfm

National Oceanic and Atmospheric Administration (NOAA). 2006a. Office of Protected Resources – Species Information. http://www.mmfs.noaa.gov/pr/species/

National Oceanic and Atmospheric Administration (NOAA). 2006b. National Marine Sanctuaries – Protecting Resources (Revised May 16, 2006). http://sanctuaries.noaa.gov/protect/regulations/welcome.html

National Science Foundation. 2007. Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for National Science Foundation-Funded Marine Seismic Research.

National Ocean Industries Association (NOIA). Oil in the Sea III: Inputs, Fates and Effects. http://www.noia.org/website/article.asp?id=129.

Nedwed, T. 2004. "Best Practices for Drill Cuttings & Mud Discharge Modeling." SPE 86699. Paper presented at the Seventh SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Calgary, Alberta, Canada. Society of Petroleum Engineers. Richardson, TX. 6 pp.

Neff, Jerry M. 2005. Composition, Environmental Fates, and Biological Effects of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment. Battelle. January 2005.

Nystuen, J. A. and D. M. Farmer. 1987. "The Influence of Wind on the Underwater Sound Generated by Light Rain." J Acoust Soc Am 82: 270-274.

Ocean Commission. 2004. An Ocean Blueprint for the 21st Century – Final Report of the U.S. Commission on Ocean Policy: Chapter 20 Protecting Marine Mammals and Endangered Marine Species. http://www.oceancommission.gov

Oceana, and Marine Conservation Biology Institute (Oceana). 2005. Deep Sea Coral Protection Around the World. www.oceana.org.

Omari, M., T. Ikeda. 1992. Methods in Marine Zooplankton Ecology. Malabar, USA: Krieger Publishing Company.

OSPAR Commission. 2006. Draft Preliminary Comprehensive Overview of the Impacts of Anthropogenic Underwater Sound in the Marine Environment. EIHA 06/3/1-E. November 2006.

Paul, Linda. 1994. International law Governing Driftnet Fishing on the High Seas. Earthtrust. http://www.earthtrust.org/dnpaper/contents.html

Pauly, Daniel; Watson, Reg; and Alder, Jackie. 2005. "Global Trends in World Fisheries: Impacts on Marine Ecosystem and Food Security." Philosophical Transactions of the Royal Society (2005) 360, 5-12.

Pearson TH & Rosenberg R 1976. A Comparative Study of the Effects on the Marine Environment of Wastes From Cellulose Industries in Scotland and Sweden. Ambio 5, 77–79.

Pomeroy, R.S., Parks, J.E., Watson, L.M. 2004. How is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness. IUCN-The World Conservation Union. IUCN, Gland, Switzerland and Cambridge, UK.

Project Puffin. 2006. Puffin Questions. Accessed August 2006. http://projectpuffin.org/questions.html.

Urick, R.J. "The noise background of the sea." Chapter 7 In: Principals of Underwater Sound. Peninsula Publishing, Los Altos, CA 1983

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego. 576 p.

Schreiner, A. E., C. G. Fox and R. P. Dziak. 1995. "Spectra and Magnitudes of t-waves from the1993 Earthquake Swarm on the Juan de Fuca ridge." Geophysical Research Letters 22(2): 139-142.

Scientific Committee on Antarctic Research (SCAR). Impacts of Marine Acoustic Technology on the Antarctic Environment. Version 1.2, July 2002.

Secretariat of the Convention on Biological Diversity (CBD). 2004. Solutions for Sustainable Mariculture - Avoiding the Adverse Effects of Mariculture on Biological Diversity. CBD Technical Series No.12. 52 p.

Shinn, E.E., Hudson, D.H., Robbin, D.M., Lee, Carol K. Drilling Mud Plumes from Offshore Drilling Operations: Implications for Coral Survival. U.S. Geological Survey, 1980.

Stephen, R. A. Duennebier, F. K., Harris, D. Jolly, J., Bolmer, S. T., Bromirski, P. Broadband Seismic Observations At The Hawaii-2 Observatory During ODP Leg 200.

Terrens, G.W., Gwyther D., and Keogh M.J. 1998. "Environmental Assessment of Synthetic-based Drilling Mud Discharges to Bass Strait, Australia." APPEA Journal. V38: Part 1. Proceedings of the APPEA Conference, Canberra, 8-11 March 1998.

Terres, J.K. 1996. The Audubon Society Encyclopedia of North American Encyclopedia of Birds. Wing Books, a division of Random House Value Publishing, Inc. New Jersey. pp 1109.

Tolstoy, M., J. Diebold, S. Webb, D. Bohnenstiehl and E. Chapp. 2004. "Acoustic Calibration Measurements." Chapter 3 In: W.J. Richardson (ed.), Marine Mammal And Acoustic Monitoring During Lamont-Doherty Earth Observatory's Acoustic Calibration Study In The Northern Gulf Of Mexico, 2003. Revised ed. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. [Advance copy of updated Chapter 3.]

Trade and Environment Database (TED). 1997. Japan Driftnet Fishing. Case Number 251.

Transocean, 2006. Environmental Management System, HQS-HSE-PR-05, Revision Number 00, June 30, 2006 (internal document available on request).

Turnpenny A., Dr. J. Nedwell. 1994. The Effects On Marine Fish, Diving Mammals And Birds Of Underwater Sound Generated By Seismic Surveys, Aquatic Research Laboratories, October 1994.

Underwater Times. 2006. Research: Over 15,000 Shipwrecks Lie Buried on the Irish Sea. http://www.underwatertimes.com.

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2001a. UNESCO Convention on the Protection of the Underwater Cultural Heritage. http://www.unesco.org/culture/laws/underwater/html_eng/conven2.shtml.

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2001b. Information Kit: UNESCO Convention on the Protection of the Underwater Cultural Heritage. http://unesdoc.unesco.org/images/0014/001430/143085E.pdf.

United Nations Food and Agriculture Organization (FAO). 2004. The State of World Fisheries and Aquaculture (SOFIA). 137 p.

United Nations Food and Agriculture Organization (FAO). 2006. Yearbooks of Fishery Statistics Summary Tables. ftp://ftp.fao.org/FI/STAT/summary/default.htm.

United Nations (UN). 2006. Oceans and Law of the Sea, Overview of Convention and Related Agreements. Division for Ocean Affairs and the Law of the Sea.

United Nations Environment Program (UNEP). 2006. The Regional Seas Programmes. http://www.unep.org/regionalseas/programmes.

United Nations Environment Programme - Global Programme of Action (UNEP-GPA). "What Happens to Oil in the Water?" Fact Sheet. http://oils.gpa.unep.org/facts/fate.htm.

USEPA, 1995. Compilation of Air Pollutant Emission Factors (AP-42), PB95-196028.

USEPA, 2000. Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data. EPA420-R-00-002. February 2000.

Varmer, Ole. 2005. "The Perspective from Across the Atlantic." Paper given at the Society of Antiquities of London conference related to the 2001 UNESCO Underwater Heritage Convention, 28 October 2005. http://www.sal.org.uk/downloads/unesco/Ole-Varmer-Across-the_Atlantic.rtf.

Whale and Dolphin Conservation Society (WDCS), Oceans of Noise 2004, A WDCS Science Report. 2004.

Whitford, Jacques. 2003. Strategic Environmental Assessment, Laurentian Subbasin. November 2003.

Whitford, Jacques. 2006. Strategic Environmental Assessment, Sydney Basin Offshore Area. Draft Two September 2006.

World Wildlife Fund (WWF). 2006a. Deep Sea Ecology: Hydrothermal Vents and Cold Seeps. http://www.panda.org/about_wwf/what_we_do/marine/blue_planet/deep_sea/vents_seeps/index.cfm. [Cited August 2006.]

WWF. 2006b. Coral Reefs: Ecology. http://www.panda.org/about_wwf/what_we_do/marine/blue_planet/coasts/coral_reefs/coral_reef_ecology/index.cfm. [Cited August 2006.]

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9.0 IODP FREQUENTLY USED ACROYNMS AND GLOSSARY

Table 9-1 provides an explanation of acronyms which are frequently commonly used in the IODP or this PEIS. A comprehensive technical glossary of IODP terms may be accessed through the following website link:
http://iodp.tamu.edu/publications/resources/IODP_dictionary.pdf

Table 9-1. Commonly Used Acronyms and Terms

Acronym	Meaning
ADCP	Acoustic Doppler Current Profiler
AESTO	Advanced Earth Science and Technology Organization (Japan)
AGI	American Geophysical Institute
AGU	American Geophysical Union
AOGS	Asia-Oceana Geosciences Society
APC	Advanced Piston Core
APCT	APC Temperature Tool
API	American Petroleum Institute
APP	Annual Program Plan
AUV	Autonomous Underwater Vehicle
BCR	Bremen Core Repository
BGS	British Geological Survey
BHA	Bottom Hole Assembly
BMP	Best Management Practice
BoG	Board of Governors
BOD_5	Biological Oxygen Demand (5-day)
BP	Before Present
BSR	Bottom Simulator Reflector
cc	Cubic Centimeter
CCD	Carbonate Compensation Depth
CDEX	Center for Deep Earth Exploration
CDP	Complex Drilling Projects
CEQ	Council on Environmental Quality (U.S.)
CMCR	Center for Advanced Marine Core Research (Kochi University)
CMO	Central Management Office
CNRS	Centre National de la Research Scientific (France)
COL	Consortium for Ocean Leadership, Inc. (formerly the Joint Oceanographic Institutions, Inc.)
CORK	Circulation Obviation Retrofit Kit
dB	Decibel
DIS	ICDP Drilling Information System
DP	Dynamic Positioning

Table 9-1. Commonly Used Acronyms and Terms

Acronym	Meaning
DPG	Detailed Planning Group
DSDP	Deep Sea Drilling Project
DSS	Drilling Sensor Sub
DVTP	Davis-Villinger Temperature Probe
E&O	Education and Outreach
ECORD	European Consortium for Ocean Drilling Research
EDP	Engineering Development Panel
EGU	European Geosciences Union
EMA	ECORD Management Agency
EMS	Environmental Management System
EOR	Expedition Objective Research
EPC	European Petrophysical Consortium
EPSP	Environmental Protection and Safety Panel
ESA	Endangered Species Act (U.S.)
ESO	ECORD Science Operator
ESSAC	ECORD Science Support and Advisory Committee
ESSEP	Environmental Science Steering and Evaluation Panel
ETF	Engineering Task Force
FMS	Formation Micro Scanner
GCR	Gulf Coast Repository
GI	Generator-Injector (airgun)
GIS	Geographic Information System
HCFC	Hydrochlorofluorohydrocarbon
HG DPG	Hotspot Geodynamics Detail Planning Group
HSE	Health, Safety and Environment
HVAC	Heating/Ventilation/Air Conditioning
Hz	Hertz
ICDP	International Continental Scientific Drilling Program
IFREE	Institute for Frontier Research on Earth Evolution
IHA	Incidental Harassment Authorization
IIS-PPG	Industry-IODP Science Program Planning Group
ILP	Industry Liaison Panel
IMO	International Maritime Organization
IO(s)	Implementing Organization(s)
IODP	Integrated Ocean Drilling Program
IODP-MI	Integrated Ocean Drilling Program Management International, Inc.
ION	International Ocean Network
iSAS	Interim Science Advisory Structure
ISC	Information Service Center

Table 9-1. Commonly Used Acronyms and Terms

Acronym	Meaning
ISP	Initial Science Plan
ISSEP	Interior Science Steering and Evaluation Panel
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JANUS	USIO Database System
J-CORES	Japanese Database System
J-DESC	Japan Drilling Earth Science Consortium
JOI	Joint Oceanographic Institutions, Inc. (predecessor to the Consortium for Ocean Leadership)
JOI Alliance	Former USIO consisting of JOI, LDEO, and TAMU
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
JPIO	Japan Implementing Organization
JR	*JOIDES Resolution*
KCC	Kochi Core Center Repository
KIGAM	Korea Institute of Geoscience and Mineral Resources
kt	knots
L	liter
LDEO	Lamont-Doherty Earth Observatory
LGM	Last Glacial Maximum
LTBMS	Long-Term Borehole Monitoring System
LWC	Logging While Coring
LWD	Logging While Drilling
m	Meters
Ma	Meg-annum (one million years)
MARPOL	International Convention for the Prevention of Pollution from Ships (1973), as modified by the Protocol of 1978 (MARPOL 73/78)
MAT	Mid-Atlantic Transect
mbsf	meters below sea floor
MCS	Multi Channel Seismic
MEXT	Ministry of Education, Culture, Sports, Science, and Technology (Japan)
mg/L	Milligrams Per Liter
mg/kg	Milligrams Per Kilogram
mHz	Megahertz
MMPA	Marine Mammal Protection Act
MOST	Ministry of Science and Technology (People's Rep. of China)
MPA	Marine Protected Area
MSP	Mission Specific Platform
MW	Megawatt
MWP	Measurement While Drilling

Table 9-1. Commonly Used Acronyms and Terms

Acronym	Meaning
NanTroSEIZE	Nankai Trough Seismogenic Zone Experiment
NEPA	National Environmental Policy Act
NERC	National Environmental Research Council
nm	nautical miles
NMFS	National Marine Fisheries Service (U.S.)
NMSP	National Marine Sanctuary Program (U.S.)
NOAA	National Oceanic and Atmospheric Administration (U.S.)
NOx	Nitrogen Oxides
NSF	National Science Foundation (U.S.)
OCC	Oceanic Core Complex
OCE	Division of Ocean Sciences, NSF
ODL	Oversees Drilling Limited (with Transocean, operator of the SODV)
ODP	Ocean Drilling Program
OOI	Ocean Observing Initiative
OPCOM	Operations Committee (now Operations Task Force)
ORI	Ocean Research Institute
ORION	Ocean Research Interactive Observatory Networks
OTF	Operations Task Force
PCS	Pressure Core Sampler
PEIS	Programmatic Environmental Impact Statement
PI	Primary Investigator (Proponent)
PMO	Program Member Offices
PMT	Project Management Team
ppm	Parts Per Million (mg/L, mg/kg)
PSDIM	Publications, Sample and Data Integration manager
PSG	Project Scoping Group
PTS	Permanent Threshold Shift
QAQC	Quality Assurance Quality Control
RCB	Rotary Core Barrel
RIS	Rig Instrumentation System
rms	Root Mean Square
ROD	Record of Decision
ROV	Remotely Operated Vehicle
SAS	Science Advisory Structure
SASEC	SAS Executive Committee, Science Advisory Executive Committee
SciMP	Scientific Measurements Panel (in ODP)
SECA	SOx Emission Control Area
SEDIS	Scientific Earth Drilling Information System
SEL	Sound Exposure Level

Table 9-1. Commonly Used Acronyms and Terms

Acronym	Meaning
SIO	Scripps Institution of Oceanography
SIT	Systems Integrated Training
SMCS	Sample Materials Curation Management System
SODV	Scientific Ocean Drilling Vessel
SOPEP	Shipboard Oil Pollution Emergency Plan
SOx	Sulfur Oxides
SPC	Science Planning Committee
SPPOC	Science Planning and Policy Oversight Committee (< April 2006)
SRMs	Standard Reference Materials
SSDB	Site Survey Data Bank
SSEP	Science Steering and Evaluation Panel
SSP	Site Survey Panel
STP	Scientific Technology Panel
TAMU	Texas A&M University
TAP	Technology Advice Panel (in ODP)
TD	Total Depth
tonne	1,000 Kilograms
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
UBI	Ultra Borehole Imager
USAC	U.S. Advisory Committee for Scientific Ocean Drilling
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USIO	United States Implementing Organization
USAC	United States Advisory Committee for Scientific Ocean Drilling
USSSP	U.S. Science Support Program
VSP	Vertical Seismic Profile
WDC	World Data Center
WOB	Weight on bit
WST	Well Seismic Tool
XCB	Extended Core Barrel
μPa	Micropascal