Alaska Fisheries Science Center: NOAA's Gateway to the Arctic

NOAA's Alaska Fisheries Science Center is responsible for research on marine species, and their habitats, living in the coastal oceans of Alaska. This region of nearly 3 million square miles includes waters in the Gulf of Alaska, Bering Sea, Aleutian Islands, and the Arctic Ocean, and supports some of the most important commercial fisheries in the world.

Key Species

- Groundfish and crabs (29 stocks)
- Deep water corals
- Steller sea lion
- Cook Inlet beluga whale
- Western Arctic bowhead whale
- Ice-dependent seals
  - Bearded seal
  - Spotted seal
  - Ringed seal
  - Ribbon seal

Sample Technologies Employed

- Trawls and longlines
- Acoustic profilers
- Environmental monitors
- Archival tagging
- Genetic stock identification
- Modeling
- Bycatch reduction devices
- Electronic monitoring devices
- Underwater video systems

Our Strengths

- Fishery stock assessment expertise incorporating fishery dependent and independent data to support groundfish and crab management Economic and socio-cultural information to resource managers, commercial and subsistence fishers, and other stakeholders
- Marine mammal stock assessment incorporating state of the survey technology, telemetry, and passive acoustics to support management
- Integrated ecosystem level observation and process studies to understand Arctic and sub-Arctic ecosystems

What Makes Us Unique

- Applied research on groundfish and salmon supporting the largest commercial fishery in the US
- Operate the nation's largest fishery observer program to meet science and fishery management demands. Fishery-dependent data is available in near real-time to both the agency and the fishing industry for managing fishery quotas
- Applied research on marine mammals, fish and shellfish in the Arctic supports management decisions regarding oil and gas development and Alaska Native subsistence communities
- Four Large Marine Ecosystems occur in waters off Alaska
- Provide the science to support the sustainable harvest of over half the nation's commercially fished seafood

New Directions

- Baseline ecosystem data for the northeastern Bering and Chukchi Seas to assess potential effects of oil and gas exploration and extraction in the Arctic
- Comprehensive abundance estimates for four species of ice-associated seals in the Bering , Chukchi and Beaufort Seas
- Investments in advanced technology for improved assessment surveys

June 1, 2010

NOAA Alaska Fisheries Science Center Science Plan

Executive Summary

The Alaska Fisheries Science Center (AFSC) is responsible for research on living marine resources in the coastal oceans of Alaska. This region of nearly 3 million square miles includes waters in the Gulf of Alaska, Bering Sea, Aleutian Islands, and the Arctic Ocean, and supports some of the most important commercial fisheries in the world. These waters are also home to the largest marine mammal populations in the Nation, and some of the most critically endangered marine mammal populations. The Obama Administration has identified several aspects of AFSC research among its top priorities, including ensuring sustainable marine fisheries, and strengthening Arctic science and stewardship, and supporting coastal and marine spatial planning. While our research efforts will continue in the Gulf of Alaska, southern Bering Sea and Aleutian Islands, they will also extend into the northern Bering, Chukchi, and Beaufort Seas.

Our Science Plan addresses the research activities, infrastructure and support services envisioned for the AFSC over the next 3 - 5 years. This effort is organized around the following three research themes.

- *Monitor and assess fish, crab, and marine mammal populations, fisheries, marine ecosystems, and the associated communities which rely on these resources.*
- *Understand and forecast effects of climate change on marine ecosystems.*
- *Describe and assess the role of habitats in supporting healthy marine ecosystems and populations of fish, crab, and marine mammals.*

Accompanying the Science Plan is an Implementation Process, outlining the procedures for resource allocation, decision-making, and communication to accomplish core activities and high priority research. Although separate documents, the Implementation Process and Science Plan work together as guiding documents for the AFSC.

Background and Purpose

The AFSC faces the immediate challenge of an expanding mission, both in the types of research required to meet the Nation's needs and in the geographical areas where we carry out our work, and yet we have limited resources to accomplish this research. The Science Plan addresses the desired research activities, infrastructure, and support services for the AFSC over the next 3 - 5 years. The intent is to organize and communicate our research activities in a way that: 1) shows the full suite of research under three main research themes and 12 research foci (Figure 2) so staff can see how their work contributes to AFSC research needs and others can easily understand these needs and 2) identifies the core research activities which would be conducted even under stringent budget scenarios.

Figure 1: The AFSC's research responsibilities are expanding in Arctic waters.

Further, the Science Plan and Implementation Process documents will serve as guidance for decision-making within the AFSC with the goal of increasing the transparency of these decisions. These documents help position the AFSC to meet these challenges by clearly stating our core and desired research, providing focus, and enabling a concentration of AFSC resources to accomplish these goals.

National Priorities for Ocean Research

NOAA Fisheries describes its mission as "responsible for the management, conservation and protection of living marine resources within the United States Exclusive Economic Zone. NOAA Fisheries also plays a supportive and advisory role in the management of living marine resources in coastal areas under state jurisdiction, provides scientific and policy leadership in the international arena and implements international conservation and management measures as appropriate. "

Many factors, both natural and anthropogenic, affect populations of fish, crab and marine mammals and marine ecosystems. Although natural factors cannot be controlled, and many human-caused factors are outside the control of NOAA Fisheries, the agency collects and maintains scientific information to inform and advise policymakers and managers. Understanding and predicting the health and productivity of marine ecosystems is critical to our stewardship mission. The AFSC Science Plan is aligned with this mission and with the priorities of the Obama Administration.

On August 2, 2009, Dr. Jane Lubchenco, Undersecretary of Commerce for Oceans and Atmosphere, issued her Annual Guidance Memo calling on NOAA to focus on five strategic priorities:

1. *Enhancing NOAA's climate services…in support of the nation's need for sound, scientifically-backed policies and programs to respond to climate change;*

2. *Supporting comprehensive marine spatial planning, where NOAA can help the nation reconcile competing*

> *"We have a stewardship responsibility to maintain healthy, resilient, and sustainable oceans, coasts, and Great Lakes resources for the benefit of this and future generations. Yet, the oceans, coasts, and Great Lakes are subject to substantial pressures and face significant environmental challenges. Challenges include water pollution and degraded coastal water quality caused by industrial and commercial activities both onshore and offshore, habitat loss, fishing impacts, invasive species, disease, rising sea levels, and ocean acidification. Oceans both influence and are affected by climate change. They not only affect climate processes but they are also under stress from the impacts of climate change. Renewable energy, shipping, and aquaculture are also expected to place growing demands on ocean and Great Lakes resources."*
>
> *- President Barack Obama*

demands on ocean and coastal resources;

3. *Ensuring the sustainability of marine fisheries, where NOAA can simultaneously strengthen ocean ecosystems and local economies;*

4. *Strengthening Arctic science and stewardship, where NOAA can help to improve our understanding of changing climate and environmental condition and better inform policy options and management responses to the unique challenges in the Arctic region; and*

5. *Sustaining satellite-based earth observations.*

With a broad research portfolio, the AFSC's work is directly responsive to the first four of these priorities.

Role of the Alaska Fisheries Science Center

The Alaska Fisheries Science Center is responsible for research on living marine resources in the coastal oceans off Alaska. The region covers about three million square miles, encompassing the Gulf of Alaska, Bering Sea and Aleutian Islands, the Chukchi and Beaufort Seas, and the Arctic Ocean. The region supports some of the Nation's most important commercial fisheries many of which are among the most productive and sustainable fisheries in the world. These waters are also home to the largest marine mammal populations in the Nation.

The mission of the Alaska Fisheries Science Center is to conduct scientific research that improves the ability of NMFS to understand, manage, and conserve Alaska's fish, crab and marine mammals and to protect the habitats essential for their existence. This research is authorized by the Magnuson-Stevens Fishery Conservation and Management Act of 1996, the Marine Mammal Protection Act of 1972, and the Endangered Species Act of 1973.

AFSC scientists collect, compile, and analyze extensive information on fisheries, resouce-dependent communities, and many fish, crab, and marine mammal species, and their food sources and habitats, including oceanography and environmental research. Analyses based on these data are used to develop policies and strategies for fisheries and protected species management within the U.S. Exclusive Economic Zone, monitor and assess the health of the region's marine mammal populations, and develop the scientific understanding and predictive methodologies needed to implement NOAA Fisheries' ecosystem approach to management. In addition to ongoing survey and assessment activities, the AFSC is engaged in cutting-edge research related to global warming which focuses on concerns such as ocean acidification and the loss of sea ice in the Bering Sea.

The primary responsibility of the AFSC is to provide scientific data, analysis and technical advice to the NMFS Alaska Regional Office, North Pacific Fishery Management Council, State of Alaska, Alaskan coastal subsistence communities, and U.S. representatives participating in international fishery and marine mammal negotiations. The AFSC also provides scientific information to members of the fishing community (commercial, subsistence, and recreational)

and to the general public. The AFSC coordinates and collaborates with other Federal and state agencies, academic institutions, and international agencies and organizations on fisheries and marine mammal research. The AFSC has strong ties to regional NOAA Cooperative Institutes which facilitate long-term collaborations among AFSC and university researchers and have the added benefit of training the next generation of the scientific workforce through student involvement. The AFSC also maintains direct working relationships with a variety of academic institutions to further our research mission.

Figure 2: Summary of 12 major research foci for the AFSC grouped into three themes.

Theme 1: Monitor and assess fish, crab and marine mammal populations, fisheries, and marine ecosystems and the associated communities which rely on these resources
Maintain the current assessment tier of fish, crab, and marine mammal stocks (Core Activity)
Support NMFS and North Pacific Fishery Management Council analyses and international obligations (Core Activity)
Improve or expand fish, crab, and marine mammal stock assessments and biological and socioeconomic data collections
Conduct integrated ecosystem assessments
Theme 2: Understand and forecast effects of climate change on marine ecosystems
Monitor and understand the effects of loss of sea ice on marine ecosystems
Understand ecological interactions within and between species
Understand effects of ocean acidification
Forecast indirect effects of climate change on fish, crab, and marine mammal species
Theme 3: Describe and assess the role of habitats in supporting healthy marine ecosystems and populations of fish, crab and marine mammals
Assess and evaluate the importance of specific habitat types for fish, crab, and marine mammal populations
Evaluate and forecast ecosystem impacts of fishing and develop mitigation tools
Evaluate and forecast impacts of human activities (other than fishing) on fish, crab, and marine mammals and their habitats
Provide information and analyses to support coastal and marine spatial planning

Research Themes

*RESEARCH THEME 1: **Monitor and assess fish, crab and marine mammal populations, fisheries, and marine ecosystems and the associated communities which rely on these resources***

The primary responsibility of the AFSC is to provide scientific data and analysis and technical advice to the NMFS Alaska Regional Office, North Pacific Fishery Management Council (NPFMC), the State of Alaska, the International Pacific Halibut Commission, the Pacific Salmon Commission, Alaskan tribal governments, and U.S. representatives participating in international fishery and marine mammal negotiations as well as the fishing industry and the general public. The work of monitoring and assessing fish, crab and marine mammal populations, fisheries, and marine ecosystems are mandated by legislation which includes the Magnuson-Stevens Fishery

Conservation and Management Act (MSA), the Marine Mammal Protection Act (MMPA), the U.S. Endangered Species Act (ESA), and the National Environmental Policy Act (NEPA). The first two Research Foci within this theme directly support these responsibilities and can be considered our 'core' activities, representing work the AFSC would continue under the most restrictive budget scenarios. The final two foci in this Theme address improvements to our core work that might be supported, depending on funding availability and priorities.

Research Foci for Research Theme 1

- MAINTAIN THE CURRENT ASSESSMENT TIER OF FISH, CRAB AND MARINE MAMMAL STOCK ASSESSMENTS

*Maintain the information and capabilities needed to support the assessments required for the current NPFMC tiers for fish and crab (*Appendix 1*). Maintain the information and capabilities required to support the current tier of Protected Resources Stock Assessment Improvement Plan (SAIP) tier of marine mammal stocks listed as strategic[1] under the MMPA (*Appendix 2*). Maintaining these tiers requires preserving the current quality and quantity of data used in the assessments.*

The stock assessments produced by the AFSC provide critical information to fishery and protected resource managers. Maintaining stock assessment activities requires adequate resources to collect fishery independent and dependent data as well as to conduct stock assessments and to evaluate the likely biological and socioeconomic outcomes of management options. Fish and crab stock assessments include recommendations for overfishing levels and acceptable biological catch. These recommendations are used by the NPFMC when setting total allowable catches and are a key contributor to ensuring that Alaska's fisheries are managed based on the best available scientific information. As required by the amended MSA, these catch limits will be restructured for each of our managed fisheries as Annual Catch Limits (ACLs) which prevent overfishing and include Accountability Measures, as required, that would be triggered if the ACL is met or exceeded.

Annual marine mammal stock assessments are critical to Alaska Regional Office's (AKRO) protected resources managers as they provide the information necessary for annual evaluations of the level of fishery-related incidental serious injury and mortality of marine mammals relative to a marine mammal stock's Potential Biological Removal (PBR) level.

The AFSC conducts a wide variety of research to support fish stock assessments. Research activities such as conducting field surveys of population abundance, determining age composition of stocks, age at maturity, fecundity, stock structure and spawning behavior,

[1] Strategic stocks are those listed as Threatened or Endangered under the ESA, or Depleted under the MMPA, or those stocks with a level of human-related serious injury and mortality that is greater than the PBR level for that stock.

estimating fishing and natural mortality, and growth rate, and identification of geographical boundaries and essential habitat all contribute to the AFSC's ability to maintain the quality of our stock assessments.

In general, the types of assessment information currently available for marine mammal stocks are more limited than those for fish stocks. Due to a lack of resources, marine mammal assessment scientists conduct abundance surveys and analyze the resulting data for less than half of the stocks for which the AFSC is responsible for developing population estimates, evaluating stock structure, and assessing trends in abundance. Evaluations of age-specific survival and reproductive rates, information on key habitat, and the causes of population trends are conducted for only a small handful of marine mammal stocks.

Maintaining adequate information and capabilities to support current tier designations requires ongoing monitoring and assessment activities. These include conducting surveys at a sufficient geographic scope and frequency, measuring age and other life history parameters, and maintaining observer coverage at levels which support the fishery-dependent data needs for the assessments. The accompanying infrastructure, including staffing these activities, must also be sustained.

- SUPPORT NMFS AND COUNCIL ANALYSES AND INTERNATIONAL OBLIGATIONS

Provide biological and socioeconomic information to the North Pacific Fishery Management Council and NMFS Alaska Regional Office to inform and evaluate management decisions and support quota monitoring and analyses required by legal and regulatory processes.

The AFSC provides scientific support to the AKRO and NPFMC to assist science-based management, reporting, and decision making. The AFSC also provides scientific support to a number of international conventions and organizations such as the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, the International Whaling Commission, the North Pacific Anadromous Fish Commission, the Pacific Salmon Commission, the North Pacific Marine Science Organization, and the International Council for the Exploration of the Sea.

This scientific support takes many forms and includes: 1) the maintenance of the infrastructure for the North Pacific Fisheries Observer Program, 2) the collection, maintenance and analysis of scientific information on ecological and socioeconomic effects of management strategies and alternatives; 3) the participation in international, national and regional working groups; 4) scientific analysis to support the MSA (including National Standards 1-8), NEPA, ESA and MMPA, and 3) scientific data collection activities that form the basis of these analyses and advice. The AFSC provides biological information necessary to evaluate the implications of management actions on fish, crab, and marine mammal stocks and marine ecosystems and conducts social and economic research to support and inform management decisions. The Observer Program support involves training, briefing, debriefing and overseeing observers and maintaining quality of observer data. Analytical support may involve retrospective and prospective methods

including techniques such as management strategy evaluations, socioeconomic surveys, and model-based evaluations.

- IMPROVE OR EXPAND FISH, CRAB AND MARINE MAMMAL STOCK ASSESSMENTS AND BIOLOGICAL AND SOCIOECONOMIC DATA COLLECTIONS

Increase knowledge (e.g., life history and abundance) of fish and crab species listed in fishery management plans and advance current fish and crab assessments for individual stocks by reducing the level of uncertainty in the assessment. Collect basic information (e.g., abundance, stock structure) for non-strategic marine mammal stocks and increase knowledge (e.g., life history, responses to stressors, and interpretation of trends in abundance) of strategic stocks and advance current Protected Resources SAIP tier. Collect and analyze information on social and economic conditions to support decision making based on social and economic effects associated with fishery and species management alternatives.

The AFSC conducts stock assessments that differ according to the specific needs of implementing regulations under the MSA, ESA and MMPA, and according to the differing characteristics of and information available for the populations of fish, crab and marine mammals. Under current budget levels, the AFSC intends on improving assessments and, if possible, expanding the number of populations surveyed through technological innovation and/or redirecting resources and examining the tradeoffs between survey frequency and the number of stocks surveyed. The AFSC also intends to seek additional resources for the improvement and expansion of stock assessments.

The NMFS has developed stock assessment improvement plans for fish, crab, and marine mammals. These improvement plans outline types of information needed in assessments at increasing levels of specificity or confidence, and provide a ranking system for stock assessments that includes maintaining existing levels of information, elevating stock assessments to national standards of excellence, and producing next generation assessments that explicitly incorporate ecosystem considerations such as multispecies interactions and environmental effects, fisheries oceanography, and spatial and seasonal analyses. Next generation assessments for marine mammal populations would include the considerations identified above and would also take into account exposure to and effects of specific threats to a population, behavioral and physiological information, estimates of dispersal rates that include estimates of uncertainty, and assessments using stochastic models. In addition to basic information on abundance, distribution, and stock structure, next generation assessments will often require information about foraging habits, fine-scale distribution, or changes in behavior in response to stressors. Improved fish, crab, and marine mammal stock assessments also require improved information on stock structure and boundaries.

Implementation of the MSA will require development of strategies to measure and incorporate uncertainty into annual catch limits and will be an important activity for fish and crab assessments in the next 5 years. Including ecosystem forcing within single species population

dynamics models will demand development of new modeling approaches to improve stock and ecosystem assessments including incorporating ecosystem indicators, predator-prey interactions and habitat information into stock assessments and assessing the effects of fishing and the environment on the spatial distribution of managed species.

The AFSC will maintain and as feasible, improve collection of the data required for fish and crab stock assessments and socioeconomic assessments. Fish and crab stock assessments require three major categories of quantitative information: 1) trends in relative and/or absolute abundance of the population, 2) direct and incidental harvest, and 3) life history data (growth, maturity, and survival). Data collection will be expanded or improved through the use of new and developing technologies in order to better assess managed species and management activities. More quantitative information is necessary to improve social and economic assessments of management decisions affecting fishing communities and the commercial, recreational, and subsistence fishing sectors.

A high priority for the AFSC is to improve assessments of strategic marine mammal stocks to include trends in abundance, interpretation of these trends, and when needed by managers, information on foraging habitat, fine scale distribution, and behavioral responses of marine mammals to stressors. As funds allow, assessments of non-strategic marine mammals will be improved to meet the minimum requirements of the MMPA for abundance, human-related mortality and serious injury (estimated with acceptable precision), distribution and stock structure.

- CONDUCT INTEGRATED ECOSYSTEM ASSESSMENTS

Develop integrated analyses that monitor and evaluate multiple ecosystem components (e.g., fish, seabirds, marine mammals, oceanography, and human dimensions) by Large Marine Ecosystem (LME). LMEs are relatively large areas of ocean space of approximately 200,000 km² or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas. Unlike geographical ocean boundaries, LMEs are defined by ecological, rather than political or economic, criteria.

> ***Ecosystem thinking**: Social and natural systems are inextricably linked. Human health, prosperity, and well-being depend upon the health and resilience of natural ecosystems; human activities modify the coupled human-natural systems. At the broadest level, NOAA must seek to advance more holistic approaches to understand and balance human use, sustainability, and preservation of ecosystem resources and functioning.*
>
> *-One of four overarching principles presented in the August 5, 2009 NOAA Annual Guidance Memo*

Under the MSA, NOAA is charged with implementing an Ecosystem Approach to Management (EAM) for the nation's ocean and coastal resources. Realizing EAM will require developing an understanding of the manner in which atmospheric and oceanic processes interact with habitat to control the dynamics of fish, crab, and marine mammal populations, and the manner in which management systems influence the impact

of human activities on ecosystem productivity and organization. Forecasting these impacts will require understanding the factors controlling production at various trophic levels, predator-prey interactions, climate pressures, and the interaction of these factors with human behavior. Monitoring these impacts will require improvement of current ecosystem indicators and development of additional indicators of fishing and climate impacts and incorporation of these indicators into fish, crab and marine mammal stock assessments. More fully realizing EAM will require the ecosystem-level data gathering and synthesis known as Integrated Ecosystem Assessment (IEA) for each of the Large Marine Ecosystems (LMEs).

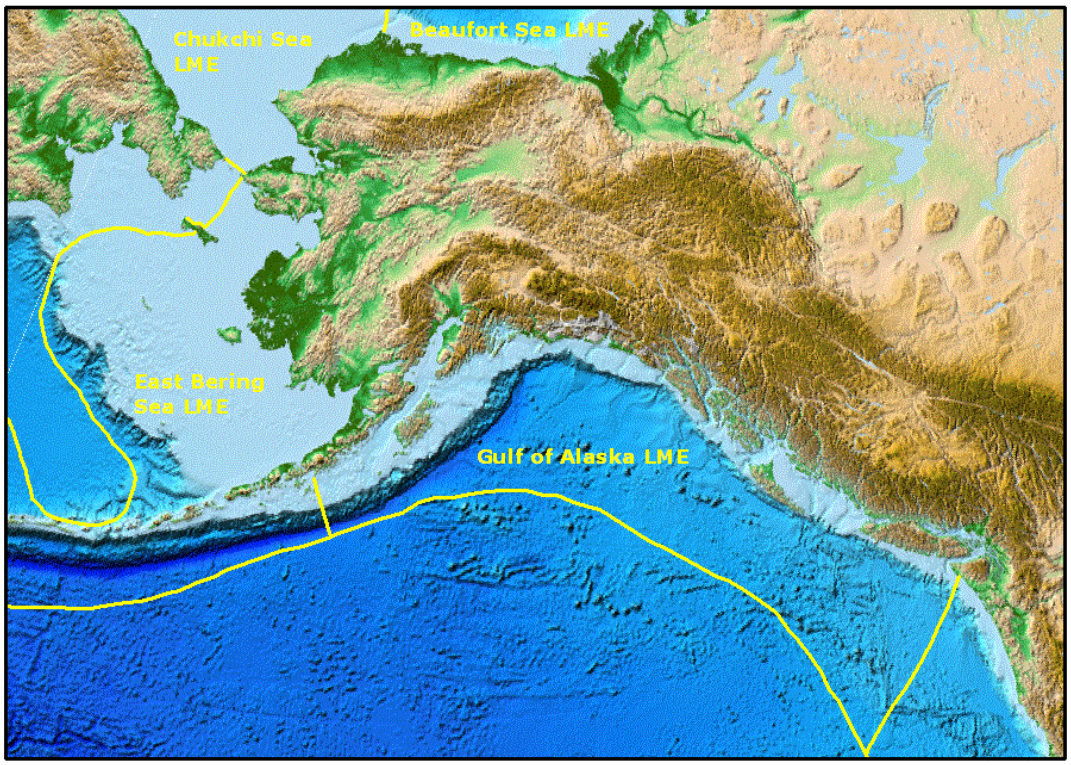

Figure 3: Alaska's four Large Marine Ecosystems: the Gulf of Alaska, the East Bering Sea, which includes the Aleutian Islands, the Chukchi Sea, and the Beaufort Sea

An IEA is the synthesis and analysis of all available information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives. IEAs provide an efficient means of summarizing the status of ecosystem components, screening and prioritizing potential risks, and evaluating alternative management strategies against a backdrop of environmental (e.g., temporal and spatial) variability. They also provide a means of evaluating tradeoffs in management objectives among potentially competing ocean-use sectors in support of marine spatial planning. The four Alaska LMEs, the Gulf of Alaska, eastern Bering Sea, Chukchi, and Beaufort Seas, all lack fully developed IEAs. The Ecosystems Considerations chapter of the Groundfish Stock Assessment and Fishery Evaluation reports provides a foundation for developing IEAs for the eastern Bering Sea and Gulf of Alaska but no such bases exist for the Chukchi and Beaufort Seas.

Both the EAM and IEAs require development and improvement of ecosystem indicators of fishing and climate impacts necessary for advancing EAM stock assessments for fish, crab, and marine mammal populations. Assessment and forecasting of ecosystem indicators will provide a powerful means for assessing management efficacy and a basis for adaptively improving management practices.

RESEARCH THEME 2: ***Understand and forecast effects of climate change on marine ecosystems***

Climate change will impact all four of the LMEs under the research responsibility of the AFSC. The AFSC has extensive research programs in the Gulf of Alaska, southeastern Bering Sea and Aleutian Islands and is carrying out research to improve our understanding of the manner in which *these LMEs may respond to climate change. The AFSC needs to develop and conduct baseline assessments in the northern Bering, Chukchi and Beaufort Seas.*

Research Foci for Research Theme 2

- MONITOR AND UNDERSTAND THE EFFECTS OF LOSS OF SEA ICE ON MARINE ECOSYSTEMS

Monitor and understand the effects of loss of sea ice on fish, crab, ice seals and whales in the Bering, Chukchi and Beaufort Seas not currently assessed by standard AFSC surveys.

There have been dramatic changes in the coverage and thickness of sea ice in the Arctic in the past several years. These changes are known to have impacted the oceanography of the Bering Sea, and are likely to have influenced the abundance and distribution of high-latitude species of fish, crabs, and marine mammals; many of these species are economically important and/or legally protected. The AFSC needs to monitor and understand these changes in the eastern Bering, Chukchi, and Beaufort Seas in order to advise the AKRO and other management bodies such as the NPFMC on mitigating their ecological, social, and economic impacts.

- UNDERSTAND ECOLOGICAL INTERACTIONS WITHIN AND BETWEEN SPECIES

Understand the spatial and seasonal trophic relationships between phytoplankton, zooplankton, fish, crabs, seabirds and mammals. Understand the effect of climate change on recruitment strength. Measure growth, maturity and survival of fish, crabs, and marine mammals and understand changes in response to climate change. Understand the role disease plays in altering the distribution and productivity of Alaska's living marine resources.

Understanding ecological interactions between trophic levels and the impact of ocean conditions provides important insight into factors affecting the productivity of marine species. Predator-prey interactions, inter- and intra-specific competition, and parasites and pathogens can influence the survival, growth, and reproductive success of fish, crabs and marine mammals. Moreover, climate change (e.g., ocean warming) can change early life survival and thus recruitment strength. Addressing questions about ecological interactions requires field and laboratory studies that complement population and ecosystem models including: conducting

food habits analysis; understanding the effect of climate on early life survival of fish, crabs and marine mammals; conducting age and growth analyses for key species; understanding the role that disease plays in altering distribution patterns and productivity of fish, shellfish and marine mammal populations. Addressing fisheries interactions with marine mammals also requires field and modeling studies of predator-prey interactions and foraging ecology including marine mammal food habits, behavioral response, prey availability and seasonality and the influence of climate and oceanographic variability on those processes.

- UNDERSTAND EFFECTS OF OCEAN ACIDIFICATION

Understand the effect of ocean acidification on fish, crab, cold water corals, calcareous plankton and marine mammal species.

> *"Now is the time...for NOAA to spur the creation of new jobs and industries, revive our fisheries and the economies and communities they support…, provide credible information about climate change and ocean acidification to Americans, and protect and restore our coastal waters [and] ecosystems."*
>
> *Dr. Jane Lubchenco*
>
> *March 20, 2009 message to NOAA staff*

The LMEs in which the AFSC conducts research are those that are most likely to experience the strongest effects of ocean acidification the earliest. Corrosive waters reach shallower depths more often in the four Alaskan LMEs, so biological impacts are expected to occur earlier in Alaskan waters than in other places. Ocean acidification creates corrosive waters by reducing the calcium carbonate ($CaCO_3$) saturation point, causing stress in calcifying organisms by increasing the bioenergetic costs of calcification. Ocean acidification will likely impact the ability of marine calcifiers, such as cold water corals and crabs, to make shells and skeletons from $CaCO_3$. Ocean acidification may also affect fish, marine mammal and seabird species through reduced abundance of calcareous plankton commonly found at the base of food webs. Species-specific studies of crabs, calcareous plankton, cold water corals and fish will be conducted to understand physiological effects (growth and survival). Species-specific study results will be incorporated into population and ecosystem models to forecast population responses and ecosystem level impacts. In conjunction with other models, bioeconomic models of Alaskan crab fisheries will be used to forecast fishery performance for a range of climate and ocean acidification scenarios.

- FORECAST INDIRECT EFFECTS OF CLIMATE CHANGE ON FISH, CRAB, AND MARINE MAMMAL SPECIES

Forecast population changes in response to climate change (ocean warming, ocean acidification) on fish, crab, and marine mammals. Forecast socioeconomic effects on coastal communities and effects on the Alaska Native marine mammal subsistence harvest. Alaska's fishery resources support commercial fisheries worth $5.8 billion[2] employing tens of thousands of people each

[2] 2007 economic impact on the state of Alaska; Marine Conservation Alliance

year. Additionally, subsistence harvests of fish and mammals continue to be an important practice in Alaska's native communities. Subsistence uses of marine resources support cultural practices as well as ensure local food supplies in remote communities. While the AFSC seeks to understand the environment's effect on exploited marine populations, it is also critical to predict changes in these populations that may occur in response to climate change because of their economic and social importance. It will be important to determine if climate change will create long-term shifts in abundance and distribution. The goal of this effort is to provide scientific information that helps sustain a healthy commercial fishing economy and an ongoing subsistence lifestyle in Alaska.

> *RESEARCH THEME 3:* ***Describe and assess the role of habitats in supporting healthy marine ecosystems and populations of fish, crab and marine mammals***

The AFSC conducts research to understand the role habitat (Essential Fish Habitat (EFH) and Critical Habitat) plays in the health and sustainability of Alaska's fish, crab and marine mammal populations. The MSA requires NMFS to designate EFH and minimize the effects of fishing and non-fishing activities on EFH. The ESA requires the Federal government to designate Critical Habitat for any listed stocks.

Research Foci for Research Theme 3

- ASSESS AND EVALUATE THE IMPORTANCE OF SPECIFIC HABITAT TYPES FOR FISH, CRAB, AND MARINE MAMMAL POPULATIONS

Determine which habitats are essential for sustainability of fish, crab and marine mammal populations.

The AFSC conducts habitat assessments following the implementing regulations under the MSA, MMPA and ESA and other federal laws, or according to the differing characteristics of the targeted populations of fish, crab and mammals. The AFSC intends to assess, evaluate and understand the importance of specific habitat types for fish, crab and marine mammal populations within existing budget levels and to seek additional funding as necessary. Under the MSA, NMFS is required to designate Essential Fish Habitat (EFH) and minimize the effects of fishing and non-fishing activities on EFH. Essential Fish Habitat is defined as "…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." This definition includes both benthic (biotic and abiotic structures) and pelagic (estuaries, ocean-frontal zones, etc.) habitat. Under the ESA the Federal government is required to designate Critical Habitat for all listed species. Critical Habitat is defined as areas within the geographical area occupied by listed species, if these contain physical or biological features essential to conservation and may require special management considerations or protection, and specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. Support of AKRO's coastal permit review responsibilities requires the AFSC to assess habitats and to analyze these permit requests with respect to

potential to impact fish and mammal species. Surveys of ocean and coastal benthic habitats are essential to AFSC's responsibilities under both MSA and ESA. The AFSC will continue to support the joint AKRO-AFSC Fish Atlas coastal habitat database and the assessments of coastal habitats that contribute to it. The AFSC will continue to rely on coastal habitat assessments for ESA stock assessments and also for oil spill response, damage assessment and restoration activities.

- EVALUATE AND FORECAST ECOSYSTEM IMPACTS OF FISHING AND DEVELOP MITIGATION TOOLS

Evaluate ecosystem impacts of fishing. Understand factors affecting bycatch and develop mitigation strategies.

Assessment of the historical, present, and future states of marine ecosystems and the effects that humans and climate have on the state of these ecosystems is crucial to the scientific advice required to implement ecosystem-based fishery management and develop mitigation strategies. Management of Federal fisheries in Alaska considers not just target fisheries, but also the impact those fisheries might have on other species and the ecosystem. Management actions have ranged from providing protection for endangered species to preventing new fisheries from starting on key food web components such as forage fish. Research is necessary to evaluate impacts of fishing and possible mitigation approaches, and to provide appropriate advice to policymakers and managers. For example, research on salmon distribution and stock origin was used to develop mitigation strategies to reduce salmon bycatch in groundfish fisheries. Gear research is directed toward reducing seafloor impacts of fishing with bottom trawls and other fishing gear and to reducing levels of bycatch and bycatch mortality in directed fisheries. Behavioral research has been applied to predict bycatch handling mortalities of halibut and king, snow, and Tanner crabs.

A scientific framework for providing ecosystem-based advice has recently evolved. This framework provides a way of assessing ecosystem factors that influence target species, the impact the target fishery may have on associated species, and ecosystem-level impacts of fishing. This framework currently is used to provide advice to fishery managers. Continued research that evaluates fishing impacts and mitigation tools is necessary to ensure sustainable fisheries and marine ecosystems.

- EVALUATE AND FORECAST IMPACTS OF HUMAN ACTIVITIES (OTHER THAN FISHING) ON FISH, CRAB, AND MARINE MAMMALS AND THEIR HABITATS

Evaluate the effects of anthropogenic noise on marine mammals and fish. Monitor and evaluate direct and indirect effects of oil spills on fish, crabs, and marine mammals. The overlap between managed species and non-fishing human activities (oil/gas exploration and development, Department of Defense activities, dredging, contaminants, coastal infrastructure, etc.) has increased. Non-fisheries human activities have increased rapidly in recent years in the Bering, Chukchi and Beaufort Seas. The AFSC has an important role in conducting habitat and organism sampling after oil spills to help quantify the levels of exposure to oil and consequent toxic effects for damage assessment. Managers will continue to need science-based information on potential

impacts of these changes on fish, crab, and marine mammals and their habitats to manage and mitigate the activities.

Increasing human populations and activities in Alaska increase the potential for impacts on the fish, crab and marine mammal species in the oceans off Alaska. Managers need information about how these human activities impact fish, crab and marine mammal species in order to understand, forecast, and mitigate those impacts. Such information is valuable for analyses in NEPA compliance documents, biological opinions, Section 7 consultations under the ESA[3], and for marine spatial planning. Expansion of some human activities (e.g., oil/gas exploration, development and production, shipping, Department of Defense activities) is expected to increase sound levels in the ocean which may affect marine mammals and fish. It will be important to understand the short- and long-term noise effects, particularly for marine mammal species. Other types of anthropogenic activities expected to increase in Alaska include dredging, release of contaminants into the ocean, and alternative energy production. The impacts of each type of activity must be evaluated in the context of our stewardship responsibilities, so that both activity-specific and cumulative effects are understood and analyzed accurately.

- PROVIDE INFORMATION AND ANALYSES TO SUPPORT COASTAL AND MARINE SPATIAL PLANNING

Coastal and marine spatial planning is a comprehensive, ecosystem-based process through which compatible human uses are allocated spatially and temporally to sustain critical ecological, economic and cultural services.

> *Coastal and marine spatial planning will use "an ecosystem-based management approach that addresses cumulative effects to ensure the protection, integrity, maintenance, resilience, and restoration of ocean (and) coastal….ecosystems, while promoting sustainable uses." coastal waters [and] ecosystems."*
> - *Interim Framework for Effective Coastal and Marine Spatial Planning December 9, 2009*

This focus necessitates understanding of the linkages between traditional marine resource use (e.g., fish and marine mammal harvesting) and emerging activities (e.g., increased shipping, ocean energy projects, increased oil and gas exploration, eco-tourism, and recreational fisherman and boaters). Spatially-explicit information on activities and ecosystem characteristics and use are required along with the development of decision-support tools to inform decision makers of these linkages and potential impacts. Many of the AFSC's existing and planned research activities will provide the tools necessary to support Alaska's coastal and marine spatial planning. The AFSC's continued integration of biological and socioeconomic studies will be essential to ensure that the development and implementation of coastal and marine spatial plans in Alaska are informed by best available scientific information.

[3] Section 7 of the ESA requires, among other items, Federal agencies to consult with the US Fish and Wildlife Service to ensure that they are not undertaking, funding, permitting, or authorizing actions likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat.

Research infrastructure and support

AFSC research activities require the active development and improvement of AFSC infrastructure and support capabilities. This section briefly describes the tools, facilities, and support staff needed to enable high-priority research.

- INFRASTRUCTURE: THE AFSC MAINTAINS THE INFRASTRUCTURE FOR CRITICAL DATA MANAGEMENT FUNCTIONS, LABORATORY FACILITIES, FIELD SAMPLING, AND ADMINISTRATIVE ACTIVITIES

The data management responsibilities of the AFSC are complex and must be supported to ensure that data and data products are high quality, accessible, and released in a manner consistent with applicable laws and policies. The AFSC must have the capacity to archive, compile and interrelate, model, and analyze numerous independent data types totaling millions of records. The AFSC must maintain and expand the documentation of metadata and other data management requirements.

Building, office, laboratory, and library facilities and sea-water systems are required to achieve research goals. The AFSC maintains several facilities which are required to support research. The AFSC has research facilities in Seattle, Washington; Juneau, Kodiak, Anchorage, Dutch Harbor, Little Port Walter, St. George, and St. Paul, Alaska; and Newport, Oregon. The AFSC will seek additional funding to maintain and expand this functionality.

The AFSC owns and operates a fleet of small boats necessary for nearshore research activities. The AFSC also relies on both NOAA and chartered commercial vessels and aircraft to complete mission critical field work. The AFSC is committed to maintaining and expanding the functionality and available operational days of these NOAA ships and aircraft by continuing to work closely with NOAA's Office of Marine and Aviation Operations and by working with the commercial community to retain access to and use of chartered ships and aircraft.

Support staff

The AFSC research activities require dedicated and knowledgeable technical and support staff to design, prepare, stage, and maintain critical equipment and instruments and facilities. The AFSC must continue to dedicate staff and budgetary resources for operations and administrative functions. Continued information technology support is critical to ensure computer systems are secure and functional and to develop and maintain necessary databases and applications for research and administrative functions. Laboratory, field, and office safety is a priority and an essential part of successful performance of AFSC research. Staff with expertise and resources to maintain our facilities and ensure workplace safety and environmental compliance are critical support functions that must be supported.

The AFSC communications staff provide publication, web, graphics, outreach, and education services to promote and support effective communications of our scientific research activities and findings to a broad audience.

Implementation strategy

Accompanying the Science Plan will be an Implementation Process, outlining the processes for resource allocation decision-making and communication to accomplish core activities and high priority research. While this is envisioned as a separate document, the Implementation Process and Science Plan will work together as guiding documents for the AFSC.

Appendices

1. Table of fish and shellfish species and species groups managed by NOAA Fisheries within the U.S. Exclusive Economic Zone off Alaska.

2. Table of pinniped and cetacean species and species groups managed by NOAA Fisheries within the U.S. Exclusive Economic Zone off Alaska.

Appendix 1: Table of fish and shellfish species and species groups managed by NOAA Fisheries within the U.S. Exclusive Economic Zone off Alaska.

NPFMC Tiers are defined in the introduction of the annual BSAI and GOA groundfish and BSAI Crab Stock Assessment and Fishery Evaluation (SAFE) reports (http://www.afsc.noaa.gov/REFM/docs/2009/BSAIintro.pdf.; http://www.fakr.noaa.gov/npfmc/SAFE/2009/CRABSAFE09.pdf). In general, assessments in lower-numbered tiers (e.g., Tier 1) have more information and assessments in high-numbered tiers (e.g., Tier 6) have minimal information.

Stock	***North Pacific Fishery Management Council Management Tier***
Eastern Bering Sea Pollock	Tier 1
Aleutian Is. Pollock	Tier 3
Bogoslof Is. Pollock	Tier 5
GOA Pollock	Tier 3
BSAI Pacific cod	Tier 3
GOA Pacific cod	Tier 3
BSAI Sablefish	Tier 3
GOA Sablefish	Tier 3
BSAI Yellowfin Sole	Tier 1
GOA Shallow-water Flatfish[4]	Tier 5 (Rock soles in Tier 4)
BSAI Greenland turbot	Tier 3
GOA Deep-water Flatfish[5]	Tier 6 (Dover sole in Tier 3)
BSAI Arrowtooth flounder	Tier 3
GOA Rex Sole	Tier 5
BSAI Northern Rock Sole	Tier 1
GOA Arrowtooth Flounder	Tier 3
BSAI Flathead Sole	Tier 3
GOA Flathead Sole	Tier 3
BSAI Alaska Plaice	Tier 3
GOA Pacific Ocean Perch	Tier 3
BSAI Other Flatfish[6]	Tier 5
GOA Northern Rockfish	Tier 3
BSAI Pacific Ocean Perch	Tier 3
GOA Shortraker/Other Slope[7]	Tier 5 (Sharpchin in Tier 4)

[4] The GOA shallow water flatfish complex includes northern rock sole, southern rock sole, yellowfin sole, butter sole, starry flounder, English sole, sand sole and Alaska plaice. Northern and southern rock sole are in Tier 4 while the other species in the complex are in Tier 5.

[5] The GOA deepwater flatfish complex includes Dover sole, Greenland turbot and deepsea sole. Turbot and deepsea sole are in Tier 6 while Dover sole is in Tier 3.

[6] The BSAI other flatfish group includes those flatfish besides rock sole, yellowfin sole, arrowtooth flounder, Greenland turbot, flathead sole and Alaska plaice. Although over a dozen species of flatfish are found in the BSAI area, the other flatfish biomass consists primarily of starry flounder, rex sole, longhead dab, Dover sole and butter sole.

[7] The GOA shortraker and “other slope rockfish” complex includes sharpchin, redstripe, harlequin, silvergrey, and redbanded rockfish.

Stock	*North Pacific Fishery Management Council Management Tier*
BSAI Northern Rockfish	Tier 3
GOA Rougheye and Blackspotted	Tier 3
BSAI Other Rockfish	Tier 5
GOA Pelagic Shelf Rockfish[8]	Tier 5 (Dusky in Tier 3)
BSAI Shortraker rockfish	Tier 5
GOA Demersal Shelf Rockfish	Tier 4
BSAI Blackspotted and Rougheye rockfish	Tier 5 for Eastern Bearing Sea; Tier 3 for Aleutian Islands)
GOA Thornyheads	Tier 5
BSAI Atka Mackerel	Tier 3
GOA Atka Mackerel	Tier 6
BSAI Squid	Tier 6
GOA Skates, Sharks	Tier 5 Skates, Tier 6 Sharks
BSAI Skates	Tier 5 (Tier 3 for Alaska skate)
BSAI Sharks	Tier 6
BSAI Sculpin	Tier 5
BSAI Octopus	Tier 6
GOA Squid, Octopus, Sculpins	Tier 6 Squid, Tier 6 Octopus, Tier 5 Sculpins
BSAI/GOA Grenadiers	Tier 5[9]
GOA Forage Fish	
Eastern Bering Sea Snow Crab	Crab Tier 3
Bristol Bay Red King Crab	Crab Tier 3
St. Matthew Island Blue King Crab	Crab Tier 4
Eastern Bering Sea Tanner Crab	Crab Tier 4
Pribilof Islands Red King Crab	Crab Tier 4
Pribilof Islands Blue King Crab	Crab Tier 4
Norton Sound Red King Crab	Crab Tier 4
Aleutian Islands Golden King Crab	Crab Tier 5
Pribilof Islands Golden King Crab	Crab Tier 5
Adak Red King Crab	Crab Tier 5

[8] The GOA pelagic shelf rockfish complex includes dark, widow, yellowtail and dusky rockfish. Dark, widow and yellowtail are managed as Tier 5 species and dusky rockfish are managed as a Tier 3 species.

[9] Grenadiers are not yet a managed species in the GOA or BSAI groundfish FMP. Future NPFMC action is anticipated to bring them into a managed category. Information is sufficient at present to warrant a Tier 5 assessment when it becomes required.

Appendix 2: Seal, sea lion and whale species and species groups managed by NOAA Fisheries within the U.S. Exclusive Economic Zone off Alaska.

Strategic stocks are those listed as Threatened or Endangered under the ESA, or Depleted under the MMPA, or those stocks with a level of human-related serious injury and mortality that is greater than the PBR level for that stock. The Marine Mammal Stock Assessment Improvement Plan (SAIP) Tier generally describes the level of information included in the stock assessment for that stock. Assessments ranked as being in Tier 1 have minimal or no information on abundance, stock structure, distribution, or anthropogenic impacts; often, PBR levels cannot be calculated for stocks in Tier 1 because of lack of information. Assessments ranked as being in Tier 2 include estimates of abundance (although they may be imprecise), some information on stock structure from a directed study, and a minimum estimate of anthropogenic impacts. The Tier system for marine mammals is described in Merrick et al 2004 http://www.nmfs.noaa.gov/pr/pdfs/sars/improvement_plan.pdf.

Common Name	*Stock*	*Threatened/ Endangered/ Depleted*	*Strategic*	*SAIP Tier FY09*
Steller sea lion	Western US	E , D	Y	2
Steller sea lion	Eastern US	T, D	Y	2
Northern fur seal	Eastern Pacific	D	Y	2
Harbor seal	Southeast Alaska			2
Harbor seal	Gulf of Alaska			2
Harbor seal	Bering Sea			2
Spotted seal	Alaska			1
Bearded seal	Alaska			1
Ringed seal	Alaska			1
Ribbon seal	Alaska			1
Beluga whale	Beaufort Sea			1
Beluga whale	Eastern Chukchi Sea			1
Beluga whale	Eastern Bering Sea			1
Beluga whale	Bristol Bay			1
Beluga whale	Cook Inlet - Alaska	E, D	Y	2
Killer whale	Eastern North Pacific Alaska Resident			1
Killer whale	Eastern North Pacific Northern Resident			1
Killer whale	AT1 Transient/Prince William Sound	D	Y	2
Killer whale	Eastern North Pacific Gulf of Alaska, Aleutian Islands, Bering Sea Transient			1
Killer whale	West Coast Transient			1
Killer whale	Eastern North Pacific Transient			
Killer whale	Eastern North Pacific Offshore			1
Pacific white-sided dolphin	North Pacific			1
Harbor porpoise	Southeast Alaska		Y	1

Common Name	*Stock*	*Threatened/ Endangered/ Depleted*	*Strategic*	*SAIP Tier FY09*
Harbor porpoise	Gulf of Alaska		Y	1
Harbor porpoise	Bering Sea		Y	1
Bowhead whale	Western Arctic	E, D	Y	2
Cuviers beaked whale	Alaska			1
Dalls porpoise	Alaska			1
Fin whale	Northeast Pacific	E, D	Y	1
Gray whale	Eastern North Pacific			2
Harbor porpoise	Bering Sea Stock		Y	1
Sperm whale	North Pacific	E, D	Y	1
Baird's beaked whale	Alaska			1
Stejnegers beaked whale	Alaska			1
Humpback whale	Western North Pacific	E, D	Y	1
Humpback whale	Central North Pacific	E, D	Y	1
Minke whale	Alaska			1
Right whale, North Pacific	Eastern North Pacific	E, D	Y	1
Blue whale	Eastern North Pacific	E, D	Y	1