APPENDIX E

Public Comments to 22 September 1995 Biological Assessment

PUBLIC COMMENTS

INDEX

PUBLIC COMMENTS	COMMENT DATE
Office of Planning and Budget State of Georgia	13 Oct 95
College of Atlantic	26 Sep 95
Massachusetts Sierra Club	27 Oct 95
Richard Max Strahan	21 Oct 95
Foley, Hoag & Eliot	27 Oct 95

MARINE MAMMAL COMMISSION
1825 CONNECTICUT AVENUE, N.W. #512
WASHINGTON, DC 20009

24 October 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street, S.W.
Washington, D.C. 20593-0001

Dear Commander Marquardt:

Thank you for sending a copy of the 22 September 1995 "Environmental Assessment of Potential Impacts of U.S. Coast Guard Activities along the U.S. Atlantic Coast". The Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the report and offers the following comments.

The Environmental Assessment provides a thorough and useful analysis of the effects on protected species, including right whales and certain other marine mammals, of Coast Guard activities along the U.S. Atlantic Coast. Measures identified in the proposed action would increase protection of marine wildlife and the Marine Mammal Commission supports their adoption. The Commission also believes that there are certain other steps that might be taken. These, along with a few comments specific to the draft, are noted below.

Page 3-2: The first bulleted paragraph on this page notes that, to avoid collisions between Coast Guard vessels and protected species, slow safe speeds for surface vessels and increased altitude for aircraft would be used in sanctuaries, critical habitats, and other important wildlife areas during non-emergency situations. Emergency actions are described as those required to avoid loss of life. There may be other "emergencies", such as some law enforcement situations (including enforcement of protected species laws) and environmental emergencies (including responding to oil spills), where exceptions to the slow, safe speed policy may be warranted. With regard to vessel operations, there also may be merit in investigating the feasibility and use of forward looking sonar on some vessels to help detect and avoid large whales.

Page 3-3: The third bulleted paragraph on this page notes that the Coast Guard will "maintain active membership on the SEUS Right Whale Recovery Team." We believe this action would be a great benefit to the Southeastern Implementation Team and the right whale recovery program. We note, however, that the name of the team is cited incorrectly and might be confused with the Right Whale Recovery Team, which has been inactive for some time.

It would probably be useful therefore to correct the Team's name, which is the Southeastern Implementation Team for the Recovery of the Northern Right Whale. Also, as we understand it, the Coast Guard participates on the New England Implementation Team for Right Whales and Humpback Whales, and the Florida Manatee Recovery Team. It might be useful to note, therefore, that the Coast Guard plans to continue participating on these Teams and, as requested, would participate on such other relevant recovery teams as may be formed.

Page 3-3: The fifth bulleted paragraph on the page notes the Coast Guard's intent to use the NAVTEX communication system to notify vessels in real-time of locations for right whales in certain areas. It might be useful to note that this or other vessel advisory systems may be used as appropriate with regard to humpback whales and perhaps other protected species, as well. This paragraph also notes that VHF radio communications would be used to notify vessel traffic of the presence of whales. This could incidentally serve to increase close approaches by whale watchers and, for some areas, it may be useful to consider developing some guidelines on the situations, methods, and frequency that whale sighting locations are communicated to vessels.

Page 3-4: To help update and improve information on protected species habitat use patterns within areas of Coast Guard operations, it may be appropriate to expand the list of measures for the proposed action that ends on page four by adding a bullet to note that the Coast Guard also may assist with logistical support of research and monitoring programs set forth in endangered species recovery plans as Coast Guard resources, schedules, and operational requirements permit. Among other things, this would help provide the Coast Guard with timely data on areas where vessel encounters with protected species would be most likely.

I hope these comments are helpful. If you have questions, please contact Mr. David W. Laist, the Policy and Program Analyst on the Commission's staff (202/606-5504).

Sincerely,

John R. Twiss, Jr.
Executive Director

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Fisheries Science Center
Research Management Division
75 Virginia Beach Drive
Miami, Florida 33149

October 10, 1995

MEMORANDUM FOR: LCDR - Wesley C. Marquardt
U.S. Coast Guard

FROM: F/SEC - Bradford E. Brown

SUBJECT: Environmental Assessment of Potential Impacts of U.S. Coast Guard Activities Along the U.S. Atlantic Coast

Per your request, my staff at the Southeast Fisheries Science Center, NMFS, has reviewed the subject document. The document is well prepared. In our opinion recommended alternative #2 is the most appropriate and is properly documented.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
[illegible] Science Center

Tel: 508-548-5123, Ext. 261
Fax: 508-548-5124
EMAIL: jpearce@whsun1.wh.whoi.edu

26 September 1995

LCDR Wesley C. Marquardt, Cmmdr. (G-NIO)
U.S. Coast Guard
2100 Second Street, S.W.
Washington, DC 20593-0001

Dear Commander Marquardt:

The document concerned with environmental assessment of potential impacts of U.S.C.G. activities was recently received in this office. It will be reviewed within a week or so and comments sent back to you. Perhaps the most immediate shortcoming that I see is a necessity for a brief executive summary, spelling out the needs for the assessment and including terse descriptions of the significant actions or alternatives needed.

Finally, I have just chaired a Workshop mandated by Congress and having to do with marine mammals, fisheries, and their habitats and the interactions between all of these. We were fortunate to have U.S. Coast Guard representation (Boston District) at the Workshop. If you have any interest in tracking this further, please let me know.

Most sincerely,

Dr. John B. Pearce
Deputy Center Director
DOC/NOAA/NMFS/NEFC

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OCEAN AND COASTAL RESOURCE MANAGEMENT
SANCTUARIES AND RESERVES DIVISION
Stellwagen Bank National Marine Sanctuary
14 Union Street
Plymouth, Massachusetts 02360
(508) 747-1691 (508) 747-1949 FAX

29 October, 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street, S.W.
Washington, D.C. 20593-0001

VIA FACSIMILE

Dear Commander Marquardt:

We have reviewed the draft Environmental Assessment of USCG Activities Along the US Atlantic Coast, and believe that the document is generally thorough and well prepared. We support the Coast Guard's selection of the preferred alternative and believe that the implementation of these measures will provide apporpriate protection for the marine mammals and other protected species in your operating area.

One small correction, however. Table 4-11 incorrectly lists the Gray's Reef National Marine Sanctuary in Florida, when in fact it is located off the coast of Georgia.

Thanks you for the opportunity to review this document.

Sincerely,

Bradley W. Barr
Sanctuary Manager

cc: Reed Bohne, GRNMS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
[illegible]
[illegible]

October 24, 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

RE: Environmental Assessment of potential impacts of U.S. Coast Guard activities along the U.S. Atlantic Coast

Dear Commander Marquardt:

Thank you for the copy of the environmental assessment (EA) of potential impacts from U.S. Coast Guard (USCG) activities along the U.S. Atlantic Coast. The U.S. Fish and Wildlife Service (FWS) has reviewed the EA for potential affects the proposed action may have on federally listed species. Based on this review, we concur with Alternative 2 as the Preferred Alternative for the USCG in modifying its operational activities while performing its mission. Furthermore, we agree with the FONSI and that an Environmental Impact Statement is not necessary. We have submitted the following comments for your consideration.

<ins>Page 3-2</ins>: Who is the FWS contact in the Regional Office working with the USCG on training their personnel to improve their wildlife observation skills? Also, who is the FWS contact working with the USCG and DEP on finalizing draft guidelines for marine events in manatee habitat? Since these guidelines are not completed, is that why they are not in Appendix C?

<ins>Page 3-3</ins>: The USCG states guidelines will be developed to further recovery actions for threatened and endangered marine mammals, yet, there is no reference to the recovery plan for the Florida manatee (*Trichechus manatus latirostris*).

<ins>Page 4-17</ins>: Again, who is the FWS contact working with the USCG on developing procedures to eliminate or minimize potential impacts to federally listed species?

<ins>Page 4-18</ins>: The Dry Tortugas National Park needs to be included on the list of protected areas.

We recommend you contact Tom Baugh (404/679-7133) or Jon Andrew (404/679-7123) in the Regional Office to provide you with initial assistance and guidance.

Thank you for the opportunity to provide these comments and for your efforts in the protection of threatened and endangered species and their designated critical habitats. If you have any questions regarding these comments, please contact Kalani Cairns of our office at (407)562-3909.

Sincerely,

Kalani D. Cairns

for Craig Johnson
Supervisor, South Florida Ecosystem Office

cc:
FWS, Atlanta, GA
NMFS, Miami, FL
NMFS, St. Petersburg
FDEP, Tallahassee, FL
FGFWFC, Tallahassee, FL

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1270 Norwich Street
Brunswick, Georgia 31520

November 13, 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

RE: Environmental Assessment of Potential Impacts of U.S. Coast Guard Activities along the U.S. Atlantic Coast
FWS Log 4-4-95-285 (ATTN:RBG)

Dear LCDR Marquardt:

Thank you for the opportunity to review the referenced document, which presented five alternatives for Coast Guard activities along the U.S. Atlantic Coast. We agree that the proposed action, Alternative 2, is likely to reduce impacts on Federally listed species, species of special concern, and critical habitats without significantly affecting Coast Guard operations during emergencies. Proposed changes to current Coast Guard activities under Alternative 2 include:

- increasing overall U.S. Coast Guard awareness of the marine environment and inhabitants through cross-agency training;
- plotting Federally listed species' critical habitats and marine sanctuary boundaries on all navigational and law enforcement working charts;
- operating vessels at slow, safe speeds during nonemergency operations when crossing marine sanctuaries, critical habitats, and areas of intermittent protected species concentrations;
- flying aircraft during nonemergency operations at an altitude of at least 3000 feet over wildlife habitat (as outlined in the First Coast Guard District Law Enforcement Bulletin 33-94, Appendix C);
- posting a lookout to identify and avoid objects in the water; and
- avoiding wildlife and/or nesting habitat, particularly whales and sea turtle nesting beaches from April through October.

The Environmental Assessment stated that areas with intermittent concentrations of Federally listed species will be identified during informal Section 7 consultation under the Endangered Species Act with the Fish and Wildlife Service and National Marine Fisheries Service's Regional Offices. We recommend that Section 7 consultation be conducted annually with these offices to ensure Coast Guard personnel have updated information for charts and other materials that identify areas where wildlife and/or nesting habitat will be avoided, where vessels will be operated at slow, safe speed, and where aircraft will be flown at least 3000 feet in altitude during nonemergency actions. In addition to Federally listed species, coastal Georgia supports numerous other wildlife resources. For example, up to 15,000 waterfowl winter in the Altamaha River Waterfowl Area, and rafts of up to 100,000 birds occur in coastal waters off Blackbeard, St. Catherines, and Wolf Islands (J. Robinette, USFWS, pers. comm.; D. Forster, GADNR, pers. comm.). Coastal Georgia has numerous wading bird rookeries and shorebird nesting sites, including Egg Island, which supported 1200 nesting pairs of brown pelicans, 9000 nesting pairs of royal terns, and 255 nesting pairs of black skimmers in 1995 (M. Harris, GADNR, pers. comm.). In addition to these native wildlife populations, the American Museum of Natural History and the New York Zoological Society breed and conduct research on rare and endangered wildlife on St. Catherines Island. Based on these data, we recommend that the Coast Guard contact the Brunswick Field Office annually to receive information on concentrations of wildlife resources along Georgia's coast that could be hazardous to Coast Guard planes flying at low altitudes.

We appreciate the opportunity to comment on the environmental assessment. Please contact Robin Goodloe of my staff (912-265-9336) if you have questions or require additional information.

Sincerely,

Greg Masson

Gregory Masson, Ph.D.
Acting Field Supervisor

cc: ES, FWS, Atlanta, GA (Dave Fleming)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

SE 27

LCDR Wesley C. Marquardt, Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

Subject: Environmental Assessment (EA) for Potential Impacts of U.S. Coast Guard (USCG) Activities Along the U.S. Atlantic Coast

Dear Sir:

Pursuant to Section 309 of the Clean Air Act, EPA, Region 4 has reviewed the subject document which assesses the consequences of revising current USCG operations together with how these changes will affect selected physical, biological, and socioeconomic environments along the Atlantic Coast of the United States. Our evaluation focused on the reach from North Carolina to Florida; other Regional Offices will comment on proposed changes and their impacts from Virginia north. We support the USCG decision to modify its current operational practices and agree that these changes can be implemented without significantly degrading mission capabilities. By extension, we are in accord with the specific stipulations noted in Alternative 2, i.e., if properly implemented they should significantly minimize disturbance/harm to endangered or threatened species and their critical habitat.

Since we have no significant objections to your proposal, the use of an EA as opposed to the more comprehensive environmental impact statement format is acceptable. Thank you for the opportunity to comment. If we can be of further assistance in this matter, Dr. Gerald Miller (404-347-3776 VM 6853) will serve as initial point of contact.

Sincerely yours,

Heinz J. Mueller, Chief
Environmental Policy Section
Federal Activity Branch

State of New Jersey
Christine Todd Whitman
Governor
Department of Environmental Protection
Division of Fish, Game and Wildlife
CN 400
Trenton, N.J. 08625-0400
Robert C. Shi...
Commi...

October 19, 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

Dear LCDR Marquardt:

This serves to inform you that the New Jersey Division of Fish, Game and Wildlife's Marine Fisheries and Endangered and Nongame Species elements have reviewed your *Environmental Assessment of Potential Impacts of U.S. Coast Guard Activities Along the U.S. Atlantic Coast* dated September 22, 1995 by the U.S. Coast Guard and Battelle Ocean Services. Both elements support the proposed actions and concur with a finding of no significant impact.

We hope this information is of service to you.

Sincerely,

Robert McDowell, Director
Division of Fish, Game and Wildlife

c. T. McLoy
W. Andrews
C.D. Jenkins

MARYLAND DEPARTMENT OF NATURAL RESOURCES
Resource Assessment Administration
Monitoring and Non-Tidal Assessment Division
"Science in the Public Interest"
416 Chinquapin Round Road
Annapolis, Maryland 21401
(410)974-3238

Parris N. Glendening
Governor

John R. Griffin
Secretary

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

20 October, 1995

RE: Comments on Environmental Assessment and Proposed FONSI

Commander:

My only correction is on page 4-1, last paragraph. The average depth of the Chesapeake Bay is closer to 7 meters, and the deepest point is approximately 55 meters. You might check the figures for Delaware Bay also. Otherwise the document reads well.

Sincerely

Niles L. Primrose
Biologist

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

Peter W. Schmidt
Director

October 27, 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U. S. Coast Guard
2100 Second Street S. W.
Washington, D, C. 20593-0001

RE: Environmental Assessment and Proposed Finding of No Significant Impact of Potential Impacts of U. S. Coast Guard Activities Along the U. S. Atlantic Coast

Dear LCDR Marquardt:

The Commonwealth of Virginia Agencies have completed their review of the Environmental Assessment (EA) and proposed Finding of No Significant Impact (FONSI) for the noted actions. The Department of Environmental Quality is responsible for coordinating Virginia's review of federal environmental documents and responding to the appropriate officials on behalf of the Commonwealth. The following agencies participated in this review:

Department of Environmental Quality;
Department of Conservation and Recreation
Marine Resources Commission; and
Virginia Institute of Marine Sciences.

In addition, the Department of Game and Inland Fisheries, the Department of Agriculture and Consumer Services, the Hampton Roads Planning District Commission and the Accomac-Northampton Planning District Commission were invited to comment through the Department of Environmental Quality.

This project involves modifying U. S. Coast Guard activities to enhance the ability to avoid or minimize harm to protected species while performing their mission. Routine operations and practices will be modified in order to avoid or minimize disturbance or harm to endangered or threatened species, or species of special concern and their critical habitats.

We believe that there is sufficient information contained in the EA to support the proposed Finding of No Significant Impact. The Commonwealth offers the following comments and recommendations:

1. **Natural Heritage Resources.** The Department of Conservation and Recreation (DCR) would appreciate the opportunity to review any construction project proposals in the Commonwealth. While they do not maintain information on marine species such as marine mammals and turtles, they offer information on potential impacts to rare shoreline plant and animal species and significant communities. DCR would be happy to provide natural heritage information which may enhance the U. S. Coast Guard's ability to avoid and minimize harm to protected species.

Activities in the Commonwealth should be coordinated with the U. S. Fish and Wildlife Service, the Virginia Department of Game and Inland Fisheries, and the Virginia Department of Agriculture and Consumer Services, as these agencies have purview over threatened and endangered species in Virginia.

2. **Federal Consistency Certification.** Pursuant to the Coastal Zone Management Act of 1972, as amended, the proposed activities must be operated and constructed in a manner which is consistent with the Virginia Coastal Resources Management Program (VCRMP). In this regard, the U. S. Coast Guard must receive all applicable permits and approvals listed under the Enforceable Programs of the VCRMP (Attached).

Thank you for the opportunity to comment on the Environmental Assessment and proposed Finding of No Significant Impact for these activities. The comments of the reviewing agencies are attached for your review and consideration. The Commonwealth appreciates your consideration of endangered and threatened species, and species of special concern and their critical habitats while performing your mission.

Sincerely,

Michael P. Murphy
Director, Grants Management
and Intergovernmental Affairs

Attachments

cc: John Davy, Jr., DCR
Thomas A. Bernard, Jr., VIMS
Chris W. Frye, MRC
Cheryl Cashman, VDACS
Traycie West, DEQ-TRO

COMMONWEALTH of VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Peter W. Schmidt
Director

P. O. Box 10009
Richmond, Virginia 23240-0009
(804) 762-4000

Enforceable Regulatory Programs comprising Virginia's Coastal Resources Management Program

a. Fisheries Management - The program stresses the conservation and enhancement of finfish and shellfish resources and the promotion of commercial and recreational fisheries to maximize food production and recreational opportunities. This program is administered by the Marine Resources Commission (Virginia Code §28.1-23.1) and the Department of Game and Inland Fisheries (Virginia Code §29-13 and §29-125).

The State Tributyltin (TBT) Regulatory Program has been added to the Fisheries Management program. The General Assembly amended the Virginia Pesticide Use and Application Act as it related to the possession, sale, or use of marine antifoulant paints containing TBT. The use of TBT in boat paint constitutes a serious threat to important marine animal species. The TBT program monitors boating activities and boat painting activities to ensure compliance with TBT regulations promulgated pursuant to the amendment. The MRC, DGIF, and VDACS share enforcement responsibilities.

b. Subaqueous Lands Management - The management program for subaqueous lands establishes conditions for granting or denying permits to use ~~state~~-owned bottomlands based on considerations of potential effects on marine and fisheries resources, wetlands, adjacent or nearby properties, anticipated public and private benefits, and water quality standards established by the Department of Environmental Quality, Water Division. The program is administered by the Marine Resources Commission (Virginia Code §62.1-13.1 et. seq.).

c. Wetlands Management - The purpose of the wetlands management program is to preserve tidal wetlands, prevent their despoliation, and accommodate economic development in a manner consistent with wetlands preservation. This program is administered by the Marine Resources Commission (Virginia Code §62.1-13.1 through §62.1-13.20).

d. Dunes Management - Dune protection is carried out pursuant to The Coastal Primary Sand Dune Protection Act and is intended to prevent destruction or alteration of primary dunes. This program is administered by the Marine Resources Commission (Virginia Code §62.1-13.21 through §62.1-13.28).

e. Non-point Source Pollution Control - Virginia's Erosion and Sediment Control Law requires soil-disturbing projects to be designed to reduce soil erosion and to decrease inputs of chemical nutrients and sediments to the Chesapeake Bay, its tributaries, and other rivers and waters of the Commonwealth. This program is administered by the Department of Conservation and Recreation (Virginia Code §10.1-560 et.seq.).

f. Point Source Pollution Control - The point source program is administered by the State Water Control Board pursuant to Virginia Code §62.1-44.15. Point source pollution control is accomplished through the implementation of:

(i) The National Pollutant Discharge Elimination System (NPDES) permit program established pursuant to Section 402 of the federal Clean Water Act and administered in Virginia as the VPDES permit program.

(ii) Water Quality Certification pursuant to Section 401 of the Clean Water Act.

g. Shoreline Sanitation - The purpose of this program is to regulate the installation of septic tanks, set standards concerning soil types suitable for septic tanks, and specify minimum distances that tanks must be placed away from streams, rivers, and other waters of the Commonwealth. This program is administered by the Department of Health (Virginia Code §32.1-164 through §32.1-165).

h. Air Pollution Control - The program implements the federal Clean Air Act to provide a legally enforceable State Implementation Plan for the attainment and maintenance of the National Ambient Air Quality Standards. This program is administered by the State Air Pollution Control Board (Virginia Code §10-17.18).

George Allen
Governor

Becky Norton Dunlop
Secretary of Natural
Resources

H. Kirby Burch
Director

COMMONWEALTH of VIRGINIA

DEPARTMENT OF CONSERVATION AND RECREATION

203 Governor Street, Suite 302
TDD (804) 786-2121 Richmond, Virginia 23219-2010 (804) 786-6124 FAX: (804) 786-6141

MEMORANDUM

DATE: October 26, 1995

TO: Thomas M. Felvey, Department of Environmental Quality

FROM: John R. Davy Jr., Planning Bureau Manager

SUBJECT: DEQ#95-130F, Potential Impacts of U.S. Coast Guard Activities

The Department of Conservation and Recreation (DCR) has reviewed the Environmental Assessment (EA) for Potential Impacts of U.S. Coast Guard Activities along the Atlantic Coast. This EA addresses the environmental impacts related to U.S. Coast Guard activities. DCR commends the U.S. Coast Guard for the proposed efforts toward minimizing impacts to threatened and endangered species.

DCR's Division of Natural Heritage functions to identify, preserve, and protect the natural heritage resources of the Commonwealth. Natural heritage resources are defined as the habitat of rare, threatened, or endangered plant and animal species, unique or state significant natural communities or geologic sites, and similar features of scientific interest.

DCR would appreciate the opportunity to review any construction project proposals in the Commonwealth of Virginia. While we do not maintain information on marine species such as marine mammals and turtles, we offer information on potential impacts to rare shoreline plant and animal species and significant communities.

Activities occurring in the Commonwealth should also be coordinated with the Unites States Fish and Wildlife Service (USFWS), the Virginia Department of Game and Inland Fisheries (VDGIF), and the Department of Agriculture and Consumer Services (VDACS), as these agencies have purview over threatened and endangered species in Virginia.

DCR would be happy to provide natural heritage information which may enhance the U.S. Coast Guard's ability to avoid and minimize harm to protected species while performing its mission.

The proposed project is not anticipated to have any adverse impacts on existing or planned recreational facilities nor will it impact any streams on the National Park Service Nationwide

Inventory, Final List of Rivers, or any potential State Scenic Rivers.

Thank you for providing us the opportunity to comment on this project.

/jeg
cc: Cindy Schulz, USFWS
Ray Fernald, VDGIF
Rebecca Wadja, VDGIF
John Tate, VDACS

If you cannot meet the deadline, please notify ELLIE IRONS at 804/762-4325, THOMAS M. FELVEY at 804/762-4315, or R. THOMAS GRIFFIN AT 804/762-4337 prior to the date given. Arrangements will be made to extend the date for your review if possible. An agency will not be considered to have reviewed a document if no comments are received (or contact is made) within the period specified.

REVIEW INSTRUCTIONS:

A. Please review the document carefully. If the proposal has been reviewed earlier (i.e. if the document is a federal Final EIS or a state supplement), please consider whether your earlier comments have been adequately addressed.

B. Prepare your agency's comments in a form which would be acceptable for responding directly to a project proponent agency.

C. Use your agency stationery or the space below for your comments. **IF YOU USE THE SPACE BELOW, THE FORM MUST BE SIGNED AND DATED.**

Please return your comments to:

DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF ENVIRONMENTAL IMPACT REVIEW
629 EAST MAIN STREET, SIXTH FLOOR
RICHMOND, VA 23219
FAX #804/762-4319

Rec'd. by Dept. of Environmental Quality
OCT 23 1995
Public & Intergovernmental Affairs

Thomas M. Felvey
Environmental Technical Services Administrator

COMMENTS

Does not appear that the potential impacts from the continued USCG activities have any adverse impacts on the programs administered by the Virginia Marine Resources Commission.

(signed) Chris W. Inge (date) 10-19-95

(title) Environmental Engineer

(agency) VMRC

PROJECT #95-130 8/95

If you cannot meet the deadline, please notify ELLIE IRONS at 804/762-4325, THOMAS M. FELVEY at 804/762-4315, or R. THOMAS GRIFFIN AT 804/762-4337 prior to the date given. Arrangements will be made to extend the date for your review if possible. An agency will not be considered to have reviewed a document if no comments are received (or contact is made) within the period specified.

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Please return your comments to:

DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF ENVIRONMENTAL IMPACT REVIEW
629 EAST MAIN STREET, SIXTH FLOOR
RICHMOND, VA 23219
FAX #804/762-4319

Thomas M. Felvey
Environmental Technical
Services Administrator

COMMENTS We have reviewed the subject document from a marine environmental perspective. We concur with the preferred alternative (Alternative 2) and have no additional comments at this time.

(signed) T A Barnard Jr (date) 10/25/95

(title) T. A. Barnard, Jr., Marine Scientist

(agency) VIMS

8/95

PROJECT #95-130 U.S. Coast Guard

If you cannot meet the deadline, please notify ELLIE IRONS at 804/762-4325, THOMAS M. FELVEY at 804/762-4315, or R. THOMAS GRIFFIN AT 804/762-4337 prior to the date given. Arrangements will be made to extend the date for your review if possible. An agency will not be considered to have reviewed a document if no comments are received (or contact is made) within the period specified.

REVIEW INSTRUCTIONS:

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Please return your comments to:

DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF ENVIRONMENTAL IMPACT REVIEW
629 EAST MAIN STREET, SIXTH FLOOR
RICHMOND, VA 23219
FAX #804/762-4319

Thomas M. Felvey
Environmental Technical
Services Administrator

COMMENTS

The staff of the Tidewater Regional Office has finished its review of this document. There were no comments from the air, waste, and water quality sections. Thank you for the opportunity to participate in the review process.

(signed) Traycie L. West Traycie L. West (date) 10/27/95 27OCT95

(title) Environmental Specialist Senior

(agency) Department of Environmental Quality Tidewater Regional Office

PROJECT #95-130

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Marine Fisheries
James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
Bruce Freeman, Director

DEHNR

October 04, 1995

LCDR Wesley C. Marquardt
Commandent (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

LCDR W. Marquardt:

The North Carolina Division of Marine Fisheries (NCDMF) supports the Proposed Action (Alternative 2) and Finding of No Significant Impact (FONSI) in the circulated document 'Environmental Assessment of Potential Impacts of the U.S. Coast Guard Activities Along the U.S. Atlantic Coast (09/22/95)'. The NCDMF agrees with the finding that Alternative 2 will have minimal adverse impacts on the physical and biological environments.

The document notes that the U.S. Coast Guard wishes to document 'critical habitat'. For descriptions and maps of critical fisheries habitat in North Carolina (spawning sanctuaries, primary nursery areas, etc.) you may wish to contact Mr. Paul Phalen (919-726-7021), Chief of the DMF Information and Management Section.

Thank you for the opportunity to comment.

Sincerely,

Katy West
Permit Review Coordinator

1424 Carolina Avenue, Washington, North Carolina 27889 Telephone 919-946-6481 FAX 919-946-3967
An Equal Opportunity Affirmative Action Employer 50% recycled/10% post-consumer paper

OFFICE OF PLANNING AND BUDGET

GEORGIA STATE CLEARINGHOUSE MEMORANDUM
EXECUTIVE ORDER 12372 REVIEW PROCESS

ZELL MILLER
GOVERNOR

TIM BURGESS
DIRECTOR

TO: LCDR Wesley C. Marquardt
Commandant (C-NIO) U.S.C.G.
2100 Second Street SW
Washington, DC 20593-0001

FROM: Tripp Reid, Administrator/Barbara L. Melvin
Georgia State Clearinghouse

DATE: 10/13/95

SUBJECT: Executive Order 12372 Review

PROJECT: EA/Potential Impacts on Atlantic Coast

STATE ID: GA950926006

CFDA#:

The State level review of the above referenced document has been completed. As a result of the environmental review process, the activity this document was prepared for has been found to be consistent with state social, economic, physical goals, policies, plans, and programs with which the State is concerned.

Additional Comments:

None.

TR/blm

ENCL: EPD/Director's Office, October 11, 1995

AN EQUAL OPPORTUNITY EMPLOYER

Form SC-4-EIS-4
January 1995

254 WASHINGTON ST., S.W. • ATLANTA, GEORGIA 30334-8500

GEORGIA STATE CLEARINGHOUSE MEMORANDUM
EXECUTIVE ORDER 12372 REVIEW PROCESS

TO: Tripp Reid, Administrator/Barbara L. Melvin
Georgia State Clearinghouse

FROM: MR. BRUCE OSBORN
DNR/EPD/DIRECTOR'S OFFICE → KIRBY S. OLSON, Ph.D.
DNR/EPD/RIGHT-TO-KNOW

SUBJECT: Executive Order 12372 Review

PROJECT: EA/Potential Impacts on Atlantic Coast

STATE ID: GA950926006

DATE: 10/11/95

☒ This notice is considered to be consistent with those state or regional goals, policies, plans, fiscal resources, criteria for developments of regional impact, environmental impacts, federal executive orders, acts and/or rules and regulations with which this organization is concerned.

This notice is not consistent with:

☐ The goals, plans, policies, or fiscal resources with which this organization is concerned. (Line through inappropriate word or words and prepare a statement that explains the rationale for the inconsistency. Additional pages may be used for outlining the inconsistencies).

☐ The criteria for developments of regional impact, federal executive orders, acts and/or rules and regulations administered by your agency. Negative environmental impacts or provision for protection of the environment should be pointed out. (Additional pages may be used for outlining the inconsistencies).

☐ This notice does not impact upon the activities of the organization.

Alternative 2 (the proposed action) should have a positive impact on the coastal environment. We particularly applaud your commitment to personnel training, which should reduce the number of vessel/marine vertebrate collisions.

Form SC-3
January 1995

College of the Atlantic

Office of the President
Steven K. Katona

105 Eden Street
Bar Harbor, Maine 04609-1198

TEL (207) 288-5015
FAX (207) 288-4126

September 26, 1995

LCDR Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street S.W.
Washington, D.C. 20593-0001

Dear Lieutenant Commander Marquardt:

Thank you for the opportunity to comment on the Environmental Assessment of Potential Impacts of U.S. Coast Guard Activities along the U.S. Atlantic Coast, dated September 22, 1995. The document demonstrates a very thoughtful and comprehensive approach to its subject.

The document contains a useful summary of the Coast Guard's missions, five different ways in which the Coast Guard could accomplish those missions, summaries of the species and environments potentially affected by Coast Guard activities, and summaries of the environmental consequences of the alternative actions proposed. Appendices contain summaries of federal laws and conventions authorizing Coast Guard activities, organization of the U.S. Coast Guard, contingency plans and forms for reporting strandings, entanglements or other events governed by the Marine Mammal Protection Act and the Endangered Species Act.

The document is well organized, clearly written and useful to the reader. With slight modifications, it could be used as a primer for appropriate Coast Guard personnel.

I would like to recommend two changes. First, on p. 5-5, start of first full paragraph. the document notes that "Marine and coastal birds are not vulnerable to collision with USCG or other motor vessels on the water." This is not true. Two circumstances may render individuals or flocks vulnerable, seasonal molting and heavy feeding. Seasonal molting makes it impossible for flocks of eider ducks, for example, to fly during late summer or for flocks of loons to fly during winter. Both species can only escape by paddling furiously or by diving. Similarly, pelagic birds, such as shearwaters or fulmars, can gorge themselves so thoroughly when fish or krill are abundant that they cannot take off from the water surface. In such cases, large fast ships can inflict substantial mortality if they go through a flock. I have personally seen this occur. Captains should not assume that flocks can always fly to safety.

Second, the discussion on Physical and Acoustic Disturbance from Vessels, Aircraft, or Human Presence (pp. 5-5, ff.) would benefit from inclusion of some materi from Payne and Webb (1971), a copy of which is enclosed. In particular, it would be useful to note that the very loud noises produced by large ships are at very low frequencies which are used by fin whales, and also blue whales and minke whales, for long-distance communication. In Table 5-3 the document parenthetically notes frequency for a 274-m container ship as 23 Hz and frequency for a 337-m tanker as 20 Hz. The text would be improved if it emphasized the importance of frequency, as well as amplitude, as characteristics of noise in the marine environment.

Thanks for considering these comments and for the environmental concern that is evident throughout your document.

Sincerely,

Steven K. Katona
President and Professor of Biology

SKK:mp

Enclosure

ORIENTATION BY MEANS OF LONG RANGE ACOUSTIC SIGNALING IN BALEEN WHALES

Roger Payne

and

Douglas Webb

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ORIENTATION BY MEANS OF LONG RANGE ACOUSTIC SIGNALING IN BALEEN WHALES*

Roger Payne
Rockefeller University and The New York Zoological Society, New York, N. Y.
and
Douglas Webb
Woods Hole Oceanographic Institution, Woods Hole, Mass.

INTRODUCTION

With very few exceptions, whales are social animals. Even though they may be widely dispersed at some seasons, most species congregate in herds during some portion of the year. As a general rule, small, toothed whales form the largest herds, which frequently contain hundreds, and exceptionally tens of thousands, of animals, whereas the much larger baleen whales, when found in herds at all, most often travel in bands of less than 20 animals, with only occasional reports of herds of up to 1,000 animals or more.[1] There has been considerable speculation on the functional significance of herd behavior in whales, but it seems unlikely that we will get any closer to understanding the role of herd behavior until we know more about what constitutes a herd.

In general usage, the word "herd" seems to mean a group of animals that are in close enough proximity to offer visible evidence to an observer (usually on the deck of a boat) that their behavior is linked (i.e., they are swimming in the same direction, or breathing in rough synchrony, or feeding in the same area or resting together, and so on). But this is a visual judgment of what may be principally an acoustic phenomenon, and therefore is more than likely to be inappropriate. Since sound is conducted in the ocean so well and light so poorly, a functional social group of whales may be held together by sound rather than sight and may stretch far beyond the horizon visible from a boat, or even from an airplane, and what appears to be a lone individual may in fact be an animal traveling in company with one or many companions some miles away—by our definition, a whale in acoustic contact with another whale is not alone.

This paper is concerned with baleen whales. Baleen whales are reticent laboratory subjects. In the absence of direct experimental evidence we might be able to get some idea of how far apart they can be and still be in acoustic contact by calculating how far their sounds might travel before being lost in the background noise of the ocean. Such calculations, while based in part on measured values, are also based on assumptions and remain theoretical. However, because of the exponential nature of acoustic phenomena, they are probably not entirely misleading.

In this paper we will try to show what kind of useful range at least one sound made by one baleen whale species, the fin whale (*Balaenoptera physalus*), might have and will suggest that its function includes long range signaling. We have chosen fin whales because they make exceptionally loud, low frequency sounds that have been the object of considerable study in recent years.

It must be borne in mind throughout this paper that we are *not* postulating meaningful communication of complex information among distant whales. Our remarks are concerned solely with simple signaling of place, for purposes of closing range and nothing more—in human terms, a message containing no more information than "there is a fin whale here." Our thesis is that fin whales, and perhaps some other large whale species as well, may be in tenuous acoustic contact throughout a relatively enormous volume of ocean and that such contact might be of use for finding each other or for joining, or keeping together in, widely dispersed herds.

* Contribution no. 2317 from the Woods Hole Oceanographic Intsitution.

CETACEAN SOUNDS

If the following discussion is to have much meaning, the sounds made by fin whales must be placed in the context of other whale sounds. Whale vocalizations have been reviewed by Tavolga,[2] Schevill,[3] Schevill and Watkins,[4] and Backus.[5] All cetaceans with which man has had more than passing contact have been found to make some type of sound. In general the sounds made by toothed whales (odontocetes) fall into three categories: 1) "impulsive sounds", i.e., broad-band clicks; 2) "squeaks" or "whistles," which are narrow band; and 3) "complex sounds," being some combination of these two categories. Besides broad-band clicks, which can contain any frequency, marine odontocetes are not known to produce sustained frequencies much below 500 Hz, and most of their vocal activity is at frequencies above 2,000 Hz.

Baleen whales (mysticetes) on the other hand, seem principally to make sounds with fundamental frequencies below 2,000 Hz, although some recent evidence by Beamish and Mitchell[6] tentatively indicates that blue whales (*Balaenoptera musculus*) may be able to produce fundamental frequencies in the ultrasonic as well as the sonic range.

Perhaps the most spectacular mysticete vocalizations known come from humpback whales. The work of Payne and McVay[7] has indicated that prolonged vocalizations of humpback whales occur in complex sequences, usually lasting from ten to 15 minutes, and may be repeated more or less exactly for several hours at a time, with no breaks longer than one minute. Without intending to imply any function for these repeating vocalizations (age and sex of the whales are unknown), we have called them "songs," in the same sense that this word is applied to the many repetitive, patterned sounds of birds, frogs, and insects—regardless of the functions served.

There seem to be several "song types" that are adhered to by different individuals, although there is much individual variation. Although the function of the songs is unknown, they have impressed many human hearers with their surprising complexity, and many people seem quick to want to ascribe some advanced communicatory function to them. It is well to remember, however, when trying to assess their function that these sounds are, within fairly narrow limits, monotonous, and any one who advances a theory that is to explain the songs satisfactorily cannot afford to overlook this fact.

Humpbacks are not the only baleen whales producing repetitive, or monotonous, vocalizations. There is some evidence from Cummings and Philippi[8] that right whales (*Eubalena glacialis*) do so as well. But perhaps the most precisely repeating sounds yet ascribed to a mysticete are the 20 Hz signals thought by Schevill and coworkers[9] to be produced by fin whales. We will consider them in some detail here.

20 Hz Sounds

Occurrence, Timing and Source

A group of remarkably loud and repetitive naturally occurring sounds, with their principal energy centered at frequencies near 20 Hz, has been the subject of considerable study.[9-15] Although the signals in this group are often referred to collectivley as "20 Hz signals," they are diverse in form and can be imagined

iave their origins in several animal species (usually thought to be whales). On
ious occasions Patterson and Hamilton[12] have heard each of the various pulse
es (subsequently described) change to one of the other types, and this sug-
ts that all can be produced by one species, although, of course, this is not proof
t such is the case. About all that can currently be said about the origin of
Hz sounds is that at least one of the animals producing at least some of the
nds is the fin whale. This determination was made by Schevill and colleagues[9]
m several lines of evidence including 1) a recording of 20 Hz sounds from a
nded fin whale, and 2) successful "homing" on several 20 Hz sources that
ved each time to be one or more of the genus *Balaenoptera*.
chevill and colleagues unfortunately do not describe the 20 Hz signals they
rd while in the vicinity of fin whales, but their general comments suggest they
re usually short signals similar to those reported by Patterson and Hamilton,[12]
o called them "blips." These are very loud, nearly pure tone pulse trains,
tered at about 20 Hz. They last about one second and are repeated at very
ular intervals several times per minute. Trains of pulses are made for about
minutes and then followed by a silence of about 2½ minutes, a spacing that
gests the sounding-breathing cycle of a whale. The most common spacing
pulse trains reported by Patterson and Hamilton was 12 seconds. They also
orted paired pulses, which they call "doublets"; these consist of a large ampli-
e pulse followed by a smaller amplitude pulse, the pair repeating every few
onds. These authors recognized several categories of doublets by their inter-
se and interpair intervals, naming them, for example, the "22–15 second
," the "9–12 second type," and so on. When using the term "20 Hz" sounds
his paper we will mean sounds of the kinds described by Patterson and
milton.

nsity

Valker,[10] Patterson and Hamilton,[12] and Northrop and coworkers[15] were all
e to track 20 Hz pulse sources with hydrophone arrays and thus determine
position of the source. Once the distance from hydrophone to a source was
wn, it was possible to determine what has proven to be the most interesting
ect of the 20 Hz signals: their exceptionally high intensity. Because they are
oud, research on 20 Hz sources was first entered intensively with the certain
ing that these sounds could not be natural and thus might have military
lications.[10,12] There were even speculations that such intense pure tones
ld not originate in the water, e.g. this quote from Patterson and Hamilton:[12]
hen these signals were first called to our attention, we could not visualize such
egular, large amplitude, low frequency signal having a natural origin in the
an. Accordingly a search was made for similar signals in other geophysical
dia. Recorders were set up in this frequency band to monitor the geomagnetic
d, airborne acoustic signals and seismic signals in the Earth. The program was
n abandoned because with the hydrophone recorders overloading on the
cps signals the other monitors showed no signals above background noise."
se same authors also note at first, "in the press of other work the repetitive
cps] signals were recorded unnoticed apart from an occasional passing
ught that the hydrophone amplifier was intermittently motorboating."
pparently Walker,[10] at first, also had similar, incredulous feelings about such
d sounds being made by animals in the ocean for he notes that after many
s "it was concluded that the pulses originated neither from deep within the
th nor from the action of breaking surf on continental shore lines."

We are dealing then with an animal sound so loud that it was at first thought to be everything from surf on distant shore lines to faulty electronics, including sources not even in the ocean– How loud then are these sounds?

The calculations by Walker[11] seem most reliable. He used a 3-hydrophone array, about which he notes: "The receiving system had been carefully calibrated and the transmission characteristics for the region were well known." Most of Walker's roughly 150 measurements of source level (for 20 Hz sounds of the kind described by Patterson and Hamilton) fell between 70–85 decibels (dB) re 1 dyne/cm² at 1 yard with most of his readings near the higher values and a few readings well above 85 dB.

Patterson and Hamilton also used a 3-hydrophone array, but the amplifiers in their array were not calibrated, so they could not make direct determinations of source intensity once they knew distance to the source. However, by comparing the ratio of signal strength to background noise levels over the bandwidth involved (assumed to be the same as previously measured ambient noise values for a nearby location) they found, in roughly 400 measurements, that 66% of the values fell between 73 and 81 dB re 1 dyne/cm² at 1 yard.

Northrop and associates[15] used an array consisting of a pair of hydrophones. This technique allows reliable determination of intensities only for sources on or near the axis of the pair. The range of their 20 such measurements (these were Pacific Ocean 20 Hz sounds) is 65–100 dB re 1 dyne/cm² at 1 yard.

The following discussion makes use of the value of 80 dB re 1 dyne/cm² at 1 yard, unless otherwise stated, since it is in keeping with all determinations and is near the median determined by what appears to be the most reliable data, Walker's. We will assume that some whales make 20 Hz sounds at this intensity some of the time, but we are aware that they make softer as well as louder sounds.

Bandwidth

Of equal significance to the loudness of these pulses is their remarkable purity of frequency. Spectral analysis of 20 Hz pulses by Walker[10] indicates that the energy is confined in a band 3 Hz wide. Cummings (personal communication) notes that the energy lies in a 4 Hz band width. Patterson and Hamilton[12] refer to a 1/5 octave band centered at 20 Hz, which, at this frequency, means energy in a band ca. 3 Hz wide.

Considerations Underlying Calculation of Transmission Loss

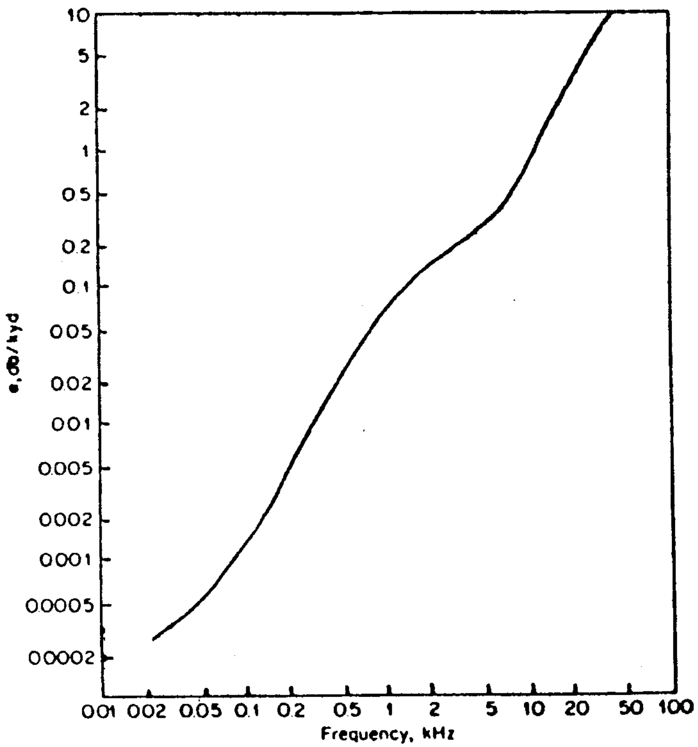
We have seen something of the characteristics of the signal under consideration. The central argument for the possibility of long range signaling by some whales rests on knowledge of the signal, the receiver, and physical principles of oceanic sound transmission. The minimum quantitative data adequate to permit rough calculation of maximum signaling range are: 1) frequency, bandwidth, duration, and intensity of the signal; 2) oceanic attenuation losses (which are frequency-dependent); 3) geometrical spreading losses (which are frequency-independent) and reflection losses (frequency-dependent); 4) directional characteristics of source and receiver; 5) receiver sensitivity; 6) background noise; and 7) lowest signal-to-noise ratio (S/N) acceptable at the receiver. We will consider these parameters one at a time.

1) *Signal*: Frequency 20 Hz, bandwidth 4 Hz, duration 1 second, intensity 80 dB re. 1 dyne/cm² at 1 yard. (= 154 dB re. 0002 dynes/cm² at 1 yard).

2) *Oceanic Attenuation Losses*: While spreading out after leaving the source

ussed under the following heading), some of the sound energy is lost to along the way. This is called attenuation and it is proportional to the distance led times a measured attenuation coefficient α. Whereas geometrical spread-oss applies equally to all frequencies, attenuation loss is proportional to fre-cy. FIGURE 1 shows α vs. frequency. At 20 Hz α is approximately 0.0003 ,000 yards, a remarkably low value. It means that a transmission distance)7 yards, or approximatley 5,600 miles, is required to reduce by 3 dB (i.e., alf the power) the sound energy lost to attenuation! Therefore, at 20 Hz uation loss can be ignored as long as we are discussing spherical propagation.

Geometrical Spreading: We will consider two cases, spherical and cylindri-preading. Spherical spreading is the simplest case: we assume that the signal gth at range r will be inversely proportional to the square of the range r. the transmission loss (TL) in decibels is calculated as follows: TL = 20 . Were the ocean an unbounded, lossless, homogeneous medium this model d suffice but the ocean is a relatively thin sheet (i.e., shallow in relation to urface area). And so at distances from the source considerably greater than lepth of the ocean the transmission of sounds includes multiple reflections surface and bottom. Under such circumstances sound energy is spread over outer surface of an expanding cylinder (of small height in proportion to the is) rather than over the surface of an expanding sphere. Since the surface



URE 1. Attenuation coefficients. Note the remarkably low attenuation of frequencies 100 Hz. (After Urick,[23] reproduced by permission of McGraw-Hill Book Co.)

area of a cylinder is directly proportional to its radius, whereas the surface area of a sphere is proportional to the square of its radius, transmission losses at a given range r are far less with cylindrical than with spherical propagation (geometrical spreading loss is 20 log r for spherical spreading but only 10 log r for cylindrical spreading).

Cylindrical spreading between parallel planes reduces geometrical spreading losses, but it introduces reflective losses. There is always some energy lost with any reflection. Such losses are severe at high acoustic frequencies but they may be relatively insignificant at frequencies as low as 20 Hz. There is a form of ducting of sound energy in the ocean in which refraction rather than reflection is responsible for cylindrical spreading (thus there are no reflection losses). This channeling results from the variations in speed of sound conduction with depth. Several ducts are recognized, but we will first consider just one, the deep sound channel, or sofar channel, as it is also called.

The speed of sound in the ocean varies directly with temperature and pressure. In mid-latitudes the speed decreases with depth (a decrease of water temperature with increasing depth is the overriding influence) until near isothermal water is reached, whereupon speed of sound increases once more (increased density of water due to increased pressure now becomes the controlling influence). In mid-latitudes in the Atlantic the speed minimum occurs at a depth of about 3,600 feet. Above and below the depth of minimum speed (that depth is the "axis" of the channel), the speed gradient continually bends any sound ray toward the depth of minimum speed. A fraction of any sound radiated at or near the sound speed minimum is trapped within this deep sound channel and finds a transmission path to great ranges without acoustic losses due to reflections from the surface or bottom. A ray diagram for sofar transmission from the original paper by Ewing and Worzel[10] is shown in FIGURE 2. It depicts ray paths at 1° intervals around a source at channel axis depth. The ray paths show the refracted propagation paths followed by sound energy leaving the source at angles near the horizontal (angles too steep to be trapped in the channel are omitted). It is apparent that the sound energy is not spread uniformly over the duct, that it is concentrated near the axis, and that some sound energy is well outside the main duct. As a result, the ocean is not uniformly insonified, and indeed, some part of the ocean volume contains no sound energy from the source, and in the remaining volume the sound intensity varies markedly with both depth and horizontal position, with time, and with motion of the source. Sounds that take the most indirect path, the path showing the greatest refraction away from the axis, arrive at a distant point first even though they have traveled farthest. This is because they travel most of the time in water that conducts sound fastest. Sounds traveling the shortest, slowest path, right down the channel axis, arrive last but are loudest. Thus an abrupt sound like an explosion, even though it lasts for only a fraction of a second at the source will, at remote distances and near the channel axis, be heard as a gradually increasing roar lasting several seconds but stopping abruptly as the final, loudest sounds go by. (The rate of increase of this roar is inversely proportional to distance and can be used as a rough indication of range.) This time-stretching lengthens a signal by about 10 seconds per 1,000 miles traveled, making it difficult or impossible to recognize the original characteristics of very distant signals. Such distortion prevents the transmission of any but the simplest messages at extremely low data rates.

The greatest ranges via sofar transmission will occur when source and receiver are both at channel axis depths. But in low latitudes this would require a whale

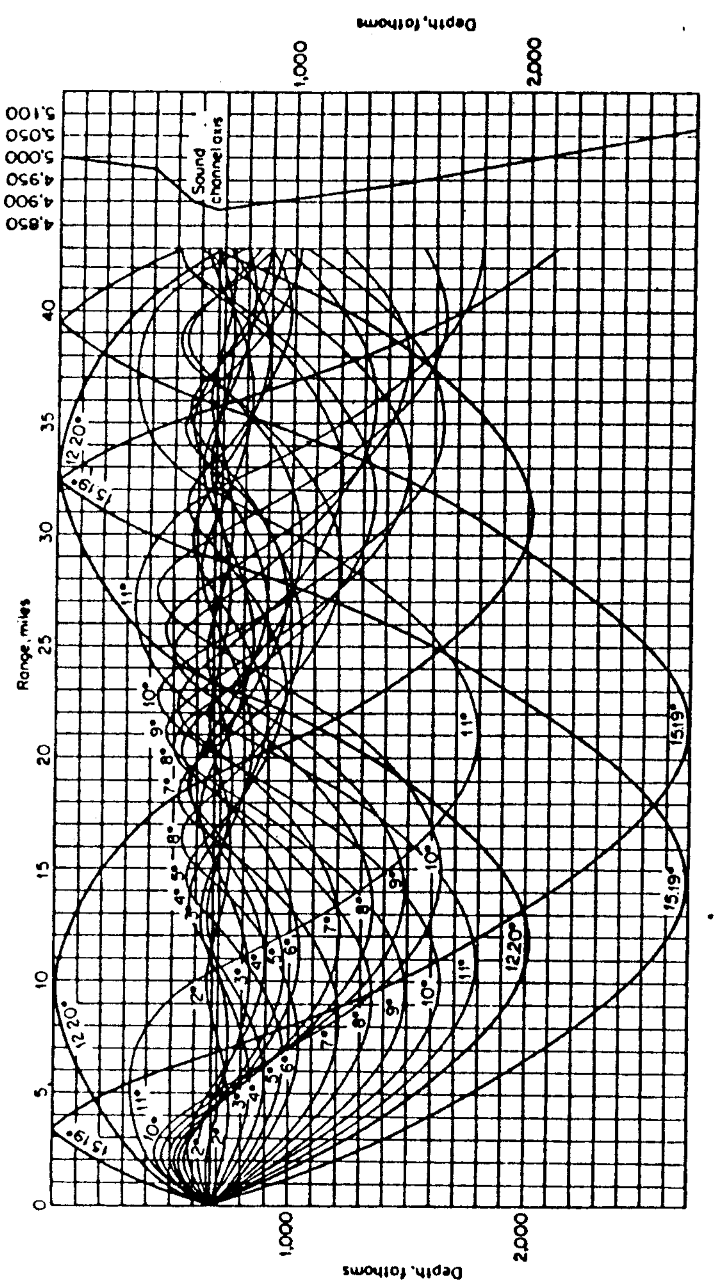
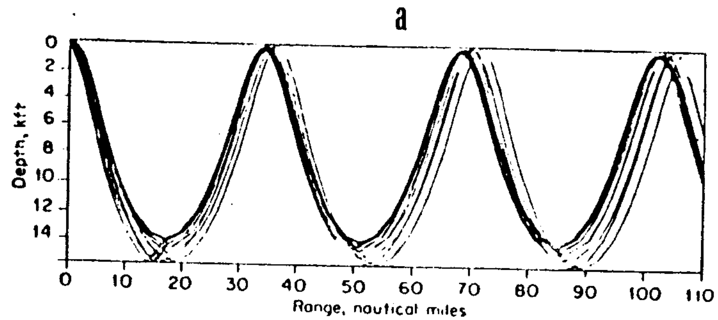


FIGURE 2. Ray diagram of transmission in the deep sound channel for a source on the axis. (Ewing & Worzel,[16] in Urick.[22] Reproduced by permission of the Geological Society of America, courtesy McGraw-Hill.)



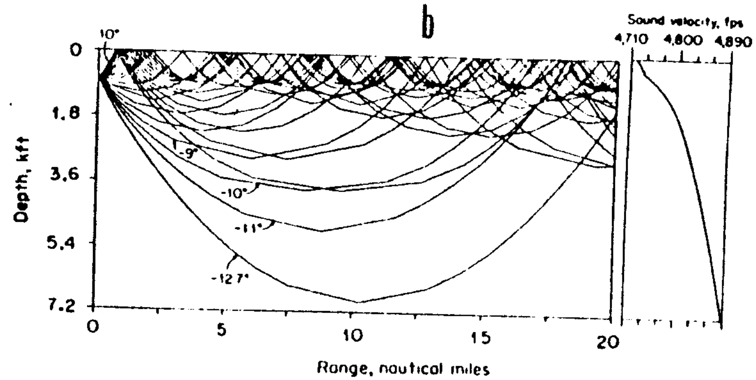


FIGURE 3. Ray diagrams showing rays at 1° intervals. Rays leaving the source at steep enough angles to reflect from surface and bottom are omitted. a) Source at a depth of 300 feet in the deep sea. Note that reception near the surface is only possible at intervals of 30–35 miles. b) Transmission in the Arctic. The velocity profile is shown at the right. Under solid ice, measurements indicate that frequencies near 20 Hz are transmitted best; owing to the loss of higher frequencies (due to scattering from the rough undersurface of ice), and of lower frequencies (due to the fact that such long wavelength cannot be transmitted in the duct). (From Urick,[22] reproduced by permission of McGraw-Hill.)

diving to depths of 3,600 feet and more. There is good evidence that sperm whales (*Physeter catadon*) reach such depths and perhaps beyond,[17] but all sounds recorded so far from this species are many octaves higher than 20 Hz (at frequencies that suffer drastic transmission losses by attenuation), and until it is shown that sperm whales make lower sounds, it is hard to see how signaling via the sound channel would be of much help to them.

The literature on whaling dramatizing its adventurous aspects abounds with supposed feats of deep diving by many species of whales (as indicated by how many fathoms of line were taken by harpooned whales). But even if such reports proved true, it is one thing to dive to a depth of 3,600 feet and another to make loud sounds once there. Patterson and Hamilton[12] attempted to measure the depth of 20 Hz sources with a 2-hydrophone array, but equipment failures limited them to a single very rough datum. It did indicate, however, a source depth of at least 1,200 feet (of course, the source was also producing sounds at that depth, alough how loud they were is not stated). Sounds are certainly produced at much allower depths,[10] but until it can be demonstrated that fin whales can dive to annel axis depths and make their sounds once there, it would be unwarranted assume that they do so. However, both source and receiver can be at relatively allow depths and still gain some of the benefits of the sofar channel.

FIGURE 3–a shows computed ray propagation paths through deep water for a urce at a depth of 300 feet in latitudes where the sound channel axis is at 000 feet. Such computed curves enable one to predict that in deep water in these titudes sounds from a near-surface source will only be audible to a near-surface ceiver at intervals of 30–35 nautical miles. (It is also obvious, since ray paths e very similar, that time-stretching and thus signal garbling will be considerably ss than with an on-axis source and receiver.) Experimental confirmation of is prediction is reported by Hale.[18] He made a series of measurements with a allow hydrophone at increasing ranges from a shallow source. He found signal tensities at 30–35-mile intervals that in some cases were 30 dB higher than gnal intensities expected by simple spherical spreading. (Less spectacular values ere more common, however.) It is not clear how far from the source such gular concentric rings of improved signal intensity (called convergence zones) ccur, but Hale found them well developed up to 400 miles away (FIGURE 4). eyond that range he found definite evidence that the simple, easily predicted nd regularly occurring zones deteriorated ". . . with evidence of overlapping ones and sporadic variation of intensity." Since he was interested in demonstrat-ng the regularity of this acoustic transmission phenomenon, he terminated his bservation at 400 miles when the phenomenon became less predictable. It is well note, however, that the signal energy was not destroyed, it did not vanish, but at at 400 miles the locations of overlapping rays (i.e., of increased signal in-nsity) simply became less predictable. Therefore, the range at which the deep ound channel no longer contributes to long-range transmission between a near-urface source and a near-surface receiver is still an open question. We would uspect that beyond 400 miles the effect would still be apparent for some dis-ance but at much reduced intensities and much less regular intervals until there s a final change to cylindrical propagation.

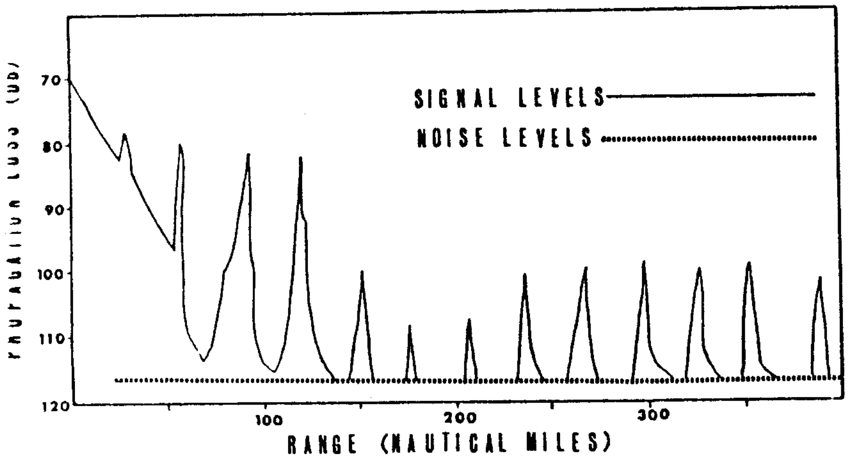


FIGURE 4. Convergence zone propagation. Low signal levels at zones around 200 miles were caused by a sea mount which temporarily obstructed the acoustic path. (From Hale.[18])

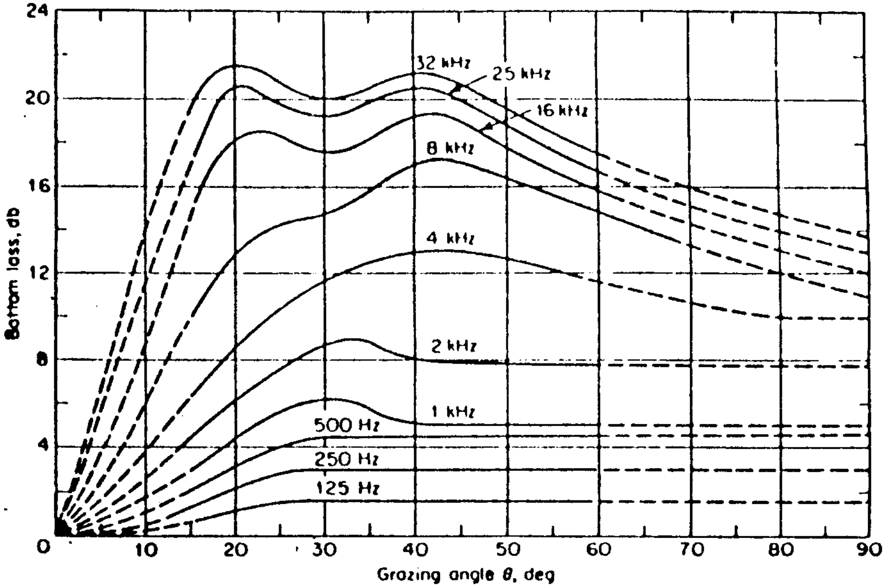


FIGURE 5. Bottom loss versus grazing angle at various frequencies. Note that at the lowest frequencies reflection losses are almost independent of the angle at which the sound is propagated relative to the bottom. (From Urick.[21] reproduced by permission of McGraw Hill.)

Such a system even in its most well-defined form would be of little use as a communication channel if one of the requirements were a high probability of successful contact at any given moment. But, if the signal were highly monotonous and of use for little more than taking a bearing in order to close range, then it would be of slight consequence whether or not reception were intermittent (even human navigators must often wait several days for the weather to clear in order to take a sight, yet this does not make celestial navigation useless). There is another way the sound channel might be of use to whales without requiring that they be able to dive to its axis in mid-latitudes. The slope of any island, continent, or sea mount passing through the sofar channel must reflect some of the energy into the channel from appropriately located sources near the surface. The converse is known to be true—that sounds from the channel follow up slopes and can be heard at lesser depths. If the reflecting slope were an island or sea mount, then direction to a source might be determined by swimming around the island until the sounds were loudest. But of more interest is the possibility that reflections provide a means for a shallow whale to inject its sounds into the channel. (It *will* occur sometimes whether or not the whale intends it.) Then passive listening at relatively great depths would still be useful even if whales could not make sounds at such high hydrostatic pressures as occur at axis depths.

The need for a reflection (or perhaps two) in this system raises the question whether the reflective loss would be worth the refractive gain. But reflective losses are frequency-dependent, and one of the advantages to a whale of "speaking" at 20 Hz is that such very low frequencies suffer only slight losses, even when reflected from highly absorbent muddy bottoms.[19] Marsh[20] gives data for reflective losses only at higher frequencies, but the trend is obvious (FIGURE 5).

From the aforementioned considerations it seems reasonable to assume that ce and receiver need not be on the sofar channel axis in order to gain some intage from it. However, we will still resort to calculations of transmission based upon on-axis sources and receivers in order to show an upper limit. , is chiefly because there is no adequate general theory for predicting trans-.ion losses under conditions of off-axis signal and source except for the special of convergence zones, where for quite shallow sources and receivers and anges out to the first 10 or so zones, there is a constant improvement in signal · that to be expected from spherical spreading, of 5–10 dB for each zone. Even ıgh our calculated values for sofar signaling will certainly give overestimates ange (unless fin whales prove to be signaling on-axis), we will, by later amining several of our other assumptions, point out that ranges approaching upper limits we have indicated may occur or may once have occurred.

he formula we have used for determining range was arrived at by the follow-:easoning: FIGURE 2 shows that only the sound leaving a deep source between ngle of approximately ±12° from the horizontal is eventually trapped in the ıd channel. At one yard from a point source the sound energy that will eventu-be trapped is distributed over a portion of a spherical surface:

$$4\pi \sin\theta \text{ yards}^2 \quad \text{where } \theta = 12°$$

t a long range r, this same sound energy will be channeled through a duct of ht H and surface area, $2\pi r H$.

eferring to FIGURE 2, if H is estimated at 1,500 yards (1000 to 2,500 yards h), then the transmission loss in decibels due to geometrical spreading is:

$$TL = 10 \log r \left(\frac{2\pi H}{4\pi \sin\theta}\right) = 10 \log r \left(\frac{H}{2 \sin\theta}\right) =$$

$$10 \log r + 10 \log \frac{H}{2 \sin\theta} = 10 \log 7.2 + 10 \log r$$

nuation must now be added because of the ranges involved and in final form quation is:

$$TL = 10 \log 7.2 + 10 \log r + \alpha r \times .001$$

ıe answer is in kiloyards, hence the multiplier .001).

ote that $H/2 \sin\theta$ is called the transition range and may be viewed as the ;e at which geometrical propagation changes from spherical to cylindrical. The straight lines in FIGURE 6 show the different rates of transmission loss for ndrical and spherical spreading. Cylindrical transmission losses (10 dB per ıde of distance) only begin at ranges beyond the transition range. Up to that ınce transmission losses are spherical, 20 dB per decade of distance. (Trans-ıion losses are considered to be 0 at a distance of 1 yard since that is the ınce at which sound intensities are traditionally measured).

lthough the transmission loss above is a correct estimate of the loss of signal gy with distance, the relationship between signal intensity and energy must ept in mind. The signal is stretched in time as the pulse propagates, and the ısity of a signal spreading cylindrically will decrease more than the inverse power of the range. As it is difficult to be sure of the extent to which the ear nsitive to the signal energy, i.e., the integral of intensity times duration, or to ısity alone, the estimates of very long ranges with cylindrical propagation ıld be treated cautiously.

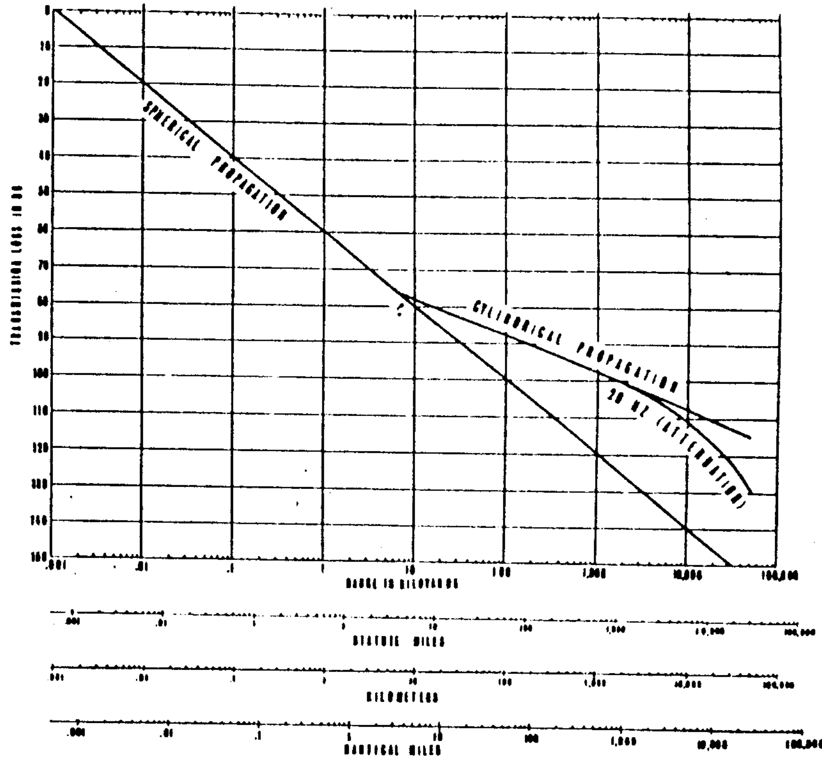


FIGURE 6. Calculated transmission loss versus range for two cases of propagation in deep ocean: 1) spherical and 2) Sofar signaling where propagation becomes cylindrical once transition range, r_o, has been reached via spherical spreading. (Source and receiver both on the axis of the channel.)

The transition range of 7.2 kiloyards arrived at by this calculation is in adequate agreement with measurements made by Webb and Tucker.[21]

The Arctic represents a third type of channeling—in some ways a hybrid between simple multiple reflections from surface and bottom and the pure refractive propagation without reflective losses found in sofar signaling. In polar seas there is no appreciable overlying layer of warmer water as in mid-latitudes, and so the sound speed is at a minimum at or very near the surface. (Speed of conduction is principally affected by density considerations and, to a much lesser degree, by salinity.) Propagation thus involves both refraction and reflection: refraction of all rays forming angles with the surface of less than about 12–13 degrees until they recurve back to hit the undersurface of the ice, and then reflection from that surface (FIGURE 3–b). Besides making very great ranges possible, one pecularity of under-ice transmission is that both high and low frequencies are rapidly attenuated, the low because they are of too great a wavelength to be effectively trapped in the channel, and the high by reflection losses from the rough surfaces of the under-ice. Thus in the Arctic, beneath solid ice cover, the best frequencies for long distance propagation have been found to be in the single octave 15–30 Hz.[22]

The measurements referred to here were made beneath solid ice, so we cannot equations derived from them to predict transmission losses under scattered However, it seems safe to assume that the kind of discontinuous cover repnted by diffuse pack ice would have a similar, though less pronounced, filtereffect on high frequencies. Fin whales are found in deep water on all sides ıack ice fields that often extend for hundreds of miles, particularly in the arctic Ocean during spring.[23] Presumably they must occasionally travel many s to find a lead to get through the pack, for under some conditions they are nded by pack ice.[24] If a fin whale found itself getting increasingly boxed in wind-drifted pack ice, it might be of vital advantage to it, in choosing the ropriate escape direction, to be able to hear even quite distant companions ard which it could pick its way to safety before the pack was too dense to rd suitable breathing spaces. The ability to produce sounds at frequencies that so peculiarly well suited to long range transmission under rough ice is of ious advantage.

) *The Directional Characteristics of Source and Receiver*: It seems reasonable ssume an omnidirectional source since the wavelength at 20 Hz is about 250 , and even large fin whales are barely more than 1/3 as long. Walker[10] notes h the meandering paths taken by 20 Hz sources and the remarkably constant plitudes of their signals, even over prolonged time periods—an unlikely pair of ervations unless the source were omnidirectional.

n the case of the receiver the question of directionality is more difficult to ss. It seems reasonable to expect that a whale could monitor a signal arriving n a given direction by selecting its characteristic phase lag between the two s, and by suppressing signals lacking the appropriate lag, thus gaining some ısure of directionality (similar to a phased hydrophone array). A similar menism, supported by compelling evidence, is postulated by Batteau[25] to explain "cocktail party effect" in humans (the ability to follow a conversation buried p in noise if, and only if, directional cues are present). Similarly, the remarke performance by bats in detecting signals in noise are now thought to be exinable by binaural, directional hearing.[26] In spite of the possibility of some eiver directionality we will conservatively assume both source and receiver to omni-directional.

i) *Receiver Sensitivity*: There are, as yet, no measurements of sound spectrum sus sensitivity in baleen whales. We would, however, expect a fin whale to ve adequate hearing and to have its greatest sensitivity somewhere near freencies of 20 Hz. We assume this because other animals that are highly dedent on hearing show a rough congruence between their "speech" and hearing ctra.[27]

In terms of absolute threshold it seems most unlikely that a fin whale would d the kind of ultrasensitive hearing found in many terrestrial mammals. (Man's solute threshold of .0002 dynes/cm² is an example.) The ocean is a very noisy ce and, therefore, in theory an acoustic system will always be limited by noise fore it is limited by sensitivity, except under the very calmest conditions and the very highest, ultrasonic frequencies (FIGURE 7). At the frequency in quesn, 20 Hz, the lowest background spectrum noise level reported by Wenz IGURE 7) is −45 dB re 1 dyne/cm² at 1 yard. (A still lower 20 Hz, spectrum, ise level, −55 dB, has been recorded but only during quiet periods and beneath frozen Arctic Ocean,[28] and it need not concern us here). If 20 Hz was a fin ıale's frequency of greatest sensitivity and if fin whales could just detect a 20 sound at −45 dB, their detection threshold would be about 30 dB higher ss sensitive) than a human ear at its most sensitive frequency. Even if a fin

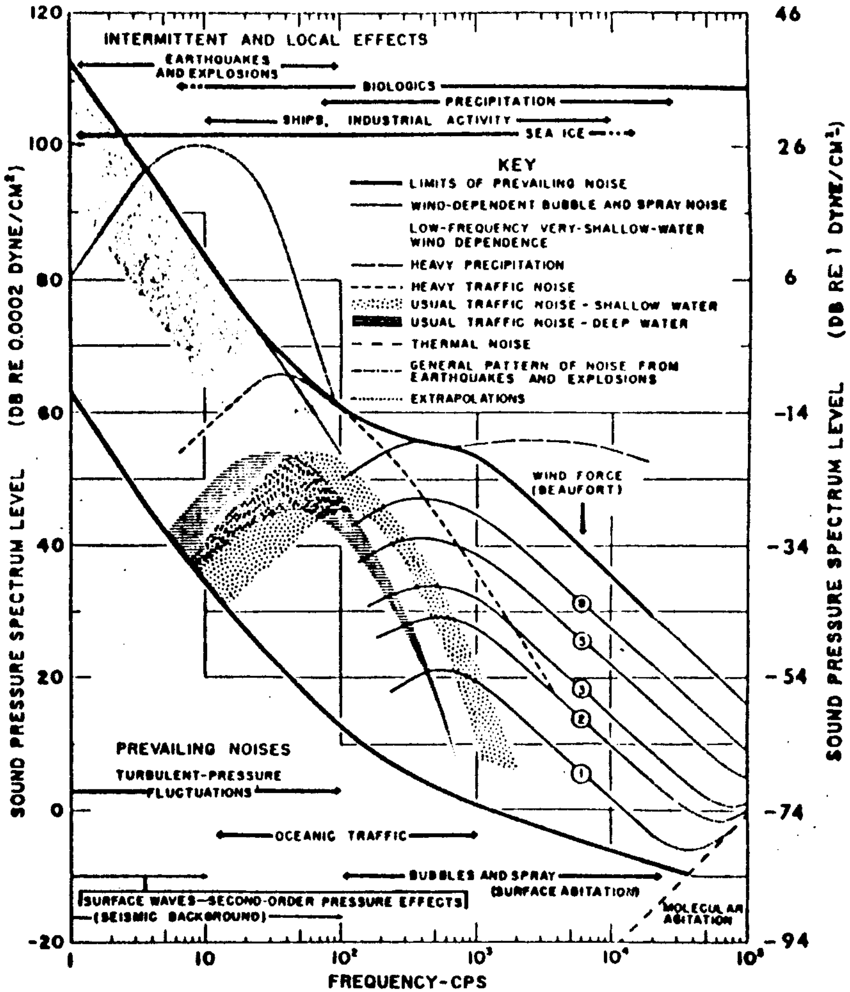


FIGURE 7. A composite of ambient-noise spectra, summarizing results and conclusions concerning spectrum shape and level and probable sources and mechanisms of the ambient noise in various parts of the spectrum between 1 Hz and 100 kHz. The key identifies component spectra. Horizontal arrows show the approximate frequency band of influence of the various sources. An estimate of the ambient noise to be expected in a particular situation can be made by selecting and combining the pertinent component spectra. (From Wenz,[29] reproduced by permission of Pergamon Press.)

whale could detect signals at a signal to noise ratio of −15 dB (see subsequent discussion), and, therefore, on calm days required a more sensitive ear, it could do it, in theory, with an ear that was still 15 dB less sensitive than the human ear at its best detection threshold. We do not feel inhibited about assuming that fin whales have adequate sensitivity at 20 Hz to make possible the ranges we have calculated.

6) *Background Noise*: The most ancient ancestors of baleen whales probably

st appeared on earth about 27 million years ago (give or take a few million ars). About 15 million years ago, the ancestors of modern fin whales appared. Propeller-driven ships and the noise they generate have been around for out 150 years—about 1/100,000th as long. If we are really interested in knowg what function 20 Hz signals evolved to serve, we can only hope to do so if look at the conditions under which they evolved. (Otherwise, we will be in e same boat with the man who was horrified to find out that in pre-Columbian nes Indians had been content to drink Hudson River water.)

The point here is crucial to the whole argument for long range signaling by leen whales. As can be seen from FIGURE 7, the most prominent of the prevalent ise sources in the frequency band from 5–200 Hz is from ship traffic.[29] Even oderate shipping produces a roar equivalent in other bands to steady winds of knots. In the most remote areas, hundreds and even thousands of miles from e nearest shipping lanes, traffic noise is still prominent in this frequency band. Before the advent of propeller-driven ships (i.e., during 99.999% of the time whales were evolving) there was absolutely no sound from propeller-driven ips. At 20 Hz the whole ocean was as quiet as it gets nowadays in the most mote areas—and perhaps a good deal quieter. This is not to say that it was iseless. Ocean noise must always have increased as frequency decreased. But, must note the position of 20 Hz once we remove shipping noise from the erage deep-water ambient-noise spectrum (FIGURE 8). It lies just below the west frequencies generated by wind noise. It is, therefore, the highest frequency e could employ to build a long-range signaling system free from all weather ise except for that generated by the very worst storms.

Of course, as things presently stand, 20 Hz is a poor choice for a signaling

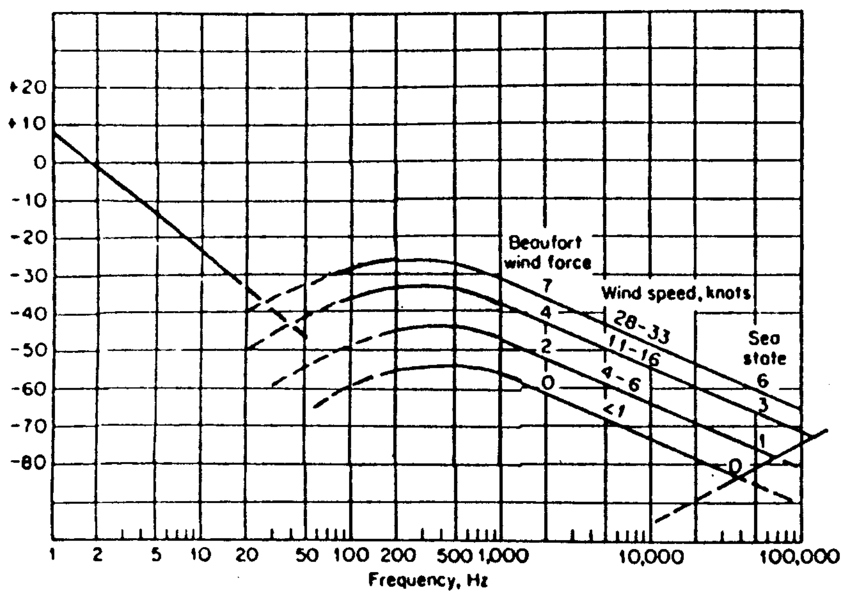


FIGURE 8. Average deep-water ambient noise spectra with components due to shipping moved; the assumed condition of the ocean during all but the last 150 years of fin whale olution. (After Wenz,[29] reproduced by permission of McGraw-Hill.)

system since it lies almost at the peak of traffic noise. Therefore, our calculations will be made at three different 20 Hz noise levels for which we will assume the following spectrum values (all re 1 dyne/cm²): contemporary noise background with moderate shipping, −25 dB; average pre-propeller ocean background, −35 dB; quiet pre-propeller ocean background, −45 dB. The spectrum value of sound pressure is the pressure measured over a band 1 Hz wide.

Because 20 Hz sounds have their energy distributed over a 4-cycle bandwidth, we will have to listen over a bandwidth of at least 4 Hz if we wish to intercept all the energy in the signal. When we widen the bandwidth, we also let in more noise, 6 dB of it (four times the power). Therefore, all of our noise levels must be increased by 6 dB to −19, −29, and −39 dB, respectively. The assumption that a whale can search a band as narrow as 4 Hz wide (1/3 octave at this frequency) is supported by the following: At frequencies of maximum sensitivity for humans the critical bands are slightly less than 1/3 octave wide.[30] (For a discussion of critical bands, see the following section). As further support, humans are able to distinguish frequency changes of 3 Hz at all frequencies below 1,000 Hz, and to distinguish less than 1 Hz at the very lowest frequencies.[31]

7) *Lowest Signal-to-Noise Ratio Acceptable at the Receiver*: Again, there is no direct information to guide us in selecting a criterion, so we will pick 0 dB S/N because humans do well in retrieving signals at 0 dB S/N in a wide variety of circumstances (see following section). As we will see shortly, 0 dB S/N may be unrealistically conservative.

Computation of Maximum Detectable Range

We will attempt to compute the maximum possible range at which one fin whale might hear another. By way of summary, the signal is assumed to be at 20 Hz with a 4 Hz bandwidth and a bandwidth intensity of 80 dB re 1 dyne/cm² at 1 yard. It lasts for one second and is repeated every few seconds. It is produced by an omnidirectional source at an unknown depth in deep ocean (20 Hz has a measured attenuation of 0.0003 dB/kiloyard, which means we can ignore losses due to attenuation below 1,500 miles.)

We will compute two types of attenuation loss: 1) spherical, the worst possible case in deep ocean, and 2) channeling by the sofar channel, the best case. We will assume a receiver and source at axis depths simply because there is no adequate general theory for computing losses at off-axis depths and we wish to define an upper limit of ranges. We therefore realize that the sofar values will represent the most favorable possible case.

We assume an omnidirectional receiver of adequate sensitivity tuned to a 4 Hz bandwidth (⅓ octave) centered at 20 Hz. Noise background is the level of noise in a 4 Hz bandwidth also centered at 20 Hz, and we will calculate for three values of noise: moderate shipping in the 20th century, −19 dB; average pre-propeller background, −29 dB; quiet pre-propeller ocean, −39 dB. We will require a 0 dB signal-to-noise ratio (S/N) for detection.

The equations used are: $TL = 20 \log r$ for spherical spreading (ignoring attenuation since it is less than 1 dB at ranges less than 1,500 miles); and $TL = 10 \log 7.2 + 10 \log r + \alpha r \times 10^{-3}$ kiloyards for sofar signaling. Realizing that signal level minus noise level equals the maximum possible transmission loss for reception at 0 dB signal-to-noise level (for example $+80 - (-19)$ dB = 99 dB), we then substitute the computed transmisson losses in these formulas and compute the ranges, or look them up in FIGURE 6. The results are shown in TABLE 1.

As we have pointed out before, the sofar ranges should be taken as the maxi-

TABLE 1

CALCULATED MAXIMUM RANGES AT WHICH FIN WHALE, 20 HZ SOUNDS REACH 0 dB S/N UNDER THREE DIFFERENT BACKGROUND NOISE CONDITIONS*

Background Noise Conditions	Backgr. Noise Level in dB in 4 Hz Band	Max. Transm. Loss for 80dB Signal (80 — Noise Level)	Range in Kiloyards	Range in Naut. Miles	Area of a Circle with Radius Equal to Range (Sq. Miles)
20 Hz — Spherical Spreading (Minimum Range) Deep Ocean					
his century (moderate noise)	−19	99	90	45	6,400
re-propeller ocean (average noise)	−29	109	280	140	62,000
)uiet, pre-propeller ocean	−39	119	900	450	636,000
20 Hz Sofar Signaling Conditions (Maximum Range) Deep Ocean					
his century (moderate noise)	−19	99	1,050	525	866,000
re-propeller ocean (average noise)	−29	109	7,000	3,500	38,000,000
)uiet, pre-propeller ocean	−39	119	23,000	11,500	no ocean big enough

* "Pre-propeller ocean noise" refers to derived, ambient, ocean noise conditions prior to ıips. Maximum ranges calculated for spherical spreading losses probably represent the miniıum propagation distances to be expected under assumed conditions. Ranges determined for ofar Channel propagation represent upper limits that may be approached but are probably ot reached, due to considerations outlined in the text.

ıum upper limit under the specified conditions, since there are bound to be losses ıat we cannot calculate, both as a result of off-axis location of source and eceiver, and due to signal stretching. In the convergence zone case if both source nd receiver are very close to the surface, then there will be intermediate areas (at rst averaging a spacing of 30–35 miles and later at more irregular distances) ı which the signal will not be audible even at very short ranges.

Only two of the figures in TABLE 1 can be tested by direct measurement – the ınges expected under modern noise conditions. Northrup and colleagues[15] acked 20 Hz signals to ranges as great as 100 miles, Walker[10] tracked them to 5 miles, and Patterson and Hamilton,[12] to about 12 miles. The differences in these ınges almost certainly reflect local noise conditions as well as different filter idths at the input. The results straddle our predicted range; in fact, they average rather better performance than we predicted since we have specified an S/N of dB, and these authors used arrival time measuring techniques that require a gnal-to-noise ratio of a few (<10) dB.

A further confirmation comes from the work by Webb, who has carried out ›w-power, long-range signaling experiments in the sofar channel. Instead of sing explosives for sources, he used tones of 380, 550, and 780 Hz and found ıe detectability of the received signals to be in good agreement with the value redicted, using a calculation analogous to the one mentioned.[21,33] For all of these asons we believe our calculations are a fair reflection of reality.

Several considerations may offset in part the losses inherent in off-axis signaling ı the sofar channel: 1) There is good evidence that some signal source levels re 5 or more dB higher than we have assumed. 2) The receiver may be direct-

tional. 3) Lower noise conditions might exist – something that would be unwise to count on in designing a system demanding reliability but which nevertheless ought to be strongly entertained when the task is to calculate maximum possible range. 4) Sequences of pulses might be suitably integrated at the receiver, thus providing signal energy greater than that from single pulses. Unfortunately, we know of no acoustic research on other animals that would indicate a time base long enough to make such a mechanism very plausible. A signal retrieval system relying on a monotonously repeated signal, such as that from a whale or from a ship's propeller, would require sampling times on the order of minutes or even hours if it were to detect signals buried very deep in noise. Should it exist, however, then one whale's sounds would, even today, be audible by another whale that knew its "signature" from anywhere within the same ocean basin. At a far simpler level of analysis there is still something to be gained from a repetitious signal containing a very simple message. If the message contained by a signal is redundant, then it need not be detected all the time or even a large fraction of the time. In fact, in the extreme, a single detection, even if thousands of repeats had gone unheard, would be sufficient for a whale seeking to rejoin a herd or mate, to choose the general direction in which to swim. (Of course, receipt of more than one signal would add confidence to the decision.) 5) There may be some summation of signals from animals in close proximity that would make it possible for a distant whale to detect a herd at ranges too great for it to detect individuals. Kibblewhite and coworkers[14] present what they believe to be an example of such summed signals, but unfortunately it seems to us more likely to be a single whale (or pair) of another species. 6) The whale might be making sounds in suitable conditions to have Arctic transmission provide long ranges. 7) The 0 dB signal-to-noise ratio we specified for a just detectable signal may be much too conservative. By choosing 0 dB we are really only saying that since baleen whales have well-developed ears and a large region of a large brain given over to acoustic function,[40] they are probably at least as good at detecting a signal in noise as is a human being – an animal that presumably does not rely so much on ears for its livelihood as does a whale. (Acoustically speaking, human beings are not exceptional; for example, they are only marginally capable of crude echolocation of large objects and cannot approach the performance of a bat, seal, or porpoise in selecting among objects on the basis of their acoustic properties alone.)

With broad-band "white" noise (20–4,000 Hz) for masking, Miller[34] found that humans could correctly identify 50% of the words on a list when intensity of masking noise and speech were the same (0 dB S/N). However, many factors can improve this performance. For example: The subjects in Miller's tests were required to pick words that were outside any context. Each word was a separate problem that gave no clue to predicting the next. The subjects were searching for a signal with almost no redundancy, which is hardly analogous to the problem faced by a fin whale in detecting what must be one of the more redundant signals in nature. Later work by Miller and coworkers[35] gives an insight into what kind of improvement is possible in detecting a signal in noise if the choices are limited, a case that seems closer to the task faced by a fin whale. They made tests with limited vocabularies containing no more than 2, 4, 8, 16, 32, etc. words. The task was to pick the one correct word from a known list of words. In all cases the percentage of correct words chosen fell to chance level only when the signal-to-noise ratio was − 18 dB. At S/N of −9 dB the percentage of time subjects could choose the correct word out of a limited vocabulary was 90% for a two-word bulary, 85% for an eight-word vocabulary, 82% for a six-word vocabulary, 62% for a 32-word vocabulary. This suggests that if a message is somewhat ictable (i.e., one of a few expected alternatives), it can be detected deep isking noise.

e have been discussing speech, but a closer analogy to the problem faced by whale might be that faced by a human in detecting pure tones in noise. ualy, a whale's signal should be intrinsically easier to find in noise than a tone, since 20 Hz signals are not pure tones and information theory indicates the detectability of a signal is improved by some complexity.) Much work een done in this area in connection with masking of pure tones by a "critical of noise." Bilger and Hirsh[36] define the critical band as ". . . that band of encies in a noise beyond which broadening the band will not further increase asking of a pure tone in the center of the band." Their measurements of l-to-noise ratios at which a tone is barely masked by a critical band show ead from −5 to −12 dB depending on frequency of the signal. Green-,[37] in a similar set of measurements, found a span from −3.5 to −8 dB. In of these examples intensity of the masked tone is measured in terms of um level SPL (the sound pressure level in a frequency band 1 Hz wide), as intensity of masking noise is given in terms of band level (the intensity requency band greater than 1 Hz wide, in this case, as wide as the critical

ectability of a signal is also dependent upon duration of the signal. The of Garner and Miller[38] shows that the signal-to-noise ratio necessary for ion decreases by about 15 dB as a signal is lengthened from 12.5 msec to cond. Beyond one second there is no significant improvement, the signal-to-ratio having reached an asymptotic value, an interesting coincidence when ired with the one-second duration of 20 Hz pulses.

of these lines of evidence indicate that there must be any number of adap-s that might very significantly improve a whale's ability to detect a signal ie and that each slight improvement would exponentially increase the area which a listening whale could detect another of its kind. For example: if e can detect signals at a —9 dB S/N rather that at the 0 dB we have worked then in pre-steamship days it might have detected sounds arriving via cal propagation from sources as far away as 1,300 miles rather than the iles we calculated earlier. This means that rather than hearing other fin anywhere within an area of 610,000 square miles, it could monitor an f 5,300,000 square miles. An ability to detect sounds at a signal-to-noise f − 15 dB would double this range, to 2,600 miles, and quadruple the area d, bringing it to 21,200,000 square miles. (To put these figures into some t, the area in square miles of the Atlantic Ocean is 25,000,000; of the it is 47,000,000; of the Indian, 21,000,000; and of the Arctic, 2,750,000

e consider propagation by the sound channel and adhere to pre-ship noise ons, the results are even more impressive, for now it will take only a 3 dB ement to double range and quadruple area monitored, and a 6 dB ement will quadruple range and multiply area by 16. (Incidentally, there deep water paths following great circle routes that are longer than about miles.)

ourse, since we do not postulate that whales produce sounds at channel oths, the ranges would serve only to indicate the extreme upper limit and almost certainly not be realized unless whales could dive to channel axis and make their sounds once there. However, such calculations clearly

indicate that there should be a strong selective pressure favoring even the slightest improvement of signal detection ability since the area thus opened up for signaling or monitoring would be so dramatically increased.

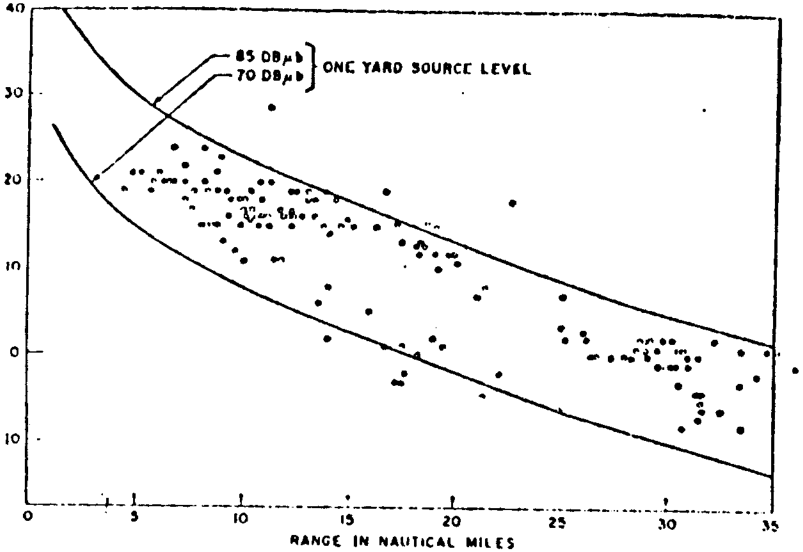
With the exception of a few simple mechanical strategies, such as making the receiver directional, the minimum signal-to-noise ratio necessary for detection can only be lowered at the expense of considerable computing cost. Whales have remarkably large brains, a fact that has led some students of cetaceans to postulate an advanced form of intelligence. It may be of little value to substitute one hypothesis for another, but we find it easier to see a selective advantage in having a sophisticated computer for detecting signals deep in noise than to see how a mammal with no means such as hands to manipulate objects in its world could gain an advantage over the competition by being able to swim about the oceans entertaining advanced, philosophical thoughts.

When trying to assess the value to a whale of an improved ability to deal with ocean noise in its environment, it is well to reexamine what is meant by "ocean noise." Urick[22] defines ocean noise as ". . . that part of the total noise background . . . which is not due to . . . some identifiable localized source of noise. It is what is 'left over' after all identifiable noise sources are accounted for." Accounted for by what computer? Ours, or the animal's in question? It may be just as erroneous to assume that an animal's noise background is like our own as it is to conclude that bats are silent because we cannot hear their cries. For example, when the Navy measures ocean noise, the sounds made by whales are included as part of the total noise. In order words, one man's signal is another man's noise. We must periodically remind ourselves that ocean noise is not entirely "white" noise generated by a random-noise generator, but only a good approximation of "white" noise. It is, in part, the jumbled totality of discrete, familiar signals. From which it follows that if a mutation appears enabling an animal to identify more "noise" sources than its fellows, it will be working at a lower noise background than are its fellows.

What If The Theory Is Correct?

The thought that an animal other than man might signal by sound over hundreds or even thousands of miles may seem alien, but it is really no more remarkable than signaling by radio. The fact that a hand-held transmitter putting out a few watts can be heard across a continent *under some conditions* is explained by a phenomenon very similar to cylindrical sound propagation—the energy of the radio is not allowed to spread, but is confined in a duct, in this case an atmospheric, rather than a marine duct. Of course there are many days during which the same small transmitter will not function beyond ten blocks. We are still content with the analogy, however, since we expect that on many days in the ocean even close whales will fail to hear each other. But we must also realize that there is a case on record of a four-pound shot of dynamite that was detonated near Australia and heard off Bermuda, a distance of 12,000 miles.[19] And without being on the axis of the sofar channel, sound sources are sometimes heard, even in these noisy times, at ranges of hundreds of miles. Let us for a moment assume that the theory of long-range signaling is right and then try to cope with some of the questions that will arise if it is:

1) If such a system is so good, why don't more species use it? Small animals could probably not make loud enough or low enough sounds; even if they could, they might not have sufficient ear separation to obtain a useful bearing on an incoming sound (see following section). Also, the signal that assembles a herd



:URE 9. Received pressure levels re 1 dyne/cm² (= 1 microbar) versus computed source for 20 Hz sources. Hydrophones in shallow water (less than 300 feet). (From Walker.[10])

ıimals must not also assemble its predators. Therefore, truly long signaling .d only be expected to evolve in animals that were reasonably independent redators, such as, for example, large whales. We feel, in fact, that some of ıther very loud, low signals reported[13,14] at different frequencies below 100 Hz at different (usually longer) durations than fin whale sounds were probably e by other baleen whale species.

Why haven't others recorded very long ranges for 20 Hz sounds before? signals are in the peak of traffic noise and inaudible to most humans; thus must interpose some form of translation between the signal and one's ears. usual strategy is some form of visual display requiring several dB S/N for :tion. For example, Walker's graph showing signal strength versus range ates that at the greatest range at which he was able to detect fin whales, 36 ., there must often have been 10 or more dB S/N (FIGURE 9), unless he in an usually high noise background, which would make 36-mile ranges ely.

ıother reason why this theory may not have appeared earlier is that people ot used to thinking in terms of *unreliable* acoustic systems. Acoustic work by the Navy often requires the most rigorously certain identification, since ıte of civilization as we know it may lie in the correct recognition of a "pecu- ource." But on the other hand, what, after all, are a few noisy days in the f a whale? If it doesn't hear its companion today, might it not tomorrow or ext day or the next week? If it wanted to join a distant companion, it would everal days to swim the distance anyway.

prime significance is that the source most often used in acoustics research explosive charge. This is particularly true in sofar work in which range is often the parameter being measured and in which, therefore, a pulsive signal rable, as well as frequencies high enough (higher than 20 Hz) to measure rupt onset or offset for accuracy in range computation later. This means

that few investigators are familiar with the characteristics of low-frequency sustained signals of modest power. We have seen that Patterson and Hamilton,[12] upon discovery of the 20 Hz sounds during their sofar research, were at first incredulous, and then sought an extra-oceanic source.

3) With what accuracy, if any, could an animal the size of a whale determine the direction to a 20 Hz sound? Let us once more start with humans. Although we can find no measurements of the ability of humans to detect direction at frequencies as low as 20 Hz, the trend is very clear. Mills[39] has studied the minimal audible angle, which he defines as "the angle formed at the center of the head by lines projecting to two sources of sound whose positions are just noticeably different, when they are sounded in succession." His results clearly show that man's best directional hearing occurs at frequencies below 1,000 Hz where phase alone is almost certainly the cue used. As frequency is lowered in this range, the ability to detect interaural phase differences improves. Mills' lowest datum (250 Hz) shows a minimum phase discrimination ability of 1.5°. This yields a minimum audible angle of 3.5°. When conditions are most favorable for making temporal discriminations, the interaural difference in time discrimination is about 10 μsec. Because of the difference of speed of sound in air and water it makes more sense, for comparative purposes, to express the separation of ears in terms of time rather than distance. The minimum acoustic path between human ears is 650 μsec. That for an adult fin whale of average size is harder to come by since the path taken by a sound wave in traveling from the body surface to the cochlea of a whale is the subject of almost as many theories as there are investigators.[40] Although the interaural acoustic path length is not known, the minimum distance between stapes footplates can be measured, and if we can assume acoustic isolation between the cochleae and no medial joining of acoustic paths, then it measures about 600 μsec for an average adult fin whale. (Another advantage of being large for an aquatic animal is that it makes fair acoustic separations possible in spite of the high speed of sound in water.) This indicates that if a fin whale could detect phase differences as well as people can, it would do very well indeed, even at such a low frequency as 20 Hz.

4) Is it not more likely that 20 Hz pulses are principally used in sonar? We, of course, feel that they would provide valuable information about range (within 250 feet, their wavelength) and major features of the ocean (the bottom, sea mounts, and perhaps large shoals of fish or even swarms of krill), but if this is their principal use, the repetition rate seems too great for such a loud, low sonar. We know that animals producing 20 Hz sounds often meander slowly about in a restricted area for long periods while vigorously pulsing.[10,12] If the pulses are the signals for a sonar, it must be a very long-range one, and when the animals are hardly moving, what new information would be gained by such relatively rapid repetition rates? If there was not such good reason to believe that the sounds are omnidirectional, then one could believe in any pulsing rate, however rapid, as the animal directed its beam about, investigating in different directions. But unless the ears are made directional by phasing in some way, there is not much to be gained by pulsing loudly 100 times over the same canyon or plain. In addition, the unchanging pulse rate makes these sounds differ from known animal sonar systems, which vary dramatically in pulse rate depending upon the activity of the animal. However, it is easy to see how a fairly fast and steady repetition rate could evolve in a communication system based on such loud sounds, for whenever an animal becomes silent, it "vanishes" from the rest of the herd.

6) What use would it be for whales to contact each other at great range?

Marine species that roam widely over a great range often rendezvous in vast numbers either annually or once in a lifetime at precise times and places (salmon, sea turtles, penguins, seals, and others). The advantage of such congregations is traditionally considered to be that they bring members of the same species together in time and space. However, there is another way of looking at it, which is seldom stressed enough: having a fixed, annual, or once-in-a-lifetime, rendezvous makes it possible for the species *not to be together* at other seasons, to spread out away from each other and to cover the maximum possible area, exploiting resources whenever and wherever encountered. A disadvantage of such a rendezvous system is that if an animal is to get its genes into the population it must leave whatever feeding areas it may have encountered at a specific time and join the breeding concentration. A second disadvantage of a large percentage of a species assembling at a large, fixed rendezvous site must be that when food supplies in the vicinity of the site fail, a large proportion of the population will probably die (even though food in the areas they left in order to join the rendezvous may be abundant).

Another mechanism that ensures breeding in widely ranging species is the nomadic life in which herds of animals move about together, keeping in close enough contact to rejoin at will. They are not tied to a specific rendezvous spot, and when good feeding conditions are encountered, they can linger as long as the conditions last. They may show some trend towards an annual drift, but they do not have to be in some given spot at some given time in order to breed. (Porpoises, tuna, mackerel, and many other shoaling fish are probably examples.) Since food supplies at any destination have to be good enough to suport the whole group, such animals might be expected to be fast swimmers, always on the move, patrolling a given beat at irregular intervals or wandering fairly widely.

As the size of, and numbers in, a herd increase, the area it needs to patrol for food must also increase, and any adaptation that improves the maximum effective signaling distance should be immediately favored by natural selection. There seems to be nothing that would limit this process, i.e., nothing that would select against an improvement in signaling range, for surely the wider the herd can be spread and still keep contact, the fewer the constraints it will face in encountering and exploiting every possible food source in every shifting and unpredictable location. Thus the trend to improve range would be limited only when the boundaries of the inhabitable range had been reached. Beyond that there would be no selective pressure to favor an increased ability to signal over greater ranges, and the system would reach equilibrium.

If there were a quantum jump from simple signaling to meaningful communication, there could be strong pressures to improve signal-to-noise ratios, but a shared communication channel becomes self-defeating after a while (like a cocktail party din), and it is most important to recall that all whales share one channel. Thus what one whale would hear from the center of a herd might be a summed roar emanating unevenly from various directions with closer individuals standing out against the jumbled background.

We postulate then something that might be called a "range herd," a new form of herd structure in which the population lives in tenuous contact throughout large portions of its range (perhaps over their whole deep-water range in any one ocean), a system in which set rendezvous sites are not necessary, and in which individuals, when in deep ocean but far from the center of the herd, are, in an acoustic sense, a part of it.

If one is skeptical about the advantages of such a system, let us make up a very simple law for the herd to follow: When a whale is well fed, it vocalizes; when searching for food, it remains silent. With such a system in effect a hungry whale could find the best concentrations of food by heading for the loudest and/or the most jumbled sounds. Such a system would allow maximum exploitation of the whole ocean by a single whale species through long-range signaling.

If some such simple signaling system as we postulate existed, the behavior of the animals that possessed it might show certain attributes. A demonstration that fin whales have such attributes would not prove the existence of range herds, but it would lend support to the idea. Such traits might include very informal migrations showing broad trends controlled more by seasons than by any adherence to precise schedules, places, or groupings (other than family); ability to migrate to different destinations in different years; ability to collect into large herds at unpredictable locations and seasons; and in fact anything that seems to involve a high element of unpredictability should suggest an underlying system of communication. With this in mind let us examine what is known about fin whale migrations.

Migratory Behavior

It is generally stated that baleen whales feed principally in summer in cold waters during annual blooms of food organisms, and then migrate during the winter to warmer waters for calving.[1,41,42]

While this observation is reliable and useful as a broad generalization, there is also evidence for several species of baleen whales that some part of the population may be found in any ice-free portion of their whole range during any season. At the time of the early Discovery II expeditions (from 1933–1939) sightings of baleen whales were recorded in the Antarctic Ocean in all months of the year. These data were later used by Macintosh and Brown[43] to estimate the numbers of whales present in ice-free Antarctic waters month by month. Their figures (FIGURE 10) indicate that populations of fin, blue, and humpback whales in the ice-free Antarctic fluctuated between roughly 10,000 individuals in the dead of winter and 200,000 in mid summer, but that at no time was the Antarctic Ocean devoid of whales. Although more recent methods of age determination and current population models might be expected to modify the absolute estimates given here, it seems unlikely that the relative proportions would be seriously changed. Thus we see that many baleen whales must linger in the Antarctic throughout the winter, even though most of them move to lower latitudes.

To consider specific cases: At a few shore stations that operate all year, finbacks are present in the catch throughout the year. For example, in the 1920's, before overexploitation caused a dramatic decline in population, fin whales were sighted year round off Spain and Portugal even though the peaks of the fin whaling season were only in May and October.[44] In Japanese and Korean waters fin whales were killed in every month of 1938; and in the same year fin whales were taken every month except January off the coast of western Norway. In the waters around the South Shetland Islands and South Georgia, fin whaling was successful in all months except June and July during 1925–26, even though operations were much reduced outside the months of December to April.* There are numerous other examples throughout the literature of seasonal sightings of fin whales far outside their areas of principal abundance.

Most of our knowledge about geographical distribution of baleen whales comes from research related to the activities of whaling. Since that industry prefers, for

* Data tabulated by Tomilin, based on reports of the Bureau of International Whaling Statistics.

vious reasons, to operate in regions of high concentration of whales, and at isons favorable for running ships, it is inevitable that our impression of fin whale tribution will exaggerate the importance of dense concentrations and therefore, deremphasize the importance of "widely scattered" individuals at the same ison outside "whaling grounds," or in different seasons on the grounds. It is likely that future discoveries concerning fin whale migrations will very much nplify this picture. The industry has only been able to profit by discovering the ain predictable concentrations of whales, and it is a fair bet that future data on distribution of whales will contribute more examples that do not conform to attern of predictable annual concentrations than examples that do!

Unlike most terrestrial animal migrations, baleen whale migrations do not seem be primarily linked to feeding. There is considerable evidence that in winter ge baleen whale species feed only at widely spaced time intervals.[45–47] The ial explanation offered is that suitable food is scarce in winter even at low tudes. However, fin whales may fare better than some other species since they known to feed on shoaling fish (in some areas they are called "herring iles"), and it seems unlikely that they would have to starve for a whole winter ardless of what latitudes they were in. Because they have broad food prefer- es, the prospects for fin whales in finding food may not be much affected by ether or not they migrate, and their capacity for long starvation may enable m to survive the universal low abundance of food in winter.

The most popular explanation of baleen whale migrations in terms of survival ie involves the thermal requirements of the newborn calf.[41,44,45,48] Most calves born at the time when most fin whales are thought to be in warm waters. The tabulated by Tomilin,[44] for 21,450 fin whale embryos taken from females tured in the Antarctic between 1925 and 1948, show a peak in births during winter months. Laws[49] shows a curve based on similar evidence, indicating il and May (southern hemisphere) as the peak season. The assumption is that newborn calf, with its thin blubber coat and relatively great surface-to-volume- would require warmer waters than the adults. Kanwisher and Sundnes[50] cize this theory strongly on theoretical grounds. Their calculations indicate the young of the largest species of whales are born with ample insulation for coldest oceans. They also calculate that the layer of blubber in which the ts are wrapped is far more than is necessary for protection against heat loss concur with the calculation of Parry[51] showing that half of a large whale's ber could maintain its basal metabolism for four to six months without feed- Kanwisher and Sundnes therefore postulate that the primary function of a s blubber coat is probably related to its potential as an energy reserve during times.

e now face a dilemma, for if migrations have not evolved primarily to ensure ntinuous food supply or to avoid thermal stress on newborn, what selective sures did shape them? The answer is by no means clear, but the temporal cidence of migration to warm waters with the time of year when births are numerous strengthens the suggestion that the two phenomena are function- inked.

ie above considerations indicate that it may not be necessary for all individu- all stages of development to participate in every migration every year, an ion that is shared by Clarke.[48] Simply stated: Why swim several thousand in one year if there is no need to do so? In fact, a large fraction of the total lation may not be directly in need of the benefits that would accrue from ation every year; if those benefits are really only necessary to new mothers

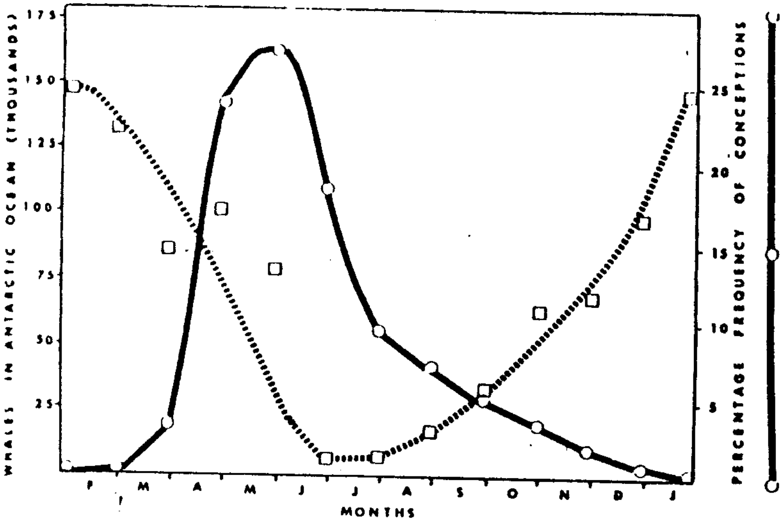
and their calves, the portion of the population for which migration to the warmer waters is less crucial might be large. It might at least include weaned but not sexually mature "adolescents" of both sexes, reproductively senile individuals of both sexes, and sexually mature females not in the terminal stages of pregnancy. Since female fin whales are thought to give birth, on the average, once every other year,[1] the need to visit warm waters may not much exceed half of their reproductive lives. Thus, even reproductive females might need to visit the calving grounds during only half of their reproductively active lives.

Although there is some evidence indicating favored migration routes,[45] fin whales are widely spread in winter (the height of the breeding season), there being no known large concentrations.[42,44,45,48] This is in contrast to the pattern observed in other baleen whales, which aggregate in large close groups during calving. (The well-known breeding grounds of grey whales in Scammons Lagoon is an example.) The movements of fin whales are complex and apparently unsynchronized in summer too. For example, observations by Hardy[52] indicate that fin whales may have different migratory destinations in different years since blooms of krill shift widely from year to year, and yet the whales tend to be found in the appropriate food-rich areas, rather than in areas that may have had abundant stocks last year but are now vacant. Tens of thousands of square miles of ocean that were ice covered last year may be quite clear of ice this year and thus freshly accessible for exploitation. If individuals are to profit by such newly opened food areas in time to harvest an annual bloom of food, they would be greatly helped by some form of sounds made by well-fed individuals.

To add to the picture of inconstant migratory habits, analysis of tag recoveries demonstrates that some fin whales wander broadly even in summer, since tagged whales are often recovered on feeding grounds far removed from those on which they were marked—as far away as the opposite side of the Antarctic continent. To quote Mackintosh:[45] "The overall picture is one of apparently disorderly movements in which it is hard to see the whales following any definite rules."

The more one examines what is known about their migration, the harder it becomes to fit fin whales into the usual, comfortable concept of a migratory species shuttling on schedule twice each year between definite fixed destinations. Although there are clear trends, there are also many exceptions and one is forced to consider rather more haphazard models, involving, in addition to a main annual trend, local opportunistic movements in response to a fluctuating yearly food supply. Summer feeding herds may well be composed of somewhat different individuals from year to year, with a few individuals wandering considerably over the summer feeding grounds. In winter there seem to be even less well-ordered patterns, with some individuals remaining on the feeding grounds, some going all the way to lower latitudes, and others scattered throughout the area between. Even in the lower latitudes towards which the main surge of the population is presumed to go there are no clear concentrations in predictable places, and a smaller proportion of the population than usually imagined would be found going all the way to the warmest waters for calving.

In spite of how little is known about the distribution of fin whales, one line of evidence clearly points out that their migratory behavior is much at variance with that of other migratory marine mammals, namely, that conception is at a minimum when fin whales are known to be concentrated,[49] and at a maximum when they are thinly dispersed over millions of square miles of ocean (FIGURE 10). This is not the usual marine mammalian pattern. Unless we postulate long-range communication, then how do fin whales find each other during the mating



...URE 10 Monthly percentage frequency of matings leading to conception (from Laws[50]); ...stimated seasonal variation in numbers of fin whales in ice-free Antarctic waters (after ...intosh and Brown[43]). Note that during the time of maximum concentration of fin whales ...g has almost ceased.

...on? And how do they manage to concentrate at different migratory destina- ... in different years? And, if all animals do not join the seasonal exodus every ... how does a dropout rejoin a concentration? Or for that matter how do ...entrations form at all without requiring many months or years for chance ...mulation? (Herds of 500–1,000 have been seen at one time.[44])

...ould the sounds made by fin whales carry far enough so that even widely ...ated whales are in fact part of the same herd, then perhaps some of the ...arently disorderly movements" or even their extraordinary feats of naviga- ... such as the ability to concentrate at different migratory destinations in ...rent years, would appear less mysterious.

...enz[53] reports slight (ca. 3 dB) periodic variations in 20 Hz ambient noise ...s throughout wide areas of the ocean. The peaking of the fluctuations oc- ...d at the same local time each day. We feel that at least some of the energy ...nsible for these regular variations in 20 Hz noise level may be contributed ...n and/or other whales. Payne has confirmed an observation, originally made ...errone (personal communication), that there is a pronounced diurnal cycle ...e vocal activity of humpback whales (*Megaptera novaengliae*) in the Ber- ...a area. If fin whales are also predictably more vocal at certain hours, Wenz's ...rved increased 20 Hz level may represent summation of very distant sounds ... animals, which, though vocal at any time, were at their most vociferous before midnight each day. Although Patterson and Hamilton show data ...wo years, the sample is not large enough to show statistical significance ...ight trends. However, in both years 20 Hz pulse activity does increase during ...ate afternoon and early evening, reaching a peak shortly before or after ...ight.

...hat other possibilities are there? The 20 Hz noise is at the right frequency ...ve derived from ships. But such could not be the case because of the pre-

dictable and widespread diurnal rhythms, which have no analog in shipping.

We suspect it would be interesting to look for evidence that 20 Hz ambient ocean noise receives a significant input from the cries of fin whales and/or other species, at least in areas where they are still fairly plentiful.

We ourselves, using a vertical hydrophone array, plan to track fin whales in the vertical plane in order to see what depths they are at while singing. Any evidence that they reach channel axis depths would have obvious interest. We also hope to try tracking fin whales at somewhat greater ranges than achieved hitherto by employing more sophisticated signal processing techniques, to see if we can get some idea of what areas they roam over.

What If The Theory Is Incorrect?

We are not the first to speculate in print on the possible function of 20 Hz sounds. Explanations have included acoustic artifacts, heartbeats, signals strong enough to stun a predator, sonar, and sounds for more local, general signaling. We, of course, recognize the great likelihood that such sounds could, and almost certainly do, serve several purposes, and that other fainter sounds accompanying them would only be useful at limited range. We do not wish to be interpreted as saying that the one function of 20 Hz sounds is for long-range signaling. If it were, for instance, useful as a means of orientation when animals travel towards a new destination, we would think it most unlikely that it replaced other navigational systems, but rather, augmented them. In other words, we do not feel that these sounds are the only means by which whales maintain contact, but rather, one of several, and the one working at greatest range.

Our theory is that the signals evolved in a quieter ocean and that the principal selective pressures all tended towards a signal detectable at great range. If we are wrong, then any alternative theory ought to explain why 20 Hz sounds are so loud, so constant in repetition rate, so pure in frequency, and so narrow-band. It must also explain why they may go on for many hours at a time, even though the animal producing them is simply meandering about in a relatively small area. An alternative theory should not overlook the fact that the frequency, 20 Hz, has particularly low transmission losses under ice, has an exceedingly low attenuation with range, has almost no losses from reflection off the bottom, and is the highest frequency that would be independent of wind-generated noise. Finally it must explain how whales find each other near the height of mating season when they are (inconveniently) most thinly distributed, and how an individual rejoins a herd, and how 500 to 1,000 fin whales ever happen to come together at one place and time when normally they are found as singles or in small herds.

Summary

1) The term "herd," as applied to whales, is challenged since it usually represents a visual judgment of a social unit that is probably held together by acoustic means. Thus, whales that appear to be traveling alone are perhaps really members of the same widely spread herd. This raises the question how far apart members of whale herds might be and still be able to keep contact.

2) The 20 Hz sounds made by fin whales are used in a calculation of maximum signaling range in deep ocean. (They are selected because they are loud and monotonous.) Two different types of sound propagation are considered, spherical, and cylindrical propagation in the deep-sound channel. Since fin whales are not known (or suspected) to make sounds at sufficient depths to utilize the most

ivorable portions of the deep-sound channel (the axis), other, less favorable, aths that are accessible from near the surface are described.

3) Our calculations indicate that in modern deep-ocean ambient noise contions and in areas of moderate shipping traffic, 20 Hz fin whale sounds should : audible at a signal-to-noise ratio of 0 dB out to ranges of 45 nautical miles hen the sounds propagate by spherical losses and to ranges of 525 miles when ropagated via the deep-sound channel. It is pointed out that so far, ranges present an upper limit that is approached but probably not attained.

4) It is noted that since modern ambient background noise in the ocean is incipally due to ship traffic and since propeller-driven ships have been present r roughly 1/100,000th the time that fin whales have been evolving, it is more an likely that whatever their function, 20 Hz sounds were designed for a set of ise conditions that no longer exists. If these conditions are assumed to correond with current ambient noise levels in remote areas, our calculations of aximum transmission range increase to 140 miles by spherical propagation and 500 miles by cylindrical propagation in the deep-sound channel. In both cases s assumes average background noise; still longer ranges are calculated for quiet nditions prior to the advent of propeller-driven ships.

5) A series of arguments is presented pointing to the conclusion that many ferent factors might reasonably extend these calculated ranges by lowering the nimum signal-to-noise ratio required at the receiver.

6) Since circles with such large radii would encompass millions of square les, it is concluded that fin whale herds prior to propeller-driven ships might thought of as "range herds," that is, a single herd covering the entire deep-water ge of the species in any one ocean. Observations that fin whales lack fixed eding rendezvous, taken together with evidence that they are most closely icentrated (for feeding and not breeding) at times when mating is nil, would nt to some special mechanism by which pairs meet. A review of the migrations fin whales, particularly the many exceptions to any stereotyped rules, is given upport of the view that fin whales can come together at will even when spread over their entire range.

') The many advantages of 20 Hz as a frequency ideal for long range signaling d the many disadvantages for its use in sonar) are reviewed. It lies just below m-generated noise, meaning that any communication system that employed ould be free of disruption by storms. Almost no energy is lost by reflection of Hz sounds from the bottom; it has remarkably low attenuation with distance lB in 5,600 miles), and is in the best octave for long-range propagation under ır ocean conditions.

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DISCUSSION

DR. TAVOLGA: It seems to me that Dr. Payne finds himself in a similar situation mine, in that the information seems to be there, but it's not clear whether or ot it's being used. On the question of the information getting to these distances hundreds of miles or so, this is a very elegant extrapolation. I would feel appier if there were some data points at the end of this extrapolation. Since e are, shall I say, unhampered by any evidence on the hearing capacities of these hales, we can assume that the whales are hearing this. But perhaps you are in a tter situation than I am. Do you have any evidence that they are using this formation?

DR. PAYNE: No, not yet. Let me comment on your two points. Nobody knows fin whales can hear these signals at all, though it is hard to explain their characristics on other than acoustic grounds. It is hard to demonstrate that large ecies of whales can hear anything, though we do know that they can hear mething, as evidenced by their rapid diving when you bang on the side of a at. If you recall the curves, I showed fin whales would require a sensitivity –30 decibels less good than a human, at his frequency of maximum sensitivity, hear 20 Hz sounds at the distances we are claiming. In other words they could quite deaf by human standards and still not have that affect our arguments the least. That is because we are talking about signal-to-noise ratio; we're not lking about ability to detect a small signal.

You say it's unfortunate there are no data points at the end of our extrapolation. Let me say only that there are dozens of such data points supporting just the kinds of calculations we have made. These points have been obtained by the Navy—in fact, marine transmission loss is one of the better measured acoustic parameters.

If we are wrong, any theory that's going to explain these sounds will have to include the fact that they're monotonous, that they're loud, that they're confined to a very narrow frequency range; that they happen to exactly correspond to one of the best places in the acoustic spectrum to get sounds a long way through the pre-ship ocean, and finally, they are at the frequency that gets through Arctic water best. Against some other theories is the fact that 20 Hz is not very useful for echolocation since you don't get better resolution than about 250 feet with a frequency that low and it's hard to have a directional transmitter or receiver.

DR. GEORGE GOUREVITCH (*Hunter College, City University of New York*): Dr. Payne, if the tremendous power of the acoustic signal these animals make might interfere with their own hearing, how would you explain this rather sizable energy that they produce?

DR. PAYNE: This same problem is faced and solved by many echolocating animals. Presumably there's some mechanism to avoid such damage, for example, increased tension on ossicular muscles during transmission, or some such. But, I don't think there is much controversy over the intensity of 20-Hz sounds and I don't think, for example, that anybody would wish to say that they were less than approximately 65 decibels in intensity, which is still a loud shout and must be coped with by the animal's receiver.

Massachusetts Sierra Club 3 Joy Street Boston MA 02108 (617) 227-5339

October 27, 1995

LCDR Wesley C. Marquardt
Commandant
USCG
2100 Second Street S.W.
Washington, D.C. 20593-0001

Dear LCDR Marquardt:

The Massachusetts Chapter Sierra Club would like to submit the following comments on the Environmental Assessment for the Potential Impacts of USCG Activities along the Atlantic Coast. We will specifically comment on the proposed Alternative 2.

The Chapter is concerned with the impacts that the Coast Guard has on the marine environment as a result of it's substantial activities in the Northeastern waters. While we are concerned with all the impacts of the USCG in these waters, we are most concerned about the potential continuing effects of the Coast Guard activities on the possible recovery of the Northern Right Whale, a federally listed endangered species. The Environmental Assessment (EA) understates these impacts by claiming that additional coordination with other state and federal agencies and additional training of USCG personnel will minimize collisions with whales. This is not enough. The continued decline of the Northern Right Whale population, despite promises such as this in the past, is evidence that more needs to be done to protect these species.

The proposed action (Alternative 2) makes some very generic statements about efforts to be made to minimize collisions. While we are encouraged on the surface by this, we feel that nothing short of a detailed conservation plan, properly implemented by coordination among the concerned agencies, with oversight by concerned and impartial members of the scientific and environmental community will give this species even the slightest chance of recovery. This will require more than a gradual education and shift in USCG activities as whales are sighted by USCG vessels, often in distress, but rather a comprehensive strategy developed to protect the whales. Consequently, the Chapter feels strongly that an Environmental Impact Statement should be required relating to Coast Guard Activities, and should include a *detailed* analysis of how the USCG intends to modify its activities to eliminate further decimation of the Northern Right Whale Species. The Chapter feels that current activities in general warrant an EIS, and therefore, the subtle modifications to these activities as proposed in Alternative 2, similarly warrants such a report, as required under the NEPA.

Thank you for the opportunity to comment.

Sincerely,
James B. McCaffrey

James Bryan McCaffrey
Director, Massachusetts Chapter

Richard Max Strahan

℅ Conservation Research Group
Boston College Law School
Newton, MA 02159

TO: Lcdr. Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street
Washington, D.C. 20593-0001

Subject: Analysis of "Environmental Assessment of Potential Impacts of U. S. Coast Guard Activities Along the U. S. Atlantic Coastline," September 22, 1995. Part I — Biological and Conservation Issues

DATE: October 21, 1995

Introduction

This document was written be professional consultants for the Coast Guard to evade the environmental review requirements of NEPA and the Coast Guard's non-discretionary duties to protect and conserve endangered marine wildlife. The Environmental Assessment ("EA") fully fails to attempt to assess the biological status of the Northern Right Whale, and other listed species of marine wildlife, nor assess the cumulative impact of the adverse effect the activities of people are having on the Northern Right Whale's ability to survive and recover as a species. The Coast Guard in no way attempts quantitatively to assess its adverse effect on endangered species, in fact it simply dismisses any such possibility on its face ("We are so small and the ocean is so big.") and then proposes mundane measures "spotters on the bridge" that simply reestablishes the status quo, with no meaningful protection for the listed species provided. All of their proposed mitigating measures and programs exist as categories of fantasy and intent with no substance to them. What the meaning of "slowest safe speed" and "give the whales a wide birth" is left to the complete discretion of the fantasy of the reader. As such all of these proposals have the stench of insincerity about them and are not meaningfully reviewable or convincing. The "enforcement programs," as all other mundane proposed activities, are not budgeted and clearly do not exist in reality. These enforcement programs abandon any attempt to meaningfully regulate vessel activity or codify enforceable standards of conduct. In fact, alerting boaters to the presence of whales can have disastrous consequences and, despite seeming claims to the opposite, the Coast Guard, like a cop on the beat, has absolutely no authority to tell boaters to "move along" if they think that they are to "close" (whatever this means) to a whale. No one will ever be convicted in a federal court got violating the Coast Guard's illusionary "enforcement policy. Stating such the EA's claims that their proposed mitigation measures will "significantly reduce" the threat of Coast Guard vessels striking whales is totally left to the reader's imagination to figure out how this is so. The EA mentions no historical or current efforts utilizing the approach of the EA's "preferred alternative" that has "significantly reduced" the threat of vessels colliding with whales in fact the opposite is true. All of the "fantasy" claims and goals of the EA's preferred alternative have failed miserably in protecting marine wildlife form collisions with vessels. The Coast Guard cutters that killed two Northern Right Whales were operating under conditions that were consistent with the policy enunciated within the EA's preferred alternative. If the preferred alternative was operational since 1990, these two whales would still have been killed. The only thing that now stands between the Coast Guard's vessel operations and the death of another Northern Right Whale, or other endangered species of whale, is simply a matter of time.

Analysis of the Threat of Coast Guard Vessel Activity.

Having already killed at least two Northern Right Whales, the U. S. Coast Guard having conceded in its Biological Assessment[1] and the National Marine Fisheries Service having conceded in its Biological opinion[2] that the killing of a single Northern Right Whale would "jeopardize the survival of their species," and therefore having already had a "significant impact upon the environment," none the less now in this environmental assessment[3] are now asserting that they will never again kill a Northern Right Whale again, nor will be likely to harm any other listed species of marine wildlife, because of protective measures that they have recently implemented. They therefore assert that their future operations will not have a "significant impact on the environment" in the future. They prove nothing and they are wrong.

1. failure to perform a "Population Viability Analysis" and assess the threat to the survival of these species of sustained losses in numbers due death and injury from collusion with Coast Guard vessels.

2. Coast Guard personnel, and their consultants, simply do not possess the expertise or training to analyze the problem of the endangered whales being killed by vessel activity. They belong to two "implementation team" that still cannot figure out, or figure out how to avoid, how to effectively stop vessels from killing whales.

3. The scope of the EA is deficient: The EA totally excludes mention of its Vessel Documentation and Inspection Program and the Coast Guard's permitting thousands of vessels, that routinely strike, kill, and injure Northern Right Whales and other federally protected species of marine wildlife, to operate along the United States coastline, (Coast Guard regulations on NEPA CMDTINST M16475.1B; <u>See also</u> *State of New Jersey, Dept. of Environmental Protection and Energy v. Long Island Powere Authority*, 30 F. 3d 403, 417 (3rd Cir. 1994) and *Jones v. Lynn*, 477 F. 2d 885 (1st Cir. 1973)).

4. Alternatives are extreme and do not include realistic alternatives that afford proactive conservation measures or attempts to regulate vessel activity.

5. The "proposed action" is a restatement of the status quo with the referred to conservation measures and appended enforcement programs serving to merely codify the complete lack of conservation efforts for Northern Right Whales, and other species of whales. The "enforcement program" fully supports commercial whale watching on Northern Right Whales and formally permits the pursuit and harassment of whales by commercial and recreational craft.

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[1] to meet rwequirements of ESA
[2] meet the requirewments of ESA
[3] to mee the requirements of NEPA

6. The EA refuses to adequately assess the threat posed by Coast Guard vessel activity and what assessment was done intentionally done without examining Coast Guard vessel logs to even begin to attempt to determine how many whales, and other species of marine wildlife, were historically struck by Coast Guard vessels.

7. No attempt to assess cumulative impact of other vessel activity in concert with Coast Guard.

8. Despite two know killings of Northern Right Whales in the last four years, simply dismisses the existence of a threat.

"The number of vessels using the area since 1960 has doubled." (pg. 4-21, ¶ 2)

Biological Facts of these Whales

Northern Right Whale numbers less than 300.

Population is Declining

Loss of Range

Decreasing Number of Sightings

The "proposed alternative" and its impact on the existing threat posed by the Coast Guard's vessel activities.

The "proposed alternative" is the status quo. All the Coast Guard will do is let everyone know where whales are when they happen by accident to see one and advise the public to use caution when they start to chase the whales after the Coast Guard tells them where they are. The EA claims this "program" will "significantly reduce" vessel collisions, but it does not show how or what a significant reduction is in hard numbers.

No mitigating or corrective measure proposed by the Coast Guard in expressed in concrete terms. These measures are not reviewable because they are apparently undetermined as to what they mean in reality. However, since the Coast Guard chose to express their proposed conservation measures in this manner, it is clear that the Coast Guard has no desire, nor knowledge and ability, to implement a concrete program and expresses it so nebulously to have it "be what they want it to be" when the need arises and also to simply do nothing, and to not propose a measure that will show such.

Also the EA expresses no quantitative assessment of possible effectiveness of these proposed measures and no statement as to how such programs have ever been demonstrated successful as applied elsewhere. Despite the relatively draconian measures to regulate vessel traffic in Florida to protect Manatees, they still get hit and killed by vessels.

In addition, the Coast Guard has never showed up at any of the "implementation team" meetings with any proposal on how to keep whales from being hit by boats. The enforcement program and other mitigating measures proposed by the EA are just insincere fantasy in response to litigation.

The proposed alternative relies on recently innovated Coast Guard programs to claim that the Coast Guard's threat to whales has been "minimized" (they do not say in numbers what this means or that the threat is eliminated). They rely completely on Law Enforcement Bulletins adopted for each district, a Coast Guard Marine Mammal and Endangered Species Program (unspecified and not reviewable), and participation in "ESA Interagency Working Group (not specified and unreviewable), SEUS Right Whale Recovery (Implementation) Team (unspecified and unreviewable) and SEUS early warning right whale survey (unspecified and unreviewable). (pg. 3-3, ¶ 2)

All of these programs have been adopted without any ESA/Section 7 consultation with NMFS or with any review under NEPA. Considering that the LEB's allow vessels too pursue whales within 100 feet and supports whale watching, these programs could be seen as being in violation of the prohibitions of the ESA and the MMPA.

The proposed alternatives mitigating measures (EA at 3-2) (None of these proposed measures has been detailed, assessed for effectiveness, or given any budget and are therefore mere speculative categorical suggestions, not programs fitting for review) and their effectiveness may be assessed as follows —

a. Simple Education of personnel — All this means is that they are going to attempt (with no budget or any goal of numbers educated or intensity of training) to be "aware of the whales out there." This is full of PC intent and empty in practice. Such sensitivity is meaningless hollow intent without a meaningful conservation program to support. If awareness means that they won't run over whales and that it is all right to be within 100 feet of whale, then awareness means ignorance and harassment if anything.

b. Plotting critical habitat has no meaning if their are no codified rules of conduct when operating in critical habitat. Telling boaters to be "careful" without real rules to follow educates boaters that the threat they pose to whales is trivial and warnings will simply be ignored. Nor does it mean anything if Coast Guard personnel are merely advised to implement and to interpret at their discretion what a "slow safe" speed is. Nor will "slow safe speed" mean not hitting whales. It is also inappropriate to only attempt to regulate vessel activity in critical habitat, and other perceived high use areas. Whales are where the whales are. Whales can show up anywhere at any time. Whale concentrations form one area to another is arbitrary and perceived subjectively by seeing whales where the observes like to go. In addition habitat use by whales is highly variable form year to year and even day to day. The "seasonable" occurrence of whales in a given area will vary extremely from year to year.

c. Posting look outs is simply the status quo. No amount of "whale training" is going to change the already acquired ability by Coast Guard personnel to perceive objects at sea. Seeing objects in the Ocean is an acquired skill, that the object is whales does not make a significant difference. Both dead Northern Right Whales were killed by Coast Guard cutters with highly trained spotters on board. The EA claims that it is an "acquired skill" to maneuver safely around whales. This statement shows a complete lack of desire to protect whales. It accepts the fact that vessel operators will be allowed to get close enough to "maneuver" around the whales and attempts to expresses the concept with lots of practice you can get better at it. This statement concedes that boats must be allowed to pursue and get very close to whales. It places a priority or boats being allowed near whales first, for their recreational and commercial interests, and that the whales should be protected to support that vested interest. The whole of the EA's intent is to protect the Coast Guard form being restricted by the Northern Right Whale, not protecting the Northern Right Whale from the Coat Guard.

d. The EA directive that "*If a whale is sighted* [our emphasis], vessels are to (1) 'give whales a wide berth using speed appropriate to the mission to avoid whale strikes' and (2) 'notify vessels in the vicinity about the location of whales via VHF radio, and direct them to proceed through the area with caution.' (LEB 33-94; see Appendix C)" (pg. 3-2, ¶ 3), is so vague and unspecified as to be meaningless and unreviewable. As such it is unenforceable and totally ineffective. It is the status quo that Coast Guard vessels steer around whales. The Coast Guard should adopt a specific distance (500 yards) that their vessels will stay away form whales.

e. Reviewing and doing ESA/Section 7 consolations of regatta permits is a latent concession to obey the law and comply with their non-discretionary duties. However, such piecemeal reviewing of events with a concrete overall policy will in practice mean nothing. If this EA dismisses the threat posed by yearly operations of the Coast Guard vessels, what perceived threat will the Coast Guard and NMFS feel is posed by a "single regatta, so small in such a big sea."

f. Enforcing the law. One innovative program for the Coast Guard is their sudden commitment to enforcing federal wildlife laws. In the EA, the Coast Guard ignores the existence of its Vessel Documentation and Inspection Program in placing all the threatening vessels out in the water and the proactive measures it could take in regulating vessel traffic. It turns to its recently adopted Law Enforcement Bulletins (LEB) for the 1st, 5th, and 7th Coast Guard districts to show its "feeling" and intent to protect marine wildlife, perhaps to show that how could its boats hit whales when they are so busy trying to protect them. It apparently references the LEB's, instead of assessing cumulative impact, to categorical dismiss cumulative impact because of any mere effort at enforcement.

The three LEB's are not simply inept attempts at "for show only" enforcement. They are hard core policy to restrict enforcement and allow the routine harassment and killing of marine wildlife. The LEB's condone that vessels will be allowed to pursue whales to within 100 feet. There will be no arrests made for violating the ESA and MMPA. They will protect the commercial whaling industry and no commercial whaling vessels will be arrested or boarded, only recreational vessels will be harassed by the Coast Guard. They will also only act on "significant violation." They will only take enforcement steps if their is well documented and video taped encounters. This means in practice that without an enforcement budget, their is not going to be an enforcement program. The LEB's also rule out regulating vessel activity and ignore the incidental taking of whales in fishing gear and through entanglement.

The LEB's are inconsistent in their enforcement policies based mostly on how far they are from New England's commercial whaling industry. Off Georgia and Florida vessels are warned to stay 500 yards away from Northern Right Whales. In New England they are told where the whales are and merely advised to be careful when vessels are chasing them.

The Coast Guard attempts too avoid the ESA by attempting to excuse Coast Guard violation of the prohibitions of the ESA and MMPA by claiming that it is for the public haealth and safety. It should not worry or claim such in the EA. It must consider only the interests of marine wildlife. It should cease ignoring conservation by attempting to excuse itself, in the interests of public safety, without a permit to do so from NMFS.

Conservation Alternative

Coast Guard should —

a. Codify a national distance rule for whales, prohibiting any person or vessel form getting with 500 yards of any Northern Right Whale and 100 yards from any other species of whale;

b. Track Northern Right Whales along the U. S. coat so has c be able to know where these whale's are on any given day. Interdict to endure vessel traffic remains away form that whale;

c. Survey Northern Right Whale habitat every day . especially cr9itical habitat. to see if the Northern Right Whale is present. then track the whales and sdopt emergency rule to close the area within one mile of every Northern Right Whale.

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October 27, 1995

By Fax (202-267-4425) and U.S. Mail

Lcdr. Wesley C. Marquardt
Commandant (G-NIO)
U.S. Coast Guard
2100 Second Street
Washington, DC 20593-0001

Re: Comments on "Environmental Assessment of Potential Impacts of U.S. Coast Guard Activities Along the U.S. Atlantic Coast" dated September 22, 1995

Dear Lcdr Marquardt:

By this letter and on behalf of Richard Max Strahan, we submit comments regarding the above-referenced Environmental Assessment ("EA").[1] The EA is deficient in three fundamental respects: (1) it fails to evaluate the impact of the Coast Guard's numerous activities, policies, and procedures along the Atlantic Coast other than the activities of its own vessels; (2) the EA fails to reflect the actual magnitude of the impacts of the United States Coast Guard ("USCG") vessels themselves; and (3) the EA fails to identify or examine serious alternatives to avoid detrimental impacts of Coast Guard operations on endangered whales.

As a result of these deficiencies, the proposed Finding of No Significant Impact ("FONSI") is unsupported and counter to the dictates of the National Environmental Policy Act ("NEPA"). The Coast Guard readily admits in the EA at p. 1-1 that it is obligated by NEPA to "take into account the effects of their policies, procedures, and actions on the environment and use all practicable means ... to restore and enhance the environment." In the EA, the Coast Guard also repeatedly admits that the Northern Right Whale is "critically endangered," dwindling in population, particularly at risk by vessel collisions, and, therefore, "continuing activities which do not focus on minimizing potentially adverse interactions with Right Whales is

[1] These comments are primarily directed at the Coast Guard's impacts on the highly endangered Northern Right Whale.

unacceptable in light of the need to protect Right Whales and other protected species." EA page 5-13 [emphasis added] (see also pages 4-3, 5-3). Despite these significant admissions, the EA identifies no action to be undertaken by the Coast Guard that will, in fact, reduce the detrimental impact of Coast Guard activities on the Northern Right Whale. The EA instead fails even to analyze most impacts of Coast Guard policies, procedures, and activities on the whale population. As to the preferred alternative for action selected by the EA, the Coast Guard provides no quantification of how the alternative will in fact reduce or eliminate impacts on endangered species, including the Northern Right Whale.

In short, the proposed FONSI does not pass muster.

I. The EA does not consider the cumulative effects of non-Coast Guard Vessels and other activities regulated or sanctioned by the Coast Guard

Non-Coast Guard vessels pose a significant and continuing threat to endangered species off the Atlantic Coast and, in particular, to the Northern Right Whale. The USCG has broad authority to regulate these vessels and their operations in the Atlantic. However, the EA improperly ignores the environmental effects of the USCG's failure to exercise its regulatory authority in a manner to prevent these vessels from killing and injuring endangered species. This omission renders this EA incomplete and an insufficient basis for concluding that no Environmental Impact Statement is required.

Although the stated purpose of the EA is to evaluate the potential environmental effects of USCG "operations" along the Atlantic Coast of the United States, EA at 1-1, the EA in fact addresses only a tiny subset of the USCG's operations, primarily the physical operation of its own vessels and its authority to grant permits to regattas. See EA at 3-1 - 3-3. The EA erroneously fails to address any of the USCG's numerous other "missions." The Coast Guard missions include, among many others, engaging in oceanographic research and maintaining a coordinated environmental program "including all aspects of marine transportation." EA at 2-1 through 2-4. These operations, policies, and procedures -- like operation of the USCG vessels themselves -- jeopardize the continued existence of the highly endangered Northern Right Whale. The cumulative impact of all Coast Guard operations must be analyzed and mitigated.

For example, the EA must evaluate the environmental impacts of the Coast Guard's failure to adopt or implement meaningful protective measures to prevent non-USCG vessels from hitting or harassing endangered species. The EA admits that a variety of human activities endanger the whales:

> "The major interactions between whales and human activities that may lead to injury or death of the whales include entanglement in fishing gear and marine debris, collisions with vessels, marine pollution, habitat change, and general harassment. Between 1973 and 1993, 27% of documented Right Whale mortalities along the Atlantic cost were due, all or in part, to collisions with vessels (Kenney and Kraus, 1993)."

Id. at page 4-3 - 4-4. Yet, the EA utterly fails to examine the role the Coast Guard can -- and should -- play to mitigate or eliminate these devastating interactions. For example, the EA does not consider the environmental effects of failing to modify traffic routes during periods when endangered species have been spotted. It does not consider the effect of failing to promulgate or enforce buffer zones between vessels and endangered species.

Accordingly, either an EIS should be prepared or the EA should be reissued with an adequate evaluation of the potentially devastating cumulative impact of the Coast Guard's policies, procedures, and activities on the environment.

Notably, the restricted scope of the EA is also inconsistent with representations made by the Coast Guard to the federal court. As part of litigation pending in Federal District Court for the District of Massachusetts, Strahan v. Linnon, C.A. No. 94-11128-DPW, the Coast Guard agreed to "voluntarily prepare an environmental assessment ("EA") under [NEPA] . . examining the effects of its operations and the cumulative effects of operations of non-Coast Guard vessels. Defendant's Memorandum Motion for Summary Judgment at 6 (emphasis added).

II. The EA significantly understates the impact the operation of USCG vessels has on endangered species, particularly Northern Right Whales

"The incidental mortality of even one right whale could jeopardize the continued existence of the population." This is the opinion of National Marine Fisheries Service (NMFS), in its September 15, 1995 Biological Opinion ("BO") relating to USCG Vessel and Aircraft Activities along the Atlantic Coast. BO at 17. Given the right whale's tenuous grasp on survival, the overwhelming significance of even one whale death, the fact that

USCG vessels have killed at least two right whales in the last four years, and the absence of any analysis or evidence that the selected course of action will in fact reduce or eliminate whale strikes, a FONSI cannot be supported. The EA utterly fails to explain or supply any support for the naked conclusion that Coast Guard activities are "not likely to have significant negative environmental impacts." EA at 6-1.

III. **The EA fails to identify or examine any meaningful alternatives to mitigate endangerment of the Northern Right Whale**

The Coast Guard's "preferred" course of action is Alternative 2. Reduced to its essence, all Alternative 2 accomplishes is an expression of a desire on the part of the Coast Guard to think about ways to reduce the number of Coast Guard vessel collisions with whales: nothing more. Alternative 2 contains absolutely no specific commitments to action by the Coast Guard. Thus, the EA does not -- and can not -- quantify how the preferred course of action will mitigate impacts of Coast Guard activities on the endangered Right Whale. The EA acknowledges at page 3-2 that:

> "marine mammals and turtles are often very difficult to spot, and collisions may still occur, especially at night or if weather conditions are adverse (i.e., foggy or windy). Spotting whales, manatees, and turtles, and maneuvering around them is an acquired skill that comes with experience and education."

Yet, the preferred Alternative contains no specific plan to provide either Coast Guard or non-Coast Guard vessel operators with the necessary skills.

Nothing in Alternative 2 identifies any actions or procedures under development at the Coast Guard to reduce the five most devastating interactions between whales and humans; namely, entanglement in fishing gear and marine debris, collisions, marine pollution, habitat change, and general harassment. See EA at 4-3. Indeed, the Coast Guard summarily rejects the idea of avoiding critical habitat areas. The idea is posed as an all or nothing option. See p. 5-22. A more sensible approach would be to fashion policies for reducing or eliminating unnecessary activity in critical habitat.

No mention is made of even the most obvious protective measures:

- Establishing and enforcing specific distance rules;
- Establishing and implementing a program to track the location of endangered whales; and
- Surveying critical habitat daily.

These are by no means the only measures that should be evaluated by the EA. They are merely offered by way of example to demonstrate the insufficiency of the Alternatives analysis in the EA.

* * *

People are the key cause of mortality of right whales. Because the USCG is charged with regulating the marine environment off the coast of the United States, it bears the responsibility to ensure that the killing and maiming stops. It is not enough to ponder ways to reduce the number of whale collisions by USCG vessels. The Coast Guard must take action to prevent USCG vessels from killing whales. It must also act responsibly in authorizing or carrying out operations performed by non-USCG vessels. Yet, the EA fails to give serious considerations to alternatives that may enable the USCG to fulfill its duties. Therefore, the EA is inadequate to support a FONSI. The EA should be reissued or else an EIS should be prepared to further study and document the impact of these interactions with one of the rarest and most magnificent species on the planet.

Thank you for the opportunity to comment on the EA. The attached document by Mr. Strahan explains in more detail the deficiencies in the USCG's alternatives analysis. If you have any questions please feel free to call Adam Kahn at 832-1206 or Wendy Jacobs at 832-1133.

Very truly yours,

Adam P. Kahn

Wendy B. Jacobs

Enclosure
cc: Richard Max Strahan