Marine Aquaculture, Marine Mammals, and Marine Turtles Interactions Workshop Held in Silver Spring, Maryland 12-13 January, 1999

Edited by:
Katie Moore and Donna Wieting
in collaboration with the Workshop Participants

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Protected Resources
Silver Spring, Maryland 20910

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Executive Summary

ISSUE BACKGROUND

Aquaculture is a growing industry with the United States production having increased roughly 5-10% each year over the past decade. Fish are now farmed in every U.S. state and territory, and marine aquaculture is expected to grow significantly over the next ten years.

Interactions between marine aquaculture facilities and marine mammals and turtles can have significant negative impacts. There are documented cases of interactions between nearshore aquaculture operations and pinnipeds[1] on both the United States east and west coasts. These interactions include injury and mortality to marine mammals from entanglement as well as economic losses to the aquaculture industry due to damaged gear. Interactions can also occur offshore. For instance, offshore aquaculture facilities in New Zealand have documented marine mammal entanglements. Marine turtles are also at risk of entanglement from offshore aquaculture operations. After hatching, some species migrate offshore and become associated with Sargassum rafts and other flotsam. Aquaculture components, such as net pens, may "collect" these rafts or interfere with their natural passive movements, and thereby may entangle, capture, or disrupt migratory movements of post-hatching or pelagic-state marine turtles. As marine aquaculture operations expand in the nearshore and offshore marine environment, it is likely that interactions with marine mammals and marine turtles will increase.

Within the Department of Commerce (DOC), the National Oceanic and Atmospheric Administration (NOAA) has taken a leadership role to support and promote the development of environmentally sound aquaculture. Many recent efforts have focused on this topic:

- The DOC Aquaculture Task Force chaired by NOAA, has developed an aquaculture policy which defines DOC's aquaculture mission and specifies objectives for the year 2025, which include: an increase in the value of domestic aquaculture production from the present $800 million to $5 billion; an increase in jobs in the aquaculture sector from the present estimate of 180,000 to 600,000 jobs; and a goal of 100% domestic compliance with a Code of Conduct for Responsible Aquaculture (to be developed).

[1]Pinnipeds: Marine mammals of the Order Carnivora, Sub-Order Pinnipedia include fur seals, sea lions, walrus, and true seals.

- In February 1998, NOAA released its own aquaculture policy which outlines aquaculture priorities for the National Marine Fisheries Service (NMFS), the Office of Oceanic and Atmospheric Research (OAR), and the National Ocean Service (NOS). These priorities include research, development, technology transfer, financial assistance to businesses, environmental safeguards including regulatory and permit procedures, and coordination among private, state, and federal partners.

- Objective 4 of NOAA's Build Sustainable Fisheries Strategic Plan is to promote the development of robust and environmentally sound aquaculture by 2002.

- NOAA identified aquaculture as a priority for Fiscal Year (FY) 1999 and FY 2000 budget initiatives, with specific research and implementation goals.

- At the National Ocean Conference held in Monterey, California in May 1998, the President committed an additional $3 million per year for the following three years to support the expansion of marine aquaculture.

The marine aquaculture industry has been associated with incidental "takes" of marine mammals and marine turtles. Incidental takes as specified under section 10 of the Endangered Species Act (ESA) refers to such taking which is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Incidental takes are regulated under the Marine Mammal Protection Act (MMPA) as well as provisions within the ESA. The NOAA's NMFS is one of a multitude of affected federal government entities involved in regulatory issues surrounding the interaction of marine aquaculture and marine mammals and turtles. NMFS and its Office of Protected Resources (OPR) is responsible for implementation of the MMPA and for the conservation and management of most marine species under the ESA. For this reason, the OPR conduced this workshop to identify ways to avoid or minimize interactions between aquaculture operations and marine mammals/turtles.

WORKSHOP BACKGROUND

The workshop sponsored by OPR was held on January 12-13, 1999 to discuss the interaction of marine mammals, marine turtles, and marine aquaculture. The workshop was attended by various governmental, industry, scientific, and environmental representatives totaling approximately 40 participants, several observers, and a facilitator.

As marine aquaculture operations expand, it is likely that interactions with marine mammals and turtles will increase, with potential adverse affects to marine mammals and turtles and aquaculture operations. The purpose of this workshop was:

> *To bring together regional NMFS experts in marine mammals, marine turtles, and marine aquaculture operations to develop recommendations on specific guidelines and standards for aquaculture siting and operation to minimize adverse impacts to marine protected species from nearshore and offshore aquaculture operations.*

The intent was to solicit individual suggestions, not consensus or group decisions. Through discussions and interactions between members of the government, the marine aquaculture industry, academia, and environmental organizations it was hoped that NMFS would gain valuable insight regarding many of the most critical interactions between aquaculture and marine mammals and turtles.

The guidelines and standards discussed in this workshop were geared towards identifying:

(a) Areas to be avoided in siting aquaculture facilities in coastal and offshore areas;
(b) Best practices to build and operate aquaculture facilities in order to avoid or minimize predation by pinnipeds;
(c) Best practices to build and operate offshore facilities to avoid interactions with marine mammals (particularly cetaceans) and turtles; And
(d) Research needs.

The guidelines and standards are intended:

(a) To guide NMFS representatives in the review of aquaculture permits;
(b) To provide siting and operational guidelines for NMFS' Code of Conduct for Responsible Fisheries; And
(c) To help NMFS accomplish the goals of its strategic plan. The plan calls for NMFS to accomplish several actions within the next five years. The actions include reducing the time and cost of permitting environmentally sound marine aquaculture, providing financial assistance for environmentally sound marine aquaculture ventures, identifying areas in the U.S. Exclusive Economic Zone[2] suitable for environmentally sound marine aquaculture, and

[2]Exclusive Economic Zone: Adjacent to state waters, which extend three miles out from the coast, the U.S. Exclusive Economic Zone includes water from three to 200 nautical miles from shore. The state waters of Texas, Puerto Rico, and the west coast of Florida extend nine miles from shore.

developing and implementing environmentally sound marine aquaculture technologies and practices.

WORKSHOP FORMAT

The workshop was held on January 12 and 13, 1999 at the NMFS office in Silver Spring, Maryland on 1315 East-West Highway. It was organized by Kate Colborn and chaired by Donna Wieting, both of OPR.

The purpose of this workshop was to bring together regional NMFS experts in marine mammals, marine turtles, and marine aquaculture operations to develop recommendations on specific guidelines and standards for aquaculture siting and operation to minimize adverse affects to marine protected species from nearshore and offshore aquaculture operations. In addition, a number of non-NMFS representatives were invited to present information and guide the development of recommendations.

The participants represented various regions of the United States including the Northeast, Southeast, Northwest, and Gulf of Mexico. In an effort to facilitate discussion, NMFS contracted Ms. Mary Skelton Roberts of the Keystone Center to lead the discussion. Participants were given an agenda, discussion topics, as well as background materials before convening the workshop.

Participants were divided into working groups that discussed various issues associated with marine mammal, marine turtle, and marine aquaculture interactions. Each subgroup participated in lengthy discussions on key issues. The workshop participants convened several times over the course of the workshop to share subgroup recommendations.

ISSUES DISCUSSED

The workshop participants were given an information booklet containing background documents for the discussions. The discussions revolved around several pre-arranged topics including the following:

Siting

- Should areas be identified where marine aquaculture should be avoided and/or encouraged?
- How should those areas be identified? General criteria? Mapping? Other?

Pinniped Predation

- Is pinniped predation a problem in all types of marine aquaculture? In all regions?

- If not, what determines whether or not pinniped predation is a problem?
- What deterrents are currently used? Are they successful? To what degree?
- How can deterrents be improved?
- What new methods are needed?

Entanglement
- Is entanglement a concern in nearshore aquaculture operations?
- If so, what is being done to avoid or minimize it?
    - What additional methods should be applied?
- Is entanglement a concern in offshore aquaculture operations?
    - If so, what should be done to avoid or minimize it?

Standards and Guidelines
- What are the existing standards and guidelines that affect aquaculture interactions with marine mammals and turtles?
- Are these standards and guidelines sufficient?
- What gaps exist in the current standard and guidelines to deal with marine mammal and turtle concerns?
- Where should we focus our efforts to address these gaps?
- Should standards be mandatory at this time?
- Or voluntary?

Research
- What are the key research needs to address policy issues and questions related to marine mammals and turtle interactions with marine aquaculture operations over the next 20 years?
- Which are priorities?

WORKSHOP OUTPUTS

NMFS had several anticipated outputs from the discussions. The anticipated outputs included
guidelines to minimize or avoid adverse effects to marine mammals and turtles:
- from nearshore aquaculture operations, and
- from proposed offshore aquaculture operations.

FINAL GROUP RECOMMENDATIONS

The workshop participants generated approximately twenty recommendations for future action. The recommendations were not formally prioritized or agreed to by consensus.

The recommendations include the following (not in any particular order):

Technology-Associated Efforts

- Evaluate the adverse effects of Acoustic Harassment Devices[3] on target and non-target species.
- Encourage the aquaculture industry to investigate new net technologies. (e.g., sponsor joint projects instead of solely governmental projects.)
- Research non-lethal, non-technical deterrence methods. .
- Develop new deterrent technologies and strategies.
- Conduct an economic review of new net technologies (e.g., a viability analysis). Optimize the effectiveness of AHDs through research on particular species.

Policy Analysis

- Research other nations' approaches to the marine mammal/marine turtle and aquaculture interaction issue.
- Quantify and characterize the economic losses to the aquaculture industry from pinniped predation.
- Compare agricultural predator deterrent policies and approaches and determine their applicability to marine aquaculture.
- Perform a risk analysis of the effect of aquaculture compared to other activities in the marine environment on marine mammals and marine turtles.

Habitat Issues

- Examine at what point the physical occupation of a habitat or the use of resources in an area by aquaculture site(s) has become a problem for marine mammals and marine turtles.
- Evaluate aquaculture site baseline habitat condition changes before and after aquaculture siting (e.g., monitoring ambient noise levels).

Behavioral Studies

- Document and characterize marine mammal and marine turtle interactions with aquaculture sites (e.g., effects of lighting on turtles, how marine mammals become entangled in aquaculture gear, etc.).
- Further characterize marine mammal/marine turtle behavior and ecology around aquaculture sites.

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[3]Acoustic Harassment Device (AHD): A sound-generating device which, because of some combination of intensity, frequency, or other characteristic(s), is aversive to marine mammals and keeps or drives them away from an area or structure (Acoustic Deterrence of Harmful Marine Mammal-Fishery Interactions Workshop. NOAA Tech. Memo. NMFS-OPR-10, December 1996.)

- Identify characteristics of rogue animals, particularly looking at pinnipeds as predators.
- Undertake further research on the distribution of protected species.
- Review and assemble baseline environmental management data. Agencies would use the data to create narrative guidance with the assistance of a Geographic Information System to guide applicants in aquaculture siting applications.

Aquaculture Facility Standard Operation Practices

- Develop changes to aquaculture facility standard operating practices in an effort to reduce marine mammal and marine turtle interactions. (e.g., rotating site locations).
- Develop a tagging method for aquaculture gear for identification purposes in case of gear loss. Research existing approaches that are currently used in other fisheries.

Information Management

- Archive literature related to marine mammal and turtle interactions with aquaculture operations.
- Explore the use of the NOAA Library to archive and store literature.
- Consider insurance as a tracking mechanism for implementing and enforcing guidelines or standards.

1.0 INTRODUCTION

Aquaculture is a growing industry with the United States production having increased roughly 5-10% each year over the past decade. Fish are now farmed in every U.S. state and territory, and marine aquaculture is expected to grow significantly over the next ten years.

Interactions between marine aquaculture facilities and marine mammals and turtles can have significant negative impacts. There are documented cases of interactions between nearshore aquaculture operations and pinnipeds on both the east and west coasts of the United States. These interactions include injury and mortality to marine mammals from entanglement as well as economic losses to the aquaculture industry due to damaged gear. Interactions can also occur offshore. For instance, offshore aquaculture facilities in New Zealand have documented marine mammal entanglements. Marine turtles are also at risk of entanglement from offshore aquaculture operations. After hatching, some species migrate offshore and become associated with Sargassum rafts and other flotsam. Aquaculture components, such as net pens, may "collect" these rafts or interfere with the rafts' natural passive movements, and thereby may entangle, capture, or disrupt migratory movements of post-hatching or pelagic-state marine turtles. As marine aquaculture operations expand in the nearshore and offshore marine environment, it is likely that interactions with marine mammals and marine turtles will increase.

Within the Department of Commerce (DOC), the National Oceanic and Atmospheric Administration (NOAA) has taken a leadership role to support and promote the development of environmentally sound aquaculture. Many recent efforts have focused on this topic:

- The DOC Aquaculture Task Force chaired by NOAA, has developed an aquaculture policy which defines DOC's aquaculture mission and specifies objectives for the year 2025, which include: an increase in the value of domestic aquaculture production from the present 800 million dollars to 5 billion dollars; an increase in jobs in the aquaculture sector from the present estimate of 180,000 to 600,000 jobs; and a goal of 100% domestic compliance with a Code of Conduct for Responsible Aquaculture (in development).

- In February 1998, NOAA released its own aquaculture policy which outlines aquaculture priorities for the National Marine Fisheries Service (NMFS), the Office of Oceanic and Atmospheric Research (OAR), and the National Ocean Service (NOS). These priorities include research, development, technology transfer, financial assistance to businesses, environmental safeguards including

regulatory and permit procedures, and coordination among private, state, and federal partners.

- Objective 4 of NOAA's Build Sustainable Fisheries Strategic Plan is to promote the development of robust and environmentally sound aquaculture by 2002.

- NOAA identified aquaculture as a priority for Fiscal Year (FY) 1999 and FY 2000 budget initiatives, with specific research and implementation goals.

- At the National Ocean Conference held in Monterey, California in May 1998, the President committed an additional 3 million dollars per year for the following three years to support the expansion of marine aquaculture.

2.0 WORKSHOP PURPOSE

Ongoing problems associated with nearshore aquaculture operations and protected species, including predation by pinnipeds, have been documented. As nearshore marine aquaculture operations expand, it is likely that interactions with marine mammals and turtles will increase. There are also growing concerns about the potential for cetacean[4] entanglement with proposed offshore aquaculture operations. Therefore, NOAA is interested in resolving conflicts regarding aquaculture siting/operation and protected resources.

We recognized that there are other concerns than those addressed in this workshop. Other issues of concern, such as genetic impacts to wild stocks and water pollution, are concurrently being addressed in other fora. This workshop was designed specifically to discuss the impacts of aquaculture operations on marine mammals and marine turtles.

In an effort to discuss marine mammal, turtle, and aquaculture interactions, NMFS' Office of Protected Resources (OPR) sponsored a two day workshop with the following purpose:

> *To bring together regional experts in marine mammals, marine turtles, and marine aquaculture operations. The experts were asked to develop recommendations on specific guidelines and standards for aquaculture siting and operation to minimize*

[4]Cetacean: Marine mammals of the Order Cetacea which includes baleen whales, dolphins, porpoises, and toothed whales.

adverse impacts to marine protected species from nearshore and offshore aquaculture operations.

Currently, the standards and guidelines used to address protected species' issues, to permit aquaculture, or to regulate aquaculture operations vary considerably among regions, states, and among federal agencies. Regional efforts have been made to deal with these concerns, such as through the Gulf of Maine Task Force[5]. However, those efforts have either been limited in scope or fairly general in nature. For instance, in the Northeast Region (NER), the state of Maine and federal agencies developed guidelines for a streamlined aquaculture permitting and monitoring process. However, the specific guidelines and standards did not address siting and operating aquaculture facilities to minimize the impacts to marine protected resources, nor did the effort expand beyond its regional approach.

The guidelines and standards discussed in this workshop were geared towards identifying:

(a) Areas to be avoided in siting aquaculture facilities in coastal and offshore areas;
(b) Best practices to build and operate aquaculture facilities in order to avoid or minimize predation by pinnipeds;
(c) Best practices to build and operate offshore facilities to avoid interactions with marine mammals (particularly cetaceans) and turtles; And
(d) Research needs.

The guidelines and standards will be useful:

(a) For NMFS representatives who review aquaculture permits;
(b) To guide NMFS' Implementation Plan for the Code of Conduct for Responsible Fisheries; and
(c) To accomplish the goals of the NMFS strategic plan. The plan calls for NMFS to accomplish several actions within the next five years. The actions include reducing the time and cost of permitting environmentally sound marine aquaculture, providing financial assistance for environmentally sound marine aquaculture ventures, identifying areas in the U.S. Exclusive Economic Zone[6]

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[5]Gulf of Maine Task Force: Section 120 of the MMPA as Amended mandates the establishment of a pinniped-fishery interaction task force to advise the Secretary of the DOC on the interaction of pinnipeds with aquaculture resources in the Gulf of Maine.

[6]Exclusive Economic Zone: Adjacent to state waters, which typically extend three miles out from the coast, the U.S. Exclusive Economic Zone includes water from three to 200 nautical miles from shore.

suitable for environmentally sound marine aquaculture, and developing and implementing environmentally sound marine aquaculture technologies and practices.

3.0 WORKSHOP PROCEEDINGS

The workshop was held on January 12 and 13, 1999 at the NMFS office in Silver Spring, Maryland on 1315 East-West Highway. It was organized by Kate Colborn and chaired by Donna Wieting, both of NOAA, NMFS, OPR.

The purpose of this workshop was to bring together regional NMFS experts in marine mammals, marine turtles, and marine aquaculture operations to develop recommendations on specific guidelines and standards for aquaculture siting and operation to minimize adverse affects to marine protected species from nearshore and offshore aquaculture operations. In addition, a number of non-NMFS representatives were invited to present information and guide the development of recommendations. Through discussions and interactions between members of the government, the marine aquaculture industry, academia, and environmental organizations, NMFS gained valuable insight regarding many of the most critical interactions between aquaculture and marine mammals and turtles. There were approximately forty participants, several observers, and a facilitator (Appendix 1). The participants represented various geographic regions including the Northeast, Southeast, Northwest, and Gulf of Mexico. NMFS contracted The Keystone Center, a neutral, nonprofit, public policy and education organization, to facilitate the workshop. Participants were mailed an agenda, discussion topics, as well as background materials prior to the workshop (Appendices 2,3, and 4).

3.1 WELCOME BY NMFS

The two day workshop began with a brief welcome by Donna Wieting of the OPR's Marine Mammal Conservation Division. Ms. Wieting discussed OPR's responsibility to implement the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) for marine species[7]. She emphasized that OPR's goals focus on finding ways to minimize adverse impacts to marine mammals and to marine turtles while minimizing economic impacts to the aquaculture industry. Ms. Wieting briefly described the workshop agenda (Appendix 1).

[7]The United States Fish and Wildlife Service also shares the authority to implement the ESA and MMPA. NMFS has responsibility for cetaceans and most pinniped species. FWS has responsibility over manatees, polar bears, sea otters, and walrus.

3.2 WELCOME BY NOAA

Donna Wieting introduced Sally Yozell, Deputy Assistant Secretary for Oceans and Atmosphere of NOAA. Ms. Yozell opened her discussion by noting that NOAA is interested in promoting environmentally sound aquaculture such that both the aquaculture industry and resource management policies can move forward in a positive way. She emphasized that aquaculture is a priority for NOAA and the DOC.

She offered some background information on aquaculture:

- The industry is exploding with a 5-10% growth rate.
- Marine aquaculture comprises approximately 50% of the worldwide aquaculture.
- The demand for fish and its associated price is increasing.

Ms. Yozell continued by acknowledging that aquaculture is an industry that not only produces food, but it also produces jobs. Considering NOAA's location within the Department of Commerce, she emphasized the DOC's dual role of promoting industry and the protection of the environment. Ms. Yozell recognized that the workshop participants are experts in their fields, and she reiterated that NOAA respects their ideas and acknowledges the need for their guidance. She hoped that this workshop would be the beginning of many ongoing discussions regarding the promotion of environmentally sound aquaculture.

Ms. Yozell further discussed how NOAA is uniquely positioned to address aquaculture issues because the agency is directly involved with the laws and policies affecting the aquaculture industry. Some of these laws include, but are not limited to the MMPA, the National Marine Sanctuaries Act (NMSA), the Coastal Zone Management Act (CZMA), the ESA, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

She noted that at the same time, NOAA falls within the DOC, which is concerned with business. Therefore, the DOC is interested in promoting aquaculture but through an environmentally sound approach. NOAA's goals for this meeting include discussion on how to address the issue of aquaculture through grants, standards, and regulations. At the same time, the DOC must develop and adhere to a Code of Conduct dealing with promoting aquaculture in an environmentally sound manner.

She acknowledged that the international community is also becoming more involved in the aquaculture issue. 1998 was the International Year of the Ocean. At the 1998 Oceans Conference, the Presidential Aquaculture Initiative was unveiled, bringing about increased funding for aquaculture issues. This workshop will help provide input on how to spend some of the federal funding, and this workshop will also

assist in determining some of the future resource and management needs surrounding environmentally sound aquaculture.

Ms. Yozell finished by highlighting that NOAA is committed to working with the private industry, academics, and other affected sectors to move the aquaculture industry forward in a positive manner. Affected stakeholders need to interact on aquaculture issues because aquaculture will be the industry of the future. NOAA is confident that the U.S. can be a leader in effective resource management.

3.2.1 QUESTION AND ANSWER SESSION

Workshop participants raised several questions to Ms. Yozell after the Welcome.

> Participant Question: How do you see our international relationships and how we can work with other countries? Other countries are now looking at models to see how aquaculture can fit into coastal environmental models, specifically addressing trophic interactions. Other countries have also been looking into fishery enhancement tools. It would be advantageous for the U.S. to sponsor an international workshop to meet with other nations and their industries to hear about what they are doing.
>
> Yozell Response: This would be a great idea. The U.S. is way behind the curve as a nation in terms of management. We can learn from other countries' actions, and we are now ready to make it a priority. The Code of Conduct is the first step to get this together, then we can move out and meet with international partners. We'll discuss this possibility at the Department level.
>
> Participant Question: Our national charge is to "Be Greener." Do you have any insight as to how we do this?
>
> Yozell Response: There are many fears surrounding the aquaculture industry including, but not limited to disease, escapement, interactions with marine mammals and marine turtles, and pollution. These need to be addressed, and the President stressed that we need to do a better job to make sure aquaculture is environmentally safe. It has the potential to be a "green industry."
>
> Participant Comment: NOAA has a lot of work to do as well as a lot of resources and skills to offer in the future.

Yozell Comment: The Agency must be smarter and think more creatively. The Agency can't have its fears stop the development of the aquaculture industry.

Participant Comment: Will there be an opportunity to use remote sensing in future initiatives?

Yozell Comment: This is a perfect opportunity for different Line Offices within NOAA to coordinate.

3.3 WORKSHOP STRUCTURE

Donna Wieting of NMFS OPR led the information exchange. The workshop is aimed to address one particular issue: marine mammals, marine turtles, and aquaculture interactions. Other workshops will have to address other aquaculture-related issues. Issues that come out in discussion, but fall outside of this workshop's purpose, will be flagged but not addressed here.

The goal of the workshop was to develop recommendations for guidelines to minimize adverse interactions between marine mammals, marine turtles, and aquaculture. These included:

- Defining ways to minimize impacts (NOAA, DOC policies);
- Facilitating permitting;
- Helping to guide states so that the federal and state governments have consistent approaches;
- Identifying research priorities; And
- Defining the attributes associated with environmentally sound aquaculture.

Regional representatives were tasked with helping to develop consistent approaches for reviewing applications and permitting. NOAA appreciates the perspective that non-NMFS participants can offer, specifically in offering realistic, reasonable approaches to management. Workshop observers have been asked to focus on NMFS' role, but the observers are encouraged to provide insight into any issue.

The expected workshop outcome was a set of recommendations with specific guidelines. NOAA did not envision regulations coming from this workshop, but NOAA welcomes suggestions on how to formalize and implement these guidelines.

3.4 INTRODUCTION OF WORKSHOP ATTENDEES

Each of the attendees introduced themselves, their geographic region and the professional sector that they represented (Appendix 2). Mary Skelton Roberts of the Keystone Center introduced her role as the workshop facilitator. She provided ground rules for discussion and emphasized that consensus was not required in the workshop discussions.

3.5 DISCUSSION: AQUACULTURE RISK MANAGEMENT AND MARINE MAMMALS IN THE PACIFIC NORTHWEST

Bob Iwamoto of NMFS' Northwest Fisheries Science Center opened the session. His presentation was in three parts. First, he offered a brief overview of aquaculture production in the U.S. and the Pacific Northwest. Next, he discussed the risks facing four sectors of the industry involving interactions with marine mammals. He followed with proposals for managing and controlling those risks. He finished his presentation with six brief conclusions.

3.5.1 OVERVIEW OF AQUACULTURE PRODUCTION IN THE U.S. AND PACIFIC NORTHWEST

The benefits associated with aquaculture technologies include:

- Seafood for human consumption, through aquatic farming and enhancement of indigenous fisheries, particularly Pacific salmon; And
- A range of marketable non-food products, such as: tropical fish for the aquarium trade, medicines, and drugs, jewel and craft materials, and organisms for research.

Farmed production (terrestrial and marine) of fish and shellfish in the United States has been approximately 350,00-400,00 metric tons/year for the last 10 years. The total value of the industry is approximately 736-800 million dollars, split between the freshwater and saltwater environments. Freshwater aquaculture constitutes about 65% of the total production, with associated freshwater species including catfish, crayfish, and rainbow trout. The remaining 35% of production is farmed in the coastal or saltwater environment, with species raised including mollusks (70% of production), crustaceans (15-20%), and salmon (10%).

The industry also accounts for approximately 16-30% of the U.S. salmon harvest through enhancement of native stocks. In the Pacific Northwest, enhancement contributes about 2-3 million salmon to the commercial and recreational fisheries and supports repopulation of ESA-listed stocks from hatcheries.

3.5.2 RISKS TO THE INDUSTRY FROM MARINE MAMMALS

The Pacific Northwest aquaculture industry is at risk from interactions with marine mammals in two areas: market risks (value of the product) and production risks (operations, technological, financial, and social). The value of the coastal aquaculture industry in the United States that is exposed to risk is approximately 350 million dollars. Of this total, about 200 million dollars is in shellfish beds (2-3 year grow-out), 130 million dollars is in net-pen complexes (excluding hatcheries), and 20 million dollars is in coastal ponds (excluding hatcheries).

The value of cultured fish in the commercial fisheries is between 60 and 115 million dollars. In the recreational fisheries, it was about 22 dollars per fish based on 1992 data, but the value is probably much more now.

In the Pacific Northwest, the risks are to four primary parts of the industry including:
1) Shellfish farming;
2) Enhanced or culture-based fisheries for Pacific salmon and steelhead trout;
3) Net-pen farming of Atlantic and Pacific salmon and rainbow trout; And
4) Humans working in the industry.

3.5.2.1 RISKS TO SHELLFISH FARMING

Some of the risks to shellfish aquaculture include:

- Contamination of mollusks from fecal coliform bacteria from harbor seals; And
- Lost production due to predators, such as otters feeding on clam beds and mollusk rafts.

Harbor seals have been responsible for contaminating two oyster beds in Washington State. The harbor seal population has increased 10-fold in British Columbia since 1970, and the numbers are back to their historic level of 135,000. In California, Oregon, and Washington coastal areas, the increase has been about 7.7% annually, and the numbers are now about 76,000. The growing seal population has resulted in an increase of feces, nutrients, bacteria, and possible pathogens into coastal areas.

3.5.2.2 RISKS TO ENHANCED OR CULTURE-BASED FISHERIES

Some of the risks to enhanced fisheries include:

- Lost production due to mortalities. Otters, seals, and sea lions are predators of out-migrating juvenile salmon. Seals and sea lions prey upon returning adults, and
- Loss of fish to the gene pool. Many fish, including ESA-listed species, are consumed directly or irrecoverably wounded by predators at aggregation points. Thus, the fish cannot reproduce and contribute to the species' gene pool. The impact on the species' gene pool may potentially cause population gene shifts.

The harbor seal population in Puget Sound and throughout Washington has varied inversely with the catch-per-unit-effort of four marine fish species. As the seal population has increased, the numbers of walleye pollock, Pacific cod, Pacific hake, and lingcod have decreased. Other fish populations have remained constant (rockfish species) or increased (dogfish) in the face of the growing seal population. Some factors which may protect rockfish or dogfish from pinniped predation may include the species' physical protection (spiny fins) or behavioral reactions to predation.

In addition to fatal interactions, many individual salmon and steelhead experience scarring and wounding. At the entry locks into Lake Washington, approximately 30-50% of winter steelhead are scarred or wounded. The wounds may lead to increased susceptibility to disease or to predation, thus further contributing to the risks involved with enhanced or culture-based fisheries.

3.5.2.3 RISKS TO NET-PEN FISH FARMS

Some of the risks to net-pen farming include:
- Lost production from predation, escapement by sea lions, seals killing fish in net-pens, or pinnipeds tearing holes in nets; And
- Lower product quality through reduced value or reduced fish weight. Predators attack and harass fish through the pen walls, thus stressing, scarring, and wounding the fish.

Pinniped populations have impacted aquaculture species to an extent approaching that of human fisheries' impact on wild fish populations. The California sea lion population has been increasing, and in California the annual pup count approaches 40,000. Sea lion males are very efficient predators of fish in net-pens. Recent data estimate that the total biomass consumed by pinnipeds in the Pacific Northwest is about half the commercial marine fisheries' catch of California, Oregon, and Washington, combined. The 1995 population of sea lions was estimated to consume a minimum of about 147,000 metric tons of fish prey, and harbor seals about 70,000 metric tons. In comparison, the combined commercial harvest of fish in the three states during 1995 was 460,000 metric tons.

3.5.2.4 RISKS TO PEOPLE IN AQUACULTURE AND COASTAL INDUSTRIES

Some of the risks to the human resources working in aquaculture, fishing, or other coastal, water-borne industries include:

- Increasing aggression from sea lions; And
- Damage to property.

In aquaculture, increasing incidents of aggression by sea lions are being reported by divers maintaining cage-complexes on farms. The same is true for workers in fishing, recreational boating and diving, and other water-related work.

3.5.3 MANAGING AND CONTROLLING THE RISKS

The speakers discussed the management and control of risks from aquaculture interactions with marine mammals. Several factors are involved and specifically address market-related risks (loss of quality and value) and production risks (operations and technological problems).

3.5.3.1 MANAGEMENT ACTIONS TO REDUCE MARKET-RELATED RISKS

To address market related risks, options include:

- Increasing the monitoring of shellfish beds for natural contaminants such as bacteria;
- Wet storage, relaying, or depuration[8] of all shellfish products after harvest; And
- Engineering improvements in net-pens to limit harassment and wounding. For instance, improvement could include the use of high tensioned net-pens, more effective predator nets, and effective acoustic deterrent devices.

3.5.3.2 MANAGEMENT ACTIONS TO REDUCE OPERATIONAL RISKS

To address operational risks, options include:

- Relocating net-pen complexes to offshore sites away from rookeries and haul-outs;
- Engineering net-pen improvements to protect net-pen complexes and aggregation sites;
- Eliminating rogue animals;
- Relocating or reducing populations of predators within the vicinity of aquaculture operations; And
- Reintroducing pinniped harvest programs.

[8]Depuration: The cleansing or freeing of impurities.

3.5.3.3 MANAGEMENT ACTIONS TO REDUCE TECHNOLOGICAL RISKS

And, finally to address technological risks:

- Develop a marine mammal behavior information base vis-à-vis human interventions in the marine environment; And
- Develop adequate technology to deter marine mammals from over-populating specific sites.

3.5.4 SUMMARY

In conclusion:
Marine mammal populations in the Pacific Northwest are growing rapidly.

- Their impact on aquaculture (and fisheries) production is significant and negative.
- The resultant financial losses to the economy are high, up to 10% of production value.
- There is evidence of ecological losses of ESA-listed species.
- The privately owned aquaculture industry is finding its own solutions.
- The publicly owned enhancement sector is not being helped. And,
- A rational strategy is required to manage and control the risks, formulated by the relevant agencies working with the private sector.

3.5.5 QUESTION AND ANSWER SESSION

Participant Comment: What about the risk *to marine mammals* as opposed to the risk *to the aquaculture industry* from marine mammal and aquaculture interactions? Is elimination of marine mammals "greener?" The charge to the group is not to reduce risks to the industry but rather to reduce risks to the animals.

Iwamoto Response: The purpose of the presentation was to provide some balance to the issue of marine mammal and aquaculture interactions. In the Pacific Northwest, the aquaculture industry does not impose much of a risk to marine mammal populations. It is not a question of being "greener", but a statement of reality.

Participant Question: What are the losses to the aquaculture industry?

Iwamoto Response: The presentation was based on actual data from fish farms and on fish losses recorded for insurance purposes. Insurance policies require a continuous estimation of stock on

hand for each enclosure. The NMFS Northwest Region also estimates numbers.

Participant Comment: The group is drifting toward a polarity. The group needs to look at the issue as an ecological problem rather than the fact that marine mammals and aquaculture must co-exist. We need to look at the relationship and determine how they can both move forward. A major portion of fish predated upon are not salmon and are not commercial fish species. We should be cautious about looking at commercial takes versus marine mammal takes of fish species. This information is only a comparison at one point in time and not a description of how numbers got to that level in the long-term. For example, commercial takes have been aggressive for years.

Participant Comment (Regarding the issue of "greening"): We ought not to decide how to get "green." We should be neutral and look at good science.

Participant Comment: I agree that a balance is needed. We want to promote aquaculture, but we must do it in an environmentally sound way.

3.6 PRESENTATION: OCEAN SPAR NET DESIGN

Conrad Mahnken, a NMFS Fisheries Biologist, led the discussion. He discussed the Ocean Spar system which is currently being used in the Puget sound area. Due to the advanced net technology, the net system appears to endure marine mammal attacks and minimize marine mammal entanglement.

3.6.1 NET DURABILITY

The Ocean Spar system utilizes taut net systems designed for the open ocean. The system also utilizes an anchor tensioned system instead of traditional gravity net systems, and the net cage sits above the sea floor. The net durability has been tested, and the net appears durable for offshore aquaculture systems. The system was tested during various weather conditions, withstanding tidal currents up to two knots. The system also demonstrated its durability through its successful suspension in sea water for two years. In addition to the durability of the nets, they are easily maintained through cleaning with hydraulic brushes.

3.6.2 MARINE MAMMAL INTERACTIONS

Mahnken displayed a video of the Ocean Spar system in use. The video showed harbor seals near the anchor-tensioned net. The net appeared as a fixed rhomboid shape, and its tautness was comparable to a trampoline's. The net's small mesh size and dark color is considered to act as a visual barrier to marine species. It is also a readily visible system to pinnipeds and probably to other echolocating predators. Therefore, the marine predators treat the net as a solid structure.

The net is also effective in minimizing marine mammal predation on enclosed fish populations as seen in field tests with California sea lions. The video displayed harbor seals near the net. Compared to California sea lions, seals are relatively tame animals. The net is difficult for pinnipeds to chew through because of the tightness of the lines. Thus, the fish and predators were kept apart. In normal gravity nets, pockets form in the netting when the netting closes together on itself. However, unlike traditional aquaculture pens, the Ocean Spar design remains taut. Overall, the taut-net system design deters pinnipeds from trapping fish, eviscerating the fish, and pulling the fish through the netting.

New cage systems which can reduce predation and entanglement of marine mammals and turtles are available to the aquaculture industry. In addition to the benefits previously described, the cage systems can also negate the need for acoustic harassment devices (AHDs)[9]. However, one drawback of the Ocean Spar design involves cost, because the cost of the Ocean Spar system is four-times the cost of traditional gravity nets.

3.7 DISCUSSION: ESA SECTION 7 REVIEWS

Laurie Allen, marine mammal program coordinator with the NMFS NER discussed Section 7 consultations regarding aquaculture projects as mandated by the ESA[10] of 1973 as amended. The permits are typically required from NMFS, the state, and/or the Army Corps of Engineers (ACE). The ESA is triggered for aquaculture permits when endangered

[9]Acoustic harassment device (AHD): A sound-generating device which, because of some combination of intensity, frequency, or other characteristic(s), is aversive to marine mammals and keeps or drives them away from an area or structure (Acoustic Deterrence of Harmful Marine Mammal-Fishery Interactions Workshop. NOAA Tech. Memo. NMFS-OPR-10, December 1996.)

[10]Section 7 consultations under the Endangered Species Act: Each Federal agency must consult with the Fish and Wildlife Service or the National Marine Fisheries Service, or both to ensure that federal actions authorized, funded, or carried out are not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat (ESA Section 7 Consultation Handbook, March 1998).

or threatened species are present in the project action area. Specifically, large whales and sea turtles are ESA-listed species in the Northeast which may be affected by aquaculture gear.

Section 7 of the ESA mandates a consultation process with Federal agencies regarding activities that may potentially impact listed species. The consultation is an impact review which stipulates conservation measures to ensure that potential impacts are minimized and that the project is not likely to jeopardize the continued existence of any listed species. In addition to consultations on applications for nearshore operations, offshore aquaculture operations also require Section 7 consultations.

Some of the nearshore aquaculture operations may affect pinniped and non-endangered finfish as well, but these are not considered under the Section 7 consultation. Marine mammals are addressed under Section 118 of the MMPA which requires NMFS to publish in the Federal Register a list of the U.S. commercial fisheries including aquaculture operations, based on the frequency and magnitude of marine mammal interactions. The fisheries are divided among three categories defined by the amount of marine mammal bycatch as compared to the marine mammal stocks' potential biological removal level (PBR)[11]. The Northeast Atlantic marine aquaculture fisheries are listed as Category III fisheries under the MMPA, indicating that there is a "remote likelihood of or no known incidental mortality or serious injury of marine mammals."

3.7.1 SEA SCALLOP PROJECT I

The NER Office was approached by the ACE with a permit application regarding a Sea Scallop Project for Cape Cod Bay. Cape Cod Bay is also considered critical feeding and nursery habitat for North Atlantic right whales, an endangered species. The original proposal had high right whale entanglement potential because the gear would occupy a significant amount of the water column. Based on the configuration of the gear, the amount of gear, and its location in

[11]Potential biological removal level (PBR): Defined in the MMPA Amendments of 1994 as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population."

critical habitat, the first biological opinion (B.O.)[12] concluded that the project would result in jeopardy[13] to the north Atlantic right whale and result in adverse modification of right whale critical habitat. Not only would the scallop gear result in a high risk of marine mammal entanglement, but it would also prevent the North Atlantic right whale from accessing a large portion of its critical habitat. Other indirect effects on habitat included the potential for physical disruption and depletion of plankton aggregations, an important right whale food source.

In response to the first B.O., the proposal was dramatically modified. The modified proposal was reduced in scope and the new design removed as many vertical line components from the design as possible, reducing them to a few corner and lane marker buoys[14]. A new B.O. was written based on the revised design. The second B.O. still highlighted the potential impacts to right whale critical habitat due to the siting of the aquaculture facility and these concerns will continue to be addressed by continued site monitoring. Entanglement potential was almost completely eliminated by the new project design.

The NER Office worked with the ACE to develop baseline criteria that would have to be met to avoid the need for formal consultations on scallop aquaculture projects under the ESA. The criteria generated were fairly limiting, including the requirements to site in depths less than 20 feet of water, to prohibit vertical line components, to site within one nautical mile of shore, and to require marine mammal observation.

3.7.2 SEA SCALLOP PROJECT II

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[12]Biological Opinion (BO): As a component of the consultation process mandated by Section 7 of the Endangered Species Act, federal actions that are likely to adversely affect listed species or designated critical habitat undergo evaluations including a "biological opinion." A biological opinion is defined as "the document that states the opinion of the Services as to whether or not the Federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification or critical habitat" (50 Code of Federal Regulations 402.02).

[13]Jeopardy Finding: If an activity is likely to "jeopardize" the continued existence of an ESA-listed species or its critical habitat, then a "jeopardy" finding is made. The determination is based on a "careful analysis of the best available scientific and commercial data" (ESA Section 7 Consultation Handbook, March 1998).

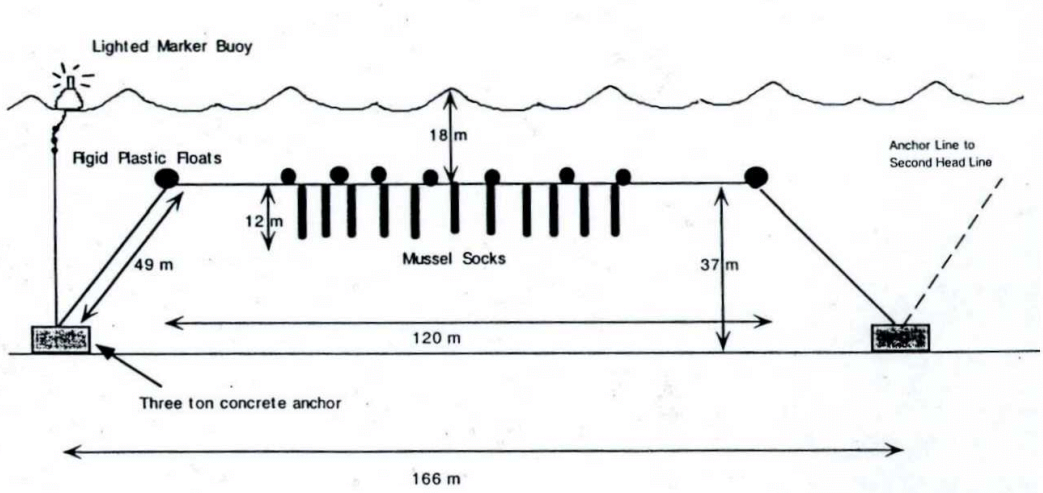
[14]Fishing gear lines that are perpendicular to the water's surface have been associated with whale entanglements. Whales can get the rope wrapped around their appendages or baleen. Such entanglement can be a minor injury, or it could develop into a life-threatening condition (NMFS stranding and entanglement data, unpublished).

The second sea scallop project that came under the NER's review incorporated the earlier recommendations regarding the Sea Scallop Project I. Sea Scallop Project II was designed to lessen the potential for marine mammal and turtle impacts. Specifically, this project cultured scallops through utilization of bottom lanes to minimize vertical components. Due to earlier collaboration with the ACE on sea scallop aquaculture permitting, the Sea Scallop Project II required limited review by NMFS.

3.7.3 UNIVERSITY OF NEW HAMPSHIRE'S MUSSELS PROJECT

Another case study involving an ESA Section 7 consultation involved the University of New Hampshire's Mussels Project (Figure 1). The project is an experimental offshore aquaculture system located five miles due east of Rye, NH. The system utilizes large diameter cables with dynamic tension. Mussel socks[15] are not considered to pose much of an entanglement risk with regard to marine mammals or marine turtles. In addition, this system is a small scale project which could lessen potential entanglement concerns.

Figure 1: Submerged Longline with Mussel Socks



University of New Hampshire

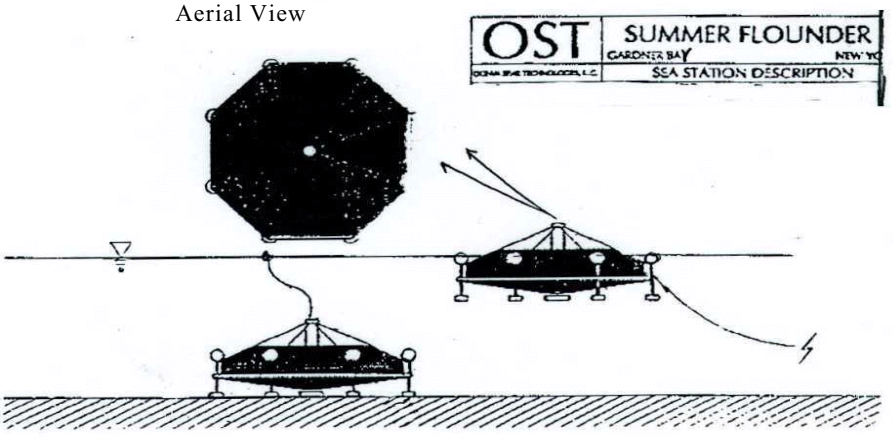
[15]Mussel socks: Mesh tubes suspended vertically in the water column from a line attached to a float. Mussel socks contain mussels in suspended tubes.

Allen suggested that a logical progression in aquaculture advancement will involve expanding these existing small-scale pilot-like projects into large-scale commercial projects. She noted that questions would likely emerge concerning engineering requirements and how many systems can be sited in a particular geographical area without having indirect habitat impact or direct impacts on protected species.

3.7.4 FLOUNDER CULTURE PROJECT

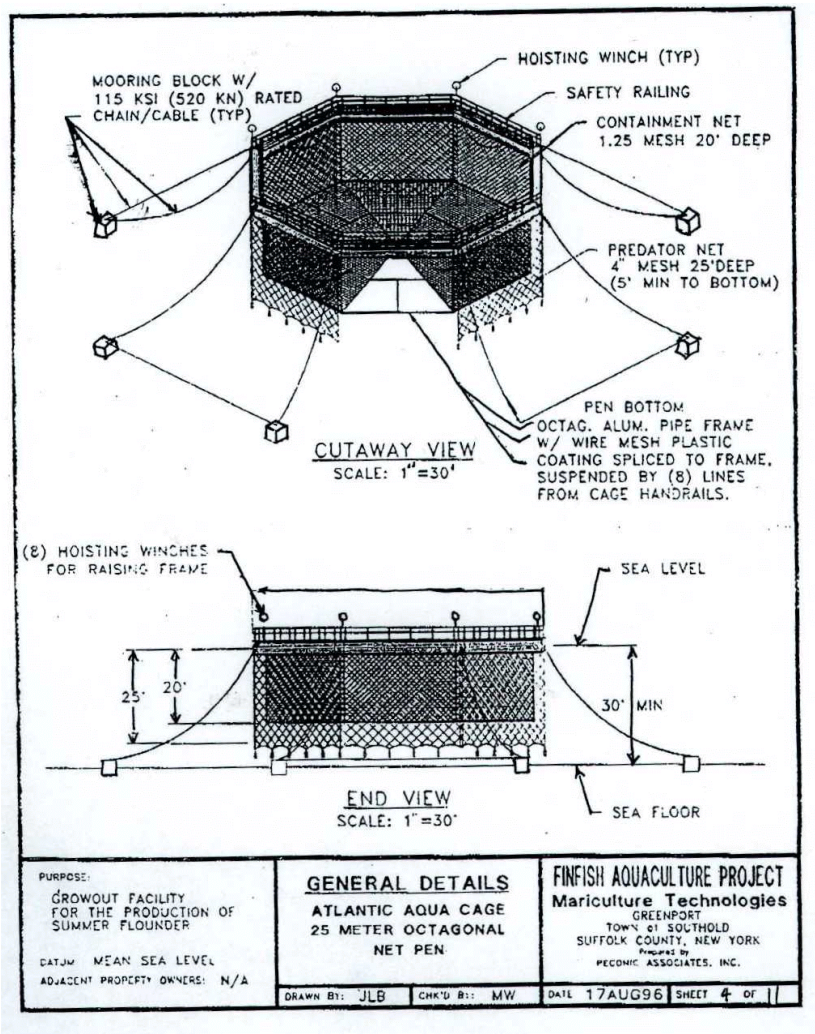
The NER has conducted an ESA Section 7 consultation on a proposed Flounder Culture Project in Long Island Sound (Figures 2,3). The geographic location of the proposed project included important developmental habitat for Kemp's ridley sea turtles. Therefore, the NER was concerned that the Flounder Culture Project would impact the important juvenile turtle habitat. Other protected species issues involved entanglement concerns and the Project's proposed proximity to seal haul-outs. In contrast to the sea scallop projects, the flounder culture project siting area is not heavily used by large whales.

Figure 2: Submersible Net Cage for the Growout of Summer Flounder



Ocean Spar Technologies

Figure 3: Growout Facility for the Production of Summer Flounder

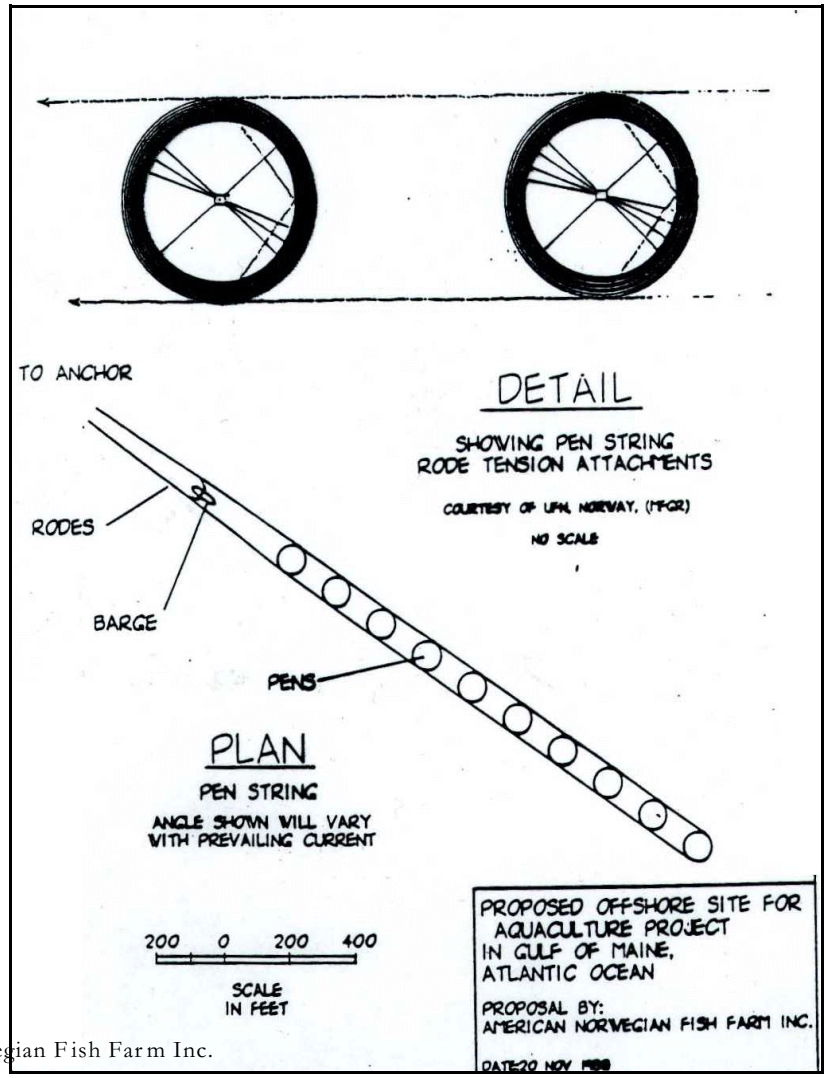


Ocean Spar Technologies

3.7.5 AMERICAN-NORWEGIAN FISH FARMS

Another project in the NER involves proposed American-Norwegian Fish Farms. The Project was initially proposed in the 1980s with both inshore and offshore components inside Sandy Bay, MA and offshore Gloucester, MA. The project changed design specifications many times during the multiple-year review. The latest design allows the structure to swing with the currents (Figure 4).

Figure 4: Pen String Diagram



American Norwegian Fish Farm Inc.

Several agencies in addition to NMFS had significant concerns about this project throughout its years of review. The ACE had concerns about the stability of the mooring construction and the Environmental Protection Agency (EPA) and NMFS' Office of Habitat Conservation voiced water quality concerns associated with the inshore portion of the proposal. Subsequently, the inshore part of the proposal was dropped.

In 1998 the Project still lacked permit approval from the ACE. However, this was not based on protected species concerns which had been resolved, but rather on the continued concern for the structure's engineering. Allen noted that to facilitate future coordination between the applicant and the agencies, it is essential to provide guidance as early as possible to the aquaculture applicants.

3.7.6 NER RECOMMENDATIONS FOR SECTION 7 REVIEWS

The NER has developed several suggestions for addressing permitting difficulties:

- Develop extensive protected resources guidance for use by permitting agencies. The EPA's guidance concerning water quality issues pertaining to aquaculture could be used as a potential template;
- Develop categories of actions associated with aquaculture projects that individually or cumulatively have a significant effect on the human environment and for which an environmental assessment or environmental impact statement under the National Environmental Policy Act[16] would be required.;
- Group area-by-area specifications (e.g., critical habitats, Long Island Sound, Gulf of Maine-offshore, etc.);
- Group by aquaculture type (e.g., longline mussel projects inshore, longline mussel projects offshore, finfish cages inshore, finfish cages offshore, etc.); And,
- Document information needs and set forth a methodical approach to answer them under a set time line.

3.7.7 QUESTION AND ANSWER SESSION

Allen Comment: NMFS NER is most concerned with entanglement in gear lines as opposed to aquaculture nets. NMFS NER is not as worried about animals getting entangled in net pens themselves, but rather is concerned about the amount of lines which are small in diameter, slack, or floating.

We should look at other nations' experiences, especially New Zealand and Australia's experiences, involving aquaculture gear and marine mammal/turtle interactions. Once information is generated, Allen agrees that there is a need to discuss these findings within the United States.

Environmental impacts associated with aquaculture gear is primarily assessed through reviews of traditional commercial gear types due to the gears' similarities. Impacts resulting from traditional gear types are then hypothesized to exemplify the types of impacts that can result from use of aquaculture gear. Much of the more recent aquaculture designs use lines and cables

[16]National Environmental Policy Act: The Act requires Agencies to analyze the potential effects of proposed Federal national which may significantly affect historical, cultural, or natural aspects of the environment. Agencies must provide detailed statements on the environmental impacts of proposed actions.

that are substantial and tensioned, thus reducing entanglement concerns. Additional review of the specific effects of aquaculture gear on marine mammals and marine turtles should occur.

3.8 DISCUSSION: ACOUSTIC DETERRENCE

Roger Gentry of the NMFS OPR lead the discussion. Acoustic deterrent devices (ADDs)[17] and AHDs are currently used to deter marine mammals from fishing gear. Acoustic devices, especially AHDs, are not particularly effective at providing deterrence. There is the potential to make the devices more effective, but in order to do so, it is vital to tailor them to the auditory anatomy and "psychology of hearing" of specific marine mammal species. Animals perceive some sounds to be more important than others, and as a result the animals react to certain sounds more strongly. For example, a sound imitating a predator or competitor may be more effective as a deterrent rather than just an amplified sound which does not imitate other species. Further research is necessary to fully explore this idea.

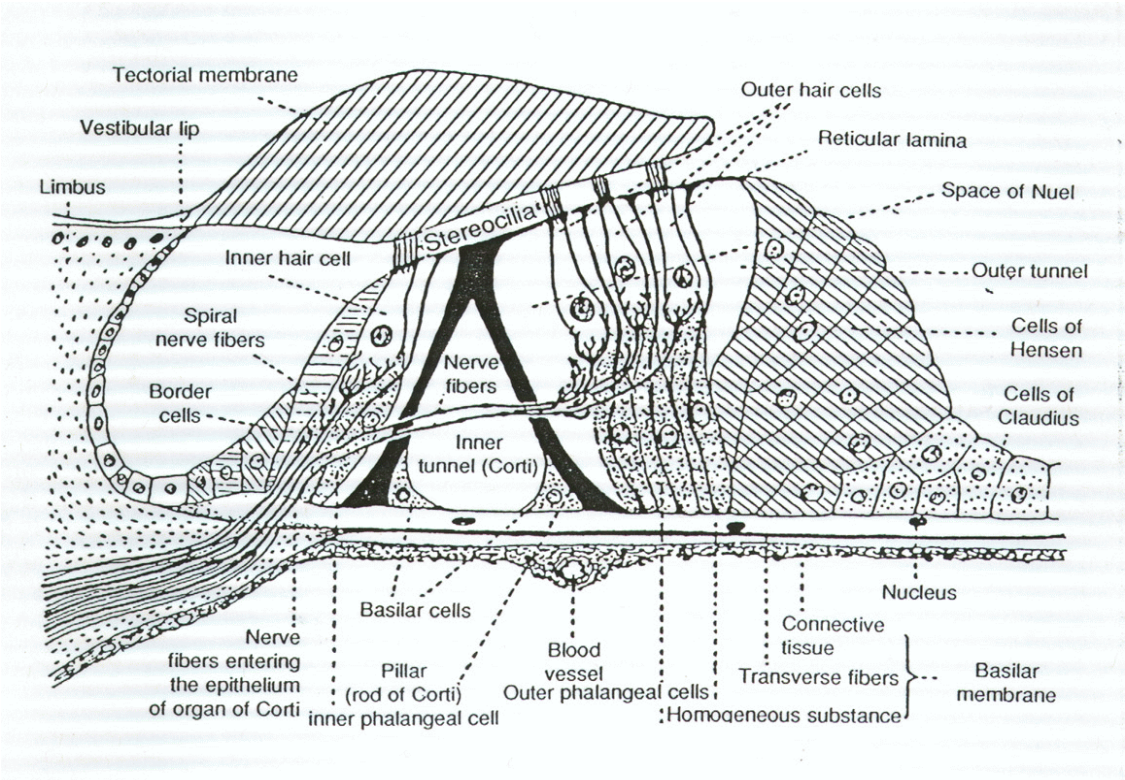
3.8.1 Auditory Anatomy of Marine Mammals

Mr. Gentry presented a brief discussion on the anatomy of marine mammal auditory ability. Pinnipeds have ears that are similar to humans. Air flows down an air-filled auditory channel creating a vibration. The vibration crosses a chain of bones and enters the round window, thus making the fluid in the cochlea vibrate. The cochlea is a transduction mechanism containing the critical element, hair cells, and nerves. Movement of the hair cells sends nerve impulses to the brain.

The auditory anatomy of marine mammals is susceptible to damage. Specifically, the hair cells within the cochlea can be easily damaged. Once the cochlea is damaged, hair cells will not regrow. In addition to permanent hair cell loss, hair cells can become fatigued as well. If the hair cells are fatigued often enough, permanent hearing loss may ensue. Therefore, when using AHDs, it is critical to avoid injuring or destroying hair cells (Figure 5).

[17]Acoustic deterrent device (ADD): A sound-producing or sound-reflecting device used to make marine mammals aware of, or to repel them from an area or structure (e.g., a net, pen, or trap.) Both passive reflectors and sound generators are included within the definition (Acoustic Deterrence of Harmful Marine Mammal-Fishery Interactions Workshop. NOAA Tech. Memo. NMFS-OPR-10, December 1996.).

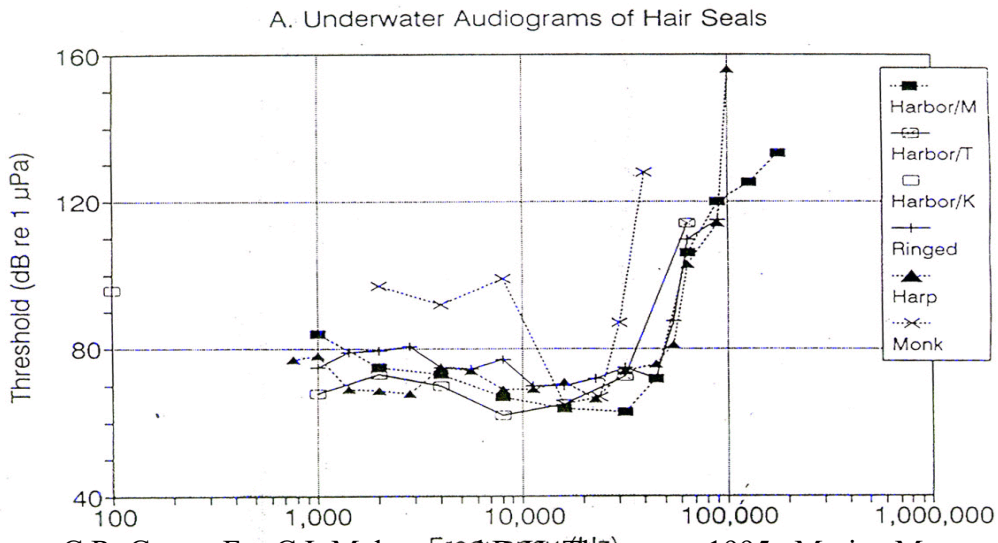
Figure 5: Illustration of the Cochlea



Kryter, K.D. The Handbook of the Hearing and the Effects of Noise. Academic Press, San Diego. p. 19

Pinnipeds have protective mechanisms in their ears. A muscle associated with the stapes bone contracts when the animal is exposed to loud sounds. This assists in preventing the sound from reaching the hair cells. AHDs should function to trigger the stapes response rather than to cause pain or risk drum rupture. The rupture can result in permanent hearing loss. *How* the ear functions is different from *what* animals hear. *What* an animal hears varies among species. For example, echolocating marine mammals are adapted to high frequencies, and long distance communicators are adapted to low frequencies. It takes different acoustic energy for animals to hear at these different frequencies. The middle range is the best (requires the least amount of sound energy to hear). Given this information, AHDs should target the best hearing frequencies which can be determined by looking at the auditory curve for a particular species. Figure 6 shows a typical behavioral audiogram for pinnipeds.

Figure 6: Audiogram



W.J. Richarson, C.R. Grene, Fr., C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, Sand Diego. P. 215.

There are some options for tailoring AHD signals for a particular species and a desired auditory response without focusing on sheer sound level:

- Change the rise time. For example, change how long it takes the sound to go from 0 amplitude to its maximum amplitude;
- Change the duration of the signal;
- Change the duty cycle, repetition rate (per minute/second/hour); or
- Alter the "texture" of the sound by modifying the sound's amplitude and frequency structure.

3.8.2 Acoustic Pain

A loud noise is usually considered to be associated with pain. It is generally believed that pain induction will deter animals from approaching aquaculture sites, and that if a little pain does a little good, a lot of pain will do better. On that basis, users are tempted to increase the sound source level as the main means of deterrence. However, hearing mechanisms and pain mechanisms are separate, and permanent hearing loss can occur without any pain to the animals. Thus, there is a widespread misperception of how an animal reacts to a sound. AHD technologies should explore the kinds and characteristics of sounds that are the most noxious to marine mammals and not focus on the production of pain as the goal of acoustic harassment. Research should include understanding various sound

features that may influence the noxiousness of the sound to animals; such as:

- Sound predictability;
- Lack of control over the sound source;
- How sound interferes with important animal processes;
- What the sound means to an animal (e.g., sound of a competitor or predator) and;
- Sounds which appear to be nearby and closing.

There has been some creativity utilized in AHD manufacturing. For instance, some AHD's mimic predator sounds. At this point, AHD manufacturers have only tried to mimic the sounds of killer whales. Some interests have surrounded the "startle response."[18] Startle response refers to the theory that acoustic signals will startle an animal. However, it is likely that seals do not have a physiological "startle response," so this may be a pointless approach.

3.8.3 Habituation to Sound

Habituation refers to the waning of response to a stimulus. It is a complex process beginning at the cellular level and eventually leading to a higher brain response. Habituation is extremely difficult to overcome, so avoiding it at the outset is preferable. It should also be noted that a continual threat that is never followed by an aversive stimulus will quickly cause the device's deterrence value to decline.

Acoustics have to be used relative to the environment. Noise is a form of pollution, and not much is known about its effects. Aquaculturists should site pens so as to have the smallest ecological impact on the environment. In addition to siting issues, aquaculturists should use noise sparingly.

An acoustic deterrence workshop was held in Seattle, Washington in 1996 to discuss the issue of ADDs, specifically looking at the problems of acoustics. The workshop developed recommendations, specifically:

- Anti-predator defenses should use the minimum amount of sound needed to be effective;

[18]Startle response: A startle response is a complex reaction to a sound. The reaction may include typical behavior consisting of freezing, looking around to gain information, involuntary flinching, or running. The reaction may also include physiological responses such as changes in heart rate, blood pressure, and adrenaline production.

- Don’t try to increase the level of sound to overcome recalcitrant animals. Current devices on the market are at the NMFS-allowed maximum sound level;
- Use sound to protect only contained marine areas, not the open ocean;
- Don’t rely on the production of pain to deter animals; And
- Use directional sound rather than an omnidirectional source.

3.8.4 Questions and Answer Session

Participant Question: Is it true that sound is a weak deterrence mechanism for all animals interacting with aquaculture facilities? Or is it just a weak deterrence mechanism for seals?

Gentry Response: It is true for all animals.

Participant Question: Can you talk more about sound’s effect on the displacement of cetaceans?

Gentry Response: Harbor porpoise is the species of concern. Harbor porpoise have high frequency hearing, are sensitive to sound and are attuned to listening to faint echos. There has been one study showing physical displacement of animals by AHDs, and another showing that animals do not respond to AHDs. This suggests that the harbor porpoise issue should be watched.

Participant Comment: Harbor porpoise in Maine have been seen swimming among aquaculture pens.

Gentry Response: This may be due to the harbor porpoises having hearing damage or because AHDs are pointed downward so porpoises are not affected too much by the sound.

4.0 WORKING GROUP PROCEEDINGS

After the presentations, the facilitator and participants established ground rules and proceeded to discuss the process for generating group recommendations. The meeting was not organized as a consensus-centered process for recommendation-building. Instead, the organizers wanted to promote the sharing and discussion of ideas without requiring consensus.

Participants were divided into pre-arranged working groups to discuss issues. Each subgroup was organized so as to represent a wide array of interests.

Each subgroup had a designated chair to lead the discussion and to assist in facilitation. Donna Wieting abstained from participating in any one group. She participated as an observer and roamed among the working groups. The workshop facilitator also floated between the various work groups to facilitate discussion.

Working Group 1:
Subgroup Chair: Laurie Allen
Note taker: Suzanne Bolton
Subgroup Participants: Kenneth Baldwin, Carolyn Brown (later replaced by Bonnie Ponwith), Linda Chaves, Paul Comar, Roger Gentry, Joe McGonigle, Jim McVey, Ben Mieremet, Donna Wieting, and Dean Wilkinson

Working Group 2:
Subgroup Chair: David Bernhardt:
Note taker: Katie Moore
Subgroup Participants: Jim Gilbert, Bob Hukki, David Kaiser, Ed Rhodes, Gordon Waring, Neng Yu, and Sharon Young

Working Group 3:
Subgroup Chair: Jon Lewis
Note taker: Kate Colborn
Subgroup Participants: Therese Conant, Pat Fitzgerald, Deirdre Kimball, Anne Liu, Rich Langan, Dot Leonard, and Tom McIlwain

Each working group was given a list of discussion topics for break-out sessions (Appendix 3). In addition to the established discussion list, participants informally added the topic of "habitat concerns" to the discussion list. The recommendations generated by the subgroups are group recommendations and may not necessarily reflect each individual's opinion expressed during the discussions.

Discussion questions are italicized followed by the working group's response.

4.1 SITING

Should areas be identified where marine aquaculture should be avoided and/or encouraged?
Group 1: Yes. There should be areas identified for marine aquaculture use. Siting is less important than determining what can be done to accommodate competing interests.

Group 2: Yes.

Group 3: Yes.

How should those areas be identified? General criteria? Mapping? Other?

Group 1: Accompanying these designated areas, general information should be provided regarding the justification for identifying these areas. This information should be provided in a Geographic Information System (GIS) context. Decision-makers need to identify areas of concern, but decision-makers should not definitively exclude areas to aquaculture use.

Group 2: An information system is needed. Narrative information is helpful in the information system. Maps must have narratives so as to better insure that they will not be misused. The group does not advocate the use of an information system to act as an exclusionary tool. The information system should be a tool for policy-makers to identify geographical areas with particular attributes that affect marine mammals and the aquaculture industry. Specific information layers for the GIS have yet to be determined.

Group 3: Identification tools could include zoning, general guidelines, GIS, or case-by case guidelines. In addition to identifying areas that should be avoided and/or encouraged, decision-makers should provide permit applicants with site-specific siting issues. Communication of this information could be via a letter or permit application packet.

Whichever site-identification tool is used, the following types of information should be incorporated:

- Areas designated as having environmental concerns. (Specific criteria to describe these areas of environmental concern were not elaborated upon);
- Interactions with fishing gear;
- Rookeries;
- Haul-outs;
- Critical habitat;
- Migratory pathways;
- Feeding areas; and
- Protected resources sighting information.

The working group had some specific concerns regarding a GIS system in particular. The concerns revolved around the issues of:

- Resolution. There are spatial and temporal difficulties to overcome in order to improve resolution;
- Danger that GIS is taken as "law." The data uncertainties will need to be identified, and the data will need to be ground-truthed to ensure its accuracy;
- Database integration;
- Expenses involved in obtaining and compiling the information (both to NMFS and to aquaculture applicants);
- Difficulties involved in maintaining and updating information;
- Difficulties involved in developing information at the local and regional levels. Information collected at the national level may not have sufficient resolution;
- Inability for GIS to recognize all of the issues which can be a problem to a particular site. Issues come out of the woodwork (through public comment periods, public contact with local agencies, etc.); And
- Danger that resource managers may lose contact with the public. GIS use does not promote communication and personal contact with the public.

FURTHER DISCUSSION

Group 3 continued to discuss siting issues, and they provided additional comments outside of those questions presented by the workshop organizers. The group noted that NMFS should not get involved in siting criteria at this time. However, NMFS should get involved administratively through developing a widely distributed, in-house resource list. The resource list would ideally provide information on NMFS staff involved with aquaculture issues as well as staff contact information. In addition to the in-house resource list, NMFS should develop a guide of legal mandates associated with aquaculture-related issues. Ideally this resource list could be used both internally within NMFS and externally by the general public. In addition to the legal mandate guide, NMFS should create a list of concerns regarding potential aquaculture interactions with marine mammals and marine turtles. The synopsis should include areas of general concern without being species-specific, and the synopsis could then be available to both NMFS and to the public.

Finally, the group strongly recommended the development of an aquaculture coordinator function in each of NMFS' regions. The function would primarily act as an aquaculture advocate or facilitator (aquaculture supporter). The aquaculture coordinator function could also address issues other than aquaculture. However, these particular duties have not yet been determined. Alongside the coordinator role, a "security assessment team" could assist with aquaculture issues through visiting and inspecting sites that are proposed for aquaculture use. The coordinator and the security assessment team could offer guidance and suggestions to aquaculture permit applicants.

4.2 PINNIPED PREDATION

Is pinniped predation a problem in all types of marine aquaculture? In all regions?

Group 1: Pinniped predation is an economic problem for finfish aquaculturists in northern latitudes.

Group 2: No, pinniped predation is not a problem in all types of marine aquaculture. For instance, pinniped predation is not an issue with shellfish aquaculture operations. There is only a pinniped predation problem associated with net-pen patriary finfish[19]. Also, pinniped predation is not necessarily a year-long issue. For instance, in the Northeast pinniped predation is a seasonal problem.

Group 3: No. Pinniped predation is not so much of a problem in the Northeast where farms are growing. Pinniped predation is a problem in the Northwest where it has a large economic impact.

If not, what determines whether or not pinniped predation is a "problem"?

Group 1: Not addressed.

Group 2: Dead, damaged, or lost fish are considered problems.

Group 3: Pinniped predation is a problem if the level of loss is not acceptable to the aquaculture industry.

What deterrents are currently used? Are they successful? To what degree?

[19]Pen Patriary Finfish: Fish that are grown in aquaculture net-pens.

Group 1: Not addressed.

Group 2: Current deterrents include predator nets. They are 100% successful in some situations. Other deterrents include using acoustic deterrents and Norwegian seal chasers.

Group 3: The group discussed several deterrent measures that are considered effective at least for the time being. Current deterrent methods include:

- Tensioned netting;
- On-site dogs;
- Propane cannons[20] (mainly for bird scares);
- Seal bombs[21]; and
- Shooting, to scare.

How can deterrents be improved?

Group 1: A joint partnership of academia, industry, government, and environmental/conservation groups should participate in monitoring to determine the effectiveness of aquaculture gear in deterring marine mammal and marine turtle interactions. The partnership should look into the idea of rotational studies with monitoring aspects. The rotational studies would involve moving the aquaculture gear to different geographical locations to monitor site-specific impacts of the facility. Monitoring should end when known effects are determined.

With regard to the policy issues, decision-makers should research land predator problems. Decision-makers should research what deterrent efforts have occurred on land and determine what methods and policies are transferable to marine environments. The group also noted that non-lethal deterrence methods should continue to be the recommended form of deterrence instead of a lethal deterrence approach.

Group 2: More effective management could itself be a deterrent. In addition, deterring rogue animals may necessitate the lethal take of individual predators who are not deterred by current methods.

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[20]Propane canons: Aerial deterrent measures used to scare birds from aquaculture facilities.

[21]Seal bombs: Deterrent measures similar to firecrackers, designed to explode in the air over a seal's head. The explosion is intended to scare the animal through utilizing a small shock wave.

Group 3: The industry and decision-makers should not forgo behavioral modification methods.

What new methods are needed?

Group 1: Acoustics should be further pursued based on the characteristics of the workshop's acoustic presentation. This is specifically with regard to sound perception issues. In addition, new technologies such as taut net systems should be reviewed alongside an economic review determining its impact to the industry. Further emphasis should be placed on net technology and should include improving the technology costs.

Group 2: Further emphasis should be placed on appropriate mesh size, small mesh predator barriers, heavy twine, and high tension mesh. The group also recommended reading a report regarding cetacean deterrence efforts in New Zealand. New methods needed include acoustic harassment, removal, and lethal take.

Group 3: The aquaculture industry could benefit from technology that furthers the obstruction of pinnipeds while at the same time ensuring the containment of fish. The research and development is fairly good at this point, and current net designs can stop predation as well as help prevent escapement.

Further work can be done with the net development industry. Efforts could include lowering gear costs and improving technology. The net development industry could also explore other net designs (e.g., cage design for non-salmon species).

In addition to advances in net technology, acoustics could be re-designed using sound perception principles as discussed in the acoustics presentation. Further examination of terrestrial predator deterrence experiences and behavior modification techniques would be useful. In addition, it is necessary to ensure that the deterrence technology industry isn't discouraged such that innovative research is stifled. Decision-makers should support ongoing technological research.

In order to make the transition to new technologies smoother, financial assistance to the aquaculture industry is required. Technology transitions would likely cost the industry millions of dollars. However, given budget

constraints, government-subsidized financial assistance would have to be determined on a case-by-case basis. In determining how to allocate federal assistance, it may also be necessary to determine which geographical regions have the most severe financial problems.

Further Remarks:

Group 1: Fishers want to be treated as farmers, yet the two industries differ. The aquaculture industry relies on a public rather than a privately-owned resource. Thus, there is a question as to whether or not fishers should receive financial assistance. An overriding question involves, "should aquaculture be treated distinctly from commercial fisheries?" This question deserves further attention in future discussions.

4.3 ENTANGLEMENT

Is entanglement a concern in nearshore aquaculture operations?

Group 1: Yes, entanglement is a concern in nearshore aquaculture operations. However, there have not been problems specifically documented for cetaceans, but there are limited problems with other predators being caught in predator nets.

Group 2: Yes. At this point, it is a concern. However, it is not a big problem.

Group 3: Pinniped entanglements have occurred in predator nets, but there have been no cases of cetacean entanglement. Group members discussed the need for acknowledging that marine turtles have the possibility of becoming entangled.

If so, what is being done to avoid or minimize it?

Group 1: Not addressed.

Group 2: Entanglement issues are relatively controllable at this point with current technologies that focus on increased line size, tautness, and minimized mesh size.

Group 3: The group discussed several gear types that would pose less of an entanglement risk. However, the group neither indicated if the gear is currently being used nor indicated the name of the gear type that should be used. Group members also offered the observation that most of the aquaculture growth is occurring nearshore, therefore limiting the potential for marine mammal and marine turtle entanglement.

What additional methods should be applied?

Group 1: The aquaculture industry should continue the use of taut, thick lines to reduce entanglement.

Group 2: Gear guidelines to minimize entanglement should be utilized. Some gear guidelines include maintaining higher line tension, increasing twine size, increasing line size, decreasing mesh size, and increasing gear marking. It would also be helpful to identify geographical areas of high risk to marine mammal and marine turtle entanglement.

Group 3: The response to this question is answered jointly in the response concerning offshore aquaculture operation methods (below).

Is entanglement a concern in offshore aquaculture operations?

Group 1: There is not a seal entanglement problem in offshore aquaculture operations. However, there may be aquaculture interactions with cetaceans and sea turtles.

Group 2: Not addressed.

Group 3: Not addressed.

If so, what should be done to avoid or minimize it?

Group 1: Proper siting, effectively engineered gear, and effective deterrent technology would avoid or minimize entanglement issues with offshore aquaculture operations.

Group 2: Not addressed.

Group 3: In order to address entanglement concerns for both nearshore and offshore aquaculture operations, there needs to be additional assessment, collection of data, and monitoring in terms of entanglement. Reporting should be voluntary in nature. In addition, more research needs to be done to look at fishing gear characteristics and to make comparisons with aquaculture gear. The research would assist in determining what aspects of the gear promote marine mammal and marine turtle encounters/entanglement.

4.4 STANDARDS AND GUIDELINES

What are the existing standards and guidelines that affect aquaculture interactions with marine mammals and turtles?

Group 1: Not addressed.

Group 2: Near and offshore standards and guidelines include:

- MMPA: "take" prohibitions, small take authorizations, or incidental harassment authorizations;
- ESA: Section 7 consultation;
- US ACE permit;
- NMFS offshore permit;
- Oceans and Coastal Resource Management sanctuary permit; And
- Coastal Zone Management Act: States review actions to ensure consistency with state coastal zone management plans.

Group 3: No standards or guidelines exist which address aquaculture and marine mammal/marine turtle interactions. However, there is coordination occurring at the agency level.

- DOC/NOAA: Steering Committee on Aquaculture. Each DOC Bureau is represented on the DOC Aquaculture Task Force;
- ESA;
- MMPA;
- US ACE; And
- Executive Committee on the Joint Sub-Committee on Aquaculture (Representatives include DOC, Department of the Interior, and the USDA. NMFS and the Office of Oceanic and Atmospheric Research have votes on that committee).

These opportunities occur at a fairly high bureaucratic level, and they are still filtering down to the regional/operational level.

Are these standards and guidelines sufficient?

Group 1: No. NMFS' efforts are not sufficient at this point.

Group 2: No.

Group 3: No. Current regulations are too stringent and/or inflexible to deal with aquaculture issues.

What gaps exist in the current standards and guidelines to deal with marine mammal and turtle concerns?

Group 1: The group recommended several aspects of the current standards and guidelines dealing with marine mammal and turtle concerns that could benefit from further review. These aspects include:

- Approaching resource management proactively;
- Focusing on the broad national picture;

- Development of consistency and stability;
- Creation of regulations that reduce unknowns for decision-makers and the industry;
- Establishment of a framework management plan; and the
- Establishment of aquaculture development zones.

Group 2: The group discussed the issue of disbursing government funding to the aquaculture industry in an equitable manner.

Group 3: The guidelines do not address marine mammal and turtle concerns with respect to aquaculture interactions.

Where should we focus our efforts to address these gaps?

Group 1: Further collaboration with other DOC efforts should be pursued. The group also recommended increased public outreach.

Group 2: Regulators should consider the following when reviewing applications:

- Does the aquaculture facility use the minimal level of effective harassment? (This would be difficult to address at this time, because current research does not fully explain animal pain thresholds.) Should the device avoid causing pain? Should the device avoid permanent damage to the animal?
- Does the aquaculture facility minimize takes from acoustic harassment?
- Does the aquaculture facility use non-acoustic solutions when available?

Regulators should also consider the following points when considering permit applications. The action items on the list aim to minimize marine mammal/turtle and aquaculture interactions:

- Create siting information through the use of a GIS;
- Provide siting information to aquaculture permit applicants;
- Do not create a unilateral prohibition for siting aquaculture. Any closed zones must be based on data;
- Minimize takes from acoustic harassment devices;
- Use non-acoustic deterrence as the primary response to pinniped predation;
- Avoid using acoustic devices in open waters;
- Use best available technology to minimize predation and entanglement;
- Give specifics on what techniques, gear, and siting protocols do and do not work;

- Provide narratives about specific potential aquaculture siting areas;
- Provide a list of environmental protection requirements associated with specific areas;
- Promote further discussion regarding legal lethal removals after having exhausted non-lethal options. The aquaculture industry is interested in furthering this discussion. Further discussion must ensue due to current legal limitations and potential public disapproval;
- Avoid considering the proximity of seal haul-out sites as a useful factor in the GIS information database;
- Research information distribution gaps;
- Research the carrying capacity for an area;
- Consider cumulative and existing impacts;
- Incorporate principles to minimize entanglement through gear engineering; And
- Ensure timely incorporation and distribution of new information by NMFS and the industry.

There are current gaps that may be hindering the above-mentioned list of actions for regulators. Some of the current gaps in the administrative structure include the lack of:

- Structure to develop and distribute information;
- Funding to help the industry;
- Guidelines and standards for acoustic devices;
- Guidelines and standards for technological gear;
- Determination of siting information necessary to create an information database;
- Analysis of siting information;
- Trust between the aquaculture industry and policy makers;
- Public involvement in the process and guideline creation; And
- Information exchange between the aquaculture industry and the policy makers about marine mammal/turtle interactions. Some of the missing information includes the amount of interaction, method of deterrence, and influence of marine mammals/turtles on the aquaculture facilities.

Group 3: The aquaculture industry needs to lobby for financial changes. At the same time, NOAA needs to alter its budget to reflect its commitment to aquaculture. NMFS should work to coordinate aquaculture efforts more efficiently and effectively both within and outside of the Agency.

Should standards be mandatory at this time? Or voluntary?

Group 1: The group would prefer the use of standards rather than guidelines given the lack of resources available to enforce guidelines.

Group 2: The group discussed the idea of mandatory regulations, however they acknowledged that mandatory standards would create a burden on both decision-makers and the industry.

Group 3: Not addressed.

4.5 RESEARCH

What are the key research needs to address policy issues and questions related to marine mammals and turtle interactions with marine aquaculture operations over the next 20 years?
Which are priorities?

Group 1: The group listed several research needs including:

- Rotational studies involving aquaculture sites that rotate across several geographical areas to determine site-specific impacts of the facilities;
- Behavioral studies regarding feeding cycles;
- Acoustic studies;
- Economic reviews of terrestrial resource management efforts (e.g., Department of Agriculture policies);
- Gear development;
- Precautionary resource management policy approach development; And
- Marine mammal and marine mammal takings[22] feasibility.

Group 2: The group developed a lengthy list of research topics. The topics were then subdivided into topics of high priority and those of lower priority. Priority was defined based on the ability to accomplish those topics in the very near future.

High Priority:

- Determine rogue animal characteristics;
- Quantify and characterize the loss of money to the aquaculture industry due to marine mammal and marine turtle interactions;
- Study the animal behavior and ecology around aquaculture sites; And

[22]Taking: Under the MMPA, "taking" is specifically defined as harassing, hunting, capturing, killing, or the attempt to harass, hunt, capture, or kill.

- Monitor changes to the habitat baseline including both pre- and post- aquaculture facility.

Low Priority

- Develop new deterrent technology;
- Evaluate the effectiveness of acoustic devices and their impacts on marine mammals, specifically,
  - Optimize the effectiveness of acoustic devices,
  - Target specific species through acoustic devices;
- Research migratory birds' interaction with aquaculture;
- Determine how to include public involvement in the policy process;
- Identify areas that should be completely closed to aquaculture;
- Research international trade treaties and issues;
- Research the potential for aquaculture insurance information to be used as an information source providing the government with information pertaining to the use of deterrent devices by aquaculture facilities. This could potentially assist in monitoring and determining what types of deterrent devices are being used; And
- Research the distribution of protected species.

4.6 HABITAT ISSUES

Group 1: There needs to be more research to discover what is going on with nutrient modeling. Research should be pursued through a trial partnership with non-governmental entities to monitor impacts. There needs to be specific research on determining at what point the removal of habitat caused by the physical occupation of a space by aquaculture facilities may eliminate native animals' use of the area. The research would likely involve the challenging task of determining the carrying capacity of specific areas.

Another habitat issue that needs more research involves water quality. There needs to be a study to determine the effects of filter feeders on water quality and water clarity. Scientists need to determine if filter feeders can clean up a localized area of water significantly.

Group 2: These factors must be taken into consideration when evaluating the potential habitat impacts associated with aquaculture facilities:

- Physical exclusion through habitat change;

- Cumulative impacts;
- Degradation;
- Quantification of benthic habitat community change (positive or negative) beneath aquaculture pens;
- Marine mammal and marine turtle attraction; And
- Acoustic exclusion.

In order to address the above-mentioned habitat considerations, decision- makers need to develop policies concerning:

- Habitat degradation,
- Physical exclusion,
- Acoustic exclusion, and
- Marine mammal and marine turtle attraction.

Group 3: Not addressed.

5.0 WHOLE GROUP DISCUSSION

5.1 OFFSHORE SITING

Definition of Offshore vs. Nearshore Aquaculture sites: The Group felt the need to clearly define and differentiate offshore versus nearshore habitats in reference to guidelines and standards. Discussion revolved around some of the characteristics that could be used to define offshore versus nearshore including:

- Physical characteristics (e.g., wave height, wave action, etc.);
- Amount of exposure (e.g., exposed site versus a sheltered site. The definition should reflect physical criteria);
- Jurisdictional authority issues (e.g., states have jurisdiction to the 3 mile limit. It might be advantageous to use this state/federal jurisdictional limit as the nearshore/offshore limit.); and
- Marine species' location. It would be difficult to decide what species occur offshore versus nearshore. However, there may not be clear boundaries for the species.

5.1.1 GEOGRAPHIC INFORMATION SYSTEMS

Many states have fine-resolution GIS systems. Decision-makers should apply those systems to use for the management of aquaculture issues. There were some concerns by group members concerning spatial and temporal resolution of GIS information, and some members questioned whether or not the GIS databases would provide data that was applicable to aquaculture decisions. In order to address that concern, group members emphasized that the GIS would need to be site-specific, rather than a global siting document. Other considerations

involved maintenance issues such as upkeep and data processing. Some group members emphasized that a GIS system has the potential to minimize personal contact between the permitting agency with the permit applicants and sites.

Workshop participants suggested using the best available information in a narrative approach that identifies factors such as marine mammal and marine turtle migration patterns, habitats, density, etc. The information should also acknowledge the level of risk associated with a particular area and methods for minimizing the risk.

5.1.2 GENERAL SITING ISSUES FOR OFFSHORE AQUACULTURE

Recommendations include investigating the concern of siting offshore aquaculture in other "use" areas such as non-fishing areas. This research would assist in reducing user conflicts by recommending siting in low-conflict areas. Group members displayed a general reluctance to exclude geographic areas from aquaculture production, and they recommend that any exclusionary areas would need to be based on data.

A lengthy discussion involved offshore aquaculture siting issues and pinniped haul-out sites. Some members recommended not to make permitting or siting decisions on the basis of proximity to haul-out sites. Other workshop participants argued that the discussion should be more species-based. Proximity to haul-out sites should not be a factor for phocids[23]. However, it might be a consideration for ottariids[24]. Further discussion ensued regarding the differences between seals and sea lion behavior.

In order to minimize interactions with commercial fisheries, decision-makers should delineate areas as soon as feasible to minimize overlap and conflict between offshore aquaculture operations and traditional fisheries. Commercial fisheries should be involved in discussing gear conflicts and solutions alongside other affected sectors.

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[23]Phocids: Marine mammals of the Order Carnivora, Sub-Order Pinnipedia, Family Phocidae are typically referred to as true seals or earless seals. Examples include harbor seals. They differ from ottariids by having internal testes and lacking mobile hind flippers.

[24]Ottariids: Marine mammals of the Order Carnivora, Sub-Order Pinnipedia, Family Otariidae are typically referred to as eared seals. Examples include fur seals and sea lions. They also differ from phocids by having mobile hind flippers.

5.1.3 OFFSHORE SITE CONSIDERATIONS

Workshop participants noted that there are some necessary considerations associated with offshore sites. Participants noted that site monitoring and visitation is a consideration. Monitoring and visitation to the aquaculture structure may not occur as often as the monitoring of nearshore sites. Therefore, monitoring and visitation frequency should be taken into account during further policy and permitting discussions.

5.2 POLICY MAKING

Policy makers should keep the information flow cross-directional between nations involved in aquaculture. Several group members suggested looking at other nations' experiences to augment the United States' understanding of aquaculture and protected species interactions with the industry.

An emphasis should be placed on encouraging innovation. Policy makers can indirectly encourage innovation through working closely with the emerging technology and policies that may be associated with the industry.

5.3 ADMINISTRATIVE STRUCTURE CHANGES

The Federal government should create a Regional Aquaculture Coordinator (RAC) position in each NMFS region. The positions would focus on GIS, facility siting, and inter-agency coordination. In order to adequately equip this position with adequate skills and funding, the position should be a full time senior policy specialist with its own budget. Due to governmental budget limitations, the establishment of several FTEs with their own budgets would likely necessitate a lengthy period of time. In order to facilitate the formation of these positions, workshop participants recommended developing policy recommendations for NOAA and the Department of Commerce regarding the necessity of these positions.

RAC roles would include:

- Updating the information resource base;
- Ensuring that the information is available to the industry; And,
- Helping aquaculture permit applicants work through the permitting process.

The group had varying sentiments regarding the position that the Regional Aquaculture Coordinators should take. Some opinions included:

- The RAC should advocate for the industry's development. Workshop participants debated the definition of "advocacy," and the group failed to come to a consensus regarding the definition;
- The RAC should support the aquaculture industry. However, the RAC would not support industry development which would lead to the detriment of the environment.
- The RAC should inform applicants about the permitting process; And,
- The RAC should facilitate aquaculture permitting.

5.4 KEY PRINCIPLES

The group discussed the benefits of having a national discussion on the issue of marine mammal and marine turtle interactions with aquaculture facilities. However, participants also recognize that interaction issues differ across the various geographical regions. In order to create a proactive policy, there must be a consistent approach within NMFS across the various regions. A well-developed management policy for approaching interaction concerns is necessary to ensure that aquaculture develops in an environmentally-sound manner. In order to create the management policy, research is a necessary component. Decision-makers should encourage new ideas and creativity through facilitating the flow of information between aquaculturists, technologists, and decision-makers.

6.0 RECOMMENDATIONS

The Keystone Center encouraged the group to prioritize the recommendations generated. Each group member was given the opportunity to vote, and voting was done openly. In an effort to keep some confidentially in the voting process, participants' votes were not recorded in the workshop minutes. Participants were given seven votes to use across twenty recommendations. The participants' votes were given two types of voting weights: top priority votes and second priority votes. The suggested voting criteria included determining if the recommendation displayed the following attributes:

- Urgency in terms of temporal importance;
- Potential for obtainable results;
- Outcome of goals is possible;
- Cost-effectiveness;
- Implementation ease;
- Logical order (short-term versus long-term activities and results);
- Ability of the recommendation to provide new information; And
- Ability to leverage dollars to undertake the recommendation.

Several voting process attributes are noteworthy. Relative weights between the first and second priority votes were not discussed. In addition, some workshop participants had to leave the meeting due to other obligations, therefore the participants in attendance had changed since the beginning of the workshop. It should be noted that the aquaculture industry, conservation community, and the Northwest region were considered to be under-represented during the voting process. Therefore, there should be limited emphasis placed on the recommendations' prioritization.

6.1 GROUP RESEARCH RECOMMENDATIONS

The recommendations include the following (not in any particular order):

Technology-Associated Efforts

- Evaluate the adverse effects of AHDs on target and non-target species. Received 12 votes total. 6 top priority votes and 6 second priority votes.
- Encourage the aquaculture industry to investigate new net technologies. (e.g., sponsor joint projects instead of solely governmental projects.) Received 12 votes total. 8 top priority votes and 4 second priority votes.
- Research non-lethal, non-technical deterrence methods. Received 0 votes.
- Develop new deterrent technologies and strategies. Received 13 votes total. 7 top priority votes and 6 second priority votes.
- Conduct an economic review of new net technologies (e.g., a viability analysis). No vote was taken.
- Optimize the effectiveness of AHDs through research on particular species.
  Received 1 vote total. 1 top priority vote.

Policy Analysis

- Research other nations' approaches to the marine mammal/marine turtle and aquaculture interaction issue. There is an inconsistency in international environmental standards, specifically related to international treaties. Received 9 votes total. 8 top priority votes and 1 second priority vote.
- Quantify and characterize the economic losses to the aquaculture industry from pinniped predation. Received 6 votes total. 3 top priority votes and 3 second priority votes.
- Compare agricultural predator deterrent policies and approaches and determine their applicability to marine aquaculture.
  Received 1 vote total. 1 Second priority vote.
- Perform a risk analysis of the effect of aquaculture compared to other activities in the marine environment on marine mammals and

marine turtles. Perform a risk analysis of all threats and concerns to marine mammals and turtles. Received 4 votes total. 4 second priority votes.

Habitat Issues

- Examine at what point the physical occupation of a habitat or the use of resources in an area by aquaculture site(s) has become a problem for marine mammals and marine turtles. Received 9 votes total. 6 top priority votes and 3 second priority votes.
- Evaluate aquaculture site baseline habitat condition changes before and after aquaculture siting (e.g., monitoring ambient noise levels). Received 12 votes total. 4 top priority votes and 8 second priority votes.

Behavioral Studies

- Document and characterize marine mammal and marine turtle interactions with aquaculture sites (e.g., effects of lighting on turtles, how marine mammals become entangled in aquaculture gear, etc.). Received 10 votes total. 7 top priority votes and 3 second priority votes.
- Further characterize marine mammal/marine turtle behavior and ecology around aquaculture sites. Received 9 votes total. 6 top priority votes and 3 second priority votes.
- Identify characteristics of rogue animals particularly looking at pinnipeds as predators. Received 5 votes total. 3 top priority votes and 2 second priority votes.
- Undertake further research on the distribution of protected species. Received 3 votes total. 1 top priority vote. 2 second priority votes.
- Review and assemble baseline environmental management data. Agencies would use the data to create narrative guidance with the assistance of a Geographic Information System to guide applicants in aquaculture siting applications. Received 4 votes total. 1 top priority vote and 3 second priority votes

Aquaculture Facility Standard Operation Practices

- Develop changes to aquaculture facility standard operating practices in an effort to reduce marine mammal and marine turtle interactions. (e.g., rotating site locations).
  Received 7 votes total. 6 top priority votes and 1 second priority vote.
- Develop a tagging method for aquaculture gear for identification purposes in case of gear loss. Research existing approaches that are currently used in other fisheries.
  Received 5 votes total. 5 second priority votes.

6.2 NON-RESEARCH RECOMMENDATIONS

In addition to the research recommendations, the group offered several suggestions that did not require research. The group members did not prioritize the non-research recommendations as they prioritized the research recommendations.

Information Management

- Archive literature related to marine mammal and turtle interactions with aquaculture operations.
- Explore the use of the NOAA Library to archive and store literature.
- Consider insurance as a tracking mechanism for implementing and enforcing guidelines or standards.

7.0 CLOSING COMMENTS

At the end of the two day workshop, the subgroups met to discuss their recommendations. Donna Wieting reemphasized the goals of the workshop. NMFS aimed to solicit comments, recommendations, and/or strategies; however, the group was not tasked with striving for consensus. Therefore, no individual's ideas would be dismissed. Participants did take the opportunity to discuss the viability of some of the recommendations, and the facilitator encouraged the discussion.

8.0 FUTURE ACTION

The Office of Protected Resources will share these recommendations with other offices within the DOC as well as within other governmental entities. The Office also hopes to spur further discussion and thoughts from the workshop participants and the sectors that they represent regarding issues that need further discussion. The workshop results will be available for future workshops and discussions within and outside of NMFS, NOAA, and the DOC. The recommendations will be particularly important in the development of the DOC Code of Conduct for Responsible Aquaculture. The Office of Protected Resources will send the recommendations to NMFS and NOAA leadership for future action.

Appendix 1: Workshop Agenda

Tuesday, January 12, 1999 Silver Spring NOAA Complex, Building 3, Room TBA

8:00 **Welcome and Introductions.**
8:45 **Overview of Agenda. General Questions.**
Donna Wieting, NMFS Office of Protected Resources
9:15 **Presentations and Questions.**
"Review of aquaculture (including hatchery-released salmonids) interactions with marine mammals in the Pacific Northwest": NMFS Northwest Fisheries Science Center
"Aquaculture in the Northeast": NMFS Northeast Region
10:15 **Break.**
10:30 **Presentations and Questions Continued.**
"Net design and construction"
"Acoustics"
11:30 **Set-up of Break-Out Group Sessions. Charge to Break-Out Groups.**
12:00 **Lunch on your own.**
1:00 - 5:00 **Break-Out Group Sessions.**
Three small break-out groups will run simultaneously. Each group will discuss the major themes identified below and be asked to provide recommendations and strategies for addressing the challenges identified.

Wednesday, January 13, 1999 Silver Spring NOAA Complex, Building 3

8:00 - 12:00 **Break-Out Group Sessions Continued.**
The three small groups will continue discussions and prepare synthesis for afternoon large group discussion.
12:00 **Lunch on your own.**
1:00 - 4:00 **Large Group Discussion** - Room TBA
Summary of break-out group discussions. Each small group will provide a synthesis of key points and individual recommendations discussed in their small group. Upon completion of the overview, all participants will be invited to comment and/or provide additional individual recommendations for each of the topics discussed.
4:00 - 5:00 **Overview. Discussion of next steps.**

Note: NMFS is soliciting individual comments, recommendations and/or strategies, not group consensus or group recommendations.

APPENDIX 2: WORKSHOP PARTICIPANTS

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Appendix 3: Discussion Topics for Break-Out Group Sessions

★ **Siting**

- Should areas be identified where marine aquaculture should be avoided and/or encouraged?
- How should those areas be identified? General criteria? Mapping? Other?

★ **Pinniped Predation**

- Is pinniped predation a problem in all types of marine aquaculture? In all regions?
- If not, what determines whether or not pinniped predation is a problem?
- What deterrents are currently used? Are they successful? To what degree?
- How can deterrents be improved?
- What new methods are needed?

★ **Entanglement**

- Is entanglement a concern in nearshore aquaculture operations?
    - If so, what is being done to avoid or minimize it?
    - What additional methods should be applied?
- Is entanglement a concern in offshore aquaculture operations?
    - If so, what should be done to avoid or minimize it?

★ **Standards and Guidelines**

- What are the existing standards and guidelines that affect aquaculture interactions with marine mammals and turtles?
- Are these standards and guidelines sufficient?
- What gaps exist in the current standard and guidelines to deal with marine mammal and turtle concerns?
- Where should we focus our efforts to address these gaps?
- Should standards be mandatory at this time? Or voluntary?

★ **Research**

- What are the key research needs to address policy issues and questions related to marine mammals and turtle interactions with marine aquaculture operations over the next 20 years?
- Which are priorities?

Anticipated Workshop Outputs

★ Recommendations for guidelines to minimize or avoid adverse affects to marine mammals and turtles:
    - at current level and future levels of nearshore aquaculture operations
    - from proposed offshore aquaculture operations

Appendix 4: Background Documents Supplied to Participants

Policies

Department of Commerce Aquaculture Policy, Final draft version. November 10, 1998.

National Oceanic and Atmospheric Administration (NOAA) Aquaculture Policy. February 13, 1998.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Strategic Plan. May 1997. pp. 16-17.

Regulatory Framework

Hopkins, D.D., R.J. Goldburg, and A. Marston. 1997. An environmental critique of government regulations and policies for open ocean aquaculture. Ocean and Coastal Law Journal, 2:235-260.

Entanglement

Kemper, C. and S. Gibbs. 1997. A study of life history parameters of dolphins and seals entangled in tuna farms near Port Lincoln, and comparisons with information from other South Australian dolphin carcasses: A summary. Report to Environment Australia, Australian Nature Conservation Agency, 2 pp.

Pinniped Predation

Arnold, H. 1992. Experimental predator control measures on marine salmon farms in Shetland. A report for Greenpeace UK. Submission to the Planning and Coordinating Committee of the Marine Mammal Action Plan, United Nations Environment Program, pp. I, 6-25.

National Marine Fisheries Service (NMFS). 1997. Impacts of California Sea Lions and Pacific Harbor Seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-28, pp. 56-57.

National Marine Fisheries Service (NMFS). 1997. Report to Congress on the interaction between pinnipeds and salmon aquaculture resources in the Gulf of Maine: Including recommendations on measures to mitigate the interaction. U.S. Department of Commerce, pp.1-5.

National Marine Fisheries Service (NMFS). 1996. Report of the Gulf of Maine Aquaculture-Pinniped Interaction Task Force. U.S. Department of Commerce, pp. 19-25 (Section 5), 27-41 (Section 6), 53-60 (Section 9).

Pemberton, D. and P.D. Shaughnessy. 1993. Interactions between seals and marine fish-farms in Tasmania, and management of the problem. Aquatic conservation: Marine and Freshwater Ecosystems, 3:149-158.

Smith, R.J. 1994. Literature survey on measures to control seal predation around aquaculture installations. Paper prepared for the Third Meeting of the Scientific Advisory Committee, Marine Mammal Action Plan, United Nations Environment Program, August 1994, Crowborough, U.K, 23 pp.

Acoustics

Olesiuk, P.F., L.M. Nichol, P.J. Sowden, and J.K.B. Ford. 1995. Effect of sounds generated by an acoustic deterrent device on the abundance and distribution of harbour porpoise (*Phocoena phocoena*) in Retreat Passage, British Columbia. Department of Fisheries and Oceans, Pacific Biological Station, 47 pp.

Reeves, R.R., R.J. Hofman, G.K. Silber, and D. Wilkinson. 1996. Acoustic deterrence of harmful marine mammal-fishery interactions: Proceedings of a workshop held in Seattle, Washington, 20-22 March 1996. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-OPR-10, pp. 27-32, 50-53.

Appendix 4: Background Documents Supplied to Participants

AQUACULTURE AND THE MARINE ENVIRONMENT
PROBLEMS AND SOLUTIONS-
White Paper by the NMFS Office of Protected Resources

INTRODUCTION The value of U.S. aquaculture production has grown by roughly 5-10% each year over the past decade (Goldburg and Triplett 1997). With the continued decline in domestic and world fisheries catches and increases in the demand for seafood, marine aquaculture production is expected to steadily increase. Increased marine aquaculture production may create significant economic benefits for the U.S., however, if care is not taken those benefits could be offset by significant environmental costs. This paper outlines the range of environmental effects associated with marine aquaculture and proposes solutions to minimize or avoid problems to ensure that aquaculture develops in an environmentally sound manner.

SUMMARY of Environmental Impacts Associated with Marine Aquaculture

Impacts on marine mammals and marine turtles

- ***Entanglement*** Protected resources may become entangled in the lines, nets, cages, cables and anchors that comprise the structure of an aquaculture facility.

- ***Behavior Changes*** Improperly sited, an aquaculture facility may obstruct marine mammal and marine turtle access to habitats of critical importance to their survival, such as haul-out sites, breeding grounds, and nesting beaches.

- ***Predation and Acoustic harassment devices*** Marine mammal predation can stress, injure, and kill fish, as well as damage nets and cages, which may lead to the escapement of farmed fish. Acoustic harassment devices have been used by aquaculturists for a number of years to combat pinniped predation with short-term results, but little long-term effectiveness. The impacts of these devices on target and non-target species are not fully understood.

Biological Pollution - Non-indigenous Species and Disease

- ***Nonindigenous Species*** Nonindigenous species can prey on or compete with native species, including protected salmonids, alter the habitat of native species, introduce pathogens and

parasites and can have long-term genetic impacts. Some experts believe that aquaculture has the potential to be the largest source of introductions of non-native fishes into North American waters.

- ***Disease*** Movement of pathogens and parasites has been a major problem both for the aquaculture industry and for wild populations. A number of diseases and parasites have been introduced to the US through aquaculture.

- ***Competition with Wild Fishery Stocks*** Aquaculture can compete with natural stocks and can quicken the demise of fishery resources rather than fostering their recovery. In addition, fishmeal is produced from the capture of wild fish stocks. With increases in aquaculture production, the demand for wild fishstocks to provide cultured fish feed will increase, putting additional pressure on wild stocks.

Habitat alterations and water pollution

- ***Nutrient overenrichment, eutrophication and toxic algal blooms.*** Aquaculture systems can produce large amounts of pollution which impact water quality and habitats. Nutrient overenrichment can lead to toxic algal blooms which affect both cultured and wild fish.

- ***Physical alteration*** The construction of aquaculture facilities can directly impact marine wildlife by reducing habitat productivity, diminishing water flow and decrease bottom habitat quality.

- ***Toxins*** Aquaculture operations also introduce harsh and toxic chemicals to their surrounding waters. Large percentages of these chemicals are lost to the environment.

Human Interactions Aquaculture is being pursued in areas where it did not exist and has become a significant competitor for space in the coastal zone. Aquaculture can conflict with competing uses such as commercial and recreational fisheries, tourism and boating, and commercial vessel traffic.

Special Issue: Enhancement Aquaculture is sometimes touted as a means to recover protected species through enhancement. There are a number of risks associated with artificial propagation, including erosion of genetic variability and increased competition and displacement There are a number of risks associated with artificial propagation, including erosion of genetic variability and increased competition and

displacement However, the goal of the ESA is to recover species in their natural habitat and the NMFS/FWS policy on controlled propagation highlights that controlled propagation be used only when necessary. .

SOLUTIONS

Siting The appropriate siting of aquaculture facilities can mitigate or prevent many environmental problems. Currently, siting criteria cannot be based on the ability of marine systems to assimilate the impacts of aquaculture because that information is not available. Therefore research is an essential aspect of any solution.

Design/Operation/Husbandry
The keywords here are reduce, reuse and recycle. Closed, recirculating systems can mitigate or prevent many environmental problems. However, opponents cite their high cost as a significant drawback, particularly in the open ocean. Other design options are available to reduce the environmental impacts of facilities, although closed systems are preferred.

Reducing Marine Mammal Predation Controlling access to nets, pens, and cages is key to curtailing marine mammal predation on aquaculture resources. Net tensioning and external weighting systems which render nets, pens, and cages less pliable appear to significantly reduce pinniped predation (Arnold 1992). Development of alternative, nonlethal methods of deterring marine mammals is a high priority.

Reducing the Introduction of Nonindigenous Species A number of solutions are available to minimize the possibility of nonindigenous species introductions into coastal and marine waters from aquaculture facilities:

- discourage farming of non-native species
- promote designs and facilities that are more secure - cages and netpens are the least secure, closed systems are the most secure
- develop sterile organisms - this is not completely reliable yet
- follow existing procedures such as the ICES Code of Conduct and the ANS Task force risk assessment protocol

Enhancement Artificial propagation of threatened and endangered species through aquaculture should only be considered under the ESA when it is called for in a recovery plan and if it meets the criteria established under the joint FWS/NMFS policy.

Appendix 5: Letter to Workshop Attendees

December 15, 1998

Dear Workshop Attendee,

Welcome to the NOAA Marine Aquaculture, Marine Mammals and Marine Turtles Workshop, January 12-13, 1999, hosted by the National Marine Fisheries Service's (NMFS) Office of Protected Resources. Thank you for your interest in this workshop. In this briefing packet, you will find a list of invited participants and observers, a draft workshop agenda, a number of background references, discussion topics, and lodging information for those of you coming from outside the Washington, D.C. area. Please take some time to review the packet.

As marine aquaculture operations expand, it is likely that interactions with marine mammals and turtles will increase, with potential adverse affects to marine mammals and turtles and aquaculture operations. The purpose of this workshop is to bring together regional NMFS experts in marine mammals, marine turtles, and marine aquaculture operations to develop recommendations on specific guidelines and standards for aquaculture siting and operation to minimize adverse affects to marine protected species from nearshore and offshore aquaculture operations. In addition, a number of non-NMFS representatives have been invited to present information and guide the development of recommendations. The intent is to solicit individual suggestions, not consensus or group decisions. Through discussions and interactions between members of the government, the marine aquaculture industry, academia, and environmental organizations it is hoped that NMFS will gain valuable insight regarding many of the most critical interactions between aquaculture and marine mammals and turtles.

Thank you for your interest in the development of guidelines and your willingness to attend this workshop. We look forward to working with you all in January. If you have any questions or comments about this packet or the workshop, please contact Kate Colborn at 301-713-2322 or Kate.Colborn@noaa.gov.

Sincerely,

Hilda Diaz-Soltero
Director, Office of Protected Resources