MEMORANDUM

TO: Council, SSC, and AP Members

FROM: Clarence G. Pautzke
Executive Director

DATE: June 1, 1998

SUBJECT: Essential Fish Habitat

ESTIMATED TIME
2 HOURS

ACTION REQUIRED

(a) Final review of essential fish habitat amendments.
(b) Final review of Cape Edgecumbe Pinnacle closure.

BACKGROUND

(a) Essential Fish Habitat Amendments

The Magnuson-Stevens Act amendments emphasized the importance of habitat protection to healthy fisheries and strengthening the ability of the National Marine Fisheries Service (NMFS) and the Councils to protect and conserve habitat of finfish, mollusks, and crustaceans. This habitat is termed essential fish habitat (EFH), and is broadly defined to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". The Councils are required to amend their fishery management plans by October 1998 to:

- identify and describe EFH for species managed under a fishery management plan;
- describe adverse impacts to that habitat from fishing activities;
- describe adverse impacts to that habitat from non-fishing activities;
- recommend conservation and enhancement measures necessary to help minimize impacts, protect, and restore that habitat; and
- include conservation and enhancement measures necessary to minimize to the extent practicable, adverse impacts from fishing on EFH.

Once the FMPs are amended with this EFH information, NMFS and the Councils can be more proactive in protecting habitat areas by alerting other federal and state agencies about areas of concern. Federal agencies engaging in activities that may adversely affect EFH must consult with NMFS regarding those activities. NMFS and the Council may make suggestions on how to mitigate any potential habitat damage. The Council will be required to comment on any project that may affect salmon habitat or habitat of any other anadromous fish (smelt, steelhead, etc.). However, the interim final rule encourages coordination between NMFS and the Councils, and may allow for the Council to delegate the consultation process to NMFS.

At this meeting, the Council will make a final review of the analysis to amend all fishery management plans (groundfish, scallops, crab, and salmon) to include definitions of EFH. The alternatives analyzed in the EA/RIR were the following:

Alternative 1: Status Quo.

Alternative 2 : (NMFS AK Region Recommendation) EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat".

Alternative 3: For stocks deemed to be in healthy condition, EFH is defined as a subset of all habitat within a general distribution [e.g., areas of known concentration] in the case of level 2 information or greater for a species life stage. For level 0 and 1 information, EFH is defined as all habitat within a general distribution for a species life stage. For stocks deemed to be in an "overfished" condition, EFH would be defined as the area of general distribution, regardless of information level. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat".

An executive summary of the analysis is attached at Item C-2(a). Item C-2(b) contains NMFS's recommendations for identification and description of EFH for the Council's FMP species. The Council will take final action on EFH identification and description at this meeting.

In April, the Council requested that the EFH core team prepare a discussion paper to assist the public with plan amendment proposals to identify Habitat Areas of Particular Concern (HAPC). A draft discussion paper is attached as Item C-2(c) for your review. We would like to distribute this document with our call for proposals this summer.

(b) Cape Edgecumbe Pinnacle Closure

Included in Section 12.5 of the analysis is an alternative to implement a no fishing closure to address potential impacts of fishing gear on a habitat area of particular concern (HAPC). A 4 square mile pinnacle area off Sitka has been proposed as a no fishing and no anchoring area to protect a rare and ecologically important habitat for juvenile rockfish and lingcod. Recall the video of this pinnacle area shown by Tory O'Connell (ADF&G) at the April meeting. There are two options for the closure, and these are as follows:

Option 1: Close the pinnacle area to anchoring and fishing for all species.

Option 2: Close the pinnacle area to anchoring and fishing for groundfish and scallops, but allow fishing for salmon within the area.

The Council is scheduled to take final action on this closure area at this meeting.

Executive Summary

This Environmental Assessment/Regulatory Impact Review (EA/RIR) addresses alternatives to protect and conserve habitat of finfish, mollusks, and crustaceans. The Magnuson -Stevens Act mandates that any FMP must include a provision to describe and identify essential fish habitat (EFH) for the fishery, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat.

Essential fish habitat has been broadly defined by the Act to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". The Councils are required to amend their fishery management plans by October 1998 to:

- identify and describe EFH for species managed under a fishery management plan;
- describe adverse impacts to that habitat from fishing activities;
- describe adverse impacts to that habitat from non-fishing activities;
- recommend conservation and enhancement measures necessary to help minimize impacts, protect, and restore that habitat; and
- include conservation and enhancement measures necessary to minimize to the extent practicable, adverse impacts from fishing on EFH.

Once the FMPs are amended with this EFH information, NMFS and the Councils can be more proactive in protecting habitat areas by alerting other federal and state agencies about areas of concern. Federal agencies engaging in activities that may adversely affect EFH must consult with NMFS regarding those activities. NMFS must, and the Council may, make suggestions on how to mitigate any potential habitat damage. The Council will be required to comment on any project that may adversely affect salmon habitat or habitat of any other anadromous fish (smelt, steelhead, etc.). The interim final rule encourages coordination between NMFS and the Councils.

There are two separate actions identified in this EA/RIR. The first action is to define and identify EFH for species in the five FMPs (BSAI groundfish, GOA groundfish, BSAI crab, scallops, and salmon). The second action is to enact a conservation and enhancement measure to minimize to the extent practicable, adverse effects from fishing on habitat identified as a habitat of particular concern.

<u>Action 1: Identify and Describe EFH</u>

The alternatives analyzed in the EA/RIR for defining EFH are the following:

Alternative 1: Status Quo. The FMPs would not be amended to meet Magnuson-Stevens Act requirements (Section 303) for required provisions of FMPs. <u>This is not a viable alternative</u>.

Alternative 2 : EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat".

Alternative 3: For stocks deemed to be in healthy condition, EFH is defined as a subset of all habitat within a general distribution [e.g., areas of known concentration] in the case of level 2 information or greater for a species life stage. For level 0 and 1 information, EFH is defined as all habitat within a general distribution for a species life stage. For stocks deemed to be in an "overfished" condition, EFH would be defined as the area of general distribution, regardless of information level. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat".

The consequences of the No Action Alternative are that a program for the conservation and management of EFH in Alaska would not be implemented. Agency decision-makers would not be able to avail themselves of information on the importance of certain habitats to marine fisheries, and their decisions regarding actions that could adversely affect EFH might not give adequate consideration to the need for conservation of particular habitats. Fish populations may remain threatened by habitat loss, and additional fish populations would most likely become threatened as habitat loss continued. Additionally, NMFS would not be following a statutory requirement if it chose Alternative 1. All of the alternatives to the status quo would be expected to benefit marine and anadromous fish populations and their habitats, and provide for improved long-term productivity of the fisheries.

Because all stocks of fish managed by FMPs in Alaska are considered to be healthy ("Report to Congress on the Status of Fisheries of the United States"; NMFS 1997), EFH for the species should be a subset of all existing habitat for the species.

<u>Action 2: Enact a conservation and enhancement measure</u> to minimize adverse effects from fishing on habitat identified as a habitat of particular concern (Section 12).

The alternatives analyzed in the EA/RIR to minimize adverse effects from fishing on a habitat area of particular concern are the following:

Alternative 1: No action. Do not implement additional conservation measures to minimize adverse effects from fishing at this time.

Alternative 2: Prohibit fishing and boat anchoring on the Cape Edgecumbe pinnacles. To minimize to the extent practicable adverse effects caused by fishing, a no-anchoring and no-fishing area would be implemented for a 4 square mile pinnacle area off Cape Edgecumbe, Sitka, which has been identified as a habitat area of particular concern.

<u>Option 1</u>: Close the pinnacle area to fishing for all species.

<u>Option 2</u>: Close the pinnacle area to fishing for groundfish and scallops, but allow fishing for salmon within the area.

The pinnacle area provides habitat for spawning, breeding, feeding, growth, and growth to maturity for a variety of species and is extremely productive, in part due to its physical oceanography. Closure of this area (Alternative 2) will allow a vital ecosystem to maintain at natural levels in an area surrounded by heavy fishing pressure. This closure would also protect the fragile nature of this rare habitat, and prevent the harvest or bycatch of these species during critical portions of their life history. Option 1 provides for better enforcement of a closure regulation. Adoption of Alternative 2 requires a regulatory amendment for halibut regulations in the Gulf of Alaska; analysis of such an amendment is included in this EA/RIR.

Summary of Impacts

None of the alternatives are expected to have a significant impact on endangered, threatened, or candidate species, and none of the alternatives would affect takes of marine mammals. Actions taken to define EFH will not alter the harvest of groundfish, crab, scallops, or salmon.

None of the alternatives is expected to result in a "significant regulatory action" as defined in E.O. 12866. However, this analysis will be conducted if appropriate for each FMP amendment.

None of the alternatives are likely to significantly affect the quality of the human environment, and the preparation of an environmental impact statement for the proposed action is not required by Section 102(2)(C) of the National Environmental Policy Act or its implementing regulations.

UNITED STATES DEPARTMEN'
National Oceanic and Atmosphe
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

AGENDA C-2(b)
JUNE 1998

May 11, 1998

RECEIVED
MAY 12 1998
N.P.F.M.C

Clarence Pautzke, Executive Director
North Pacific Fishery Management Council
605 West 4th Ave., Suite 306
Anchorage, AK 99501

Dear ~~Mr. Pautzke~~ Clarence:

In accordance with the interim final rule to implement the essential fish habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act, the National Marine Fisheries Service (NMFS) has developed draft recommendations for the identification of EFH for each of the five fishery management plans (FMPs) developed by the North Pacific Fishery Management Council (NPFMC). The draft recommendations, were submitted to the NPFMC April 3, 1998. These recommendations were reviewed by the Advisory Panel (AP) on April 20, by the Scientific and Statistical Committee (SSC)on April 21, by the public during an evening meeting on April 22, and by the NPFMC on April 24. Written comments were accepted by NMFS through April 27. Two comment letters were received. These letters are included for your information. The comments received on NMFS draft EFH recommendations by the SSC, AP, NPFMC, public, and NMFS internal comments were considered in developing NMFS final recommendations.

The NMFS final recommendation for identification and description of EFH is:

> EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat".

The NMFS final recommendation for the identification and description of EFH corresponds to Alternative 2 of the draft Environmental Assessment and Regulatory Impact Review (EA/RIR).

Rationale supporting the NMFS recommendation of Alternative 2 is included in the attached document titled "NMFS FINAL Recommendations for the Identification and Description of Essential Fish Habitat for Species of the Fishery Management Plans of the North Pacific Fishery Management Council". This document also includes NMFS recommendations and endorsements of the other components of the EFH FMP amendment requirements. Also attached to this memorandum are pertinent changes in how NMFS described or identified EFH including revised salmon EFH maps and clarification of Level 0 in EFH definitions. Electronic files with the EFH definitions and EFH information Levels tables were e-mailed to Dave Witherell.

Thank you for the support you, and your staff, have provided this effort. We are especially appreciative of Dave Witherell's work as an EFH Core Team member and primary author of the EA/RIR and Linda Roberts' document preparation efforts. I look forward to discussing our final EFH recommendations at the June Council meeting.

Sincerely,

Steve

Steven Pennoyer
Administrator, Alaska Region

Attachments

cc: EFH Core Team
Jim Balsiger
Steve Zimmerman

NMFS FINAL Recommendations for the Identification and Description of ESSENTIAL FISH HABITAT for Species of the Fishery Management Plans of the North Pacific Fishery Management Council

This document contains the NMFS final recommendations for the identification and description of essential fish habitat (EFH) for species of the fishery management plans (FMPs) of the North Pacific Fishery Management Council (NPFMC). This document also provides NMFS endorsements of other components of the EFH FMP amendment requirements as provided in the interim final rule to implement the EFH provisions of the Magnuson-Stevens Fishery Conservation and Management Act (62 Fed. Reg. 66531; December 19, 1997).

Development of NMFS EFH Recommendations: Public Involvement Process

The Magnuson-Stevens Act and the EFH regulatory guidelines require NMFS to consult with the Councils, participants in the fishery, interstate commissions, Federal agencies, state agencies, other interested parties and the public in general while developing written recommendations for the identification of EFH. Prior to submitting final EFH recommendations, the regulatory guidelines require NMFS to make available draft recommendations for public review and to hold a public meeting at which the public can comment on the draft EFH recommendations.

To meet these requirements, NMFS Alaska Region established a Core Team in April 1997. The Core Team is composed of NMFS employees and one person from the NPFMC staff. The NPFMC working with the Core Team developed a tasking plan outlining how, when and by who, required EFH tasks would be accomplished. The tasking plan established four Technical Teams (salmon, crab, scallop and groundfish). The Technical Teams were comprised of biologists from the NPFMC, the NMFS, the Alaska Department of Fish and Game (ADF&G) and from the USDA Forest Service. All are Federal or state agencies responsible for managing the species covered by the specific FMP or for managing the habitats essential to these species. The Technical Teams developed habitat assessment reports for each FMP and these reports were distributed for public comment in December 1997. Updated versions of these reports were available March 31, 1998. These reports are titled:

- Essential Fish Habitat Assessment Report for the Groundfish Resources of the Bering Sea and Aleutian Islands Regions
- Essential Fish Habitat Assessment Report for the Groundfish Resources of the Gulf of Alaska Region
- Essential Fish Habitat Assessment Report for the Bering Sea and Aleutian Islands King and Tanner Crabs

- Essential Fish Habitat Assessment Report for the Scallop Fisheries Off the Coast of Alaska
- Essential Fish Habitat Assessment Report for the Salmon Fisheries in the EEZ off the Coast of Alaska

These reports form the basis of the NMFS final recommendation.

The Core Team directed the activities of the Technical Teams and reviewed, commented on and sometimes supplemented their reports. The Core Team had four meetings between May 1997 and March 1998. These meetings were held May 20 - 22, 1997, in Juneau; July 15 - 17, 1997, in Juneau; October 21-23, 1997 in Seattle; and March 2 - 5, 1998, in Juneau. These meetings were open to the public and the public was encouraged to participate. In these meetings the Core Team discussed what was necessary to meet the EFH requirements of the Magnuson-Stevens Act, reviewed the information that was compiled by the technical teams and made the necessary assignments to update or gather more information as necessary. On March 4 and 5, 1998, NMFS only members of the Core Team met to develop the NMFS draft EFH recommendation. The meeting was not open to the public March 4 and 5, 1998. During these two days only NMFS members of the Core team met to discuss and write a NMFS draft EFH recommendation. The Core Team also had tele-conferences as necessary. In general, because of time constraints the public was not notified or encouraged to participate in these tele-conferences.

In addition to Core Team meetings, evening public meetings were held in various communities around the state. These meetings were as follows: February 5, 1997, in Anchorage, to discuss the proposed rule to establish EFH regulatory guidelines in accordance with Section 3D5(b)(1) of the Magnuson-Stevens Act; February 6, 1997, in Kodiak, to discuss the proposed rule; May 21, 1997, in Juneau, to discuss the proposed rule; February 4, 1998, in Anchorage, to discuss the effects of fishing on fish habitat, February 5, 1998, in Anchorage, to discuss the draft habitat assessment reports and other information compiled for EFH, and to discuss the interim final rule; March 3, 1998, in Juneau, to discuss the EFH information and documents and the interim final rule.

EFH was an agenda item on the Council's December 1996, February 1997, June 1997, February 1998, and April 1998 meetings. At the February 1998 Council meeting, public presentations were made to the Council, its Scientific and Statistical Committee (SSC) and its Advisory Panel (AP) by members of the Core Team on the habitat assessment reports prepared by the technical teams. Comments from the Council, the SSC, the AP, and the public were provided to the Core Team and these comments were incorporated into the habitat assessment reports. During the week of the February Council meeting, a public meeting was held the evening of February 4, 1998, at which the preliminary findings of a paper analyzing the impacts of fishing gear on habitat were presented by one of the authors and discussed. The following evening, a public EFH workshop was held at which the public was provided with a summary of the status of EFH development for the Alaska Region, and was invited to ask questions and provide comments concerning the development of EFH, and to comment on the draft EFH documents. Many of the comments received during this week were incorporated into the preliminary habitat assessment reports.

At the April 1998 Council meeting, presentations were again made to the Council, the SSC, AP and the public by the Core Team during Council and committee discussions and also at an evening EFH workshop. The presentations focused on the draft NMFS EFH recommendations, including textual descriptions of EFH for each species life stage, levels of information for each life stage and the draft Environmental Assessment and Regulatory Impact Review (EA/RIR). Comments from the Council, SSC, AP and the public on the draft NMFS recommendations and EA/RIR were provided to the Core Team. Those comments are incorporated into these final NMFS recommendations and supporting documents. NMFS, Alaska Region, received two comment letters on the draft EFH recommendations. These letters are attached to this document for Council review.

For each of the public meetings mentioned above, efforts were made to reach as many interested parties as possible, including non-fishing entities. Based on the foregoing activities, NMFS has met the public participation requirements of the Magnuson-Stevens Act and the EFH regulatory guidelines in developing the EFH recommendations contained in this document.

Explanation of Key Concepts

In terms of process, the formation of the NMFS recommendations was guided by the application of a four-tiered typology of information, and the development of a definition of "general distribution" suitable for serving as the basis for identifying EFH.

Levels of Information

NMFS EFH guidelines provide a typology of information (Level 1 to 4) for classifying the level of information available on the distribution of a life stage. The Technical Teams deemed it necessary to also define "Level 0" information as a subset of Level 1. Level 0 is intended to define a level of knowledge less than Level 1, which requires presence/absence data sufficient for applying analyses of frequency of occurrence. Level 0 information is defined by the Groundfish Technical Team as: "No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys." The BSAI Crab Technical Team used the same definition for Level 0, except they specified "research" surveys.

In general, Level 0 classification was used in the following situations:

a) some information on a species' life stage upon which to infer general distribution;
b) no information on the life stage, but some information on a similar species or adjacent life stages from which to infer general distribution; or

c) no information on the actual species' life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.[1]

Thus, in some cases EFH for a species life stage was inferred using Level 0 (a) and (b) information. However, EFH was not inferred for Level 0 (c), cases where no information was available on the actual species' life stage and no information was available on a similar species or adjacent life stages, or where stock structure prevented inference from adjacent life stages or other species. Cases where no information exists on the actual species' life stage and no information exists on a similar species or adjacent life stages from which to infer a general distribution were considered to be research priorities if the life stage is likely to be in habitat at risk to human activities. (Please note that some of the Technical Team's definition of Level 0 may differ slightly as a result of how they applied the concept relative to available information on that FMP species.)

At the April 1998, NPFMC meeting, the SSC and the Council asked NMFS to clarify the definition and use of the sub-tiers of Level 0 information. This discussion of Level 0 and the attached EFH definitions provide clarification. For species life stages that have Level 0 information the EFH definition is identified as Level 0_a, Level 0_b, or Level 0_c For Level 0_c no EFH definition is provided. Supporting summary tables are also appropriately foot noted.

General Distribution

The Technical Teams determined that information of Levels 0 and 1 was available for most life stages. Information of Level 2 was generally available for adult life stages. Higher levels of information (Levels 3 & 4) were available for some life stages of salmon in some regions of Alaska. From this information, the Technical Teams provided estimates of the general distributions and known concentrations for their respective species. The determination of general distribution and known concentration were done independently by each Technical Team. In each case, a general distribution of a species' life stage was defined as a subset of its current and historic range, and as the geographic area containing most of the individuals across all seasons. Thus, general distribution is not a proxy for, but rather a subset of range, and varies in size depending on the species.

When defining EFH the Core Team looked at all life stages of all FMP-managed species. From these life history traits, the Alaska Region Core Team found the overall distribution to be all waters -- marine, estuarine, and riverine to the headwaters of freshwater systems. To avoid defining EFH to be inclusive of all waters, the NMFS members of the Alaska Region Core Team narrowed the definition of EFH to a general distribution. General distribution

[1] This explanation of Level 0 supercedes prior descriptions of Level 0 in supporting documents.

occur where most of the individuals are found, not the species range. Thus general distribution denotes those areas where one would reasonably expect to find (high probability) a certain life stage of that species. General distribution encompasses approximately 95 percent of the total population.

The estimation of general distribution varied among Technical Teams in regard to the level of information. For example, for life stages with information Level 0, (a) and (b), the Salmon and Groundfish Technical Teams decided there was enough information available to infer general distribution (except for some forage fish species). For a life stage for which there was no direct information, general distribution was inferred from information on a similar species or distribution of an adjacent life stage. The methods for determining the salmon and groundfish general distributions and known concentrations are indicated in the respective habitat assessment reports. While differing slightly in process due to differences in type of data sources and habitat, the results are similar in degree of inclusiveness for similar amounts of information.

The Scallop Technical Team felt there was enough information to infer general distribution for species life stages with Level 0 information, except for the larval stages of Pink, Spiny, and Rock Scallops. The Crab Technical Team provides habitat association information for many species life stages, however, they made no inference of the geographic general distribution for any life stages with Level 0 information. While the lesser degree of inference in the Crab Technical Team recommendations is due in part to less information and a lesser degree of inclusiveness, inferring general distribution for crab is more complex due to the apparent stock structure of crabs. Up to 5 different stocks per crab species are identified in the Bering Sea, while for groundfish only one stock per species is identified. The general distributions of adjacent species or life stages where knowledge is at Level 2 tend to show discrete distributions in crab, compared to more contiguous distributions of groundfish. Thus interpolating or extrapolating inferred distributions is a more complex process for crab stocks. The Salmon and Groundfish Technical Teams inferred general distribution when some information was available upon which to make an inference. However, general distribution for some forage species was not inferred for life stages when there was no information on the life stage itself and no information on adjacent life stages or similar life stages of similar species. Thus, for Level 0_c life stages, general distribution is not provided and EFH is not defined.

Known Concentrations

Known concentrations were defined only for life stages for which Level 2 knowledge is available. (Level 2 information was only available for certain adult stages in the case of groundfish and shellfish, and certain life stages for salmon).

NMFS FINAL EFH RECOMMENDATIONS

The documents and explanations listed above comprise the basis of the NMFS final EFH recommendations and preliminary endorsements that follow.

Final Recommendation for Identification and Description of EFH

The NMFS members of the Alaska Region Core Team considered the alternatives of using general distribution or known concentrations to define EFH for species' life stages for which Level 2 or higher information is available. A principal concern was that using known concentrations alone to designate EFH would not ensure that adequate areas were protected as EFH. NMFS supports the conclusions of the Technical Teams and the conclusions of the NMFS members of the Alaska Region Core Team concerning the use of general distribution rather than known concentration to define EFH and has adopted their rationale as the basis for the NMFS final recommendation.

The NMFS final recommendation for identification and description of EFH is:

> **EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat."**

The NMFS final recommendation for the identification and description of EFH corresponds to Alternative 2 of the draft EFH EA/RIR.

NMFS based this recommendation on the following rationale:

- Areas of known concentrations based on current information do not adequately address unpredictable annual differences in spatial distributions of a life stage, nor changes due to long-term shifts in oceanographic regimes.

  Groundfish and salmon provide examples of this rationale. Annual differences in distribution of high concentrations of adults, particularly for pelagic or semi-demersal species (e.g., pollock, Pacific cod) occur and are unpredictable. Within the last 20 years, from which most data have been obtained, long-term changes in concentrations have been observed in Alaska groundfish. The spawning distribution of Gulf of Alaska pollock has changed dramatically since the 1970s. Relative distribution of the Alaska sablefish stock between the Bering Sea, Aleutian Islands, and the Gulf of Alaska has cycled since the late 1970s.

Habitat productivity for salmon also varies cyclically with natural long-term disturbance regimes, so that a particular watershed may have low productivity after an event such as a major flood, followed by a period of higher productivity. Locations of salmon concentrations in freshwater, estuarine, and marine habitats may change unpredictably, so that current areas of known concentration would not adequately cover required habitat.

Regime shifts in ocean conditions due to climate change can also cyclically affect physical conditions, abundance of food or predators, and as a result, the distribution and survival of salmon. Current areas of known concentrations, therefore, may not adequately cover required habitats. For example, a regime shift in the climate of the North Pacific Ocean in the 1970s altered the distribution and production dynamics of salmonids. The upper thermal limit of the distribution of steelhead in the high seas increased after the regime shift, and this change in distribution is thought to have been caused by increased ocean productivity and increased intensity of the Aleutian Low pressure system. The best model fitting changes in the productivity of Bristol Bay sockeye salmon included a one-time change in the parameters of the Ricker stock and recruitment model that first affected the 1972 brood year. Unpredictability of such regime shifts and limited knowledge of how salmon respond to such changes in ocean conditions necessitate a conservative description of essential fish habitat.

A growing body of evidence indicates that such a regime shift is currently underway, indicated by further significant declines in marine survival of salmon in the Pacific Northwest and British Columbia. This same reduced marine survival is now also affecting Alaska salmon stocks, resulting in a dramatic 45% reduction in the commercial harvest over the last 2 years (218 million fish in 1995 to 121 million fish in 1997). Designating only the habitat with current high abundance or productivity as EFH ignores the implications of such short- and long-term cycles.

- All habitats occupied by a species contribute to production at some level. Although contributions from individual locations may be small, collectively they can account for a significant part of total production. For example, fisheries for coho and pink salmon depend on the cumulative production from thousands of small streams that are widely distributed across coastal Alaska.

- A stock's long-term productivity is based on both high and low levels of abundance, and the entire general distribution may be required during times of high abundance. The total recruitment history, both high and low levels, are used in the estimation of biological reference points for many of the groundfish species managed by the NPFMC. These reference points are intended to relate to the stock's long term productivity. $B_{40\%}$ for example, is often considered a default or surrogate for the biomass that would produce MSY.

A stock's long-term productivity is based on both high and low levels of abundance, and the entire general distribution may be required during times of high abundance. The total recruitment history, both high and low levels, are used in the estimation of biological reference points for many of the groundfish species managed by the NPFMC. These reference points are intended to relate to the stock's long term productivity. $B_{40\%}$ for eg., is often considered a default or surrogate for the biomass that would produce MSY.

For example, salmon use a broader range of freshwater habitat during periods of high abundance. The broad range and diversity of salmon habitats must be conserved to provide for periods of abundance, as well as to avoid severely reduced production during poor years. Similarly, high concentrations of rock sole were found in only two discrete areas of the southeastern Bering Sea during periods of low abundance (early 1980s), but were found throughout regions with 100 m water depth in times of high abundance (mid 1990s).

- Survey information, upon which descriptions of known concentrations are primarily based, is limited to certain seasons (chiefly summer), while the general distribution is based on the best available scientific information, as well as fishery and local knowledge of a life stage.

- No discrete basis exists, or no threshold is defined to distinguish between known concentrations and general distribution of a species' life stage.

- Observed concentrations or densities do not necessarily reflect all habitat required to maintain healthy stocks within the ecosystem.

- From a science perspective, no rationale was found to identify areas outside of a known concentration as non-essential for maintaining healthy production levels without extensive knowledge of habitat related linkages to productivity and the ecosystem. Substantial rationale exists however, to justify an inclusive definition of EFH using general distribution.

- The advice in the NMFS guidelines to use the best scientific information available in a risk-averse fashion and employ an ecosystem approach suggests that, unless the information indicates otherwise, the more inclusive general distribution should be used to designate EFH. From the examples above, it is clear that density knowledge alone (Level 2 information) would be insufficient to determine that the habitat encompassed by general distribution is not essential to maintain healthy stocks and ecosystems and sustain productive fisheries. While it may be possible to make such a determination at higher levels of knowledge, NMFS is not making such a determination at this time.

- In the case of juvenile and adult salmon in marine waters, our greater knowledge of their habitat utilization indicates that they are indeed distributed over a larger expanse of the Pacific Ocean than is encompassed by the EEZ. As scientists obtain more knowledge on certain species, as in the case of salmon, they are learning that salmon spatial habitat requirements can actually be much greater and not as concentrated as one might expect. This broad geographic distribution of essential habitats provides the prey species important for their growth and maturation as well as the habitat diversity required in times of changing environmental conditions.

  With respect to Alternative 3 in the EA/RIR, it would only be possible to delineate areas of known concentration of salmon in some watersheds. First, one would identify watersheds with sufficient information and then delineate areas of known concentration within the watersheds. This would only be possible for a small number of watersheds, and generally only for adult salmon. It could be done for juvenile salmon in a few watersheds. For marine habitat, some areas of known concentration have been identified, but current information is not comprehensive and mainly reflects migration habitat. Most ocean areas have not been adequately surveyed, so that it is not possible to identify areas of concentration that are essential for growth and survival of maturing and adult salmon.

In response to comments received on the NMFS draft recommendations some changes have been made in EFH has been described or displayed. These changes include depiction of salmon EFH and clarification of EFH when Level 0 information is available.

Salmon EFH

We recommend that the Council not include the marine maps previously submitted for salmon. We would like to substitute the maps attached to this document, for the following reasons:

Areas of known concentration of maturing and adult salmon in the marine environment have been identified for some species based on bycatch in fisheries, such as chinook, sockeye, and chum salmon bycatch in the Bering Sea trawl fishery. These known concentrations, however, reflect points where fish become concentrated on migration routes from the open ocean to fresh water (e.g., Unimak Pass); they do not indicate exceptional habitats necessary for rearing and maturing. In addition, NMFS research has identified the area off Prince William Sound to Kodiak Island as a possible area of concentration of chum salmon in summer. Current knowledge of salmon distribution in the ocean is inadequate to identify other concentrations or areas of exceptional production.

The concept of "areas of known concentration" as used for marine EFH applies differently to salmon in fresh water. In fresh water, concentrations of salmon reflect locations of specific habitats for spawning, rearing, and migration that are patchily distributed on a finer scale (at the reach level) within watersheds. Freshwater habitat is very heterogeneous, and at a local level, depends on geomorphic, vegetative, hydrologic, and other factors, and also varies along the "river continuum" from headwaters to river mouth. Therefore, the distribution of habitat and fish within specific watersheds must be considered on a case-by-case basis to identify areas of concentration. Such areas of concentration, usually of spawning adult salmon, have been identified for a small number of specific river systems that have been intensively surveyed, primarily in Southeast (Region I), Southcentral (Region II); and Southwestern (Region III) Alaska. By radio tagging, for example, NMFS research has identified areas of concentrated chinook and sockeye salmon spawning in the Taku River, which could be considered areas of known concentration. For the vast majority of watersheds, however, information is insufficient to identify areas of known concentration, particularly for juvenile salmon.

The general distribution of salmon in fresh water includes virtually all the coastal streams to about 70° N latitude. Maps of documented salmon occurrence in fresh water (representing only a subset of salmon EFH) are available in the ADF&G stream Atlas. These maps show presence/absence of anadromous fish in areas that have been surveyed, but do not show fish densities, and therefore, they do not depict areas of known concentration.

Alternative 3

For clarification, NMFS wants the Council and the public to understand that the EFH definitions are written to describe the general distribution of a species life stage. The legal EFH definition is the written or text definition. For most species life stages the text is supported with maps. Maps were drawn for species with Level 1 or higher information. No maps are provided for those life stages with Level 0 information. For species with Level 2, or higher information, known concentrations are drawn on the maps within the general distribution (with the exception of salmon). For salmon, areas of known concentration are as described above.

If the Council chooses Alternative 3 of the EA/RIR more staff work is needed to both visually display (this pertains to salmon only) and verbally describe EFH in writing. However, enough information is included for the Council to make an informed decision.

Final Recommendation for Habitat Areas of Particular Concern

NMFS recommends the following general types of habitat be considered potential locations for habitat areas of particular concern (HAPC) for all FMP-managed species:

1. Nearshore areas of intertidal and estuarine habitats with submerged vegetation, rock, and other substrates that may provide food and rearing for juvenile groundfish, salmon, and shellfish; spawning or mating areas for adults of some crab and groundfish species (e.g., Atka mackerel, yellowfin sole, red king crab); and migration route areas for adult and juvenile salmon; and that are sensitive to natural or human-induced environmental degradation, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities. Examples include areas such as eelgrass beds, submerged aquatic vegetation, emergent vegetated wetlands, and certain intertidal zones. Many of these areas are unique and rare, and have a high potential to be affected by shore-based activities. The coastal zone is under the most intense development pressure, and estuarine and intertidal areas are limited in comparison with the areal scope of other marine habitats.

2. Offshore areas with substrates of high micro-habitat diversity which serve as cover for groundfish and shellfish. These can be areas with rich epifaunal communities (e.g., coral, anemones, bryozoans, etc.) or with large particle size (e.g., boulders, cobble). Complex habitat structures are considered most readily impacted by fishing activities.

3. Freshwater and estuarine habitat used for migration, spawning, and rearing of anadromous fish, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities.

To identify specific HAPCs within the above general habitat types NMFS will apply the following criteria:

- the importance of the ecological function provided by the habitat;
- the extent to which the habitat is sensitive to human-induced environmental degradation;
- whether, and to what extent, development activities are, or will be, stressing the habitat; and
- the rarity of the habitat type.

For example, an eelgrass bed would be considered a HAPC if it were threatened by development activities.

NMFS recommends the general types of habitat listed above, those identified by the Technical Teams and those included in Section 12 of the draft EFH EA/RIR, be considered as habitat areas of particular concern within the five NPFMC FMPs, whenever one or more of the four criteria (ecological function, sensitivity, stress on the habitat, and rarity) occur. This HAPC evaluation process will be further clarified in a discussion paper that will be available at the June Council meeting. The discussion paper will outline the proposal process by which HAPC could be identified by the public and analyzed by the NPFMC/NMFS for inclusion in an FMP amendment. The discussion paper will also give examples of types of management measures that might address impacts to these habitats.

Final Recommendation on Research and Information Needs

The Alaska Region EFH Core Team has developed a draft strategic framework with which to evaluate activities in the Alaska Region with respect to attaining NMFS habitat goals. To determine where investment of funds and resources should be directed, the framework considers the relative progression or status of the respective FMP species groups in terms of knowledge of habitat requirements, habitat management, and condition of habitat. Briefly, the framework identifies activities that would address the Level 0 life stages where they are likely to occur in habitat at risk; identifies the means to improve management and compatibility of human activities that affect the critical freshwater habitat of salmon; and identifies ways to evaluate and minimize effects of NMFS managed fisheries on EFH. The NMFS Core Team and Habitat Conservation Division will continue to develop the framework into an effective document.

Individual Technical Team reports indicate specific management, habitat, and ecological requirements that correspond to research needs in areas at risk. NMFS recommends that these research needs, as well as those identified in the EFH habitat assessments, EFH summary documents and Section 11 of the draft EA/RIR, be included in the EFH FMP amendments and pursued by NMFS to enhance knowledge of EFH. NMFS recommends the research needs identified for each FMP by the Technical Teams (summarized in Section 11 of the DRAFT EFH EA/RIR) and the following research needs:

1. Surveys and studies of nearshore pelagic and benthic areas are needed to determine their use by a variety of species, including Atka mackerel, Pacific cod, pollock, rockfish, sablefish, octopus, flatfishes, salmon, crabs, scallops, and juveniles and larvae of all species and forage species considered in NPFMC FMPs.

2. In salmon freshwater habitat, knowledge and management tools are needed for use in conserving or restoring habitat areas of particular concern.

3. Information on habitat distribution, in conjunction with fish distribution, is needed to determine species' habitat requirements and utilization. Information on the extent and distribution of complex habitat types susceptible to bottom fishing will greatly improve the ability to evaluate the potential of a fishery to physically alter bottom habitat and evaluate proposed measures to minimize impacts on EFH. To acquire this information, the Core Team recommends increased support to acquire information on detailed bottom topography and bottom type distribution on the continental shelf and slope.

4. Research necessary to raise the level of information known on a species life stage from Level 0 or 1 to Level 2 or higher.

Final Recommendation on Conservation and Enhancement Measures to Mitigate Adverse Impacts on EFH

NMFS recommends that the proposed Cape Edgecumbe Pinnacle closure be implemented with the EFH amendments to the FMPs. NMFS recommends no fishing for any species. This is Option 1 of Alternative 2 as described in Section 12.5.2 of the draft EA/RIR. A complete description of and need for the closure is contained in the draft EFH EA/RIR in section 12.5.

The Cape Edgecumbe pinnacle area totals 4 square miles off Cape Edgecumbe near Sitka Alaska. The area is dominated by two large volcanic pinnacles that have a diversity and density of fishes not typical of the Eastern Gulf of Alaska. The pinnacles rise abruptly from the seafloor, include a very complex habitat in a variety of depths, in a relatively compact area. Tidal and ocean currents create massive water flows over the habitat. The boulder field at the base of the pinnacles provides important refuge for adult fishes including large numbers of yelloweye rockfish, tiger rockfish, prowfish, lingcod, and octopus. Aggregations of small deep-water rockfishes occur here as well, including sharpchin, pugmy rockfish, and redstripe rockfish. Besides harboring adult fishes, the boulder field is also used as spawning habittat by lingcod. The sides and top of the pinnacle are comprised of columnar basalt and *Primnoa* gorgonians provide biogenic habitat for fishes on teh steep walls of the pinnacles. Juvenile rockfishes occur in great abundance at the top of the pinnacle. In addition to fish living directly on the habitat or using the pinnacle and associated fauna for cover, there are large schools of pelagic fishes that congregate in the water column above the pinnacle.

The pinnacle area provides habitat for spawning, breeding, feeding, growth, and growth to pmaturity for a variety of species and is extremely productive, in part due to its physical geography. Closure of this area will allow a vital ecosystem to maintain at natural levels in an area surrounded by heavy fishing pressure. The closure will also protect the fragile nature of this rare habitat, and prevent the harvest or bycatch of these species during critical portions of their life.

Endorsement of Identified Fishing and Non-Fishing Threats and Cumulative Impacts Analysis of these Activities

A description and identification of fishing and non-fishing threats is included in the draft EFH EA/RIR at Sections 10.1 and 10.2, respectively. A cumulative impacts analysis of these activities is included in the draft EFH EA/RIR at Section 10.4. NMFS endorses the statements made and conclusions reached concerning fishing and non-fishing threats and the cumulative impacts of those activities presented in the draft EFH EA/RIR.

Non-fishing adverse impacts to EFH in Alaska identified and discussed include: dredging, fill, excavation, marine mining, fish processing waste, timber harvest, non-point source pollution including urbanization, point source pollution, hazardous material, mariculture, oil and gas activities, hydroelectric projects, marine traffic, and natural adverse impacts. Habitat protection recommendations are summarized in Section 10.1.3 of the EA/RIR.

Identification of fishing threats to EFH is discussed in Section 10.2 of the EA/RIR. This Section reviews the effects of fishing gear (trawl, dredge, longline, pot and salmon fishing gear) on benthic communities. Fishery management options that may prevent, mitigate or minimize adverse effects from fishing may include, but are not limited to: fishing equipment restrictions, time/area closures, and harvest limits. Current and planned research on fishing gear and habitat interactions in the North Pacific is summarized in Section 10.2.2 of the draft EA/RIR.

Recommendation for Review and Revision of EFH Components of FMPs

The Interim Final Rule states that the Council and NMFS should periodically review the EFH components of each FMP, including an update to the fishing gear impacts assessment of the FMPs. To accomplish this, the original EFH FMP amendment should include a provision requiring a review of the FMP's EFH information in light of new information and the preparation of another EFH FMP amendment to incorporate this new EFH information, if appropriate. The schedule for this review should be based on an assessment of both the existing data and expectations when new data will become available. This information should be reviewed as part of the annual Stock Assessment and Fishery Evaluation (SAFE) report. Furthermore, the Interim Final Rule states that a complete review of EFH components should be conducted as recommended by the Secretary at least once every 5 years.

To incorporate the regulatory guidelines requirement for review and revision of EFH FMP components, NMFS recommends the following:

- First, NNFS recommends that the Council conduct a complete review of all the EFH components of each FMP once every 5 years and that the Council amend those EFH components of any or all FMPs to include revelant new information.

- Second, NMFS recommends that, in between each five-year comprehensive review, the Council utilize its annual FMP amendment cycle to solicit proposals on HAPCs and/or conservation and enhancement measures to minimize the potential adverse effects from fishing. Those proposals that the Council endorses should be developed independent of the five-year comprehensive EFH review cycle.

- Third, NMFS recommends that an annual review of existing and new EFH information be conducted and this information be provided to the Plan Team for their review during the annual SAFE report process. This information could be included in the "Ecosystems Considerations" chapter of the SAFE report.

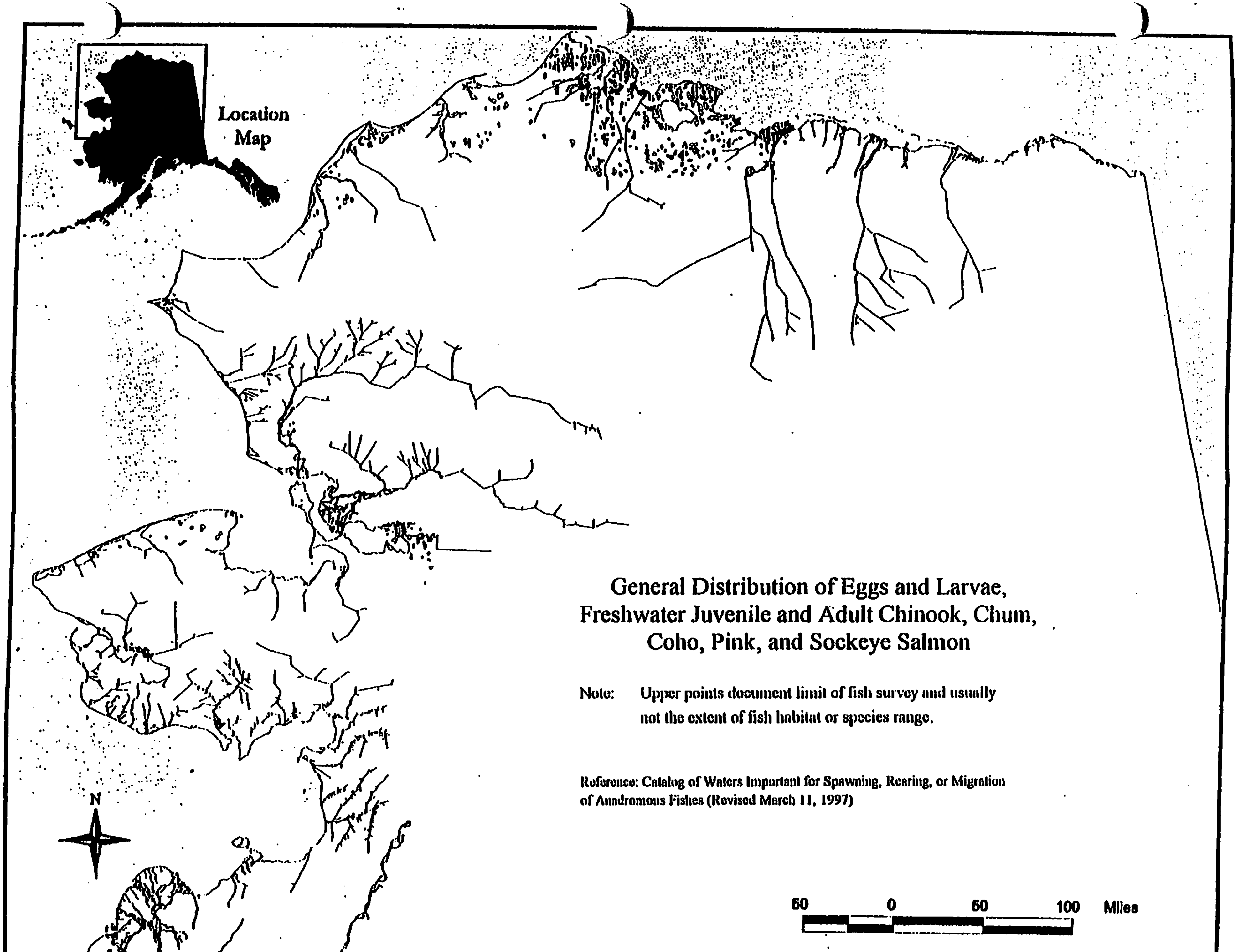
- Fourth, NMFS recommends that research and information needs be incorporated into a Strategic Investment Framework developed by the EFH Core Team and updated annually. This framework can be used as a management tool to prioritize budget requests and to prioritize recommendations for expenditures of EFH funds.

Endorsement of Identification of Important Prey Species

NMFS endorses the statements made and conclusions reached concerning important prey species presented in the Technical Team habitat assessments and in Section 8.0 of the draft EFH EA/RIR. Prey species are identified in the individual species reports in the Technical Team habitat assessments where the information was available. The diet or prey of the FMP species was included as part of the tables that summarized vital life history information for each species.

Section 8.0 of the draft EFH EA/RIR discusses important prey species for forage fish and several species of GOA and BSAI groundfish. Forage fish species are abundant fishes that are preyed upon by marine mammals, seabirds and other commercially important groundfish species. Forage fish perform a critical role in the complex ecosystem functions of the Bering Sea and Aleutian Islands management area and the Gulf of Alaska by porviding the transfer of energy from the primary or secondary producers to higher trophic levels. The forage fish species category would include all species of the following families:

Osmeridae (eulachon, capelin and other smelts),
Myctophidae (lanternfishers),
Bathylagidae (deep-sea smelts).
Ammodytidae (Pacific sand lance).
Trichodontidae (Pacific sand lance),
Philidae (gunnels),
Stichaeidae (pricklebacks, warbonnents, eelblennys, cockscombs and shannys),
Gnostomatidae (bristlemouths, lightfishes, and anglemouths), and
the Order *Euphausiacea* (krill).


Location Map
General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink, and Sockeye Salmon
Note: Upper points document limit of fish survey and usually not the extent of fish habitat or species range.
Reference: Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes (Revised March 11, 1997)
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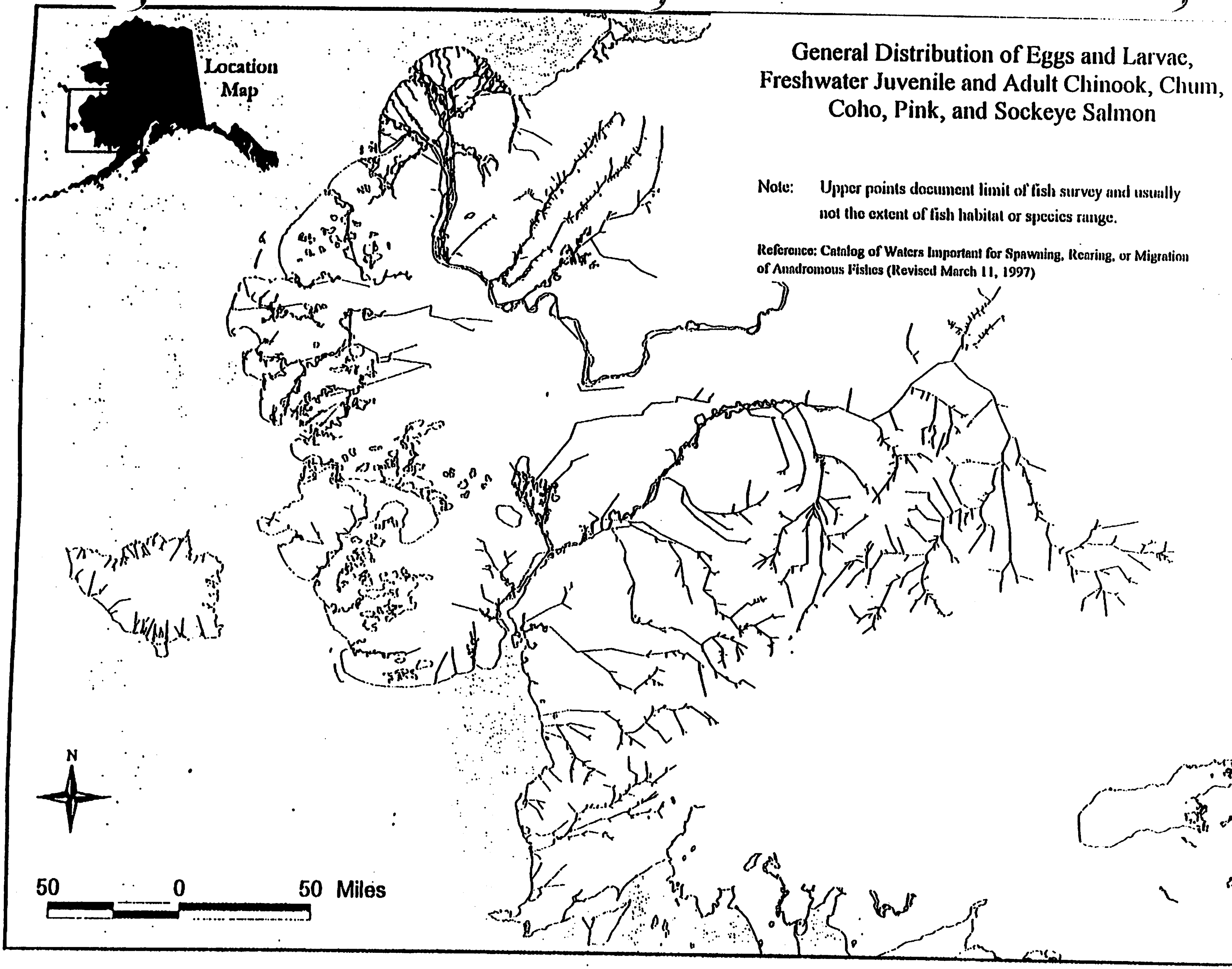
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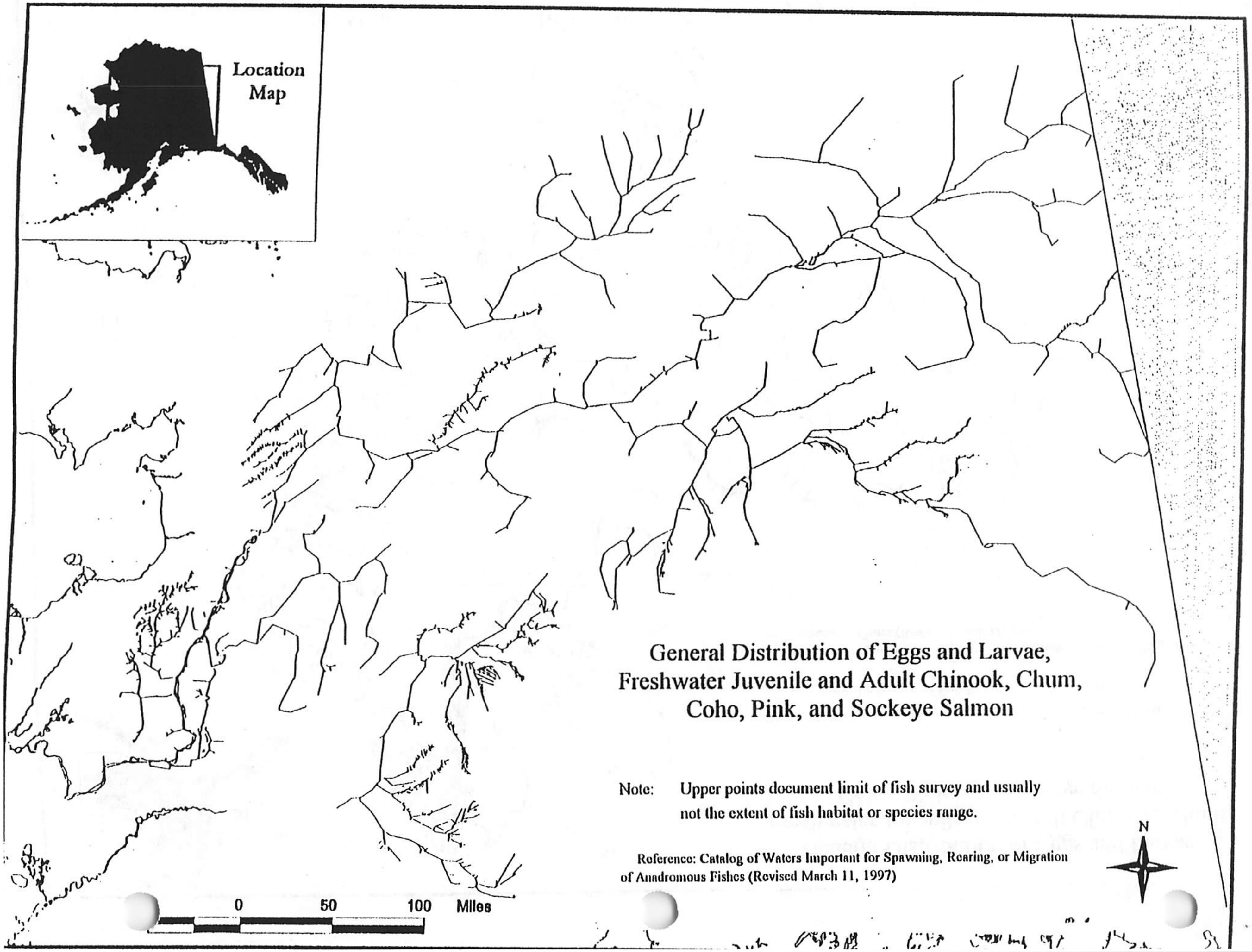
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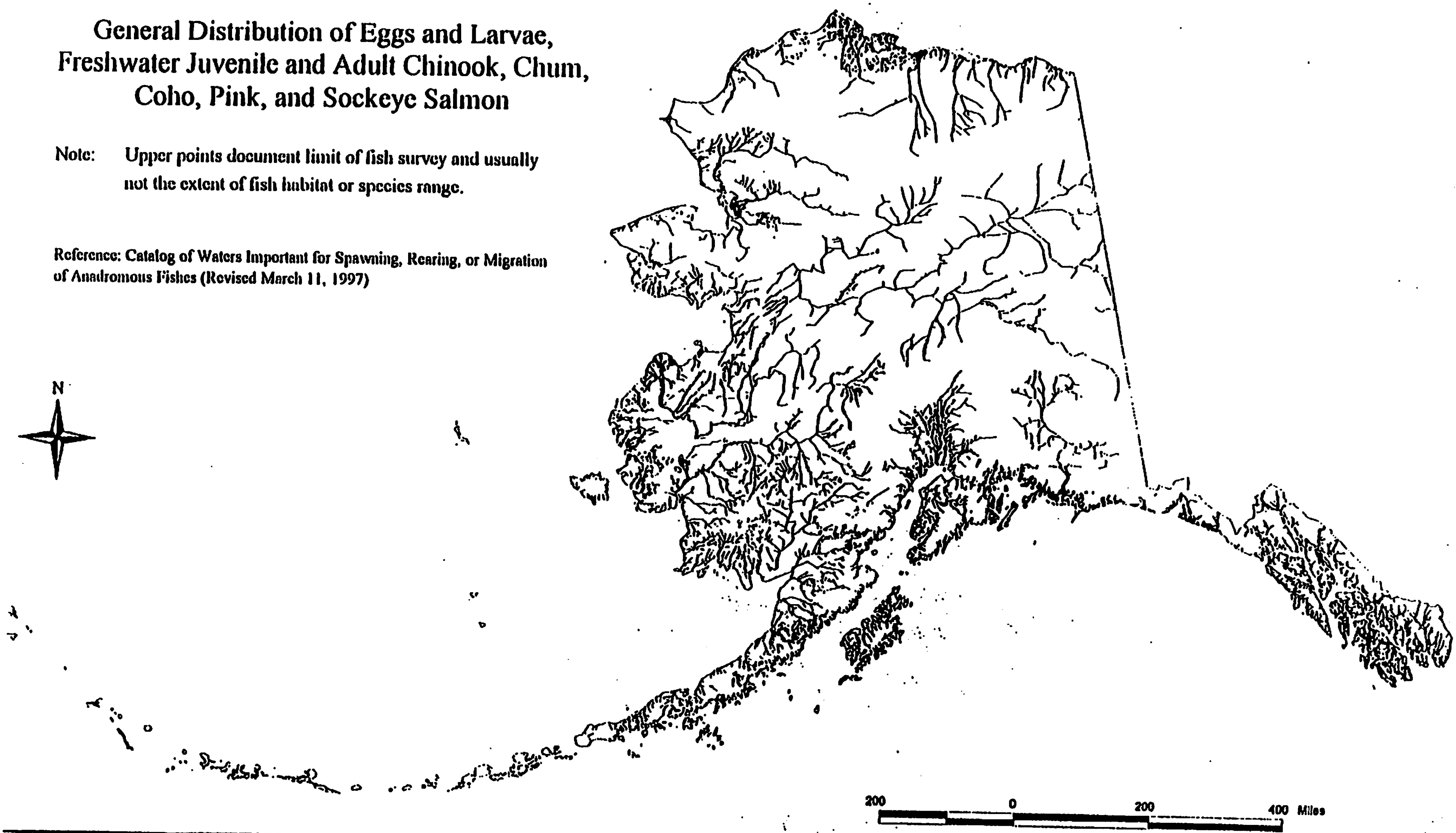

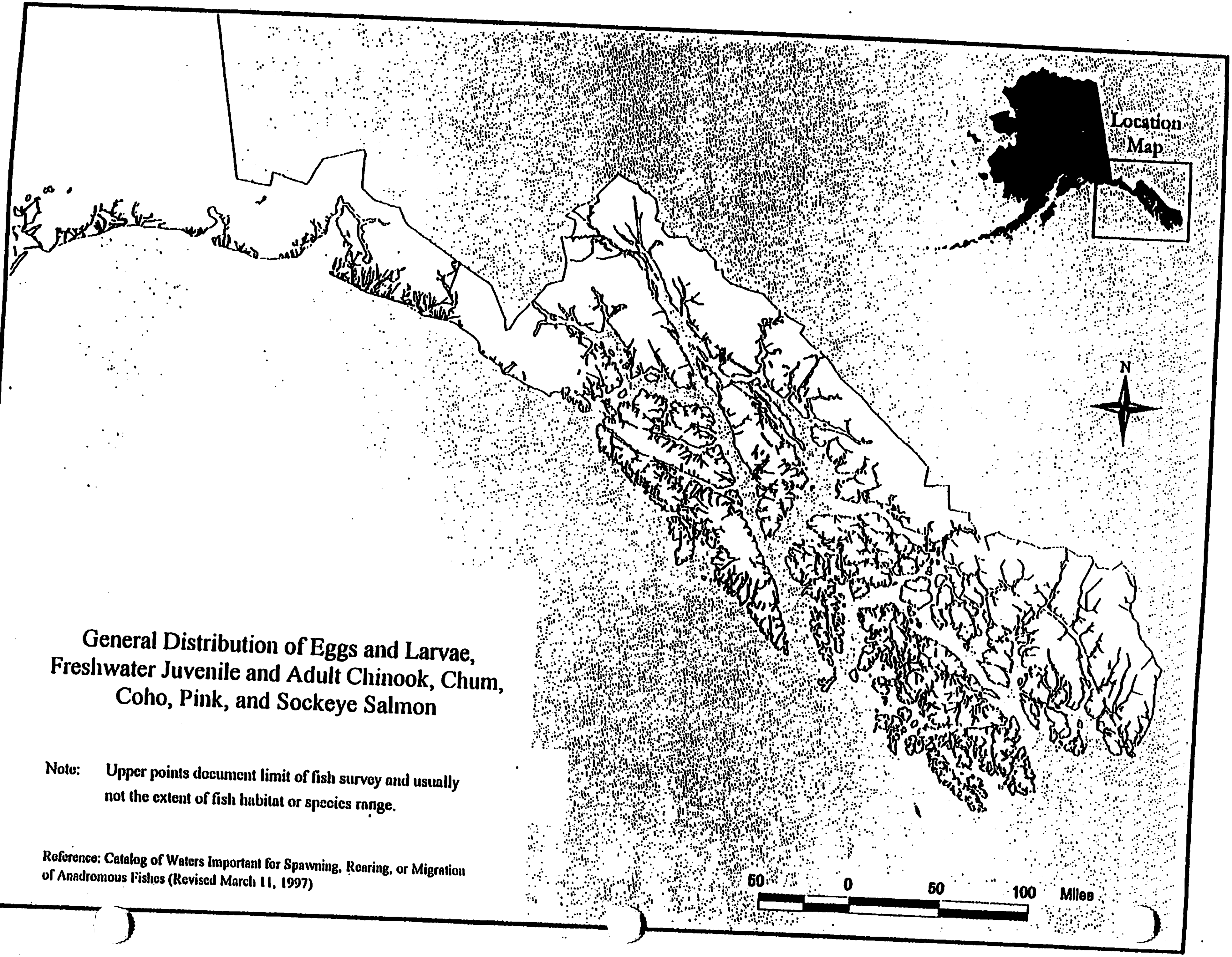

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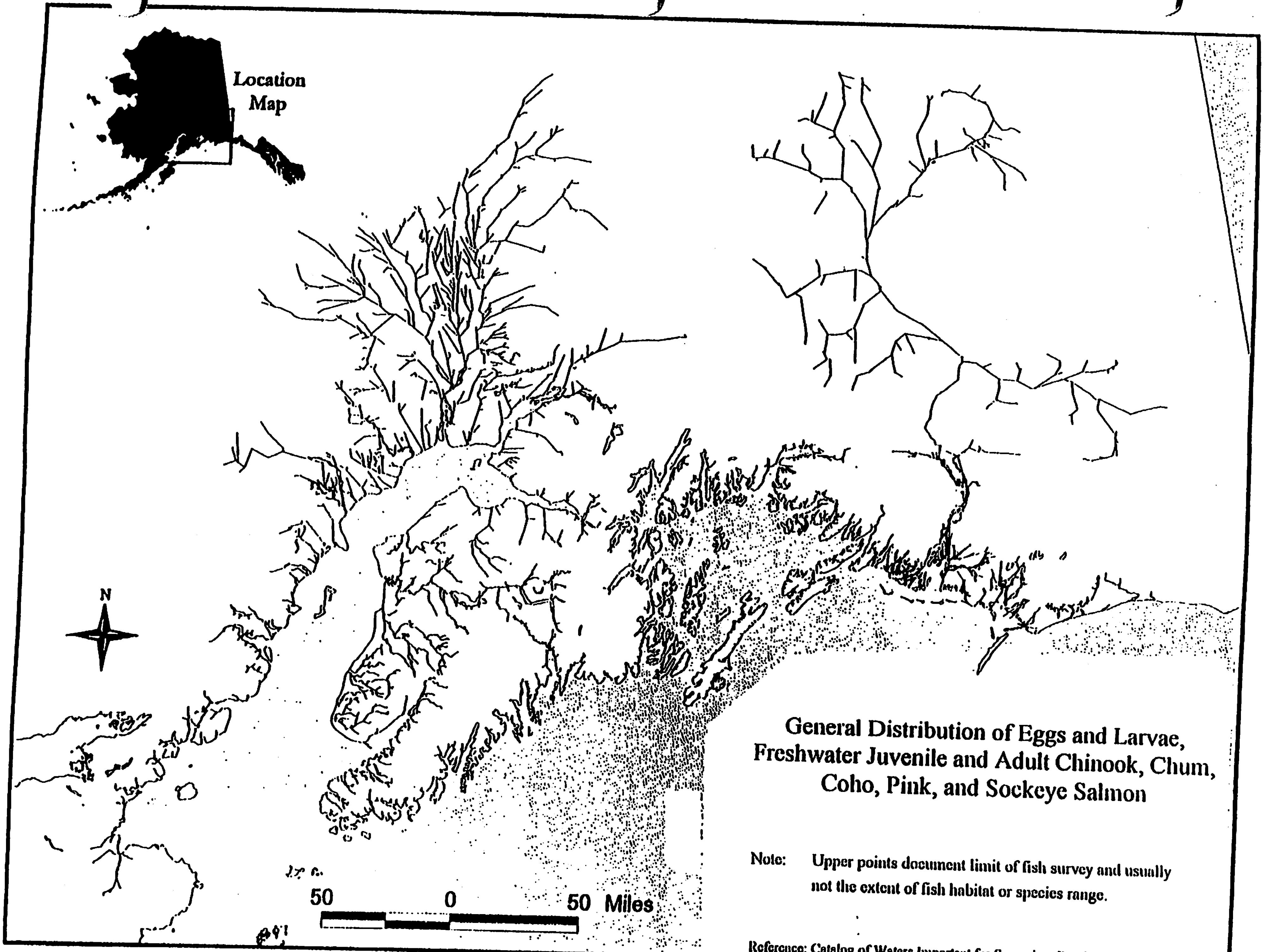

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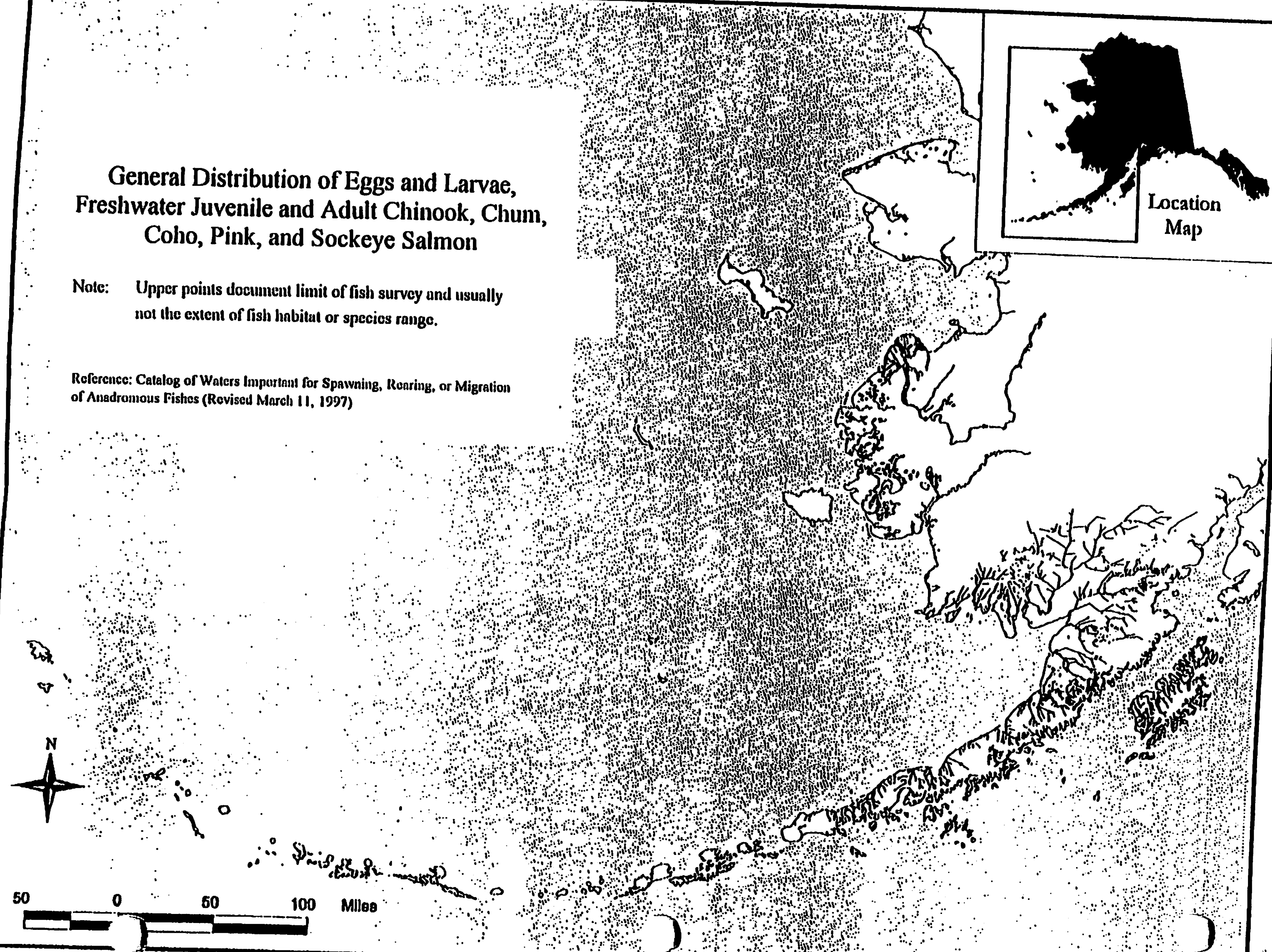

DRAFT Guidance:
Proposals to Amend Fishery Management Plans to Identify Habitat Areas of Particular Concern

What type of proposals are being requested?
The North Pacific Fishery Management Council recently adopted amendments to fishery management plans that describe essential fish habitat (EFH) for managed species. EFH is described as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The next step in this process is to identify habitat areas of particular concern (HAPC) for each fishery management plan (FMP). The Alaska region has FMPs for Gulf of Alaska groundfish, Bering Sea Aleutian Island (BSAI) groundfish, BSAI king and Tanner crab, Alaska scallops, and Alaska salmon. Proposals to amend the FMPs are being solicited to 1) identify HAPC, and 2) establish conservation measures to minimize, to the extent practicable, adverse impacts from fishing on HAPC.

Why identify habitat areas of particular concern (HAPC)?
The intent of HAPC is to identify those areas that are known to be important to species and need additional levels of protection from adverse effects. Management implications do result from their identification. Habitat areas of particular concern are intended to identify the areas within EFH that should receive more of the Council's and National Marine Fisheries Service attention when providing comments on Federal and state actions, and in establishing higher standards to protect or restore such habitat. Certain activities should not be located in areas identified as HAPC due to the risk to the habitat. Habitats that are at greater risk to impacts, either individual or cumulative, including impacts from fishing, may be appropriate for this classification. Habitats that are limited in nature or those that provide critical refugia or could provide refugia (such as sanctuaries or reserves) may also be appropriate.

How are HAPC identified?
In determining whether a type, or area of EFH is a HAPC, the Council and NMFS must consider:

(i) The importance of the ecological function provided by the habitat.
(ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
(iv) The rarity of the habitat type.

Ecological Importance is defined in the Technical Guidance to NMFS as the value of a habitat type to a species at a particular life stage, based on ecological function. Where there are few studies and observations of ecological function, the ecological importance of a particular habitat type may need to be inferred from the presence of species life-stages. Where there are little presence/absence data available, ecological importance may need to be inferred from the shelter or food items the habitat is capable of providing.

Sensitivity is defined as the degree that a habitat feature is susceptible to being degraded by exposure to activities, events, or conditions. The sensitivity of a given type of habitat to a disturbance regime depends on its ecological resistance (the ability to resist change during a disturbance) and resilience (the ability to return to its pre-disturbance structure). Factors that contribute to ecological resistance are 1) redundancy in function of component species, 2) tolerance to environmental fluctuations, 3) physical and chemical buffering capacity or flushing characteristics, and 4) proximity of the system to its ecological limits. Resilience has four components: elasticity, amplitude, hysteresis, and malleability. Elasticity is the time required for recovery, amplitude defines the level of disturbance that allows recovery, hysteresis describes the "path" of recovery, and malleability is a measure of the plasticity of the system (i.e., its capacity to persist in an altered state). Habitat types with low resistance and resilience have high environmental sensitivity, and habitats with high resistance and resilience have low environmental sensitivity.

Exposure is defined as the probability that a habitat feature will be exposed to activities, events, or conditions that may adversely affect the habitat. These activities are discussed in the Threats section of the EA/RIR. There are numerous landbased activities that may adversely affect anadromous fish freshwater habitat. In the marine environment, numerous landbased activities expose nearshore habitat to potentially adverse impacts. The most obvious marine activity that affect habitat, and the one activity NMFS and the NPFMC are most accountable for, is fishing.

Rarity is defined as how common the habitat feature is relative to other available habitats. In Alaska, little is known of the geographic extent and distribution of many habitat features and types, particularly in the marine environment.

The combination of these factors determine a habitat's vulnerability and priority for consultations. Vulnerable habitat can be defined as habitat that is susceptible to perturbation by natural or human events or activities. Further, vulnerability should be related to physical damage and removal, and degradation of condition (quality). Physical damage and removal could be caused, for example, by anchors dragging through submerged aquatic vegetation. Degradation of quality could be caused by water quality conditions, for example, that impede reproductive success of submerged aquatic vegetation.

What HAPC have already been identified?
The NMFS EFH core team has identified habitat types in Alaska that meet criteria specified in the interim final rule. Because information on ecological importance and distribution and extent of habitat is limited, specific locations and types of HAPC have not been identified. It is intended that HAPC be geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, species protection, or other critical values. Generally, these areas are acknowledged as having a significant influence or positive contribution to the overall environmental health of the entire equatic ecosystem of the region. A summary of these habitat types is provided below.

1. Living Substrates in Shallow Waters

Habitat areas of particular concern include nearshore areas of intertidal and submerged vegetation, rock, and other substrates. These areas provide food and rearing habitat for juvenile groundfish and spawning areas of some species (e.g., Atka mackerel, yellowfin sole), and may have a high potential to be affected by shore-based activities.

Shallow inshore areas (less than 50 m deep) are very important to king crab reproduction. After molting through four larval (zoea) stages, king crab larvae develop into glaucothoe, which are young crabs that settle in the benthic environment in shallow nearshore areas with significant cover, particularly those with living substrates (macroalgae, tube-building polychaete worms, kelp, mussels, and erect bryozoans). The area north and adjacent to the Alaska peninsula (Unimak Island to Port Moller) and the eastern portion of Bristol Bay are locations known to be particularly important for rearing juvenile king crab.

All nearshore marine and estuarine habitats used by Pacific salmon, such as eel grass beds, submerged aquatic vegetation, emergent vegetated wetlands, and certain intertidal zones, are sensitive to natural or human induced environmental degradation, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities. Many of these areas are unique and rare. The coastal zone is under the most intense development pressure, and estuarine and intertidal areas are limited in comparison with the areal scope of other marine habitats for salmon.

Herring also require shallow water living substrates for reproduction. Spawning takes place near the shoreline between the high tide level and 11 meters deep. Herring deposit their eggs on vegetation, such as ribbon kelp (Laminaria spp.), rockweed (Fucus sp.) and eelgrass (Zostera sp.). These "seaweeds" are found along much of the Alaska coastline, but they often occur in discrete patches.

2. Living Substrates in Deep Waters

Habitat areas of particular concern include offshore areas with substrates of high- micro-habitat diversity, which serve as cover for groundfish and other species. These can be areas with rich epifaunal communities (e.g., sponges, coral, anemones, bryozoans, etc.), or with large particle size (e.g., boulders, cobble). The rate of recolonization of sponges and their importance to fish habitat are unknown at this time. However, large sponges are easily damaged by fishing gear. The biological effect of disturbance on smaller epifauna and cobble habitat is also unknown. Complex habitat structures are considered most readily impacted by fishing activities.

Corals are generally considered to grow very slowly. Although scientists are not sure of coral's importance to fish habitat, coral would certainly provide vertical structure for fish to use for protection and cover. Submersible observations have found close association between fish and coral. Coral habitat is likely very sensitive to human-induced environmental degradation from both fishing and non-fishing threats. It is not known how much coral there is off the coast of Alaska, but it is likely to be rare relative to other habitat types.

Several species of deepwater coral are found off Alaska. Two common species are the red tree coral (Primnoa willeyi) and the sea raspberry (Eunephtya sp.). Information on coral distribution has been summarized in a 1981 report by R. Cimberg, T. Gerrodette, and K. Muzik titled, "Habitat Requirements and Expected Distribution of Alaska Coral." Copies of this report are available from the Council office. Red tree corals have been reported at depths from 10 to 800 m, with concentrations found at depths from 50 to 250 m. Other species of sea fans may be found deeper than Primnoa, at depths up to 2,000 m.

Bamboo corals also occur in the waters of both the inside passages of southeast Alaska and in the southeast Gulf of Alaska. These corals have a lower temperature tolerance, about 3.0 degrees C, and exist at depths from 300 to 3,500 m. These corals are also expected to exist in rocky stable substrate and have low tolerance for fine sediments.

Recolonization of coral communities requires at least several decades after perturbations. For example, given a predicted growth rate of 1 cm/year for Primnoa, a colony 1 m high would require at least 100 years to return to the pre-impacted state.

3. Freshwater Areas Used by Salmon

Habitat areas of particular concern also include anadromous streams, lakes, and other freshwater areas used by Pacific salmon for migration, spawning, and rearing, especially in urban areas and in other areas adjacent to intensive developmental activities.

Loss of salmon freshwater habitat can result from effects of logging, mining, hydroelectric development, oil development, urbanization, and other activities. These activities can reduce the amount and quality of salmon harvests through physical changes in habitat structure, productivity, temperature, or chemical contamination. A summary of the potential impacts of these activities can be found in the Non-Fishing Threats section of the Salmon FMP.

What measures could be proposed to minimize adverse effects of fishing on HAPC?
Adverse effects from fishing activities may include physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem. Regulations specify that FMPs must include management measures that minimize adverse effects on EFH from fishing, to the extent practicable, and identify conservation and enhancement measures. The EA/RIR for EFH contained an assessment of the potential adverse effects of all fishing activities used in waters described as EFH, as well as a review of existing management measures to protect fish habitat (NPFMC, May 12, 1998).

The regulations specify that Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing practice is having an identifiable adverse effect on EFH, particularly in HAPC. In determining whether it is practicable to minimize an adverse effect from fishing, those submitting FMP amendment proposals should consider whether, and to what extent, the fishing activity is adversely impacting EFH, including the fishery; the nature and extent of the adverse effect on EFH; and whether the management measures are practicable, taking into consideration the long and short-term costs as well as benefits to the fishery and HAPC. Fishery management options may include, but are not limited to:

> Fishing equipment restrictions. Seasonal and areal restrictions on the use of specified equipment; equipment modifications to allow escapement of particular species or particular life stages (e.g., juveniles); prohibitions on the use of explosives and chemicals; prohibitions on anchoring or setting equipment in sensitive areas; and prohibitions on fishing activities that cause significant physical damage in EFH.
>
> Time/area closures. Closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities; and designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life history stages, such as those areas designated as HAPC.
>
> Harvest limits. Limits on the take of species that provide structural habitat for other species assemblages, and limits on the take of prey species.

What should be included in a plan amendment proposal?
Persons should submit proposals using the proposal form attached to the June Council Newsletter. The form requires proposers to supply a brief statement and objectives of the proposal, justification for Council action, foreseeable impacts, possible alternative solution, and supportive data (including how the proposal meets the stated criteria for a HAPC, and also other information. It would be helpful if proposers provided as much detail as possible. Proposals are due on August ___.

FAX TRANSMITTAL

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Date: June 2, 1998
Pages: 15

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Regarding: Essential Fish Habitat - Draft EA\RIR Comments

To: Mr. Clarence Pautzke Fax No.: 907 271 2817

Mr. Pautzke:

Following are comments to be included in the NPFMC's meeting materials packet for the June 10-15, 1998 meeting in Dutch Harbor. A hard copy of the response is in the mail. These comments are submitted on behalf of the State of Alaska, and represent a consolidated state response regarding the Essential Fish Habitat Draft Environmental Analysis/Regulatory Impact Review.

If you have any questions, please do not hesitate to contact me at the above numbers.

Thank you.

Randy Bates

TONY KNOWLES, GOVERNOR

OFFICE OF THE GOVERNOR

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June 2, 1998

Mr. Richard B. Lauber, Chairman
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 99501-2252

Subject: Essential Fish Habitat – Draft Environmental Analysis / Regulatory Impact Review

Dear Chairman Lauber:

The State of Alaska has reviewed the Draft Environmental Assessment/Regulatory Impact Review (EA/RIR) that lays out draft recommendations on identifying essential fish habitat (EFH) for the groundfish, crab, scallop, and salmon fishery management plans (FMPs) the Council has developed. It is clear that a substantial amount of work has gone into the drafting of this amendment package, and under the duress of a very short time line. We appreciate that technical comments about FMPs that were previously submitted by the State (see attached letter dated July 8, 1997) have been substantially addressed in the EA/RIR. However, the continuing lack of information about the scope and mechanics of consultation envisioned under the Magnuson-Stevens Act, especially with respect to activities proposed in upland areas inhabited by anadromous salmon, concern the state and require further work. Our comments on sections of the EA/RIR, and consultation in general, are detailed below under the relevant topic heading.

Alternative 2, Option 1 – Minimize Adverse Effects From Fishing on a Habitat Area of Particular Concern

The State supports Alternative 2, Option 1 prohibiting boat anchoring and fishing on the Cape Edgecumbe pinnacles. Our support of this option stems from concern for the fragile nature of this rare habitat, the difficulties in enforcing partial fishing closures in the area, and the merits of including marine fish refuges in FMPs. The State recognizes that this closure action will likely occur, regardless of the definition of EFH or the designation of this habitat as a Habitat Area of Particular Concern.

Defining EFH

Defining EFH, identifying its physical and temporal extent, and incorporating this information into existing FMPs is both timely and important. Until now, protection of critical habitats, depressed fish stocks, and sensitive bycatch species has been addressed in a piecemeal fashion through multiple plan amendments (e.g., trawl closures in Bristol Bay, around the Pribilof Islands, and around sea lion rookeries). The goal has been to ensure that components of EFH such as rearing habitat, prey species, or commercially targeted species are protected from adverse fishery impacts in an effort to maintain healthy populations of other organisms. Healthy populations are in the best interest of Alaska and the nation. They are necessary to maintain viable commercial, subsistence, and sport fisheries and to avoid additions to the endangered species list, with the associated adverse implications such listing entails.

The Magnuson-Stevens Act defines EFH to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." In line with this, we support the NMFS recommendation for Alternative 2 which defines EFH as "all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions." At each life stage a given species tends to concentrate in particular geographic areas, habitat types, depths or times of the year. Often, however, information to carefully delineate areas of known concentrations is lacking. Thus, we concur that the use of general distributions makes sense, for the reasons listed on pages 50-52 of the EA/RIR.

For many agencies, local governments, and industries in the state, the most worrisome and critical aspect of adopting this broad definition of EFH is the need to do so in the absence of the consultation protocols. The State supports the development of a consultation process based on sound science and existing procedures. See additional comments on this topic, below.

Research and Information Needs

Much of the EA/RIR contains the work of the technical teams for salmon, crab, scallops, and groundfish. These technical teams have done good work, and we support their recommendations. Additional information can and should be compiled. For instance, prey are rather broadly defined in categories such as planktivore, omnivore, and so on. More accurate descriptions of EFH may be possible by including more detailed information on prey species because prey availability is an important factor in determining areas of a species' distribution and abundance.

Likewise, we believe that in many cases more detailed information is available on species distribution and abundance. These data could be digitized and presented in more detailed maps. Additionally, NMFS or other agencies should identify the critical data gaps and needs, who will collect the data, and how much that data collection and integration will cost. As the Alaska Department of Fish and Game has previously indicated, a large percentage of the state's anadromous fish waterbodies remain unidentified. Sound decisions require good information. Thus, the utility of the EFH amendments will rest on the ability to fill the information gaps that we and others have identified. It is critical that NMFS or other agencies be allocated funds so that EFH can be defined at a finer level for practical use in the consultation process.

Non-Fishing Activities Affecting EFH

Section 10.1 of the EFH Draft EA/RIR identifies several non-fishing activities as "threats" to EFH. There are a number of state regulatory programs which support a variety of local government and private development activities which are a key component of Alaska's economy. This description and identification of non-fishing "threats" to EFH has the potential for far reaching consequences to these activities. It should be clarified that the listed activities are not precluded in an EFH, but that site specific measures may be recommended to ensure their compatibility with EFH goals.

The State has a great deal of experience in applying mitigation measures that protect important habitat while allowing development to proceed. Section 10.1 or the guidance on implementation of EFH should provide direction for minimizing impacts to EFH's through use of mitigation measures applicable to specific activities, rather than requiring avoidance of certain activities as the only option.

Consultation

As the State has commented previously, the actual consultation process and the roles of NMFS and/or NPFMC in protecting habitat using EFH provisions are vague. It is important to note, however, that the Magnuson-Stevens Act requires consultation on federally initiated actions, and further allows for consultation with regard to state actions. We find it appropriate that NMFS is concentrating on the federal procedures. To be effective, any decisions regarding whether and how to address consultation for state actions need to be developed in consultation with the State.

Various provisions of state law could be instrumental in meeting consultation requirements, should NMFS and the Councils ultimately decide that consultation on state actions is needed to ensure long-term conservation of Alaska's marine fisheries resources. We also understand and appreciate that many NMFS staff recognize the prudence of reviewing existing programs to determine where the consultative requirements are currently satisfied, or can be most effeciently adapted. We support the development of interagency agreements to facilitate state involvement and to promote cooperation and coordination between state and federal agencies. Our comments regarding consultation incorporate those made in our July 8, 1997 letter to NMFS (attached).

Finally, we have recently learned that that there is a national group identifying priorities to be addressed in the consultation process, and developing a work plan on how to address the priorities. The State of Alaska believes that, to be responsive to Alaska conditions, priorities to be applied in Alaska must be developed in a public process held within our region.

Thank you again for this opportunity to provide comments. We look forward to working with you as this process moves forward to implement the Magnuson-Stevens Act's intent.

Sincerely,

Diane Mayer
Director

Attachment

cc: Steve Pennoyer, Regional Director, NMFS Alaska Region
Alaska Congressional Delegation

STATE OF ALASKA

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July 8, 1997

James P. Burgess
Acting Director, Office of Habitat Conservation
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3282

RE: Essential Fish Habitat Proposed Rule, Magnuson-Stevens Act

Dear Mr. Burgess:

The State of Alaska has reviewed the Essential Fish Habitat Proposed Rule published in the Federal Register April 23, 1997. The State appreciates the opportunity to comment on the Proposed rule and I am pleased to provide this consolidated response for your consideration.

The proposed rule provides a good framework for fulfilling the essential fish habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act. The State understands and appreciates that this is only direction for further work by Fishery Management Councils and that there will be additional public processes in the development of EFH designations. The State looks forward to working with the National Marine Fisheries Service (NMFS) as this work proceeds.

The Magnuson-Stevens Act struck a careful balance between state and federal authorities. The Act provides NMFS and the Councils the opportunity to make comments or recommendations regarding activities managed by states which may affect EFH. The final rule should clearly reflect that EFH comments and recommendations made by NMFS and the Councils are not mandatory for state actions such as water right applications, state and private forestry activities, and state permit approvals.

To facilitate state involvement and to promote cooperation and coordination between state and federal agencies, the final rule should encourage the development of interagency agreements which provide procedures for addressing EFH concerns in areas, or for activities, under state jurisdiction. Such agreements should stress reliance on existing administrative procedures. Additionally, the final rule should specify that NMFS and the Councils should closely consult with states throughout the EFH identification process.

The proposed rule states that "[t]he purpose of the rule is to assist Fishery Management Councils in fulfilling the requirements set forth by the Magnuson-Stevens Act to amend their [Fishery Management Plans (FMPs)] to describe and identify EFH, minimize adverse effects on EFH, and identify other actions to conserve and enhance EFH." While the proposed rule provides a framework for the Councils to meet the law's requirements for amending FMPs, significant changes in the funding of basic research are needed to fulfill the requirement to minimize adverse effects and identify conservation and enhancement actions for EFH.

The proposed rule provides direction to the Councils for determining whether minimizing an adverse impact from fishing is practicable. The Council is required to consider:

(1) Whether and to what extent, the fishing activity is adversely impacting the marine ecosystem, including the managed species;

(2) the nature and extent of the adverse effect on EFH; and

(3) whether the cost to the fishery is reasonable.

The levels of proof required under this mandate, given the minimal level of existing basic research, may mean the Councils will be limited to doing little more than describing and identifying EFH. Without additional research, Councils may be unable to fulfill requirements to minimize or correct adverse conditions. This is particularly true when the Councils are expected to judge whether or not the "cost to the fishery is reasonable." In many instances, the "cost" will be borne by one fishery, while the impact of no action will be felt in another. Without adequate data, the Councils will be in a very difficult position to make these determinations. The State strongly encourages NMFS to re-prioritize their research initiatives to address this gap in existing data.

Research initiatives should also address the need to undertake gear studies and their impact on the environment. Elevating this research priority to a higher level will resolve many unanswered questions. Such a focus may encourage improvement of fishing gear within the industry.

Another area in need of funding is in regard to cumulative impact analysis. Currently, the ability of scientists to adequately portray cumulative effects of activities on EFH is only at the descriptive stage. Significant funding is needed to even marginally imply the intertwined relationships of fish populations, habitats, and human activities. Because ecosystems are dynamic, and essentially non-linear, small changes in a component can lead to sometimes large and unanticipated effects to other ecosystem components. The proposed rule appears to imply a linear assumption that impacts can be added up and that results are predicable. As noted in the Alaska Department of Fish and Game comments dated February 20, 1997, this assumption can lead to unrealistic expectations.

The Act requires the Secretary to establish regulatory guidelines to assist the Councils in the description and identification of essential fish habitat in fishery management plans (including adverse impacts on such habitat) and in the consideration of actions to ensure the conservation and enhancement of such habitat. To fulfill the requirement to identify activities that have potential adverse effects on EFH, the proposed rule provides a list of broad categories of activities. The final rule should make it clear that the listed activities are not precluded in an EFH but that site specific measures may be recommended to ensure their compatibility with EFH goals.

To fulfill the requirement to guide the Councils in consideration of actions to ensure the conservation and enhancement of EFH, the proposed rule recommends specific activities that should be avoided where possible. The State has a great deal of experience in applying mitigation measures that protect important habitat while allowing development to proceed. The final rule should provide direction for minimizing impacts to EFHs through use of mitigation measures applicable to specific activities, rather than requiring avoidance of certain activities as the only option. We look forward to working with NMFS and the Councils during the guideline development and the General Concurrence process.

Finally, care should be taken that the process presented in the proposed rule does not increase the time it takes for an activity to secure state and federal approvals. The final rule should emphasize utilizing existing authorities and their processes, such as the Coastal Zone Management Act, to fulfill the process requirements when an EFH is identified in a fishery management plan.

Additional comments on the proposed rule are attached for your consideration (Attachment 1). Also attached are comments on the Technical Assistance Manual from the Alaska Department of Fish and Game (Attachment 2).

Thank you for this opportunity to comment.

Sincerely,

Diane Mayer for
Director

cc: Rick Lauber, Chairman, North Pacific Fishery Management Council
Steve Pennoyer, Regional Director, NMFS Alaska Region
Alaska Congressional Delegation

ATTACHMENT 1

Additional State Comments on the Magnuson-Stevens Act Proposed Rule

- The proposed rule requires an initial inventory of habitat requirements by life history stages, information on current and historic stock size and on the geographic range of managed species. The Alaska Department of Fish and Game (ADF&G) has published a number of maps, reports, and guides about fish and fish habitat. The department has also published habitat management guidelines and best management practices for some non-fishery activities. While some of the department's products will be helpful towards delineating EFH and towards developing other guidelines requirements of the proposed rule, substantial need exists to collect new data related to fish distribution, stock condition, and habitat use; habitat effects of fishing gear types; and about habitats at risk.

- The final rule should be expanded to include a separate avenue to deal with depressed species through the FMP amendment process. The Councils should be required to adopt risk averse measures which assure broadened EFH protection for depressed stocks.

- The separation of "cumulative impacts" under "non-fishing related activities" from fishing activities may preclude the analysis from combining fishing and non-fishing activities when describing the actual cumulative impacts. The final rule should describe all probable cumulative components and clearly emphasize the uncertainty surrounding the effects of potential impacts.

- Species under state management but not covered by a FMP may co-inhabit state and federal waters with plan species. For example, some ecologically and commercially important, but depressed, marine species such as king and Tanner crab in the Gulf of Alaska are not plan species but do exist in FMP fishing areas. The final rule should clarify which species and populations are to be covered by the Councils. There should be some provision for the Councils, through the FMP amendment process, to develop EFH fishing activity recommendations for the habitat of species not included within a FMP but which may be adversely impacted by fisheries conducted under a FMP.

- The final rule should recognize the role of states in the management of fishery resources and habitats.

- The final rule should require, if inland fresh-water bodies are included, that the FMP identify those streams, rivers, or lakes where in-stream flows are necessary to protect the EFH. These in-stream flows should be applied for under State law and subject to State allocation rights under existing law.

- The final rule should make it clear that the definition of EFH waters is different than federal waters for purposes of determining navigation servitude and water pollution control.

- The section on "optional components of EFH" should be clarified to recognize the authority of the state to regulate development in upland areas.

- The Coastal Zone Management Act (CZMA) requires that federal actions be consistent with a state's federally approved coastal zone management plan. The final rule should establish a framework for coordination with the states, through an early consistency review or other consultation processes. This would ensure EFH provisions are implemented in conjunction with state coastal plans. The consultation process should be implemented for the FMP amendments prepared pursuant to this rule and for future amendments and modifications to EFH provisions in FMPs.

- The final rule should minimize or eliminate any duplication that may exist between the EFH and coastal programs within the Department of Commerce. The final rule should establish a framework for coordination between NMFS and the Office of Ocean and Coastal Resource Management (OCRM).

- Consideration should be given to providing non-fishery interests that may be affected by EFH the opportunity to participate in developing EFH rules and designations. Federal funding may need to be expanded to cover such things as additional meetings and extra efforts to publicize review and comment periods.

The State understands that the proposed rules are only the framework for the EFH process and that there will be opportunities for additional comment as the Councils and NMFS implement the rules. However, the proposed rule is not clear how future EFH designations will affect state processes and jurisdictions. The State has the following questions and concerns:

- The proposed rule is not clear about the relationship of existing regulatory processes to EFH designations for anadromous species in Alaska and the consultation process in such instances.

- There is the potential for the more than 15,000 anadromous fish streams catalogued by ADF&G to be designated as essential fish habitat. This designation may require notification and consultation with NMFS as an additional layer to the existing coastal management program requirements and NEPA compliance requirements.

- How much additional time and cost will an applicant have to bear if a non-fishery project is within an EFH?

- Will an EFH for anadromous fish species mean new restrictions on mining or timber harvest programs? Will water-related development such as a new sewer outfall or reconstruction of a ferry dock need an additional review and comment process?

ATTACHMENT 2

ADF&G Comments on the Magnuson-Stevens Act Technical Assistance Manual

The National Marine Fisheries Service (NMFS) invited comments to improve the *Technical Guidance to Implement the Essential Fish Habitat Requirements for the Magnuson-Stevens Act*, also known as the *Technical Assistance Manual* or more simply, the *Technical Guidance*. We offer the following comments and observations on that document.

Page 1, Definition of EFH

At some point in project planning and permitting, a line must be drawn to separate land from waters. The Proposed Rule (PR) definition of "waters" is broad, and can be interpreted to include riparian areas and floodplains. NMFS EFH comments to permitting agencies concerning non-fishery actions would be most helpful if written in the context of current land management regulations, which may include a different definition of "waters." We suggest that, as NMFS prepares non-fishery project-specific comments related to EFH, recommendations for regulated areas or activities be presented separately from advisory comments. This format is similar to that developed by the State of Alaska Division of Governmental Coordination for Coastal Consistency Findings. (For example, NMFS EFH recommendations that would be carried on a CWA Sec. 401/404 or AS 16.05.870 authorization would be separate from advisory comments.)

Many Alaska state agencies, local governments, and local coastal districts engage in land planning. Local comprehensive plans, state plans[1], local coastal district plans, and other planning efforts often identify particular habitats of importance, and establish protective measures for these habitats. We encourage NMFS and the Council to consult existing state and local plans while developing and applying the EFH guidelines. We also encourage these entities to join on-going and future planning efforts and, within the context of FMPs, to extend protective measures to species and habitats identified as important by the various state and local plans.

Pages 2-3, Purpose and Introduction

We recommend that the guidelines used to describe and identify adverse impacts on identified EFH include the cumulative effects of both non-harvest and harvest of fish. We recommend this broader view of cumulative effects because categorizing some

[1]As used here, "state plans" includes, but is not limited to Area Plans, Tidelands Plans, Eagle Preserve Management Plans, and State Forest Plans prepared by the Department of Natural Resources, and Special Area Plans prepared by the Department of Fish and Game.

effects as non-fishery or fishery may preclude application of an appropriate mitigative measure.

Pages 4-5, Requirements of the Magnuson-Stevens Act

This section summaries requirements placed on federal agencies and the Councils. We recommend a closing paragraph to clarify that the Magnuson-Stevens Act places no obligations on States.

Pages 5-6, Scope of EFH

The Proposed Rule (PR) and the *Technical Guidance* are clear that designated EFH is only for FMP species. ADF&G remains concerned about species that are under state management but are not included in an FMP. (For example, king and Tanner crab in the Gulf of Alaska are ecologically and commercially important, though population levels are low.) We recommend that the Councils initiate a process to develop EFH management measures to protect the habitat of species not included within a FMP but affected by fisheries conducted under a FMP.

In addition, we are concerned about the relationship between EFH designations for anadromous species and existing regulatory processes. The guidelines should include anadromous species habitat under EFH, and encourage development of appropriate consultation mechanisms between states and the NMFS/Councils to address EFH concerns.

Pages 6-9, Description and Identification of EFH

As mentioned in the State of Alaska cover letter, ADF&G has published a number of maps, reports, and guides about fish and fish habitat, as well as habitat management guidelines and best management practices for some non-fishery activities. While some of our products may need only slight revisions to meet NMFS' needs under the EFH identification requirements, substantial need exists to collect new data related to fish distribution, stock condition, and habitat use; habitat effects of fishing gear types; and about habitats that are at risk from human activities.

We caution the Council and NMFS against efforts to categorize habitats as being of high, medium or low value, as such an effort would be difficult and potentially controversial. Rather, all habitats of the managed species should be considered under EFH. Instead of categorizing perceived habitat value, mitigative measures included in site- or area-specific project approvals can and should be commensurate with habitat condition and potential, stock status, and anticipated adverse effects.

Page 10, Mapping EFH

The department has undertaken many mapping projects since statehood, for varying purposes. Our statewide anadromous fish distribution cataloging project is an on-going project that is far from complete. Additions and corrections are periodically made to the catalog through the Alaska Administrative Procedures Act. We urge NMFS to join us in this ambitious mapping effort, rather than to initiate a new effort.

Page 11-18, Adverse Effects to EFH: Non-fishing Related

Sec. 305(b)(3)(B) provides for consultation between Councils to the Secretary and any federal or state agency regarding any activity that is likely to substantially affect the habitat, including EFH, of an anadromous fishery resource under its authority. The guidelines state that for purposes of this section, "under its authority" means any anadromous species where some life stage inhabits waters under a Council's authority, whether or not that species is managed under an FMP in Alaska. While this may be ecologically prudent and desirable, it may be an inappropriate extension of Council authority. Sec. 306 of the Magnuson-Stevens Act reaffirmed that, except as specifically provided, the Act did not diminish state authority to manage species not subject to FMPs. The *Technical Guidance* should be clear that EFH provisions apply only to species under the Council's authority, i.e. FMP species.

In many parts of the country, for example the Pacific Council Region, salmon are managed pursuant to an FMP. In Alaska that is generally not the case. However, we also believe that the Act anticipates that EFH designations for non-FMP species should be developed and subsequently implemented through close consultation and cooperation with states. Because of this, we strongly encourage development of an appropriate interagency agreement to address EFH concerns for non-FMP species including anadromous species.

As mentioned in the state's cover letter, the ability of scientists to adequately portray cumulative effects is only at the descriptive stage, and we believe significant funding is needed to even marginally imply such relationships. Because ecosystems are dynamic, and essentially non-linear, small changes in one ecosystem component can lead to somctimes large and unanticipated effects to other components. We are concerned that the PR still implies a linear assumption that impacts can be "added up" and that results are predictable.

We also caution that separation of cumulative impacts into "non-fishing" and "fishing" categories may preclude a through cumulative impacts analysis. The *Technical Guidance* should acknowledge the uncertainty surrounding prediction of the effect of potential impacts, and provide guidance for describing all probable cumulative components and appropriate resource management response.

Pages 23-32, Consultation Procedures

We welcome NMFS' participation in existing interagency coordination processes, such as the coastal consistency reviews coordinated by the Governor's Office Division of Governmental Coordination for projects occurring in the Coastal Zone (including navigable waters). Clearly one of the challenges will be to work together to develop coordination processes which meet the intent of the Magnuson-Stevens Act's EFH provisions yet are not unrealistically complex or costly for affected agencies and applicants seeking non-fishery project approvals.

We recognize NMFS' recommendations concerning activities that may adversely affect EFH are not mandatory, and we recommend the *Technical Guidance* describe existing procedures and other means of communication between federal and state agencies. This way, creation of another review process may be avoided, and existing mechanisms may be fully applied.

AFS American Fisheries Society
ALASKA CHAPTER

2770 Sherwood Ln., 2A
Juneau, AK 99801
(907) 586-8811 ext 228

April 27, 1998

Mr. Steven Pennoyer, Administrator
Alaska Region
National Marine Fisheries Service
P.O. Box 21668
Juneau, AK 99802-1668

Dear Mr. Pennoyer,

The Alaska Chapter of the American Fisheries Society is comprised of more than 450 scientists, managers, educators, and business people dedicated to the conservation and wise use of the aquatic resources. The Alaska Chapter relies on the expertise and diversity of its membership to provide impartial reviews of actions that may affect Alaska's fishery resources.

We are writing to comment on your agency's draft recommendations to the North Pacific Fishery Management Council (NPFMC) on Essential Fish Habitat (EFH). We generally applaud this new initiative stemming from amendments to the Magnuson-Stevens Fishery Conservation and Management Act (FCMA). Numerous and extensive threats and damage to fish habitat exist from both from fishing and non-fishing activities. These new rules will help to preserve fish habitat, which are important to healthy fisheries.

We wish to comment on several specific issues.

Support the Preliminarily Recommended Alternative.- We support defining essential fish habitat (EFH) to include all habitat that includes the distribution of all life stages of a species. Because the habitat that is critical to the majority of production for a species is typically either poorly known or highly variable as environmental conditions change, it is preferable to err on the conservative side by protecting all habitat used by a species.

Support the Cape Edgecomb Pinnacle Closure.- This sensitive area near Sitka has been identified as unique habitat supporting an unusually high biodiversity and dense concentration of marine fauna. It should be protected by closure to prevent damage from fishing gear.

Lack of Specific Habitat Protection Action. - While the Essential Fish Habitat Assessment Reports (EFHAR) thoroughly define EFH and the quality of information needed to determine EFH, less information is presented about the threats from fishing and non-fishing activities and almost no information is presented on actions to be taken to protect or restore habitat. Under the interim final rule, NMFS and NPFMC are required to recommend conservation and enhancement measures necessary to help minimize impacts and protect and restore habitat. The EFHARs do not address what will be done to 1) enforce existing laws, 2) protect existing habitat and prevent further habitat destruction, or 3) restore previously damaged habitat.

The NMFS draft recommendations also cite the draft Environmental Assessment/Regulatory Impact Review (EA/RIR) for habitat conservation and management. However, out of the 341 pages in that document, only the last page addresses "Conservation and Enhancement Measures", and then only in the most general terms. Greater detail is needed on specific actions which can and should be taken to protect EFH.

Strengthen Definitions of Habitat Areas of Particular Concern.- The definition of anadromous fish habitat of particular concern should be strengthened by eliminating or expanding the phrase "especially in urban areas and in other areas adjacent to intensive human-induced developmental activities". We believe all freshwater habitat is highly susceptible to degradation and the proposed language may be taken to exclude logging or mining activities which can have a detrimental effect on anadromous fish.

Poorly Defined Regulatory Process.- The EFH documents are also vague about the actual regulatory process and the roles of NMFS and/or NPFMC in protecting habitat. We believe that, for this new initiative to make a difference, additional regulatory authority, or at least increased regulatory activities under existing laws, will be necessary.

We appreciate this opportunity to review and comment on the EFH and we welcome any questions you might have or additional input that we might provide.

Sincerely

Mason D. Bryant
President
Alaska Chapter, American Fisheries Society

Alaska Forest Association, Inc.

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June 2, 1998

Mr. Clarence G. Pautzke, Executive Director
North Pacific Fishery Management Council
605 W 4th Avenue, Suite 306
Anchorage, AK 99501

RECEIVED
JUN - 2 1998
N.P.F.M.C

VIA FAX

Dear Mr. Pautzke:

Thank you for the opportunity to comment on the proposed amendments to the various fisheries management plans for the Alaska region to be considered at the Council's meeting in Dutch Harbor, June 10-15. The Alaska Forest Association is aware that these recommendations are an effort to address the Essential Fish Habitat language that was added to the re-authorized Magnuson-Stevens Act, and AFA is concerned about the effect these proposed amendments could have on non-fishing interests. AFA is also concerned that the proposals are flawed because they are overly inclusive and have been developed with little or no input from affected parties outside the fishing industry.

AFA is the trade association for the forest products industry in Alaska. The Association represents nearly 300 member companies doing business in Alaska's timber industry, and therefore has a substantial interest in management decisions that affect activities on upland territories and coastal areas of the state. AFA has been involved in the EFH issue for many months, and has participated by submitting written comments to the National Marine Fisheries Service and by meeting with NMFS officials on the subject. AFA has been frustrated to see that very little effort has been made by the agency to address the concerns that it and other affected non-fishing interests have raised during this process.

The final recommendations from NMFS for identification and description of EFH reflects the inappropriate decision to recommend the use of "general distribution" instead of "known concentration" to define EFH. This will likely lead to an overly broad application of EFH standards in deciding what activities may or may not constitute potential harm to EFH. Not only does this have the potential of inflicting unnecessary restrictions on non-fishing activities in or near the designated waters, it clearly allows the designation of EFH to go beyond the intent of Congress when it included EFH in the Act. This is made clear relative to salmon on page 52 of the draft recommendations where it says, "general distribution of salmon in fresh water ***includes virtually all the coastal streams*** to about 70° N latitude" (emphasis added).

Furthermore, the Technical Team recommendations clearly state that "freshwater EFH for the salmon fisheries in Alaska includes ***all*** streams, lakes, ponds, wetlands, and other water bodies ***currently or historically accessible*** to salmon in the State" (emphasis added). The paper goes on to recommend that "all habitats within the jurisdictional boundaries of Alaska ***that are accessible*** to salmon be identified as EFH for salmon."

This is the same as saying that any place a salmon has ever been ***or could have been*** will now be considered ***essential*** habitat. No one in his right mind could possibly believe that Congress intended such a broad definition when it empowered the Councils to identify and protect "essential fish habitat." The Council should reject this overly broad language and insist on a more reasoned definition.

A second area of concern for AFA members is the overly broad assumptions of harms accruing to EFH designated habitats from timber harvest activities. These are identified in the text of the recommendations and in the chart entitled "Summary of Non-fishing Adverse Impacts to Habitat" on page 303. The chart lists 15 alleged "harms," many of which cannot be documented in Alaska.

The allegedly harmful activities include road and stream crossing construction and removal of streamside vegetation. Mixed in with this list of activities are some alleged effects from harvest activities, including "exposed slope erosion," reduction of large woody debris (LWD), introduction of "excessive nutrients," altered stream temperatures, and other effects. The report completely ignores the protections afforded by riparian standards and Best Management Practices mandated by the Tongass Land Management Plan on Federal land, the Alaska Forest Resources and Practices Act on private land, and Alaska Statutes (Titles 38 and 16) for activities on state land managed by the Department of Natural Resources. The report also ignores recent scientific reports that indicate the above mentioned protections are generally working well in protecting fisheries from adverse effects of timber harvest.[1]

In summary, the proposed recommendations are overly broad and are not justified by Congressional intent as embodied in the revised Magnuson-Stevens Act. Furthermore, the effects on non-fishing interests will be disproportionate to any demonstrated harm resulting from their activities, and those interests have not been allowed an appropriate venue to provide information that could temper the effects by modifying the proposed approach. In short, non-fishing interests (such as timber operators) will be adversely affected by the proposed amendments, but have been provided no representation in the development of the amendments. The Council should insist that this inequity be corrected before adopting any of the recommendations of the agency.

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[1] See, for example, Martin, Douglas J. and Morgan E. Robinson, *The Effectiveness of Riparian Buffer Zones for Protection of Salmonid Habitat in Alaska Coastal Streams*, Martin Environmental, May 1, 1998; and Murphy, Michael L., *Forestry Impacts on Freshwater Habitat of Anadromous Salmonids in the Pacific Northwest and Alaska —Requirements for Protection and Restoration*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, October 1995.

Please feel free to contact me if you have need of any additional information relative to these comments.

Sincerely,

Jack E. Phelps
Executive Director

cc: AFA Board of Directors
Senator Ted Stevens
Senator Frank Murkowski
Congressman Don Young
Governor Tony Knowles

Resource Development Council for Alaska, Inc.
121 West Fireweed Lane, Suite 250, Anchorage, Alaska 99503-2035
(907) 276-0700 Fax: (907) 276-3887 e-mail: rdc@aonline.com

April 27, 1998

Cindy Hartmann
National Marine Fisheries Service
Habitat Conservation
Box 21668
Juneau, AK 99802

Dear Ms. Hartmann:

Thank you for the opportunity to submit comments on the Draft Essential Fish Habitat (EFH) recommendations for North Pacific Council fishery management plans.

The Resource Development Council for Alaska, Inc., is a statewide membership-funded organization working on behalf of Alaska's basic industries. RDC's membership also includes sectors which support Alaska industry, such as construction, labor and other technical service providers, individuals, Native corporations and local communities.

RDC's fishing and non-fishing entities have expressed serious concerns with the draft recommendations:

- The recommendations appear to reflect East Coast concerns; applying these recommendations elsewhere, whether they are needed or not, is inappropriate. This issue is definitely not a case of where "one-size fits all." While major impacts have occurred to fish habitat off the East Coast, the situation is quite different in Alaska where fisheries and fish habitat are healthy.

- While the statute focuses on marine fisheries and fishing impacts, the proposed regulations create an all encompassing regulatory program that targets coastal and inland development activities. Adverse effects are presumed from mining, timber harvesting and other activities. Important determinations regarding impacts of upland activities on fish habitat will apparently be made by the Councils and National Marine Fisheries Service. No real means is provided for other industries outside fishing to effectively participate.

Comments from a wide range of affected industries have strongly criticized the proposed rule as redundant, burdensome and overly broad, imposing unnecessary requirements on other federal, state and local agencies and the private sector.
The interim final rule does not include any substantial changes to address the concerns raised by non-fishing entities:

- The rule continues to maintain a very broad "ecosystem" definition of EFH.
- It identifies broad categories of non-fishing activities which can adversely affect EFH to include mining, dredging, impoundment and actions contributing to non-point pollution and sedimentation.
- The rule does not provide for any voting representation for non-fishing interests on Councils.

Numerous comments on the interim final rule from a broad range of non-fishing entities have expressed continued dissatisfaction over the unauthorized and needlessly broad scope and complexity of the regulations, and the resulting huge direct and indirect costs associated with the NMFS approach.

RDC believes the final rule will likely cause confusion and blurring of responsibilities. The result will be added cost and problems for affected agencies and an undue regulatory or monetary burden on the regulated community.

The final rule should be drastically reduced in scope and set well-defined areas of authority and responsibility to avoid conflicts, confusion and duplication of efforts between numerous federal and state agencies engaged in regulatory functions in the submerged offshore, shore or nearshore environments. Actions dictated by the final rule must be more clearly defined to not encroach on the jurisdiction of the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, Army Corps of Engineers, the U.S. Forest Service and other agencies.

It is not clear as to what measures the NMFS intends to use to persuade or force another agency to accept its recommendations. While NMFS has stated that the law only gives it a "consultation role," there is concern that disputes could potentially result in delays, added costs and legal action.

RDC fears that current draft recommendations for EFH changes to Council fishery management plans reflect the defects in the regulations. The draft recommendations for the North Pacific Council salmon plan in particular reflect an approach to identifying EFH and activities which may affect it that is far too broad to be useful or cost effective.

To preclude conflicts of authority, duplicative regulation and other unnecessary cost and confusion, regulations and the identification of EFH in Council fishery management plans should be restricted to offshore fishery areas currently under the purview of the NMFS.

Thank you for the opportunity to comment.

Sincerely,

RESOURCE DEVELOPMENT COUNCIL
for Alaska, Inc.

Carl Portman
Deputy Director

** TOTAL PAGE.003 **

AGENDA C-2
JUNE 1998
Supplemental

Alaska Marine Conservation Council
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voice (907) 277-5357; fax (907) 277-5975; email: amcc@alaska.net

June 2, 1998

Richard Lauber, Chair
North Pacific Fishery Management Council
605 West 4th Ave., Suite 306
Anchorage, AK 99501

RE: Agenda Item C-2 – Essential Fish Habitat (EFH) EA/RIR; NMFS-Alaska Region EFH recommendation

Dear Mr. Lauber:

The Alaska Marine Conservation Council appreciates this opportunity to comment on the EFH EA/RIR, and the Alaska Region EFH recommendations. The work that has been done to date is a fine start for this process and we commend the core team for its effort. However, this work is clearly not done. Our comments are primarily directed at the gaps in this process with an eye toward what appear to be the next logical steps in working to satisfy the EFH mandate of the Magnuson-Stevens Act. It is important to note that this new habitat program will be a long-term, iterative process.

NMFS-Alaska Region EFH recommendations

While we are pleased to have the Region acknowledge that all habitat is important, AMCC is quite discouraged by the recommendation that "*all habitat within a general distribution for a species life stage would be deemed EFH.. This area is a subset of a species' range.*" For practical management purposes, this is the logical equivalent of concluding that *no* habitat is essential. This recommendation effectively paralyzes habitat protection efforts by failing to rank, prioritize, or even identify truly "essential" habitat areas as intended by Congress. Thus, the next steps the core team, or some other assigned working group, should take in satisfying this mandate should be to address this significant shortcoming.

EFH EA/RIR

The most important remaining steps for the core team are (1) to conduct a higher level of analyses to identify Habitat Areas of Particular Concern within EFH and (2) to consider, recommend, or propose habitat protection needs for both fishing and non-fishing impacts as well as cumulative impacts.

Habitat Areas of Particular Concern (HAPC). The EA/RIR identifies three *types* of HAPC. Unfortunately, it seems as if this aspect of the analysis suffers from the same problem as the general distribution EFH recommendation. These three *types* of HAPC appear to cover everything along the entire coast. More work is needed to refine this aspect of the new habitat program. Specifically, this work should be designed to help managers determine what specific areas are of particular concern, and what steps, if any, may be needed to protect and conserve these areas.

Some next logical steps in analyzing HAPC could be:

•Insuring these three *types* are the only habitat *types* that need to be identified as HAPC in Alaska;

• Nominating specific *areas or places* where these types of HAPC are found - and specifying which HAPC criteria from the interim rule each place satisfies;

• If, in fact, these HAPC do indeed cover the entire coast, apply the complementary criteria (from the EA/RIR) or some other appropriate criteria (See, Langton et al. 1996. "The Interface Between Fisheries Research and Habitat Management," North American Journal of Fisheries Management, v16, no.1, pp.1-7) to further refine, rank, or prioritize areas for management purposes;

• Visually overlay or describe active and potential threats (fishing, non-fishing, cumulative) to the specific areas nominated as HAPC ;

• Visually overlay or describe existing protective measures to identify gaps in protection of these specific HAPC areas;

• Make specific recommendations of measures which could be analyzed to protect these specific HAPC areas;

• Request proposals from the public on -- (a) nominating places as HAPC, and (b) measures to protect these specific areas, or HAPC in general.

A higher level of analysis along these lines, or as designed by the core team, is absolutely essential as the next EFH stage. Previously, the BSAI groundfish FMP has listed four *areas* as HAPC on the grounds that these areas could be described as particularly rich in groundfish (See attached). The GOA groundfish FMP describes no areas as HAPC. Thus, if the Council wishes to include these BSAI areas in the EFH amendment as HAPC, the team could begin an evaluation of the extent to which these areas are threatened and the extent to which they are already protected to determine if additional measures need be considered. It seems highly unlikely that these four areas are all that constitutes HAPC in the BSAI, and it should be noted that these areas were principally selected simply because they are rich in groundfish while areas can be classified as HAPC for a variety of other important reasons (e.g. ecological function, sensitivity, rarity).

Habitat Protection. The EA/RIR states that "at this time, the need for other protective measures...was not demonstrated from a review of the best scientific information available during the development of the EFH FMP" (Sec. 1.5, page 26). This is a misleading statement that could confuse people into thinking that nothing further is needed to protect marine habitat when in fact the statement actually means that the level of analysis needed to make such a determination was not conducted during the development of the EFH FMP. This statement also does not seem to be rationally supported when considered against the "general distribution" EFH recommendation and the paucity of analysis on HAPC. The statement should be rephrased to more accurately convey the message that more work is needed on evaluating existing habitat protection measures to determine if they are sufficient. Insuring appropriate habitat protection is, after all, the reason this work is being conducted in the first place.

Cumulative Impacts Analysis. The EA/RIR includes practically no analysis of this subject at all. The core team should prepare a cumulative impacts analysis to help the public understand the cumulative and synergistic effects of multiple threats to EFH and to effectively guide management actions. Whatever information may already exist in the SAFE reports and the Ecosystem Considerations document, it has been compiled for a different purpose and likely does not put the pieces together as envisioned in a cumulative impacts analysis. The intent of this aspect of the EFH program is to combine those types of scattered information and assess cumulative impacts on habitat to help managers make more precautionary decisions to protect habitat that appears to be unharmed only when considered on a single threat by threat basis.

Review/Update of the EFH Components of FMPs: Given the significant work remaining on the questions of HAPC and habitat protection, AMCC supports the EA/RIR recommendation to review and update EFH information as part of the annual Stock Assessment and Fishery Evaluation (SAFE) Report (page 27, EA/RIR). Specifically, the Council should direct the core team, or other staff as desired and needed, to focus on a more detailed HAPC assessment (as suggested above) and a more rigorous evaluation of existing habitat protection measures to determine their adequacy based on improved information and identification of HAPC. Updates on this work could be reported periodically with an eye toward having something meaningful accomplished for inclusion in the 1999 SAFE report.

Thank you for your consideration of our habitat concerns.

Sincerely,

Steve Ganey
Project Coordinator

BSAI Groundfish FMP, January 1995, NPFMC

9.9 Habitat Areas of Particular Concern

With the possible exception of the ice-covered surface layer of the shelf during winter, there is not an area of the Bering Sea, water depth, or time of year when one or several species of commercial importance are not present at some life stage. It is difficult without better information to designate particular habitats that can be spatially and temporally defined as holding substantially more important resource values than other areas.

Adults of most of the commercially important groundfish species are known to form dense aggregations on feeding or spawning grounds at certain seasons. Most often these concentrations are found on or inside of the shelf edge in spring and early summer when and where suitable environmental conditions have formed. However, these areas shift in size and location from year to year, presumably due to a combination of environmental and population variables that are not yet well understood. For example, feeding pollock concentrations have been found to be primarily located in outer shelf waters in years when the bottom water of the middle shelf domain remained cold, but extended onto the middle shelf in warm years (Lynde, 1984).

Eggs and larvae of the groundfish species are usually more widely distributed spatially than the adults, but may be confined to a specific range of water depths. Some species such as walleye pollock lay buoyant eggs that float to the sea surface; sablefish larvae move to the surface layer during development; other species such as Atka mackerel and rock sole lay demersal eggs that sink or adhere to the bottom.

In a general way, the following areas (among others) of the Bering Sea and Aleutians can be described as particularly rich in groundfish:

- The shelf edge from Unimak Pass northwest toward the Pribilof Islands contains abundant schools of walleye pollock and Pacific cod.

- The seabed of the middle shelf of outer Bristol Bay contains dense spawning and feeding aggregations of yellowfin sole.

- Submarine canyons along the continental slope of the Bering Sea and Aleutian Islands harbor dense concentrations of Pacific ocean perch and other rockfish species.

- Atka mackerel spawning occurs on certain restricted shelf areas with suitable (rocky) bottom characteristics, and may be particularly concentrated in the western Aleutians, such as the strait between Atka and Amlia Islands.

Significant increases in knowledge of the habitat requirements of the groundfish species are yet to be made. With this additional understanding, it may be possible to develop a finer definition of habitat areas of particular concern and a better ability to manage single and multispecies fishery resources.

Alaska Marine Conservation Council

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June 2, 1998

Richard Lauber, Chair
North Pacific Fishery Management Council
605 West 4th Ave., Suite 306
Anchorage, AK 99501

RE: Agenda Item C-2; Addendum to AMCC EFH comments

Note: The GOA FMP currently does list Habitat areas of particular interest, Sec. 5.1.4.

5.1.4 Habitat areas of particular interest

Although there is good general knowledge of the fishery resources of the Gulf of Alaska, and locations of major concentrations of many finfish and shellfish can be broadly mapped, knowledge of this region is by no means complete. Spatial and temporal changes in distribution and abundance of these resources occur and and are poorly known, both offshore and in the nearshore areas. Adjacent bays may be very dissimilar from each other and very few coastal inlets have been even superficially studied. For example, four bays on the east side of Kodiak Island that were recently studied showed significant differences in their fish and shellfish communities from bay to bay, and by depth of habitat. Important seasonal changes were also observed.

Few fisheries investigations have been conducted beyond the continental shelf of the Gulf of Alaska. Much of what is known is derived from periodic NMFS exploratory surveys and from catch statistics gathered by NMFS observers aboard foreign fishing vessels, and is primarily focused on the shelf and upper slope. The biota of the lower slope, seamounts, and the ocean basins is poorly known.

It is difficult without better information to designate the particular habitats that can be spatially and temporally defined as holding substantially more important resource values than other areas. Adults of many of the commercially important groundfish species are known to form dense aggregations on feeding or spawning grounds at certain seasons. Most often these concentrations are found on the shelf or shelf edge in spring and early summer when and where suitable environmental conditions have formed. However, these areas can shift in size and location from year to year, presumably due to a combination of environmental and population variables that are poorly understood.

Eggs and larvae of the groundfish species are usually more widely distributed spatially than the adults, but may be confined to a specific range of water depths. Walleye pollock lay buoyant eggs that float to the sea surface; other species such as Pacific cod, Atka mackerel, and rock sole lay demersal eggs that sink or adhere to the bottom.

In a general way, the following areas (among others) of the Gulf of Alaska can be described as particularly rich in groundfish:

- The shelf edge in the western Gulf from Kodiak southwest along the Alaska Peninsula contains abundant schools of walleye pollock, Pacific cod, and rockfish.
- The shelf edge and upper slope in the eastern Gulf contain dense aggregations of sablefish. The central Gulf also appears to possess high sablefish concentrations.
- Submarine canyons along the continental slope from southeast Alaska to Kodiak harbor have supported dense concentrations of Pacific ocean perch and other rockfish species.
- The nearshore, extremely uneven rocky areas off southeastern Alaska appear to be a major nursery for juvenile rockfish (ages one to three years old).
- Atka mackerel spawning has occurred in the past on certain restricted shelf areas with suitable bottom characteristics, and may be particularly concentrated in the western Gulf, such as the straits nearby Kodiak Island.
- An isolated population of yellowfin sole inhabits lower Cook Inlet.

Significant increases in knowledge of the habitat requirements of the groundfish species in the Gulf of Alaska are yet to be made. With additional understanding, it may be possible to provide a finer definition of habitat areas of particular concern and a better ability to manage both single and multispecies fishery resources.

AGENDA C-2
JUNE 1998
Supplmental

The Effects of Fishing on Fish Habitat

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ABSTRACT

The Sustainable Fisheries Act of 1996 mandates that regional fishery management Councils designate essential fish habitat (EFH) for each of the species which are managed, assess the effects of fishing on EFH, and develop conservation measures for EFH where needed. This synthesis of effects of fishing on fish habitat was produced to aid the fishery management councils in assessing the impacts of fishing activities. A wide range of studies were reviewed that reported effects of fishing on habitat (i.e., structural habitat components, community structure, and ecosystem processes) for a diversity of habitats and fishing gear types. Commonalities of all studies included immediate effects on species composition and diversity and a reduction in habitat complexity. Studies of acute effects were found to be a good predictor of chronic effects. Recovery after fishing was more variable, depending on habitat type, life history strategy of component species, and the natural disturbance regime. The ultimate goal of gear impact studies should not be to retrospectively analyze environmental impacts but ultimately to develop the ability to predict outcomes of particular management regimes. Synthesizing the results of these studies into predictive numerical models is not currently possible. However, conceptual models are presented which coalesce the patterns found over the range of observations. Conceptual models can be used to predict effects of gear impacts within the framework of current ecological theory. Initially, it is useful to consider fishes' use of habitats along a gradient of habitat complexity and environmental variability. A model is presented of gear impacts on a range of seafloor types and is based on changes in the structural habitat values. Disturbance theory provides the framework for predicting effects of habitat change based on spatial patterns of disturbance. Alternative community state models, and type 1-type 2 disturbance patterns, may be used to predict the general outcome of habitat management. Primary data are lacking on the spatial extent of fishing induced disturbance, the effects of specific gear types along a gradient of fishing effort, and the linkages between habitat characteristics and the population dynamics of fishes. Adaptive and precautionary management practices will therefore be required until empirical data becomes available for validating model predictions.

"Habitat alteration by the fishing activities themselves is perhaps the least understood of the important environmental effects of fishing."

Committee on Fisheries, Ocean Studies Board, National Research Council (1994)

INTRODUCTION

Stationary fishing gear (e.g., traps, gillnets, and longlines) and small scale mobile gear (i.e., beam trawls and shellfish dredges) towed from sailing vessels were used in the nineteenth century to harvest living marine resources. The widespread use of mobile fishing gear beyond near shore regions, and the use of larger vessels for all gear types, became possible only after the development of motorized propulsion and the steam capstan and winch. This widespread and critical change in fishing technology began in England with the launch of the steam trawler BERTA in the late 1800s. Fishing effort, and the range of technologies which support the industry, has increased greatly during the last century. For a wide number of harvested species, catch per unit effort has greatly decreased, and the populations of those species have also declined (FAO 1997). Many species are targeted throughout their geographic range and the wide array of harvesting systems (e.g., traps, gillnets, longlines, trawls, scallop dredges, hydraulic clam dredges) allow fishing to occur over the widest range of habitat types.

A lack of understanding the ecological consequences of the effects of removals of fish, and the direct effects of fishing and fishing gear on community and ecosystem functions, has produced questions about the sustainability of current levels of fishing. The number of reviews on this topic which have been produced during the past decade is perhaps the best indicator of this concern (Dayton et al. 1995; Hutchings 1990; ICES 1988, 1992, 1996; Jasperse 1992; Jennings and Kaiser 1998; Jones 1992; Langton 1994; Messieh et al. 1991; National Research Council 1994, 1995; Roberts 1995). In the United States, the need for information leading to predictive capabilities and precautionary approaches on this topic will only increase as a result of the legal requirement to manage essential fish habitat (Auster et al. 1997a; Langton et al. 1996).

The Sustainable Fisheries Act of 1996 requires the regional Fishery Management Councils and the National Marine Fisheries Service (NMFS) to identify and designate essential fish habitat (EFH) for each managed species, identify adverse impacts to EFH (including those caused by fishing activities), and develop actions to conserve and enhance EFH. The Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". For the purpose of interpreting the definition (and for defining the scope of this report) "waters" is interpreted by NMFS as "aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate" and "substrate" is defined to include sediment, hard bottom, structures, and associated biological communities. These definitions provide substantial flexibility in defining EFH based on our knowledge of the different species, but also allows EFH to be interpreted within a broader ecosystem perspective. Disturbance has been defined as "any discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Pickett and White 1985). Disturbance can be caused by many natural processes such as currents, predation, and iceberg scour (Hall, 1994). Human caused disturbance can result from activities such as harbor dredging and fishing with fixed and mobile gear. Disturbance can be gauged by both intensity (as a measure of the force of disturbance) and severity (as a measure of impact on the biotic community). Table 1 summarizes the relative effects of the range of agents which produce disturbances in marine communities. From an ecological perspective, fishing is the most widespread form of direct disturbance in marine systems below depths which are affected by storms (Watling and Norse MS1997).

One of the most difficult aspects of estimating the extent of fishing impacts on habitat is the lack of high resolution data on the distribution of fishing effort. Fishers are often resistant to reporting effort based on locations of individual tows or sets (for the obvious reason of divulging productive locations to competitors and regulators). Effort data in many fisheries are therefore apportioned to particular statistical areas for monitoring purposes. Using this type of data it has been possible to obtain averages of effort, and subsequent extrapolations of area impacted, for larger regions. For eight of the most heavily fished areas in the southern North Sea, for example, Rijnsdorp et al. (1996) estimated that between 1993 and 1996 a mean of 51% of the area was trawled 1-5 times per year, 33% was trawled less than once per year, and 4% was trawled 10-50 times per year. Trawling effort in the Middle Atlantic Bight off the northeast U.S. was summarized by Churchill (1989). Trawled area estimates were extrapolated from fishing effort data in 30' latitude x 30' longitude blocks. The range of effort was quite variable but the percent area impacted in some blocks off southern New England was over 200% with one block reaching 413%. Estimating the spatial impact of fixed gears is even more problematic. For example, during 1996 there were 2,690,856 lobster traps fished in the State of Maine (Maine Department of Marine Resources, unpublished data). These traps were hauled on average every 4.5 d, or 81.4 times $year^{-1}$. Assuming a 1 m^2 footprint for each trap, the area impacted was 219 km^2. If each trap was dragged across an area three times the footprint during set and recovery, the area impacted was 657 km^2. A lack of data on the extent of the area actually disturbed makes analysis of the impacts of fishing on habitat in those fisheries difficult.

The overall impact of fishing on the North American continental shelf is unknown despite research efforts in the United States spanning nearly 80 years. Alexander et al. (1914) reported that the effect of trawling on the bottom was negligible and stated that "otter trawls do not seriously disturb the bottom over which they are fished nor materially denude it of organisms which directly or indirectly serve as food for commercial fishes". Their conclusion was based on data from the catches, discounting the lack of data on organisms that passed through the trawl meshes. They also attributed shifts in species composition and abundance only to harvesting by the fishery with no connection to changes in habitat structure or the benthic community. This conclusion is not surprising given the state of ecological knowledge at the time (Auster 1988). Many more studies, using a wide range of gear types, have been conducted since that time at locations around the world.

Herein we summarize and interpret the current scientific literature on fishing impacts as they relate to fish habitat. We discuss these studies within three broad subject areas: effects on structural components of habitat, effects on benthic community structure, and effects on ecosystem level processes. The interpretation is based on commonalities and differences between studies. Fishing gear types are discussed as general categories (e.g., trawls, dredges, fixed gear). The necessity for these generalizations is based on two over-riding issues: (1) many studies do not specify the exact type and configuration of fishing gear used, and (2) each study reports on a limited range of habitat types. We recognize that individual units of fishing effort with different gears will produce a gradient of results (e.g., a scallop dredge or beam trawl will produce a greater force on the seafloor than a small whiting trawl, tickler chains will produce a different effect than rock-hopper or "street-sweeper" gear on the groundline of a trawl, king crab pots are larger and heavier than pots used for American lobster). However, our interpretation of the wide range of studies is based on the type and direction of impacts, not absolute levels of impacts. We do not address the issues of bycatch (Alverson et al. 1994), mortality of gear escapees (Chopin and Arimoto 1995), or ghost fishing gear (Jennings and Kaiser 1998, p. 11-12 and references therein) as these issues do not directly relate to fish habitat and recent reviews have been published which address these subjects.

EFFECTS ON STRUCTURAL COMPONENTS OF HABITAT

Interpretation of Results

The environmental characteristics which define species distributions can be found at a variety of spatial and temporal scales (e.g., Langton et al. 1995). At regional scales, the seasonal variations in seawater temperature can explain annual variations in the distribution of fishes (e.g., Murawski 1993). Within regions, temporally stable associations of species have been found and tend to follow isotherms and isobaths (Colvocoresses & Musick 1984, Overholtz & Tyler 1985, Phoel 1986, Gabriel 1992, Gabriel and Tyler 1980). Species groups are sometimes seasonal and may split or show changes in composition that correlate with temperature patterns. Nested within regional scale patterns are small-scale variations in abundance and distribution of demersal fishes which can be partially attributed to variation in topographic structure. In contrast, habitat associations for coral reef fishes, kelp bed fishes, seagrass fishes, and rock reef fishes are relatively clear (e.g., Ebeling and Hixon 1991, Heck and Orth 1980, Sale 1991). The entire demersal stage of the life history of many species associated with these unique habitats have obligate habitat requirements or demonstrate recruitment bottlenecks. Without the specific structural components of habitat, the populations of fishes with these habitat requirements would not persist. However, a gradient of habitat dependence can be found in the range of demersal fish species globally. For example, early benthic phase Atlantic cod require cobble or similar complex bottom for survival but have a refuge in size, and habitat associations are more facultative as size increases (Gotceitas and Brown 1993, Lough et al. 1989, Tupper and Boutilier 1995). Other species, however, have facultative habitat associations throughout their life (e.g., Able et al. 1995, Auster et al. 1991, 1995, 1997b, Langton et al. 1995, Sogard and Able 1991, Szedlmayer and Howe 1997). These associations may increase survivorship of individuals, and may contribute to wide variations in recruitment, but they are not obligate for the survival of populations (e.g., Lindholm et al. 1998).

Habitat has been defined as "the structural component of the environment that attracts organisms and serves as a center of biological activity" (Peters & Cross 1992). Habitat in this case includes the range of sediment types (i.e., mud through boulders), bed forms (e.g., sand waves and ripples, flat mud) as well as the co-occurring biological structures (e.g., shell, burrows, sponges, seagrass, macroalgae, coral). A review of 22 studies (Table 2) all show measurable impacts of mobile gear on the structural components of habitat (e.g., sand waves, emergent epifauna, sponges, coral), when defining habitat at this spatial scale. Results of each of the studies show similar classes of impacts despite the wide geographic range of the studies (i.e., tropical to boreal). In summary, mobile fishing gear reduced habitat complexity by: (1) directly removing epifauna or damaging epifauna leading to mortality, (2) smoothing sedimentary bedforms and reducing bottom roughness, and (3) removing taxa which produce structure (i.e., taxa which produce burrows and pits). Studies which have addressed both acute and chronic impacts have shown the same types of effects.

Little has been written about the recovery of seafloor habitat from fishing gear effects. Recovery of storm caused sedimentary features depends primarily on grain sizes of sediment and depth to which storm generated surge and currents occur. Some features can be reformed after seasonal or annual storm events while others will depend on larger meteorological events which occur on decadal time scales or longer. Recovery of biogenic features will depend on recruitment or immigration, depending on the spatial extent of impacts. Recovery will also depend on whether impacts are short term or chronic. For example, on coral-sponge hard bottom off the coast of Georgia, Van Dolah et al. (1987) found no long-term effects of trawling on the benthic community. After one year the sponge and octocorals that were experimentally trawled recovered with densities reaching or exceeding pretrawling levels at the study site. However, it is important to note that this study did not address chronic effects but a single tow of a roller-rigged trawl.

Few published accounts of the impacts of fixed gears on habitat have been written. Eno et al. (1996) studied the effects of crustacean traps in British and Irish waters. One experiment assessed the effects of setting and hauling pots on emergent epifaunal species (i.e., sea pens) on soft bottom. Both impacts from dragging pots across the bottom, and pots resting for extended periods on sea pens, showed the group was able to mostly recover from such disturbances. Limited qualitative observations of fish traps, longlines, and gillnets dragged across the seafloor during set and recovery showed results similar to mobile gear such that some types of epibenthos was dislodged; especially emergent species such as erect sponge and coral (High 1992, SAFMC 1991). While the area impacted per unit of effort is smaller for fixed gear than with mobile fishing gear, the types of damage to emergent benthos appear to be similar (but not necessarily equivalent per unit effort). Quantitative studies of fixed gear effects, based on acute and chronic impacts, have not been conducted.

The issue of defining pelagic habitats and elucidating effects of fishing is difficult because these habitats are poorly described at the scales that allow for measurements of change based on gear use. While pelagic habitat can be defined based on temperature, light intensity, turbidity, oxygen concentration, currents, frontal boundaries, and a host of other oceanographic parameters and patterns, there are few published data that attempt to measure change in any of these types of parameters or conditions concurrently with fishing activity and associations of fishes. Kroger and Guthrie (1972) showed that menhaden (*Brevortia patronus* and *B. tyrannus*) were subjected to greater predation pressure, at least from visual predators, in clear versus turbid water, suggesting that turbid habitats were a greater refuge from predation. This same type of pattern was found for menhaden in both naturally turbid waters and in the turbid plumes generated by oyster shell dredging activities (Harper and Hopkins 1976). However, no work has been published that addresses the effects of variation in time and space of the plumes or the effects using turbid water refugia on feeding and growth. There are also examples of small scale aggregations of fishes with biologic structures in the water column and at the surface. Aggregations of fishes may have two effects on predation patterns by: (1) reducing the probability of predation on individuals within the aggregation, and (2) providing a focal point for the activities of predators (a cue that fishermen use to set gear). For example, small fishes aggregate under mats of *Sargassum* (e.g., Moser et al. 1998) where high density vessel traffic may dis-aggregate mats. Also, fishes have been observed to co-occur with aggregations of gelatinous zooplankton and pelagic crustaceans (Auster et al. 1992, Brodeur in press). Gelatinous zooplankton are greatly impacted as they pass through the mesh of either mobile or stationary gear (unpublished observations), which may reduce the size and number of aggregations and disperse associated fishes. These changes could reduce the value of aggregating, resulting in increased mortality or reduced feeding efficiency.

Implications for Management

Commonalties in gear impact studies on habitat structure allow for the production of a conceptual model to visualize the patterns in gear impacts across a gradient of habitat types. Auster et al. (1998) developed a hierarchical, categorical, approach for classifying habitats on the cold temperate/boreal continental shelf of the northwest Atlantic. This type of classification scheme has proven very useful in habitat management for freshwater fisheries. The range of habitat types were condensed into eight habitat categories increasing from simple to complex (Table 3). For example, currents form sand wave fields which provide shelter for fish from high current speeds. This reduces the energy needed to maintain position on the bottom and permits ambush predation of drifting demersal zooplankton. Storm currents sort loose sediments and deposit shells and cobbles in the troughs of sand waves; the small crevices providing an ephemeral habitat for small fishes and crustaceans. Cobble bottoms provide interstices for shelter sites but also provide a hard surface for epibenthic organisms such as sponges and bryozoans to attach. These emergent epifauna provide additional cover value. Scattered boulders also provide shelter from currents but boulder piles provide deep crevices for shelter required by some species such as redfish (*Sebastes* spp.).

Habitat value for each habitat type does not increase linearly. Each category was assigned a numerical score based on its level of physical complexity (note that this model does not include effects of fishing on biodiversity per se). Categories 1 through 5 increase linearly. Staring at category 6, the score of 10 is based on a score of 5 (i.e., the score for cobble) from the previous category plus 5 for dense emergent epifauna which was assumed to double the cover value of small interstices alone. Category 7 is scored for cobble and emergent epifauna (i.e., 10) plus 2 more points for shallow boulder crevices and refuges from current. Finally, category 8 is scored as 15 because of the presence of shallow crevices and current refuges, previously scored as 12, plus deep crevices scored as 3. These scores are therefore the starting points representing unimpacted habitats.

A pictorial representation of the model, shown in Figure 1, indicates the response of the range of seafloor habitat types to increases in fishing effort (Auster MS1997). The range of fishing effort increases from left to right along the x axis with 0 indicating no gear impacts and 4 indicating the maximum effort required to produce the greatest possible change in habitat complexity. The numbers at present are dimensionless because better data are needed on the effects of various gear types, at various levels of effort, over specific habitats. The y axis is a comparative index of habitat complexity. Each habitat type starts at the value of the habitat in an unimpacted condition. The habitat categories are representative of the common types found across the northeast U.S. continental shelf and are likely to be found on most other continental shelf areas of the world. The responses to different types of bottom contact fishing gear are assumed to be similar.

This model shows a range of changes in habitat complexity based on gear impacts. It predicts reductions in the complexity provided by bedforms from direct smoothing by the gear. Biogenic structures are reduced by a number of mechanisms such as direct gear impacts as well as removal of organisms which produce structures (eg. crabs that produce burrows). There are some habitats where the model shows no significant reductions, such as gravel areas with very little epifaunal settlement. While mobile gear would overturn pebbles and cobbles, the actual structural integrity of the habitat would not be reduced (although organisms on the undersides of cobbles are exposed to predation). However, the value of cobble pavements are greatly reduced when epifauna are removed, as biogenic structures provides additional cover. Gear can move boulders and still provide some measure of hydraulic complexity to the bottom by providing shelter from currents. On the other hand, piles of boulders can be dispersed by large trawls and this reduces the cover value for crevice dwellers. The model should be widely applicable as the habitat types are widely distributed worldwide and the impacts are consistent with those described in the literature.

This conceptual model serves two purposes. First, it provides a holistic summary of the range of gear impacts across a range of habitat types. The end points in the model are based on empirical data and observations and should be useful for considering management actions for the conservation of fish habitat. The second purpose for developing the model is to provide a basis for future research. While it is possible to ascribe the endpoints of habitat complexity at both unimpacted and fully impacted states, the slope of the line remains unknown and the level of fishing effort required to produce specific rates of change is also unknown for all gear types. Responses may be linear or non-linear (e.g., logarithmic). Perhaps there are thresholds of disturbance beyond which some habitat types exhibit a response. Regardless, responses will most likely be habitat specific.

The impact model does not have an explicit time component. Here we add such a conceptual framework to the discussion. Cushing's match-mismatch hypothesis (Cushing 1975) has served as one of several hypotheses which explain annual variation in larval recruitment dynamics and has been the focus of large amounts of research effort for several decades. Here we propose a similar type of match-mismatch paradigm for linking variation in the survivorship of early benthic phase fishes with the abundance epibenthic organisms, particularly those with annual life histories, which may serve as habitat. Figure 2 shows the pattern in percent cover for an idealized benthic species which produces emergent structure (e.g., hydroid stalk, amphipod tube, mussel). This type of species has widespread settlement and occurs at high densities. At the time of settlement, large areas of the seafloor are occupied by this species. Over the course of time, predation and senesence reduce the cover provided by such taxa. The timing of settlement of early benthic phase fish will greatly effect the cover value provided by the benthic taxa. In addition to natural processes, fishing gear impacts further reduce the cover value over time and can narrow the window in which particular patches of epibenthos serve as effective cover for newly settled fishes. The time scale (x-axis) and patterns in the figure were developed to show an annual pattern representative of many taxa with such life history strategies, but this pattern can also be extended in time for longer-lived organisms. Like the conceptual impact model above, the timing and changes in slope of these lines is critical for understanding the dynamics of this interaction.

Ultimately, it will be necessary to develop models which include sensitivity indices for specific habitats, communities, and key taxa based on the effects of specific gear types, levels of effort, and life history patterns (of both fish and taxa which serve a habitat function). MacDonald et al. (1996) has developed such a sensitivity index to quantify the impact of fishing on particular epifaunal taxa in the North Sea region. The index is a function of recovery time after damage, fragility of the animal and intensity of the impact.

Lack of information on the small scale distribution and timing of fishing make it difficult to ascribe the patterns of impacts observed in field studies to specific levels of fishing effort. Auster et al. (1996) estimated that between 1976 and 1991, Georges Bank was impacted by mobile gear (i.e., otter trawl, roller-rigged trawl, scallop dredge) on average between 200-400% of its area on an annual basis and the Gulf of Maine was impacted 100% annually. Fishing effort was however not homogeneous. Sea sampling data from NMFS observer coverage demonstrated that the distribution of tows was nonrandom (Fig. 3). While these data represent less than 5% of overall fishing effort, they illustrated that the distribution of fishing gear impacts is quite variable.

Recovery of the habitat following trawling is difficult to predict as well. Timing, severity, and frequency of the impacts all interact to mediate processes which lead to recovery (Watling and Norse MS1997). For example, sand waves may not be reformed until storm energy is sufficient to produce bedform transport of coarse sand grains (Valentine and Schmuck 1995) and storms may not be common until a particular time of year or may infrequently reach a particular depth, perhaps only on decadal time scales. Sponges are particularly sensitive to disturbance because they recruit aperiodically and are slow growing in deeper waters (Reiswig 1973, Witman and Sebens 1985, Witman et al. 1993). However, many species such as hydroids and ampelescid amphipods reproduce once or twice annually and their stalks and tubes provide cover for the early benthic phases of many fish species and their prey (e.g., Auster et al. 1996, 1997b). Where fishing effort is constrained within particular fishing grounds, and where data on fishing effort is available, studies which compare similar sites along a gradient of effort, have produced the types of information on effort-impact that will be required for effective habitat management (e.g., Collie et al. 1996, 1997; Thrush et al. in press).

The role these impacts on habitat have on harvested populations is unknown in most cases. However, a growing body of empirical observations and modeling demonstrate that effects can be seen in population responses at particular population levels. For example, Lindholm et al. (1998) have modeled the effects of habitat alteration on the survival of 0-year cohorts of Atlantic cod. The model results indicate that a reduction in habitat complexity has measurable effects on population dynamics when the adult stock is at low levels (i.e., when spawning and larval survivorship does not produce sufficient recruits to saturate available habitats). At high adult population levels, when larval abundance may be high and settling juveniles would greatly exceed habitat availability, predation effects would not be mediated by habitat and no effect in the response of the adult population to habitat change was found.

Empirical studies that most directly link changes due to gear impacts on habitat structure to population responses are being carried out in Australia. Sainsbury (1987,1988, 1991) and Sainsbury et al. (in press) have shown a very tight coupling between a loss of emergent epifauna and fish productivity along the north west continental shelf. In these studies there was a documented decline in the bycatch of invertebrate epifauna in trawl catches, from 500 kg hr^{-1} to only a few kg hr^{-1}, and replacement of the most commercially desirable fish associated with the epifaunal communities by less valuable species associated with more open habitat. By restricting fishing the decline in the fish population was reversed. This corresponded to an observed recovery in the epifaunal community, albeit the recovery for the larger epifaunal invertebrates showed a considerable lag time after trawling ceased. This work is based on a management framework which was developed to test hypotheses regarding the habitat dependence of harvested species. The hypotheses, described in Sainsbury (1988, 1991), assessed whether population responses were the result of: (1) independent single-species (intraspecific) responses to fishing and natural variation, (2) interspecific interactions such that as specific populations are reduced by fishing, non-harvested populations experienced a competitive release, (3) interspecific interactions such that as non-harvested species increase from some external process, their population inhibits the population growth rate of the harvested species, and (4) habitat mediation of the carrying capacity for each species, such that gear induced habitat changes alter the carrying capacity of the area. This is a primary example of adaptive management in which regulations were developed to test hypotheses and were the basis for modifying subsequent management measures. This type of management process exemplifies management of fisheries based primarily on an understanding of ecological relationships.

EFFECTS ON COMMUNITY STRUCTURE

Interpretation of Results

Studies on the effects of fishing on benthic communities have often produced variable results regarding the impact on community structure. The reasons for these differences may include sampling strategies, use of different metrics, different methods of fishing, different functional groups of species which compose the community, and subtle differences in habitat type. Furthermore, studies have often been conducted in areas that have a history of fishing activity and therefore may not have truly undisturbed reference areas for comparison, despite the efforts of the investigator (see Hall et al. 1993, Kaiser MS1997). Changes in benthic community structure also have to be understood against a background of natural disturbance and variability (Thrush et al., in press). Bearing in mind these caveats, the literature on fishing gear impacts can be divided into short term and long term studies that reveal some common characteristics and patterns resulting from fishing on the seafloor.

An immediate reduction in the density of non-target species is often reported following impacts from mobile gear (Table 4). In assessing this effect it is common to compare numbers and densities for each species before and after fishing and/or with an undisturbed reference site. Kaiser and Spencer (1996a), for example, found a reduction in diversity and abundance of some taxa at one location in the Irish Sea where sediments were relatively stable. They reported a 58% decrease in mean abundance and 50% reduction in the mean number of species per sample. In contrast, at a location where the sediments were more mobile the impact of beam trawling was not as substantial. In other European studies, Bergman and Hup (1992) and Santbrink and Bergman (1994) have documented species and size specific differences in macrofaunal abundance and mortality, with densities decreasing for some species, and mortality increasing, after trawling but in other cases there were no observable effects. In a scallop dredging study in New Zealand two experimentally fished sites showed an immediate decrease in macrofaunal densities in comparison to corresponding reference sites (Thrush et al. 1995). In another study of scallop dredging in Australia, Currie and Parry (1994) found that the number of individuals at the dredged sites was always lower than the reference sites despite an overall increase in animal numbers, over the 88 day study, because of amphipod recruitment to both the experimental and reference areas.

Time series data sets that allow for a direct long term comparison of before and after fishing are essentially nonexistent, primarily because the extent to which the worlds oceans are currently fished was not foreseen, or because time series data collection focused on the fish themselves rather than the impact of fishing on the environment. Nevertheless, there are several benthic data sets that allow for an examination of observational or correlative comparisons before and after fishing (Table 5). Perhaps the longest time series comparisons of long-term impact of fishing on benthic community structure are the studies of Reise (1982) and Riesen and Reise (1982) in the Wadden Sea. In reviewing change for 101 species in the benthic community over 100 years Reise (1982) noted no long-term trends in abundance for 42 common species but found 11 of these species showed considerable variation. Sponges, coelenterates and bivalves suffered the greatest losses while polychaetes showed the biggest gains. Subtidally there was a decrease in the most common species from 53 to 44 while intertidally the opposite was observed, an increase from 24 to 38. Riesen and Reise (1982) examined a 55 year data set and documented increases in mussel beds and the associated fauna. They noted a loss of oysters, due to overexploitation, and *Sabellaria* reefs, because they were systematically targeted by trawlers, as well as the loss of seagrass from disease. In another European study, Pearson et al. (1985) compared changes in the Kattegatt following a 73 year hiatus in sampling. In this case, community composition had changed to the extent that there was only a 30% similarity between stations over time, with the primary shift being a decrease in sea urchins and an increase in brittle stars. They observed a general decline in deposit feeders and an increase in suspension feeders and carnivores as well as a decline in animal size. Holme (1983) also made some comparisons from data collected over an 85 year time span in the English Channel and noted changes in the benthic community which he speculated might relate to the queen scallop fishery. The results of these long term studies are consistent with the patterns found in short term studies of habitat and community structure.

Data sets on the order of months to a few years are more typical of the longer term studies on fishing impacts on benthic community structure. The impact of experimental trawling has been monitored over a series of months, for example, in the Bay of Fundy at a high energy sandy site (Brylinsky et al. 1994, Watling et al. MS1997). Trawl door marks were visible for 2 to 7 months but no sustained significant impact on the benthic community was noted. However, Watling et al. (MS1997) measured community level changes caused by scallop dredging at a lower energy muddy sand location in the Gulf of Maine. There was a loss in surficial sediments and lowered food quality of the sediments. The subsequent variable recovery of the benthic community over the following six months correlated with the sedimentary food quality which was measured as microbial populations, abundance of chlorophyll *a* and enzyme hydrolizable amino acid concentrations. While some taxa recolonized the impacted areas quickly, the abundances of some taxa (i.e., cumaceans, phoxocephalid and photid amphipods, nephtyid polychaetes) did not recover until food quality also recovered.

The most consistent pattern in fishing impact studies at shallow depths is the resilience of the benthic community to fishing. Two studies in the intertidal, harvesting worms and clams using suction and mechanical harvesting gear, demonstrated a substantial immediate effect on the macrofaunal community but from seven months to two years later the study sites had recovered to pre-fished conditions (Beukema 1995, Kaiser and Spencer 1996a). At nearshore subtidal depths, harvesting bay scallops in a North Carolina seagrass bed and razor clams in a Scottish sea loch, Peterson et al. (1987) and Hall et al. (1990) found little long term impact on the benthic community structure except at the most intense level of fishing. After 40 days, the loch showed no effect of fishing and in the lightly harvested seagrass bed, with <25% seagrass biomass removal, recovery occurred within a year. In the seagrass bed where harvesting was most extensive, with 65% of the seagrass biomass removed, recovery was delayed for two years and after four years preharvesting biomass levels were still not obtained. In a South Carolina estuary, Van Dolah et al. (1991) found no long term effects of trawling on the benthic community. The study site was assessed prior to and after the commercial shrimp season and demonstrated variation over time but no trawling effects *per se*. Other studies of pre and post impacts from mobile gear on sandy to hard bottoms have generally shown similar results (Currie and Parry 1996, Gibbs et al. 1980, MacKenzie 1982) with either no or minimal long term impact detectable.

Other benthic communities show clear effects which can be related to fishng. Collie et al. (1997) has, for example, characterized disturbed and undisturbed sites on Georges Bank, based on fishing records, and found more individuals, a greater biomass and greater species richness and diversity in the undisturbed areas. Engel and Kvitek (MS 1997) also found more fish and epifaunal invertebrates in a lightly trawled area compared to a more heavily trawled site over a three year period off Monterey, California. Perhaps the most convincing cases of fishing related impacts on the benthic community are from studies in Northern Ireland, Australia, and New Zealand. Brown (1989) has reported the demise of the horse mussel community in Strangford Loch with the development of the queen scallop fishery. The horse mussel beds were essentially unchanged from 1857 until 1980 when the trawl fishery for scallops was initiated. Along the northwest Australian shelf Bradstock and Gordon (1983) and Sainsbury (1987, 1988, 1991) and Sainsbury et al. (in press) describe a habitat dependent fishery with fish biomass being related to the coral-like byrozoan community. With the demise of this epifaunal community there was a shift in fish species composition to less commercially desirable species. In experimentally closed areas there has been a recovery of fish and an increase in the small benthos but, based on settlement and growth of larger epifaunal animals, it may take 15 years for the system to recover. Finally, sampling of fishing grounds along a gradient of fishing effort in the Hauraki Gulf of New Zealand has shown that 15-20% of the variability in the macrofauna community could be attributed to fishing (Thrush et al. in press). As fishing effort decreased there were increases in the density of large epifauna, long-lived surface dwellers (with a decrease in deposit feeders and small opportunistic species), and in the Shannon-Weiner diversity index. These results validated most predictions made from small scale studies, suggesting that there is value in continuing such work. However, where data are available to determine patterns of fishing effort at the scale of fishing grounds, large scale studies such as this are beneficial for validating predictions from limited experimental work and, most importantly, establishing the range of ecological effects along a gradient of disturbance (i.e., produced by resource extraction and variable intensity of impacts from particular harvesting methods. Ultimately, such data can be used to develop strategies for the sustainable harvest of target species while maintaining ecosystem integrity.

Implications for Management

Clearly the long term effects of fishing on benthic community structure are not easily characterized. The pattern that does appear to be emerging from the available literature is that communities that are subject to variable environments and are dominated by short-lived species are fairly resilient. Depending on the intensity and frequency of fishing, the impact of such activity may well fall within the range of natural perturbations. In communities which are dominated by long-lived species in more stable environments the impact of fishing can be substantial and longer term. In cases such as described for Strangford Loch and the Australian shelf, recovery from trawling will be on the order of decades. In many areas, these patterns correlate with shallow and deep environments. However, water depth is not the single variable that can be used to characterize fishing impacts. There are few studies that describe fishing impacts on shallow mud bottom communities or deep areas at the edge of the continental shelf. Such sites would be expected to be relatively low energy zones, similar to areas in Strangford Loch, and might not recover rapidly from fishing disturbances. Studies in these relatively stable environments are required to pattern fishing impacts over the entire environmental range but, in anticipation of such results, it is suggested here that one should expect a tighter coupling between fish production and benthic community structure in the more stable marine environments.

EFFECTS ON ECOSYSTEM PROCESSES

Interpretation of Results

A number of studies indicate that fishing has measurable effects on ecosystem processes, but it is important to compare these with natural process rates at appropriate scales. Both primary production and nutrient regeneration have been shown to be effected by fishing gear. These studies are small in scope and it is difficult to apply small-scale studies at the level of entire ecosystems. Understanding that processes are affected confirms the need to understand the relative changes in vital rates caused by fishing and the spatial extent of the disturbances.

Disturbance by fishing gear in relatively shallow depths (i.e., 30-40 m depth) can reduce primary production by benthic microalgae. Recent studies in several shallow continental shelf habitats have shown that primary production by a distinct benthic microflora can be a significant portion of overall primary production (i.e., water column plus benthic primary production; Cahoon and Cooke, 1992; Cahoon et al., 1990; 1993). Benthic microalgal production supports a variety of consumers, including demersal zooplankton (animals that spend part of each day on or in the sediment and migrate regularly into the water; Cahoon and Tronzo, 1992). Demersal zooplankton include harpacticoid copepods, amphipods, mysids, cumaceans, and other animals that are eaten by planktivorous fishes and soft bottom foragers (Thomas and Cahoon, 1993).

The effects of fishing were elucidated at Stellwagen Bank in the northwest Atlantic during 1991 and 1994. Measurements showed that a productive benthic microflora exists on the crest of the Bank (Cahoon et al., 1993; Cahoon et al., unpubl. data) but demersal zooplankton was low in comparison to the other shelf habitats and lower than would be expected given the available food supply (Cahoon et al.1995). Several explanations can be advanced for this anomalously low abundance. These include competitive or predatory interactions with meiofauna or the holozooplankton, disturbance by macrobenthos, intense predation by planktivorous fishes, and physical disturbance by mobile fishing gear. Many demersal zooplankters appear to construct and/or inhabit small burrows or capsules made of accreted or agglutinated sand. These formations provide shelter for demersal zooplankters in a habitat otherwise devoid of structure. Many small biogenic structures were observed on the sediment surface and even gentle handling by divers destroyed them easily. Movement by divers and an ROV caused demersal zooplankters to exhibit escape responses. Events that disturb the bottom, particularly such relatively powerful events as storms and towing mobile fishing gear along the sediment surface, must destroy these delicate habitat features. Disturbance of demersal zooplankters may result in increased predation which reduces local populations of zooplankters. Juvenile fish that feed on these taxa may require greater times and longer distances away from benthic shelter sites to forage in the water column in order to capture prey, exposing themselves to greater predation risk (Walters and Juanes 1993).

Recovery rates of populations of benthic primary producers are not well known. Brylinski et al. (1994) showed that trawling had significant effects on benthic diatoms, but recovery occurred at all stations after about 30 days. The experimental sites which were trawled were in the intertidal in the Bay of Fundy. Trawling occurred during high tides and sampling at low tide. It is important to note that light intensity (and spectral composition) in this experiment are much greater than at sites where trawling normally occurs; where seawater constantly overlays the substrate.

Experimental measurements from scallop dredge and otter trawl impacts off coastal Maine showed that dragging can both resuspend and bury labile organic matter (Mayer et al. 1991). Burial shifts the decomposition and availability from aerobic eucaryotic-microbial pathways to anerobic pathways. Short term effects may include shifts from metazoan communities which support harvested species (e.g., meiofauna-polychaetes-flounders) toward anerobic microbial respiration. Studies by Watling et al. (MS1997) empirically demonstrate these short term trends. Longer term effects of chronic dragging and burial are difficult to predict.

Reimann and Hoffmann (1991) measured the short term effects of mussel dredging and bottom trawling off Denmark in a shallow coastal marine system. Dredging and trawling increased suspended particulates immediately to 1361% and 960-1000% respectively, above background. Oxygen decreased and nutrients such as amminia and silicate increased. Dyekjaer et al. (1995) calculated the annual effects of mussel dredging in the same region. The total annual release of suspended particles during dredging is relatively minor when compared with total wind-induced resuspension. Similarly, the release of nutrients is minor when compared with the nutrient loading from land runoff. However, local effects may be significant when near bottom dissolved oxygen concentrations are low and reduced substances are resuspended, depending upon the depth of stratification, water flow rates, and the number of dredges operating simultaneously.

Direct movement of fishing gear over and through the sediment surface can change sediment grain size characteristics, change suspended load, and change the magnitude of sediment transport processes. Churchill (1989) showed that trawling could resuspend sediments on the same magnitude as storms and can be the primary factor regulating sediment transport over the outer continental shelf in areas where storm related currents and bottom stresses are weak. Gear induced resuspension of sediments can potentially have important impacts on nutrient cycling (Pilskaln et al. MS1997). Open continental shelf environments typically receive approximately half of their nutrients for primary production from sediment resuspension and pore water exchange. The nutrients are produced from the microbial based decay of organic matter and remineralization within sediments. Changes in rates of resuspension from periodic to steady pulses of nutrients (e.g., nitrate fluxes), caused by gear disturbance to the seafloor, can shift phytoplankton populations from picoplankton towards diatoms which may ultimately be beneficial for production of harvested species, while changes in nutrient ratios may stimulate harmful algal blooms.

Implications for Management

The disturbances caused by fishing to benthic primary production and organic matter dynamics are difficult to predict. Semi-closed systems such as bays, estuaries, and fjords are subject to such effects at relatively small spatial scales. Open coastal and outer continental shelf systems can also experience perturbations in these processes. However, the relative rates of other processes may minimize the effects of such disturbances depending upon the level of fishing effort.

Mayer et al. (1991) discuss the implications of organic matter burial patterns in sediments versus soils. Their results are similar to organic matter patterns found in terrestrial soils. Sediments are essentially part of a burial system while soils are erosional. While gear disturbance can enhance remineralization rates by shifting from surficial fungal dominated communities to subsurface communities with dominant bacterial decomposition processes, burial caused by gear disturbance might also enhance preservation if material is sequestered in anaerobic systems. Given the importance of the carbon cycling in estuaries and on continental shelves to the global carbon budget, understanding the magnitude of effects caused by human disturbances on primary production and organic matter decomposition will require long term studies as have been conducted on land.

DISCUSSION

Direct Alteration of Food Webs

In heavily fished areas of the world it is undebatable that there are ecosystem level effects (Gislason, 1994; Fogarty and Murawski 1998) and that shifts in benthic community structure have occurred. The data to confirm that such shifts have taken place is limited at best (Riesen and Reise, 1982) but the fact that it has been documented at all is highly significant. If the benthic communities change, what are the ecological processes that might bring about such change?

One of these is an enhanced food supply, resulting from trawl damaged animals and discarding both nonharvested species and the offal from fish gutted at sea. The availability of this food source might affect animal behavior and this energy source could influence survival and reproductive success. There are numerous reports of predatory fishes and invertebrate scavengers foraging in trawl tracks after a trawl passes through the area (Medcof and Caddy 1971, Caddy 1973, Kaiser and Spencer 1994, Ramsey et al. 1997a, b). The prey available to scavengers is a function of the ability of animals to survive the capture process, either being discarded as unwanted by-catch or having been passed through or over by the gear (Meyer et al. 1981, Fonds 1994, Rumhor et al. 1994, Santbrink and Bergman 1994, Kaiser and Spencer 1995). Studies in both the Irish and North Sea on the reaction of scavengers to a trawling event, usually involving beam trawling, are the most comprehensive. In the Irish Sea studies focused on the movement of animals over time into an experimentally trawled areas, at locations that range in sediment type from mud to gravel. Results were found to be habitat dependent (Ramsay et al. 1997a,b) and not always consistent (Kaiser and Ramsay 1997) although the general trends are that the rate of movement of scavengers into a trawled area reflects the mobility of the animals, their sensory abilities and their behavior (Kaiser and Spencer 1996b). Fish were usually the first to arrive and slower moving invertebrates like whelks and starfish, which were also attracted to the area, required a longer time to respond to the availability of damaged or dead prey. That the scavengers are feeding has been documented both by direct diver observations and analysis of stomach contents (see Caddy 1973, Rumhor et al. 1994). Stomach contents data demonstrate that fish not only feed on discarded or damaged animals, and often eat more than their conspecifics at control sites, but they also consume animals that were not damaged but simply displaced by the trawling activity, or even those invertebrates that have themselves responded as scavengers (Kaiser and Spencer 1994, Santbrink and Bergman 1994). Hence the biomass available for consumption from discards and offal are not effecting the community equally but selectively providing additional food resources for those taxa which differentially react to the disturbance created by fishing.

It is of interest to note that Kaiser and Spencer (1994) make the comment, as others have before them, that it is common practice for fishermen to re-fish recently fished areas to take advantage of the aggregations of animals attracted to the disturbed benthic community. The long term effect of opportunistic feeding following fishing disturbances is an area of speculation. In the North Sea, for example, the availability of "extra" food, either from discarded bycatch or as a more direct result of trawling induced mortality, has been suggested as one reason why the population of dab, *Limanda limanda*, has increased. Kaiser and Ramsay (1997) argue that the combination of predator and competitor removal by fishing together with an increased food supply has resulted in the increase in the dab population. Obviously the negative effects on the prey organisms themselves are also important and may have an equal but opposite effect on their density. Faunal changes in the North Sea have been noted with major shifts in the composition of the benthic community that can be correlated with trawling. The general decline in populations of hard bodied animals, such as bivalves and heart urchins, has been suggested to be the direct result of trawl damage with, one might speculate, this food becoming available to scavengers.

Another process that can indirectly alter food webs is alteration of the predator community by removing keystone predators. Removal of herbivorous fishes and invertebrates produced a shift in coral reef communities from coral-invertebrate dominated systems to filamentous and fleshy algae dominated (Roberts 1995 provides a synoptic review). The removal of sea otters from kelp bed communities in the western Pacific has also had cascading effects on urchin populations and the dynamics of kelp (Duggins 1980, Estes 1996). In the northwest Atlantic, Witman and Sebens (1992) showed that onshore-offshore differences in cod and wolffish populations reduced predation pressure on cancrid crabs and other megafauna in deep coastal communities. They suggest that this regional difference in predation pressure is the result of intense harvesting of cod, a keystone predator, with cascading effects on populations of epibenthos (e.g., mussels, barnacles, urchins) which are prey of crabs. American lobsters were also considered a keystone predator by controlling urchin populations, which controlled the distribution of kelp (e.g., Mann and Breen 1972, Mann

1982). Communities shifted from kelp dominated to coralline algae dominated under the influence of intense urchin predation, with concomitant shifts in the mobile species which use such habitats. A hypothesis about this shift in communities focused on the role of lobster removals by fishing, where urchins which are a primary prey of lobsters, had large population increases resulting in greater herbivory on kelp. However, Elner and Vadas (1990) brought the keystone predation hypothesis into question as urchins did not react to lobster predation by forming defensive aggregations and lobster diets were not dominated by urchins. Understanding the ultimate control of such shifts remains elusive but recent harvesting of urchins has coincided with a return of kelp dominated habitats. Other processes (e.g., annual variation in physical processes effecting survivorship of recruits, climate change, El Nino, recruitment variability of component species caused by predator induced mortality) can also result in food web changes and, while it is important to understand the underlying causes of such shifts, precautionary approaches should be considered given the strong inference of human caused effects in the many cases where studies were focused on identifying causes.

Predicting the Effects of Disturbance

This review of the literature indicates that fishing, using a wide range of gear, produces measurable impacts. However, most studies were conducted at small spatial scales and it is difficult to apply such information at a regional levels where predictive capabilities would allow us to manage at an ecosystem scale (Jennings and Kaiser 1998). Studies can be divided into those focused on acute impacts, of a single or a small number of tows, or those which focus on chronic effects. While the former type of study is most common and amenable to experimental manipulation, the latter is the type most directly applicable in the arena of habitat management. Unfortunately, few long term monitoring programs allow for an analysis of all of the appropriate metrics needed to ascertain the effects of fishing on EFH. Additionally, while there are clear effects on local and regional patterns of biodiversity, an obvious metric needed to monitor the effects of ecosystem level management, we do not have a good understanding of how communities respond to large scale disturbances. This level of knowledge is needed to separate the responses of natural versus anthropogenic caused variability.

Our current understanding of ecological processes related to the chronc disurbances caused by fishing make results difficult to predict. Disturbance has been widely demonstrated as a mechanism which shifts communities (Dayton 1971, Pickett and White 1985, Witman 1985, Suchanek 1985). While a full discussion of this area of ecology is beyond the scope of this review, general models produced from such work are useful for understanding fishing as an agent of disturbance in an ecological perspective. Assumptions regarding the role of fishing on the dynamics of marine communities generally assert that the cessation or reduction of fishing will allow populations and communities to recover. That is, recover to a climax community state as is the case in long-lived terrestrial plant communties. Succession of communities implies a predictable progression in species composition and abundance (Connell 1989, Bell et al. 1991). Such knowledge of successional patterns would allow managers to predict future community states and directly manage EFH. While direct successional linkages have been found in some communities, others are less predictable.

Two types of patterns in shifts in communiy states due to disturbance are illustrated in Figure 4. The first model is the traditional successional model where communties change from type A to B to C and so forth. There are empirical examples of this type of succession in soft substrate benthic communties (e.g., Rhoads et al. 1978). Succession is based on one community of organisms producing a set of local environmental conditions (e.g., enriching the sediments with organic material) which make the environment unsuitable for continued survival and recruitment but are favorable for another community of organisms. Disturbance can move the succession back in single or multiple steps, depending on the type of conditions which prevail after the disturbance. The successional stages are predictable based on the conditons which result from the organisms themselves or from conditions after a perturbation. The second type of model is disturbance mediated and lottery based (based on Horn 1976). Empirical studies of such relationships are generally found in hard substrate communities (e.g., Dayton 1971, Horn 1976, Sebens 1986, Witman 1987). Shifts in community type are produced by competition and disturbance (e.g., predation, grazing, storms, fishing gear) that can result in shifts toward community types which are often unpredictable because they are based on the pool of recruits available in the water column at the time that niche space is available.

The spatial extent of disturbed and undisturbed communities is a concern in designing and interpreting studies (Pickett and White 1985, Barry and Dayton 1991, Thrush et al. 1994). Single, widely spaced disturbances may have little overall effect on habitat integrity and benthic communities, and may show reduced recovery times as a result of immigration of mobile taxa (e.g., polychaetes, gastropods). In the ecological literature, this is a type 1 disturbance, where a small patch is disturbed but surrounded by a large unimpacted area. In contrast, type 2 disturbances are those in which small patches of undisturbed communities are surrounded by large areas of disturbed communities. Immigration into such patches requires large scale transport of propagules from outside source patches, or significant reproductive output (and high planktonic survival and larval retention) from the small undisturbed patches. Making predictions about the outcome of disturbances even where spatial extent is known is difficult since transport of colonizers (i.e., larvae, juveniles, and adults) depends on oceanographic conditions, larval period, movement rates of juveniles and adults, time of year, and distance from source. However, as an example of disturbance effects given specific sets of conditions, it is possible to illustrate general trends in the response of biogenic habitat structure to type 1 and 2 disturbances and the population responses based on characteristics of obligate and facultative habitat users (Fig. 5). Type 1 disturbances have recovery rates that are generally faster because they are subject to immigration dominated recovery versus the dependence of larval recruitment for recovery of type 2 disturbances. Population responses to such disturbances are also variable. Obligate habitat users have a much greater response to habitat disturbance such that type 1 disturbances would produce substantial small scale effects but overall population responses would be small. Comparatively, it would be difficult to detect responses from populations of facultative habitat users because of large areas of undisturbed habitat. However, type 2 disturbances would produce large responses in obligate habitat users such that a large percentage of required habitat would be effected. Facultative habitat users would have a measurable response at population levels where habitat mediated processes are important.

The dependence of fish communities on particular habitat features is well represented in the literature on coral reef, kelp forest, and seagrass fish communities (e.g., Sale 1991, Ebeling and Hixon 1991, Heck and Orth 1980). Studies at this particular scale are generally lacking for most harvested taxa on outer continental shelves. One problem in interpreting existing studies is that we tend to compartmentalize the processes which structure these communities and not apply our general knowledge of habitat mediated processes to other fish assemblages using other habitats. In reality, fish assemblages occur in a continuum along two gradients; one of habitat complexity and the other of environmental variation (Fig. 6). Only limited numbers of species, and communities, have hard (limited) linkages between parts of the food web where gear impacts on prey communities would have obvious and easily measurable effects. Large temperate and boreal marine ecosystems are characterized by soft (flexible) linkages with most species having flexible prey requirements. Measuring effects which can be linked to changes in prey availability, and ultimately back to effects of fishing gear will be challenging in these situations. New molecular and stable isotope techniques offer the possibility for better tracking of trophic transfer of carbon and labeling of the role of particular prey taxa in secondary and tertiary production. The same can be said for effects of structural habitat change. It is difficult to detect signal changes because variability in populations are the cumulative result of many factors. Small scale field studies producing information on the patterns of survivorship and predator-prey interactions in particular habitats, laboratory tests to determine relative differences in habitat mediated survivorship under constant predator-prey densities, and numerical modeling to link the small scale approaches with population level responses provides the bridge to link small scale studies to large scale patterns.

Further Considerations for Management

Fishing is one of the most widespread human impacts to the marine environment. The removal of fish for human consumption from the world's oceans has effects not only on the target species but also on associated communities. The size specific, and species specific, removal of fish can change the system structure but, fortunately, the regions of the continental shelf which are normally fished appear to be fairly resilient. The difficulty for managers is defining the level of resilience, in the practical sense of time/area closures or mesh regulations or overall effort limits, that will allow for the harvest of selected species without causing human induced alterations of ecosystem structure to the point that recovery is unduly retarded or community and ecosystem support services are shifted to an alternate state (Steele 1996). Natural variability forms a backdrop against which managers must make such decisions and, unfortunately, natural variability can be both substantial and unpredictable. The above discussion on the impact of fishing on marine communities does not address the role of natural variability directly but it is apparent that in many of the systems studied there is an inherent resistance to biological change. In the very long term one can expect natural variability to generate regime shifts but the challenge for natural resource managers is not to precipitate these shifts prematurely or in unintended directions.

Much of the research described herein is not at a scale that directly relates to effects on fish populations and therefore does not link directly to fishery management decisions. The research on fishing gear impacts does offer an indication of the types and direction of changes in benthic communities over large spatial scales as well as confirmation that benthic communities are dynamic and will ultimately compensate for perturbations. However, as observations show, shifts in communities are not necessarily beneficial to the harvested species. The scale of fishing is a confounding factor in management because systems are being fished to the point where recovery is delayed so long that the economic consequences are devastating. We are currently seeing this pattern in many U.S. fisheries (and many other fisheries worldwide for that matter). Because our knowledge of ecosystem dynamics is still rather rudimentary managers bear the responsibility of adopting a precautionary approach when considering the environmental consequences of fishing rather than assuming that the extraction of fish has no ecological price and therefore no feedback loop to our non-ecologically based economic system.

This review has revealed that primary information is lacking for us to strategically manage fishing impacts on EFH without invoking precautionary measures. A number of areas where primary data are lacking, which would allow better monitoring and improved experimentation ultimately leading to improved predictive capabilities, are:

1. **The spatial extent of fishing induced disturbance.** While many observer programs collect data at the scale of single tows or sets, fisheries reporting systems often lack this level of spatial resolution. The available data makes it difficult to make observations, along a gradient of fishing effort, in order to assess the effects of fishing effort on habitat, community, and ecosystem level processes.

2. **The effects of specific gear types, along a gradient of effort, on specific habitat types.** These data are the first order needs to allow an assessment of how much effort produces a measurable level of change in structural habitat components and associated communities. Second order data should assess the effects of fishing disturbance in a gradient of type 1 and type 2 disturbance treatments.

3. **The role of seafloor habitats on the population dynamics of fishes.** While there is often good time series data on late-juvenile and adult populations, and larval abundance, there is a general lack of empirical information (except perhaps in coral reef, kelp bed, and seagrass fishes) on linkages between habitat and survival, which would allow modeling and experimentation to predict outcomes of various levels of disturbance.

These data and research results should allow managers to better strategically regulate where, when, and how much fishing will be sustainable in regards to EFH. Conservation engineering should play a large role in developing fishing gears which are both economical to operate and minimize impacts to environmental support functions.

The ultimate goal of research on fishing impacts is not to retrospectively evaluate what fishing does to the environment but to predict cause and effect given a particular management protocol. This requires the application of the conceptual models introduced in this discussion to actual management decisions and, at the same time, increasing our understanding of ecological mechanisms and processes at the level of the fish populations and associated communities. This demands, in particular, an appreciation of the importance of both the intensity and frequency of fishing impacts. Fishing should be conducted with an intensity that does not create isolated patches of communities whose progeny are required to recolonize an impacted area, if the objective is maintenance of habitat integrity. Similarly the habitat requirements of the harvested species must be taken into account to insure that harvesting strategies do not disturb habitats more frequently than is required to balance economic as well as ecological sustainability.

ACKNOWLEDGMENTS

This review and synthesis was funded, in part, by a contract from the American Fisheries Society with funds from the National Fish and Wildlife Foundation. In addition, PJA was supported with funds from the National Undersea Research Program and Stellwagen Bank National Marine Sanctuary. RWL was supported with funds from The Sport Fish Restoration Act and the State of Maine. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of it's subagencies.

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Table 1. Comparisons of intensity and severity of various sources of physical disturbance to the seafloor (based on Hall 1994, Watling and Norse MS1997). Intensity is a measure of the force of physical disturbance and severity is the impact on the benthic community.

Source	Intensity	Severity
ABIOTIC		
Waves	Low during long temporal periods but high during storm events (to 70-80 m depth)	Low over long temporal periods since taxa adapted to these events but high locally depending on storm behavior
Currents	Low since bed shear normally lower than critical velocities for large volume and rapid sediment movement	Low since benthic stages rarely lost due to currents
Iceberg Scour	High locally since scouring results in significant sediment movement but low regionally	High locally due to high mortality of animals but low regionally
BIOTIC		
Bioturbation	Low since sediment movement rates are small	Low since infauna have time to repair tubes and burrows
Predation	Low on a regional scale but high locally due to patchy foraging	Low on a regional scale but high locally due to small spatial scales of high mortality
HUMAN		
Dredging	Low on a regional scale but high locally due to large volumes of sediment removal	Low on a regional scale but high locally due to high mortality of animals
Land Alteration (Causing silt laden runoff)	Low since sediment laden runoff per se does not exert a strong physical force	Low on a regional scale but high locally where siltation over coarser sediments causes shifts in associated communities
Fishing	High due to region wide fishing effort	High due to region wide disturbance of most types of habitat

Table 2. Studies of the impacts of fishing gear on the structural components of fish habitat.

Habitat	Gear Type	Location	Results	Reference(s)
Eelgrass	Scallop dredge	North Carolina	Comparison of reference quadrats with treatments of 15 and 30 dredgings in hard sand and soft mud substrates within eelgrass meadows. Eelgrass biomass was significantly greater in hard sand than soft mud sites. Increased dredging resulted in significant reductions in eelgrass biomass and number of shoots.	Fonesca et al. (1984)
Eelgrass and shoalgrass	Clam rake and "clam kicking"	North Carolina	Comparison of effect of two fishing methods. Raking and "light" clam kicking treatments, biomass of seagrass was reduced approximately 25% below reference sites but recovered within one year. In "intense" clam kicking treatments, biomass of seagrass declined approximately 65% below reference sites. Recovery did not begin until more than 2 years after impact and biomass was still 35% below the level predicted from controls to show no effect.	Peterson et al. (1987)
Eelgrass and shoalgrass	Clam rakes (pea digger and bull rake)	North Carolina	Compared impacts of two clam rake types on removal of seagrass biomass. The bull rake removed 89% of shoots and 83% of roots and rhizomes in a completely raked 1 m2 area. The pea digger removed 55% of shoots and 37% of roots and rhizomes.	Peterson et al. (1983)
Seagrass	Trawl	western Mediter-ranean	Noted loss of *Posidonia* meadows due to trawling; 45% of study area. Monitored recovery of the meadows after installing artificial reefs to stop trawling. After 3 years plant density has increased by a factor of 6.	Guillen et al. (1994)
Sponge-coral hard-bottom	Roller-rigged trawl	off Georgia coast	Assessed effect of single tow. Damage to all species of sponge and coral observed; 31.7% of sponges, 30.4% of stony corals, and 3.9% of octocorals. Only density of barrel sponges (*Cliona* spp.) significantly reduced. Percent of stony coral damage high because of low abundance. Damage to other sponges, octocorals, and hard corals varied but chnages in density not significantly different. No significant differences between trawled and reference sites after 12 months.	Van Dolah et al. (1987)
Sponge-coral hard-bottom	roller-frame shrimp trawl	Biscayne Bay, Florida	Damage to approximately 50% of sponges, 80% of stony corals, and 38% of soft corals.	Tilmant (1979) (cited in Van Dolah et al. 1987)

Habitat	Gear Type	Location	Results	Reference(s)
Various tropical emergent benthos	Trawl	North West Shelf, Australia	Catch rates of all fish and large and small benthos show that in closed areas fish and small benthos abundance increased over 5 years while large benthos (>25 cm) stayed the same or increased slightly. In trawled areas all groups of animals declined. Found that settlement rate and growth to 25 cm was on the order of 15 years for the benthos.	Sainsbury et al. (In press)
Gravel pavement	Scallop dredge	Georges Bank	Assessed cumulative impact of fishing. Undredged sites had significantly higher percent cover of the tube-dwelling polychaete *Filograna implexa* and other emergent epifauna than dredged sites. Undredged sites had higher numbers of organisms, biomass, species richness, and species diversity than dredged sites. Undredged sites were characterized by bushy epifauna (bryozoans, hydroids, worm tubes) while dredged sites were dominated by hard-shelled molluscs, crabs, and echinoderms.	Collie et al. (1996, 1997)
Gravel-boulder	Assumed roller-rigged trawl	Gulf of Maine	Comparison of site surveyed in 1987 and revisited in 1993. Initially mud draped boulders and high density patches of divërse sponge fauna. In 1993, evidence of moved boulders, reduced densities of epifauna and extreme trucation of high density patches.	Auster et al. (1996)
Cobble-shell	Assumed trawl and scallop dredge	Gulf of Maine	Comparison of fished site and adjacent closed area. Satistically significant reduction in cover provided by emergent epifauna (e.g., hydroids, bryozoans, sponges, serpulid worms) and sea cucumbers.	Auster et al. (1996)
Gravel	Beam trawl	Irish Sea	An experimental area was towed 10 times. Density of epifauna (e.g., hydroids; soft corals, *Alcyonium digitatum*) was decreased approximately 50%.	Kaiser and Spencer (1996a)
Boulder-Gravel	Roller-rigged trawl	Gulf of Alaska	Comparisons of single tow trawled lane with adjacent reference lane. Significant reductions in density of structural components of habitat (two types of large sponges and anthozoans). No significant differences in densities of a small sponge and mobile invertebrate fauna. 20.1% boulders moved or dragged. 25% of ophiuroids (*Amphiophiura ponderosa*) in trawled lanes were crushed or damaged compared to 2% in reference lanes.	Freese et al. (In prep.)
Gravel over sand	Scallop dredge	Gulf of St. Lawrence	Assessed effects of single tows. Suspended fine sediments and buried gravel below the sediment-water interface. Overturns boulders.	Caddy (1973)

Habitat	Gear Type	Location	Results	Reference(s)
Bryozoan beds (on sand and cobble)	Otter trawl and roller-rigged trawl	New Zealand	Qualitative comparison of closed and open areas. Two bryozoans produce "coral-like" forms and provide shelter for fishes and their prey. Comparisons of fished site with reference sites and prior observations from fishers show reduced density and size of colonies.	Bradstock and Gordon (1983)
Mussel bed	Otter trawl	Strangford Lough, Northern Ireland	Comparison of characteristics of trawled and untrawled *Modiolus modiolus* beds as pre and post impacts of a trawl. Trawled areas, confirmed with sidescan sonar, showed mussel beds disconnected with reductions in attached epibenthos. The most impacted sites were characterized by few or no intact clumps, mostly shell debris, and sparse epifauna. Trawling resulted in a gradient of complexity with flattened regions at the extreme. Immigration of *Nephrops* into areas previously dominated by *Modiolus* may result in burial of new recruits due to burrowing activites; precluding a return to a functional mussel bed habitat.	Magorrian (1995)
Sand-mud	Trawl and scallop dredge	Hauraki Gulf, New Zealand	Comparisons of 18 sites along a gradient of fishing effort (i.e., heavily fished sites through unfished reference sites). A gradient of increasing large epifaunal cover correlated with decreasing fishing effort.	Thrush et al. (In press)
Soft sediment	Scallop dredge	Port Phillip Bay, Australia	Compared reference and experimentally towed sites in BACI designed experiment. Bedforms consisted of cone shaped callianasid mounds and depressions prior to impact. Depressions often contained detached seagrasses and macroalgae. Only dredged plot changed after dredging. Eight days after dredging the area was flattened; mounds were removed and depressions filled. Most callianasids survived and density did not change in 3 mo following dredging. One month post impact, seafloor remained flat and dredge tracks distinguishable. Six months post impact mounds and depressions were present but only at 11 months did the impacted plot return to control plot conditions.	Currie and Parry (1996)
Sand	Beam trawl	North Sea	Observations of effects of gear. As pertains to habitat, trawl removed high numbers of the hydroid *Tubularia.*	DeGroot (1984)
Gravel-sand-mud	Trawl	Monterey Bay	Comparison of heavily trawled (HT) and lightly trawled (LT) sites. The seafloor in the HT area had significantly higher densities of trawl tracks while the LT area had significantly greater densities of rocks >5 cm and mounds. The HT area had shell debris on the surface while the LT area had a cover of flocculent material. Emergent epifauna density was significantly higher for all taxa (anenomes, sea pens, sea whips) in the LT area.	Engel and Kvitek (MS1997)

Habitat	Gear Type	Location	Results	Reference(s)
Sand	Otter trawl	North Sea	Observations of direct effects of gear. Well buried boulders removed and displaced from sediment. Trawl doors smoothed sand waves. Penetrated seabed 0-40 mm (sand and mud).	Bridger (1970, 1972)
Sand-shell	Assumed trawl and scallop dredge	Gulf of Maine	Comparison of fished site and adjacent closed area. Statically significant reduction of habitat complexity based on reduced cover provided by biogenic depressions and sea cucumbers. Observations at another site showed multiple scallop dredge paths resulting in smoothed bedforms. Scallop dredge paths removed cover provided by hydrozoans which reduced local densities of associated shrimp species. Evidence of shell aggregates dispersed by scallop dredge.	Auster et al. (1996)
Sand-silt to mud	Otter trawl with chain sweep and roller gear	Long Island Sound	Diver observations showed doors produced continuous furrows. Chain gear in wing areas disrupted amphipod tube mats and bounced on bottom around mouth of net, leaving small scoured depressions. In areas with drifting macroalgae, the algae drapped over groundgear of net during tows and buffered effects on the seafloor. Roller gear also created scoured depressions. Spacers between discs lessened impacts.	Smith et al. 1985

Table 3. Hierarchical classification of fish habitat types (from Auster et al. MS1997, 1998) on the outer continental shelf of the cold temperate and boreal northwest Atlantic. Categories are based on Auster et al. 1995, Langton et al. 1995, Auster et al. 1996, and unpublished observations).

Category	Description	Rationale	Complexity Score
1	flat sand and mud	areas with no vertical structure such as depressions, ripples, or epifauna	1
2	sand waves	troughs provide shelter from current; previous observations indicate species such as silver hake station keep on the downcurrent sides of sand waves and ambush drifting demersal zooplankton and shrimp	2
3	biogenic structures	burrows, depressions, cerianthid anenomes, hydroid patches; features which are created and/or used by mobile fauna for shelter	3
4	shell aggregates	provide complex interstitial spaces for shelter; as an aside shell aggregates also provide a complex high contrast background which may confuse visual predators	4
5	pebble-cobble	also provides small interstitial spaces and may be equivalent in shelter value to shell aggregate, however shell is a more ephemeral habitat	5
6	pebble-cobble with sponge cover	attached fauna such as sponges provide additional spatial complexity for a wider range of size classes of mobile organisms	10
7	partially buried or dispersed boulders	while not providing small interstitial spaces or deep crevices, partially buried boulders do exhibit high vertical relief; dispersed boulders on cobble pavement provide simple crevices; the shelter value of this type of habitat may be less or greater than previous types based on the size class and behavior of associated species	12
8	piled boulders	provides deep interstitial spaces of variable sizes	15

Table 4. Studies of short-term impacts of fishing on benthic communities.

Taxa	Gear and Sediment Type	Region	Results	Reference(s)
Infauna	beam trawl; megaripples and flat substrate	Irish Sea, U.K.	Assessed at the immediate effects of beam trawling and found a reduction in diversity and abundance of some taxa in the more stable sediments of the northeast sector of their experimental site but could not find similar effects in the more mobile sediments. Out of the top 20 species 19 had lower abundance levels at the fished site and nine showed a statistically significant decrease. Coefficient of variation for numbers and abundance was higher in the fished area of the NW sector supporting the hypothesis that heterogeneity increases with physical disturbance. Measured a 58% decrease in mean abundance and a 50% reduction in the mean number of species per sample in the sector resulting from removal of the most common species. Less dramatic change in the sector where sediments are more mobile.	Kaiser and Spencer (1996a)
Starfish	beam trawl; coarse sand, gravel and shell, muddy sand, mud	Irish Sea, U.K.	Evaluated damage to starfish at three sites in the Irish sea that experienced different degrees of trawling intensity. Used ICES data to select sites and used side scan to confirm trawling intensity. Found a significant correlation between starfish damage (arm regeneration) and trawling intensity.	Kaiser (1996)
Horse mussels	otter trawl; horse mussel beds,	Strangeford Lough; N. Ireland	Used video/rov, side scan and benthic grabs to characterize the effect of otter trawling and scallop dredging on the benthic community. There was special concern over the impact on *Modiolus* beds in the Lough. Plotted the known fishing areas and graded impacts based on a subjective 6 point scale; found significant trawl impacts. Side scan supported video observations and showed areas of greatest impact. Found that in otter trawl areas that the otter boards did the most damage. Side scan suggested that sediment characteristics had changed in heavily trawled areas.	Industrial Science Division. (1990)
Benthic fauna	beam trawl; mobile megarip ple structure and stable uniform sediment	Irish Sea, U.K.	Sampled trawled areas 24 hours after trawling and 6 months later. On stable sediment found siginificant difference immediately after trawling. Reduction in polychaetes but increase in hermit crabs. After six months there was no detectable impact. On megaripple substrate no significant differences were observed immediately after trawling or 6 months later.	Kaiser et al MS 1997

Taxa	Gear and Sediment Type	Region	Results	Reference(s)
Bivalves, sea scallop, surf clams, ocean quahog	scallop dredge, hydraulic clam dredge; various substrate types	Mid-Atlantic Bight, USA	Submersible study of bivalve harvest operations. Scallops harvested on soft sediment (sand or mud) had low dredge induced mortality for uncaught animals (<5%). Culling mortality (discarded bycatch) was low, approx. 10%. Over 90% of the quahogs that were discarded reburrowed and survived whereas 50% of the surf clams died. Predatorsy crabs, starfish, fish and skates, moved in on the quahogs and clams ithe predator density 10 tiems control area levels within 8 hours post dredging. Noted numerous "minute" predators feeding in trawl tracks. Non-harvested animals, snd dollars, crustaceans and worms significantly disrupted but sand dollars suffered little apparent mortality.	Murawski and Serchuck (1989)
Ocean quahog	hydraulic clam dredge;	Long Island, N.Y., USA	Evaluated clam dredge efficiency over a transect and changed up to 24 hours later. After dredge fills it creates a "windrow of clams". Dredge penetrates up to 30 cm and pushes sediment into track shoulders. After 24 hours track looks like a shallow depression. Clams can be cut or crushed by dredge with mortality ranging from 7 to 92 %, being dependent on size and location along dredge path. Smaller clams survive better and are capable of reburrowing in a few minutes.Predators, crabs, starfish and snails, move in rapidly and depart within 24 hours.	Meyer et al. (1981)
Macro-benthos	scallop dredge; coarse sand	Mercury Bay, New Zealan d	Benthic community composed of small short-lived animals at two experimental and adjacent control sites. Sampling before and after dredging and three months later. Dredging caused an immediate decrease in density of common macrofauna. Three months later some populations had not recovered. Immediate post-trawling snails, hermit crabs and starfish were feeding on damaged and exposed animals	Thrush et al. (1995)
Scallops and associated fauna	scallop dredge; "soft sediment"	Port Phillip Bay, Australia	Sampled twice before dredging and three times afterwards, up to 88 days later. The mean difference in species number increased from 3 to 18 after trawling. The total number of individuals increased over the sampling time on both experimental and control primarily as a result of amphipod recruitment, but the number of individuals at the dredged sites were always lower than the control. Dissimilarity increased significantly, as a result of dredging, because of a decrease in species numbers and abundance.	Currie and Parry (1994)
Sea Scallops and associated fauna	otter trawl and scallop dredge; gravel and sand	Gulf of St. Lawrence, Canada	Observed physical change to sea floor from otter doors and scallop dredge and lethal and nonlethal damage to the scallops. Noted an increase in the most active predators within the trawl tracks compared to outside; winter flounder, sculpins and rock crabs. No increase in starfish or other sedentary forms within in an hour of dredging.	Caddy (1973)

Taxa	Gear and Sediment Type	Region	Results	Reference(s)
Macrofauna	beam trawl; hard-sandy substrate	North Sea, coast of Holland	Sampling before and after beam trawling (*hrs, 16 hrs and 2 weeks) showed species specific changes in macrofaunal abundance. Decreasing density ranged from 10 to 65% for species of echinoderms (starfish and sea urchins but not brittle stars), tube dwelling polychaetes and molluscs at the two week sampling period. Density of some animals did not change others increased but these were not significant after 2 weeks.	Bergman and Hup (1992)
Benthic fauna	beam trawl and shrimp trawl; hard sandy bottom, shell debris and sandy-mud	North Sea, German coast	Preliminary report using video and photographs comparing trawled and untrawled areas. Presence and density of brittle stars, hermit crabs, other "large" crustaceans and flatfish was higher in the controls than the beam trawl site. Difference in sand ripple formation in trawled areas was also noted, looking disturbed not round and well developed. Found a positive correlation with damage to benthic animals and individual animal size. Found less impact with the shrimp trawl, diver observations confirmed low level of impact although the net was "festooned" with worms. Noted large megafauna, mainly crabs, in trawl tracks.	Rumhor et al. (1994)
Soft bottom macrofauna	beam trawl; very fine sand	North Sea, Dutch Sector	Compared animal densities before and after trawling and looked at fish stomach contents. Found that total mortality due to trawling varied between species and size class of fish, ranging from 4 to 139% of pretrawling values. (values> 100% indicate animals moving into the trawled area). Mortality for echinoderms was low, 3 to 19%, undetectable for some molluscs, esp. solid shells or small animals, while larger molluscs had a 12 to 85% mortality. Burrowing crustaceans had low mortality but epifaunal crustaceans approximated 30 % but ranged as high as 74%. Annelids were generally unaffected except for Pectinaria, a tube building animal. Generally mortality increased with number of times the area was trawled (once or twice). Dab were found to be the major scavanger, immigrating into the area and eating damaged animals.	Santbrink and Bergman (1994)
Hemit Crabs	beam trawl	Irish Sea, U.K.	Compared the catch and diet of two species of hermit crab on trawled and control sites. Found significant increases in abundance on the trawl lines two to four days after trawling for both species but also no change for one species on one of two dates. Found a general size shift towards larger animals after trawling. Stomach contents weight was higher post-trawling for one species. Diets of the crabs were similar but proportions differed.	Ramsey et al. (1996)

Taxa	Gear and Sediment Type	Region	Results	Reference(s)
Sand macrofauna and infauna	scallop dredge	Irish Sea	Compared experimental treatments based frequency of tows (i.e., 2,4,12,25). Bottom topography changes did not change grain size distribution, organic carbon, or chlorophyll content. Bivalve molluscs and peracarid crustaceans did not show signficant changes in abundance or biomass. Polychaetes and urchins showed significant declines. Large molluscs, crustaceans and sand sand eels were also damaged. In general, there was selective elimination of fragile and sedentary components of the infauna as well as large epifaunal taxa.	Eleftheriou and Robertson (1992)

Table 5. Studies of long-term impacts of fishing on benthic communities.

Habitat Type and Taxa Present	Time Period	Location	Effect	Reference
Sand; macrobenthos and meiofauna	2-7 months	Bay of Fundy	Experimental trawling in high energy area. Otter trawl doors dug up to 5 cm deep and marks were visible for 2 to 7 months. Initial significant effects on benthic diatoms and nematodes but no significant impact on macrofauna. No significant longterm effects.	Brylinsky et al. (1994)
Quartz sand; benthic infauna	5months	South Carolina Estuary	Compared benthic community in two areas, one open to trawling one closed, before and after shrimp season. Found variation with time but no relationship between variations and trawling per se.	Van Dolah et al. (1991)
Sandy; ocean quahogs	----	Western Baltic	Observed otter board damage to bivalves, especially ocean quahogs, and found an inverse relation between shell thickness and damage and a positive correlation between shell length and damage.	Rumhor and Krost (1991)
Subtidal shallows and channel; macrobenthos	100 years	Wadden Sea	Reviewed changes in benthic community documented over 100 years. Considered 101species. No long term trends in changing abundance for 42 common species, with 11 showing considerable variation. Sponges, coelenterates and bivalves suffered greatest losses while polychaetes showed the largest gains. Decrease subtidally for common species from 53 to 44 and increase intertidally from 24 to 38.	Reise (1982)
Intertidal sand; lug worms	4 years	Wadden Sea	Studied impact of lugworm harvesting versus control site. Machine digs 40 cm gullies. Immediate impact is a reduction in several benthic species and slow recovery for some the the larger long-lived species like soft shelled clams. With one exception, a polychaete, the shorter-lived macrobenthic animals showed no decline. It took several years for the area to recover to prefishing conditions.	Beukema (1995)
Various habitat types; all species	---	North Sea	Review of fishing effects on the North Sea based primarily on ICES North Sea Task Force reports. Starfish, sea urchins and several polychaetes showed a 40 to 60 % reduction in density after beam trawling but some less abundant animals showed no change and one polychaete increased. At the scale of the North Sea the effect of trawling on the benthos is unclear.	Gislason (1994)

Habitat Type and Taxa Present	Time Period	Location	Effect	Reference
Sand; macrofauna	73 years	Kattegatt	Compared benthic surveys form 1911-1912 with 1984. Community composition has changed with only approximately 30% similarity between years at most stations. Primary change was a decrease in sea urchins and increase in brittle stars. Animals were also smaller in 1984. Deposit feeders have decreased while suspension feeders and carnivores have increased.	Pearson et al. (1985)
Subtidal shallows and channels; Macrofauna	55 years	Wadden Sea, Germany	Documented increase in mussel beds and associated species such as polychaetes and barnacles when comparing benthic survey data. Noted loss of oyster banks, *Sabellaria* reefs and subtidal sea grass beds. Oysters were overexploited and replaced by mussels; *Zostera* lost to disease. Conclude that major habitat shifts are the result of human influence.	Riesen and Reise (1982)
146 stations; Ocean Quahogs	---	Southern North Sea, Europe	Arctica valves were collected from 146 stations in 1991 and the scars on the valve surface were dated, using internal growth bands, as an indicator of the frequency of beam trawl damage between 1959 and 1991. Numbers of scars varied regionally and temporally and correlated with fishing.	Witbaard and Klein (1994)
Various habitats; Macrofauna	85 years	Western English Channel, UK	Discusses change and causes of change observed in benthic community based on historic records and collections. Discusses effects of fishing gear on dislodging hydroid and bryozoan colonies, and speculates that effects reduce settlement sites for queen scallops.	Holme (1983)
Gravel/sand; Macrofauna	3 years	Central California, USA	Compared heavily trawled area with lightly trawled (closed) area using Smith MacIntyre grab samples and video transect data collected over three years. Trawl tracks and shell debris were more numerous in heavily trawled area, as were amphinomid polychaetes and oligochaetes in most years. Rocks, mounds and flocculent material were more numerous at the lightly trawled station. Commercial fish were more common in the lightly trawled area as were epifaunal invertebrates. No significant differences were found between stations in term of biomass of most other invertebrates.	Engel and Kvitek (MS 1997)
Fine sand; razor clam	----	Barrinha, Southern Portugal	Evaluated disturbance lines in shell matrix of the razor clam and found an increase in number of disturbance lines with length and age of the clams. Sand grains were often incorporated into the shell suggestive of a major disturbance , such as trawling damage, and subsequent recovery and repair of the shell.	Gaspar et al. (1994)
Fine to medium sand; ocean quahogs	----	Southern New Jersey, USA	Compared areas unfished, recently fished and currently fished for ocean quahogs using hydraulic dredges. Sampled invertebrates with a Smith MacIntyre grab. Few significant differences in numbers of individuals or species were noted, no pattern suggesting any relationship to dredging.	MacKenzie (1982)

Habitat Type and Taxa Present	Time Period	Location	Effect	Reference
Gravel, shell debris and fine mud; Horse mussel community	8 years	Strangford Lough, Northern Ireland	Review paper of effects of queen scallop fishery on the horse mussel community. Compared benthic survey from the 1975-80 period with work in 1988. Scallop fishery began in 1980. *Modiolus* community has remained unchanged essentially from 1857 to 1980. The scallop fishery has a large benthic faunal bycatch, including horse mussels. Changes in the horse mussel community are directly related to the initiation of the scallop fishery and there is concern about the extended period it will take for this community to recover.	Brown (1989)
Shallow muddy sand; scallops	6 months	Maine, USA	Sampled site before, immediately after and up to 6 months after trawling. Loss of surficial sediments and lowered food quality of sediments, measured as microbial populations, enzyme hydrolyzable amino acids and chlorophyll *a*, was observed. Variable recovery by benthic community. Correlation with returning fauna and food quality of sediment.	Watling et al. (MS 1997)
Sand and seagrass; hard shelled clams and bay scallops	4 years	North Carolina, USA	Evaluated effects of clam raking and mechanical harvesting on hard clams, bay scallops, macroinvertebrates and seagrass biomass. In sand, harvesting adults showed no clear pattern of effect. With light harvesting seagrass biomass dropped 25% immediately but recovered in a year. In heavy harvesting seagrass biomass fell 65% and recovery did not start for >2 years and did not recover up to 4 years later. Clam harvesting showed no effect on macroinvertebrates. Scallop densities correlated with seagrass biomass.	Peterson et al. (1987)
Gravel pavement; benthic magafauna	Not known	Northern Georges Bank, USA	Used side scan, video and naturalist dredge sampling to characterize disturbed and undisturbed sites based on fishing activity records. Documented a gradient of community structure from deep, undisturbed to shallow disturbed sites. Undisturbed sites had more individual organisms, greater biomass, greater species richness and diversity and were characterized by an abundant bushy epifauna. Disturbed sites were dominated by hard-shelled molluscs, crabs and echinoderms.	Collie et al. (1997)
Sand; epifauna	3 year	Grand Banks, Canada	Experimentally trawled site 12 times each year within 31 to 34 hours for three years. Total invertebrate bycatch biomass declined over the three year study in trawls. Epibenthic sled samples showed lower biomass, averaging 25%, in trawled areas than reference sites. Scavanging crabs were observed in trawl tracks after first 6 hours and trawl damage to brittle stars and sea urchins was noted. No significant effects of trawling were found for four dominant species of mollusc.	Prena et al. (MS 1997)
Sand, shrimp and macrobenthos	7 months	New South Wales, Australia	Sampled macrofauna, pretrawling, after trawling and after commercial shrimp season using Smith McIntyre grab at experimental and control sites. Under water observation of trawl gear were also made. No detectable changes in macrobenthos was found or observed.	Gibbs et al. (1980)

Habitat Type and Taxa Present	Time Period	Location	Effect	Reference
Soft sediment; scallops and associated fauna	17 months	Port Phillip Bay, Australia	Sampled 3 months before trawling and 14 months after trawling. Most species showed a 20 to 30% decrease in abundance immediately after trawling. Dredging effects generally were not detectable following the next recruitment within 6 months but some animals had not returned to the trawling site 14 months post trawling.	Currie and Parry (1996)
Bryozoans; fish and assocaited fauna	----	Tasman Bay, New Zealand	Review of ecology of the coral-like bryozoan community and changes in fishing gear and practices since the 1950s. Points out the interdependence of fish with this benthic community and that the area was closed to fishing in 1980 because gear had developed which could fish in and destroy the benthic community thereby destroying the fishery.	Bradstock and Gordon (1983)
Various habitat types; diverse tropical fauna	5+years, ongoing	North West Shelf, Australia	Describes a habitat dependent fishery and an adaptive management approach to sustaining the fishery. Catch rates of all fish and large and small benthos show that in closed areas fish and small benthos abundance increased over 5 years while large benthos (>25 cm) stayed the same or increased slightly. In trawled areas all groups of animals declined. Found that settlement rate and growth to 25 cm was on the order of 15 years for the benthos.	Sainsbury et al. (In press)
Mudflat; commercial clam cultivation and benthos	7 months	South-east England	Sampled benthic community on a commercial clam culture site and control area at the end of a two year growing period, immediately after sampling, and again 7 months later. Infaunal abundance was greatest under the clam culture protective netting but species composition was similar to controls. Harvesting with a suction dredge changed the sediment characteristics and reduced the numbers of individual animals and species. Seven months later the site had essentially returned to the unharvested condition.	Kaiser et al. (1996a)
Sand; razor clam and benthos	40 days	Loch Gairloch, Scotland	Compared control and experimentally harvested areas using a hydraulic dredge at 1 day and 40 days after dredging. On day one a non-selective reduction in the total numbers of all infaunal species was apparent but no differences were observed after forty days.	Hall et al. (1990)
Sand and muddy areas; Macro-zoobenthos	3years; ongoing	German Bite, Germany	Investigated macrozoobenthos communities around a sunken ship that had been "closed" to fishing for three years. Compared this site with a heavily fished area. Preliminary results show an increase in polychaetes and the bivalve Tellina in the fished, sandy, area. The data does not yet allow for a firm conclusion regarding the unfished area but there is some (nonsignificant) increase in species numbers and some delicate, sensitive species occurred within the protected zone.	Arntz et al. (1994)

Figure Legends

Figure 1. Conceptual fishing gear impact model. The range of fishing effort increases from left to right along the x axis with 0 as a pristine condition and 4 as a maximally impacted state. The y and z axis are based on information in Table 3. The y axis is a comparative index of habitat complexity. The z axis shows the range of habitat categories from simple (bedforms) to complex (piled boulders).

Figure 2. Habitat match-mismatch paradigm which links variation in the survivorship of early benthic phase fishes with abundance of epibenthic organisms. The illustration shows a temporal pattern in percent cover for an "idealized" benthic species with emergent structure (e.g., hydroid, amphipod tubes) under conditions of natural variation (solid line) and when impacted by fishing activities (dotted line). The habitat value of such areas is dependent on the timing of recruitment of fishes in relation to settlement and subsequent mortality of epibenthos from natural and human caused sources. For example, at the time period marked A, settlement into unimpacted benthos provides greater cover for fishes than an area impacted by fishing. However, at the settlement period marked B, recruitment of epibenthos has recently occurred and the cover provided under either state is nearly identical. The settlement period marked C is similar to A, and reflects the dichotomy of natural versus fishing enhanced changes in a dynamic habitat.

Figure 3. Spatial distribution of trawl and scallop dredge tows from NMFS Sea Sampling database for 1989-1994 (April). This illustration represents a total of 14,908 tows. Note that the spatial distribution of effort is not homogeneous but aggregated in productive fishing areas.

Figure 4. Models of alternative community states. Arrows indicate direction of community shifts. A. The successional model which has relatively predictable shifts in community type. B. A lottery based model which has more stochastic, non-linear responses to disturbance.

Figure 5. Comparison of biogenic habitat structure and population responses to type 1 and type 2 forms of habitat disturbance.

Figure 6. Habitat complexity and environmental variability domain of fish assemblages as it relates to obligate and facultative habitat users. Fish assemblages occur in a continuum along the two gradients.

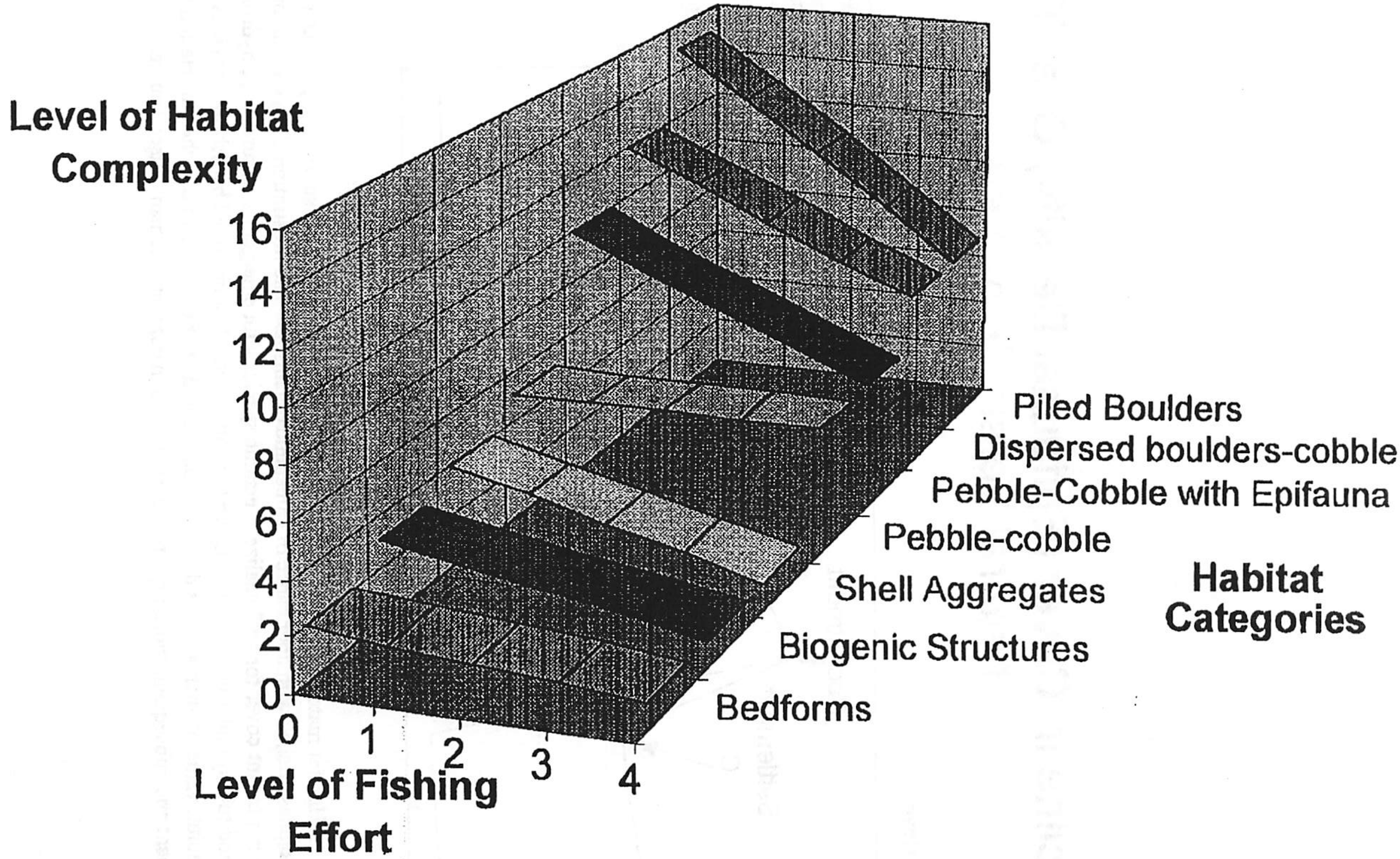
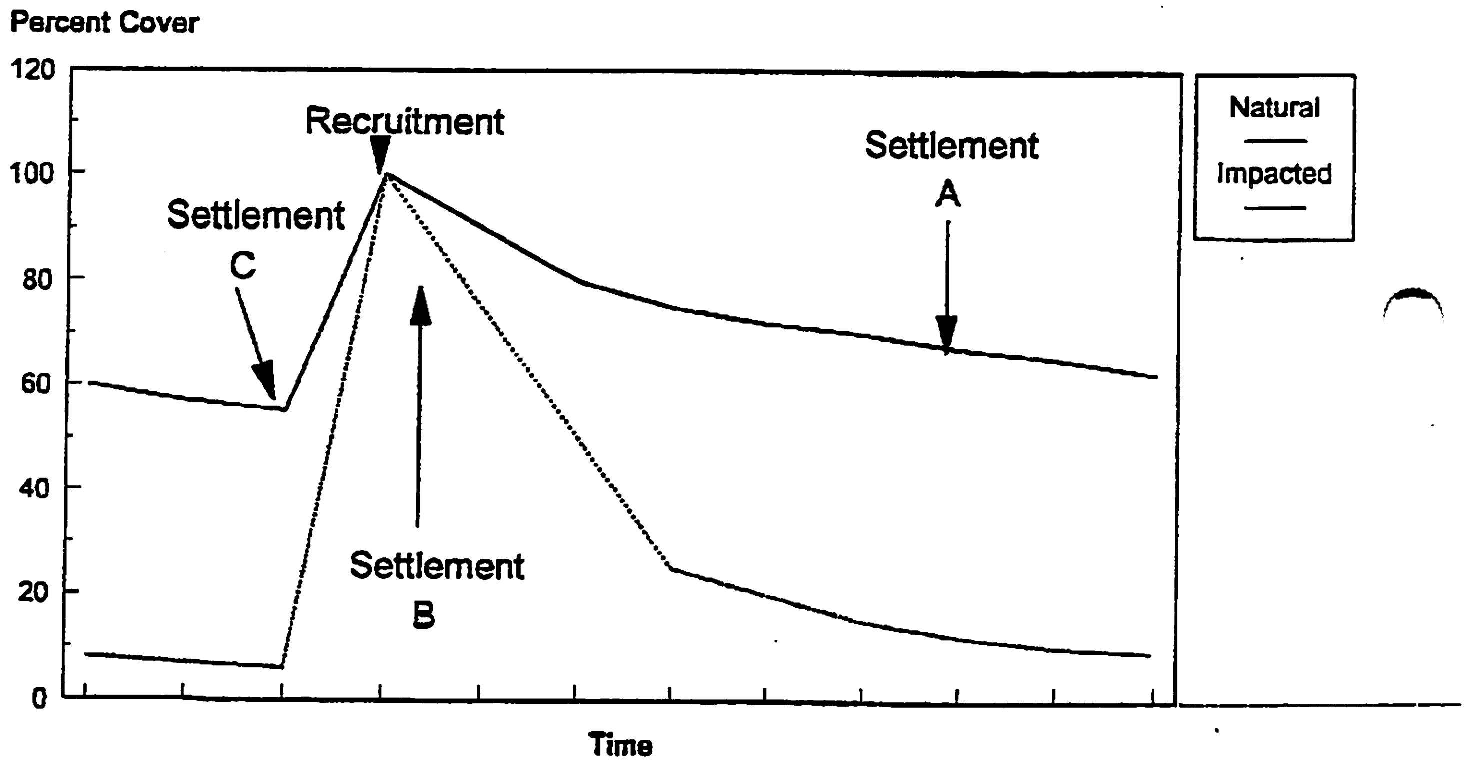


Figure 1. Conceptual fishing gear impact model. The range of fishing effort increases from left to right along the x axis with 0 as a pristine condition and 4 as a maximally impacted state.. The y axis is a comparative index of habitat complexity.

Decline in Cover (Epifaunal Density) Over Time: Natural Versus Impacted



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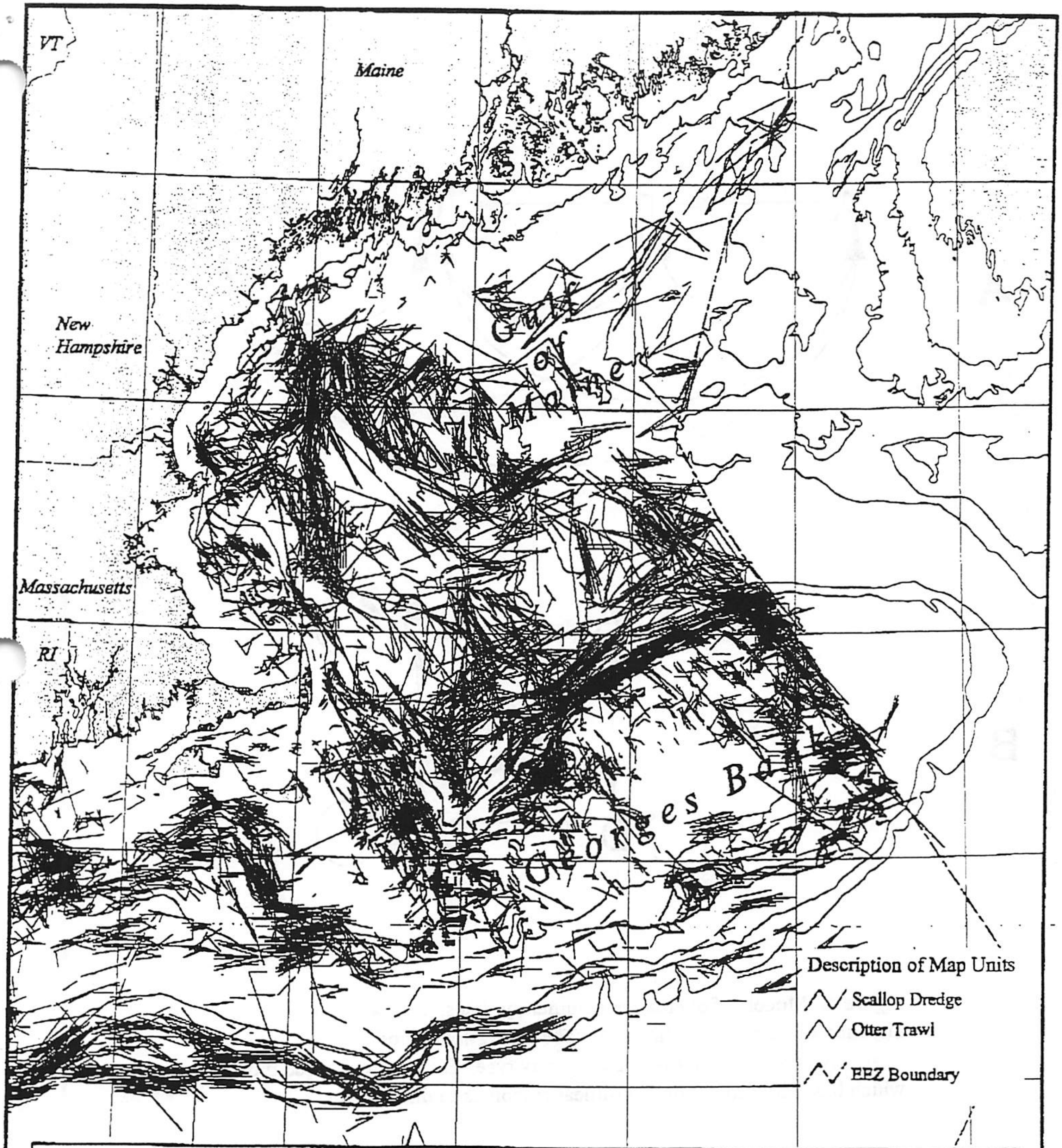

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A

B

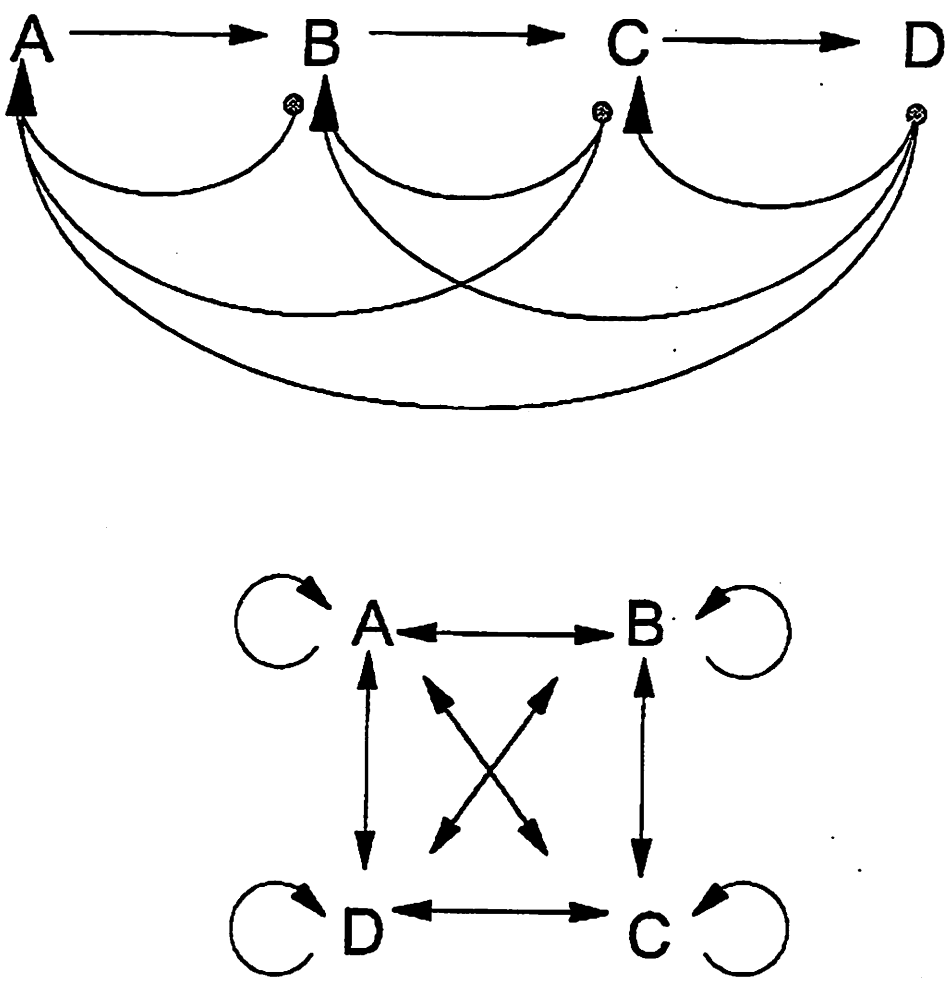
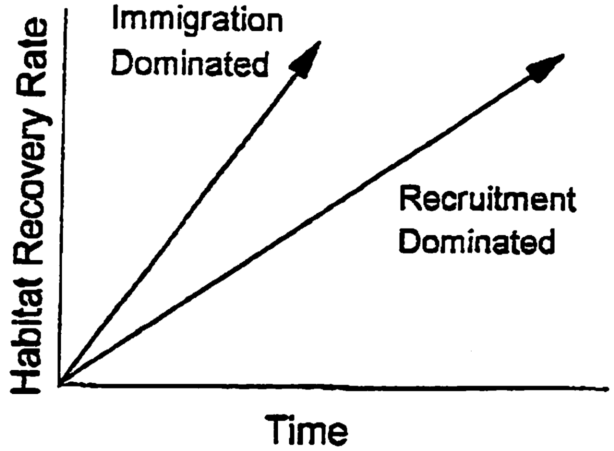


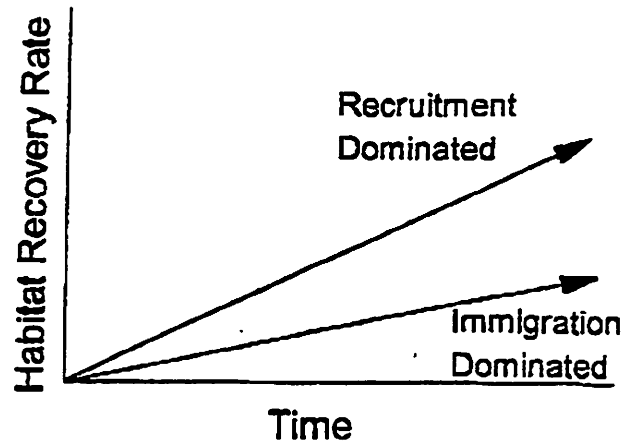
Figure 4. Models of alternative community states. Arrows indicate direction of community shifts. A. The successional model which has relatively predictable shifts in community type. B. A lottery based model which has more stochastic, non-linear responses to disturbance.

TYPE 1

TYPE 2

A

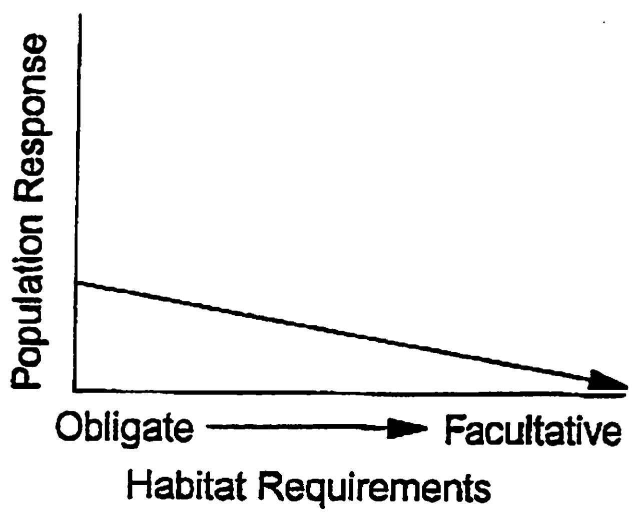


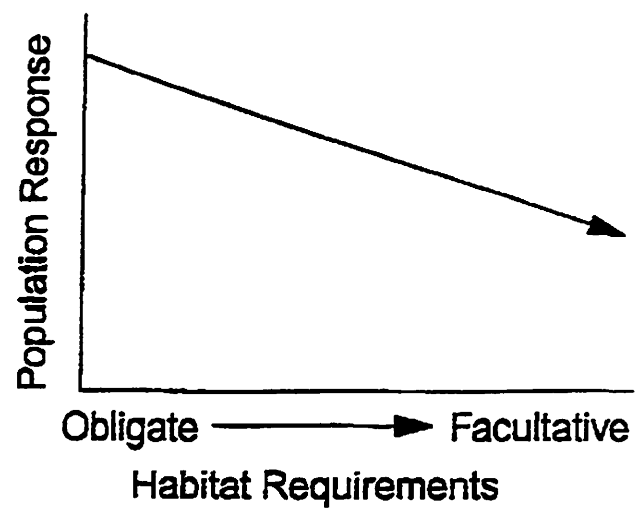


Comparatively higher rate due to high densities of larval recruits and more rapid immigration from adjacent undisturbed areas.

Comparatively lower rate due to dependence on larval recruitment, lower density of larval recruits, and small pool of immigrants from limited undisturbed patches.

B





In general, difficult to detect due to comparatively small area of disturbance.
Obligate - Small effect if disturbances are a small % of required habitat.
Facultative - No detectable effect.

In general, easier to detect due to large area where processes mediated by EFH occur.
Obligate - Large effect due to disturbance of many habitat patches.
Facultative - Detectable effect at population sizes where habitat mediated effects are dominant.

Figure 5. Comparison of biogenic habitat structure and population responses to type 1 and type 2 forms of habitat disturbance

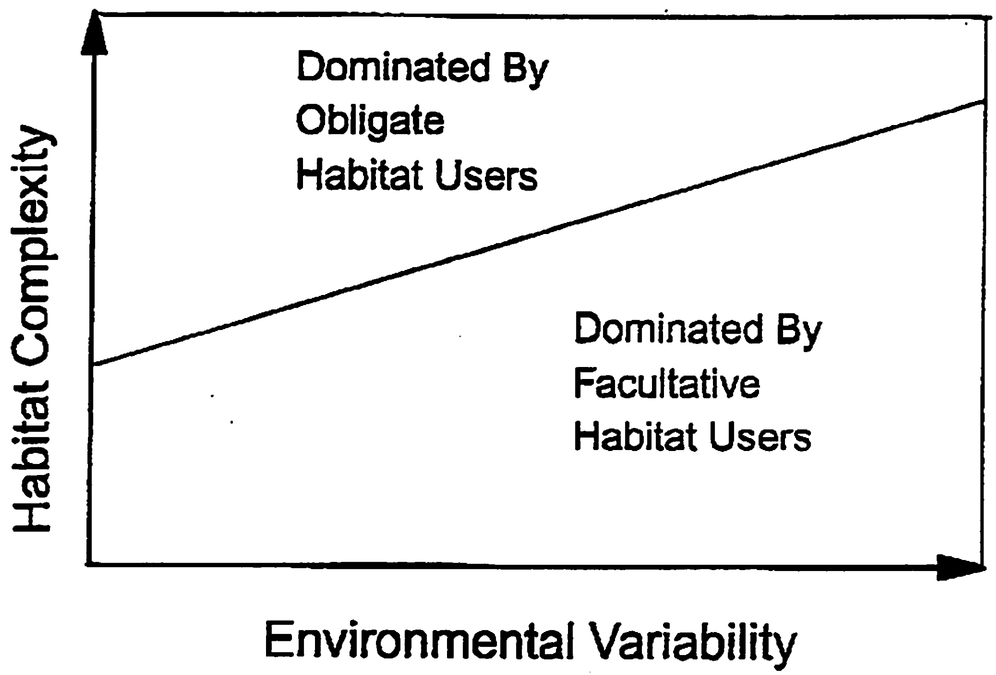


Figure 6. Habitat complexity and environmental variability domain of fish assemblages as it relates to obligate and facultative habitat users. Fish assembalges occurr in a continuum along the two gradients.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1335 East-West Highway
Silver Spring, MD 20910
THE DIRECTOR

AGENDA C-2
JUNE 1998
Supplemental

MAY

RECEIVED
JUN - 1 1998
N.P.F.M.C

Mr. Richard B. Lauber
Chairman
North Pacific Fishery Management Council
605 West Fourth Avenue
Anchorage, Alaska 99501-2252

Dear ~~Mr. Lauber~~ Rich:

After a series of incoming comments and meetings with constituents affected or potentially affected by essential fish habitat (EFH) designation, there remains a lot of concern regarding how EFH will be identified and how the EFH provisions are implemented. Two issues, in particular, have been raised by the nonfishing industry--(1) how does a community not usually involved with the Council process get involved and (2) they would rather see specific identified features identified for EFH designation rather than a broad definition. Further, they are concerned that the October 11, 1998 completion date may lend itself to wide scale designation.

I take these comments from the nonfishing industry seriously and do not view them as an attempt to avoid EFH designation, but to make it meaningful. Therefore, I would ask that you make an extraordinary attempt to contact constituents from the nonfishing industry to participate in future Council meetings regarding EFH. As far as the scope of EFH designation, be as specific as possible. Please keep us informed regarding this process. I appreciate your efforts in bringing this community into the EFH process. If we need more time, let me know.

Sincerely,

Rollie

Rolland A. Schmitten

THE ASSISTANT ADMINISTRATOR
FOR FISHERIES

MAY 04 '98 05:05PM 907 463 2216 CG D17 (MPC)

AGENDA C-2
JUNE 1998
Supplemental

U.S. Department of Transportation

United States Coast Guard

Commander
Seventeenth Coast Guard District

P.O. Box 25517
Juneau, AK 99802-5517
Staff Symbol: mpo
Phone: (907) 463-2226
FAX: (907) 463-2299

RECEIVED
MAY - 5 1998
N.P.F.M.C

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MAY - 4 1998

Mr. David Witherell
North Pacific Fisheries Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 99501-2252

Dear Dave,

This responds to your letter of 28 April 1998 asking us to look at enforcement issues related to the Mount Edgecumbe Pinnacle Closed Area. We looked at two alternatives: closing a four square mile area to all fishing, and closing the same area to all fishing except trolling.

From an enforcement standpoint, closing the area to all fishing is our preferred option. Violations could be determined from an aircraft. As you know, this area is near Air Station Sitka and could be monitored during the normal course of our operations.

Allowing trolling in the area means we would have to board vessels to ascertain what type of gear they were using and what catch they have on board. Although we have a buoy tender stationed in Sitka, it does not present the same opportunities for monitoring the closed area as the helicopter operations do. In addition, the coming and going of the buoy tender are more predictable and noticeable by the fleet. However, if this alternative were chosen, prohibiting possession of lingcod and rockfish in the closed area (by all vessels) would facilitate enforcement.

The shape of the closed area is not of concern to us. There may be ways to configure the closed area to protect the pinnacle and minimize the impact to troll fishers, perhaps resulting in stronger support for the closed to all fishing alternative.

When the pinnacle closure was briefed to the Council at the April meeting, staff from Alaska Department of Fish and Game stated the proposal had strong support from all segments of the commercial and recreational fishing community. This type of support is important in evaluating potential compliance with a regulation and a situation we should always try to work towards. Thank you for asking for our input on this. Please call me if you have any questions or would like to discuss this further.

Sincerely,

J. V. O'Shea

J. V. O'SHEA
Captain, U. S. Coast Guard
Chief, Maritime Operations Plans and Policy Branch
Seventeenth Coast Guard District
By direction of the District Commander

Sitka, AK
June 3, 1998

To Chairman Richard Lauber
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 99501-2252

Dear Chairman Lauber, North Pacific Fishery Management Council Members and Staff,

Linda Behnken and Dan Falvey have advised me that members of the Council family have informed them that there is a problem with the Council following the Board of Fisheries lead to protect groundfish and lingcod by closing the 19/34 pinnacles area off of Cape Edgecumbe to all groundfish and lingcod fishing while leaving the area open to salmon trolling. I have talked to many local trollers who supported the closure because it did not interfere with trolling for salmon in the area. They are very upset about an amendment that would close the area to trolling. In fact a case could be made that the Cape Edgecumbe area is the most important troll drag in Alaska and the square would cut right across part of that drag.

Because I am a troller and a conservationist and have supported the proposal to protect groundfish and lingcod in this area I have been accosted by several trollers who heatedly expressed their opinion of this action. While I have taken lots of heat over the years and am willing to take it when needed I am a bit frustrated that I am taking heat over an action that I do not support. The proposal I support, the local fish and game advisory committee supported, AMCC supported, and the Board of Fisheries adopted permits trolling for salmon in the area.

My recommendation to the Council is to adopt the proposal adopted by the Alaska Board of Fisheries. Trollers are not a problem in this area. It is important that the area be closed completely to sport fishing because of the increase in the catch and release fisheries in our area and the likelihood that there would be a targeted catch and release lingcod fishery on the pinnacles if it was left open to sport fishing.

Having said that, I can also support a complete closure of the pinnacle area if the closed area is a 1.5 mile diameter circle with the center at 56 56.283 North by 135 55.771 West. This would accomplish the goal of protecting the area and would not interfere with any legitimate trolling. I do not know if local trollers would support this. They have got their backs up now and are not likely to support any closure. I would recommend consulting with Sitka Fish & Game Advisory Committee Chairman Bill Paden and local Alaska Trollers Association representative Howard Pendell about trollers position.

The other possibility would be to consider a 2 mile diameter closure with the center at 56 56.283 North by 135 55. 771 West. I do not support this because it also interferes with legitimate trolling but it would be much less onerous to trollers in my opinion than a square because the North East corner of the square cuts right through the troll fishing drag. I have faxed copies of these options to you.

In conclusion, I strongly oppose closing trolling in the square adopted by the Board of Fisheries to protect the 19/34 pinnacle area off of Cape Edgecumbe. If the Council must close the area to salmon trolling to protect the area and close it to other fisheries then I support closing a 1.5 mile diameter circle around the pinnacles to all fishing.

I hope the council can figure a way through this because the area is truly unique and deserving of protection. However if the Council is not careful and oversteps what is needed to protect the area, the lingcod, and the groundfish then future protection for areas as deserving could be jeopardized. It is important to work with and recognize the legitimate interests of fishermen in the area. I wish I could be at your meeting to speak with you directly and go over the maps. Please call me at 747-6743 if you have any questions.

Sincerely,

Eric Jordan

Eric Jordan
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