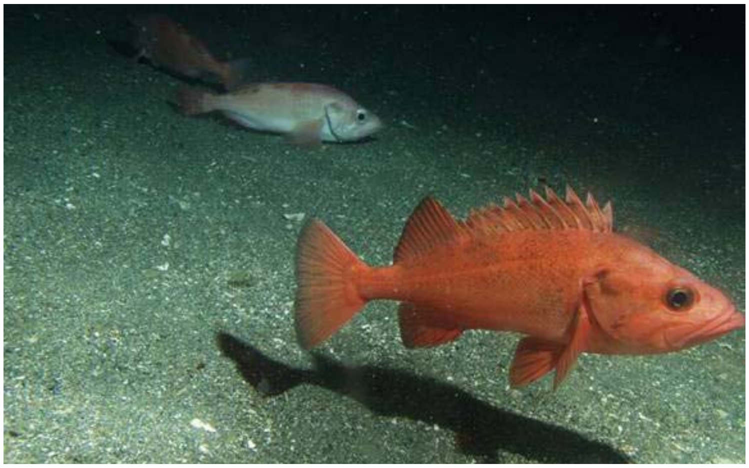
Conservation and Management of North Pacific Rockfishes



ALASKA MARINE CONSERVATION COUNCIL

August 2005

Conservation and Management of North Pacific Rockfishes

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Prepared by Ben Enticknap and Whit Sheard

Alaska Marine Conservation Council

AMCC is a community-based organization of people working to protect the health and diversity of Alaska's marine ecosystem. Our members are fishermen, subsistence harvesters, marine scientists, conservationists, small business owners and families. AMCC works to minimize bycatch, protect habitat, prevent overfishing and promote clean, community-based fishing opportunities.

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Cover photo: Rougheye rockfish (*Sebastes aleutianus*) photographed from the submersible Delta off the Aleutian Islands. R. Reuter, NOAA Fisheries.

TABLE OF CONTENTS

Several life history characteristics of Pacific rockfish require that they be managed more conservatively than most marine fishes. Applying the precautionary principle to these species will require decreases in fishing mortality rates and management strategies that protect the physical habitat, allow for a full complement of age classes, and prevent recruitment overfishing throughout the entire geographic range of the stock. Uncertainty associated with actual harvest levels, spawning biomass, and annual recruitment must be buffered with conservation measures such as reduced fishing mortality, long-term species monitoring, habitat protection, and protection of a significant portion of the population through the use of appropriately designed MPAs (Lauck et al. 1998). The population dynamics of rockfishes require that these management actions be taken quickly. . .

—American Fisheries Society. 2000. Policy Statement #31d: Management of Pacific Rockfishes

EXECUTIVE SUMMARY

North Pacific rockfishes, living in the marine waters off Alaska's coast, are receiving increased attention from scientists, fisheries managers, conservationists and fishermen. Much of this attention has been spurred by the collapse of rockfish populations off the Pacific Coast of California, Oregon and Washington. In 2000, the U.S. Secretary of Commerce pronounced West Coast groundfish a "fisheries failure" and declared the industry an economic disaster as catch levels plummeted and large areas of the continental shelf and slope were closed to fishing.

Characteristics of rockfishes including fidelity to localized habitats, slow growth, late maturation, and remarkably long life spans, elevate their susceptibility to overfishing. This susceptibility raises serious questions about the long-term viability of rockfish populations under current management practices and the fisheries that rely on them. *Conservation and Management of North Pacific Rockfishes*, a report of the Alaska Marine Conservation Council (AMCC), seeks to answer these questions.

In June 2004, concerns about rockfish management were voiced by members of the North Pacific Fishery Management Council (NPFMC) Scientific and Statistical Committee, independent scientists and other interested parties. This prompted the NPFMC to request an investigation of alternative harvest rates, bycatch reduction, and refugia as strategies for meeting their programmatic goals and objectives to minimize bycatch and prevent overfishing. The NPFMC again reiterated this request in February 2005, plus asked for a review of spatial and temporal bycatch information.

Conservation and Management of North Pacific Rockfishes is intended to augment the NPFMC investigation by providing a basic understanding of rockfish ecology, illustrating the current impact of North Pacific fisheries on rockfish populations, and highlighting the need for effective conservation of these unique and vulnerable fishes. Based on findings from independent reviews, published scientific literature, and agency documents, AMCC concludes that the long-term viability of rockfishes in Alaska is directly threatened by age truncation (the removal of older fish via fishing), localized depletion, and overfishing of distinct populations. These problems call for precautionary management policies initially identified by the American Fisheries Society in its policy statement of 2000 and recommended in this report. In the five years that have passed since AFS prescribed its course of action, AMCC finds the threats facing North Pacific rockfishes more pronounced and the need for action more urgent.

Findings

Current state and federal fisheries management does not adequately account for the unique biological and ecological characteristics of rockfishes. While fisheries managers exercise some precaution in setting catch levels and protecting certain habitat areas, there

remains fundamental cause for concern regarding the impacts of fisheries on rockfish populations. Issues of greatest concern include:

- Inadequate biomass estimates
- Inadequate biological and genetic information
- Excessive harvest rates
- Overfishing of individual species managed as part of an assemblage
- Localized depletion of spatially or genetically distinct populations
- Age truncation
- Habitat loss and degradation.

Specific findings in this report substantiate the above concerns and underscore the need for a responsive management approach. For example:

- Basic biological information including life history, population size, distribution, and habitat requirements is poorly understood for nearly all Alaskan rockfish species (pgs 12, 13, 21).

- Certain rockfish species, including rougheye and shortraker, are among the longest-lived vertebrates on earth (pg 9).

- The Aleutian Islands Atka mackerel bottom trawl fishery is responsible for over 90% of northern rockfish discards, with over 9 million pounds in 2003 and 8.5 million pounds in 2004 (pg 23).

- In 2004, over 40% of rougheye, shortraker, and “other” rockfish, taken in Bering Sea and Aleutian Islands fisheries were wasted, dead or dying (pg 24).

- Rougheye rockfish in the Aleutian Islands have declined by as much as 61% since 1980 (pgs 27-30).

- Biological research indicates that old rockfish are critical for maintaining sustainable population levels. Meanwhile, preliminary research on Pacific ocean perch indicates that the proportion of older fish has been in decline for the past two decades (pg 25).

- Evidence of localized depletion is appearing for several species of Gulf of Alaska rockfish (pg 26).

- For some rockfish species, information is so sparse that managers cannot determine whether they are overfished or approaching an overfished condition (pg 13).

- While information is not available to quantify stock productivity in relation to essential habitat, bottom trawling is expected to significantly degrade hard coral and sponge habitats considered essential to many deep-water rockfish species (pg 22).

- Management boundaries do not coincide with the spatial boundaries of rockfish populations (pgs 10, 26, 27).

- Current management allows for individual species within stock assemblages and distinct populations managed across broad areas to be overfished without triggering any conservation measures (pgs 11, 28-30).

- The harvest rates, generally set to reduce spawning biomass to 35% to 40% of the estimated unfished biomass or set at 75% of the estimated natural mortality, lack sufficient precaution for North Pacific rockfishes (pgs 15-18).

Taken together, these findings demonstrate the high degree of uncertainty and vulnerability characterizing rockfishes and their management. In light of current conditions, AMCC calls for a deliberate course of action capable of ensuring the long-term conservation and sustainability of Alaska rockfish populations.

Recommendations

AMCC's recommendations for improving rockfish conservation and management in the North Pacific closely follow those already made by the American Fisheries Society in its policy statement. AMCC recommends that state and federal fisheries managers act without further delay to reduce rockfish harvest rates, minimize and avoid rockfish bycatch, and protect sensitive habitat areas by:

- Reducing fishing mortality through reduced harvest rates ($F_{50\%}$ - $F_{60\%}$) and designing management systems to reduce bycatch and discards.

- Developing mechanisms, including spatial management, to reduce the bycatch of rockfish in non-rockfish fisheries, and to reduce the capture of unmarketable sizes or species in all fisheries.

- Implementing measures that explicitly account for the importance of larger, older females when setting rockfish catch levels.

- Determining total mortalities by species, including mortalities associated with recreational and subsistence fishing to allow the total catch of each species to be monitored with high confidence.

- Establishing mechanisms to limit harvest to the targets established each year and set limits for each species, not groups of species, where weak stocks can be overfished. In recreational fisheries where there are only daily bag limits for individual fishermen, appropriate overall harvest levels should be evaluated and set.

- Collecting species-specific information on age, maturity, fecundity, and location of capture. Essential information includes stock structure and natural mortality estimates.

- Establishing adequate fishery-independent surveys and new survey techniques to monitor population abundance and promote accurate stock assessments.

- Buffering fishing pressure against variability in stock recruitment levels and unforeseen fishing mortality effects by protecting a portion of each population and its habitat through the use of refugia. Refugia should be implemented as part of an adaptive management framework to develop effective criteria for conserving rockfish populations. Furthermore, refugia should be designed to protect multiple species, their habitats, demographic and genetic structure, and community structure.

Success in carrying out this comprehensive strategy will require the commitment of fisheries managers, scientists, and stakeholders recognizing the vital need to improve upon present measures, and, as learned by neighboring fisheries to the south, the potentially devastating consequences of inaction. AMCC looks forward to working with these interests to realize the shared goal of maintaining healthy North Pacific rockfish populations for generations to come.

INTRODUCTION

The management of Pacific rockfishes is a complex task that requires multiple and complementary management tools to ensure viable populations and sustainable fisheries.[1] There are many species of rockfish, most with unique life history characteristics that put them at high risk for over-harvest, including moderate to extreme longevity, relatively old age at maturity, habitat associations, physiology, and distinct population structures.

The West Coast commercial rockfish fishery first began in California sometime in the early to mid-1800s. Heavy fishing pressure, however, did not begin until 1963 when a fleet of foreign factory trawlers began targeting rockfish. The West Coast rockfish fishery rapidly grew and by 1966, a fleet of 115 foreign factory trawlers began harvesting approximately 20,000 metric tons (mt) of Pacific ocean perch annually off Oregon and Washington and large volumes of deep water rockfish off California.[2] After passage of the 1976 Magnuson Fisheries Conservation and Management Act, a U.S. based fleet dominated by bottom trawl vessels targeted rockfish into the 1990s with annual catches of 22,000 to 50,000 mt. Catches steadily declined during the 1990s and early 2000s, after it became apparent overfishing was occurring.

Overfishing of some rockfish species along the U.S. West Coast reduced several stocks to levels near extinction and also resulted in declaration of an economic disaster when the $30 million per year fishery was closed. In order to rebuild eight rockfish populations to meet the minimum standards of the 1996 Magnuson-Stevens Fisheries Conservation and Management Act (MSA), managers implemented widespread closures of the continental shelf and parts of the slope. These closures and other management measures will likely remain in force for decades.

Subsequent assessments of rockfish populations indicated that several species had been fished down to less than ten percent of their unfished populations. For two species, cowcod and bocaccio, low biomass levels warranted listing as “Species of Concern” under the Endangered Species Act.

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[1] American Fisheries Society. 2000. Policy Statement #31d: Management of Pacific Rockfish.
[2] Bloeser, J.A. 1999. Diminishing Returns: The Status of West Coast Rockfish. Pacific Marine Conservation Council.

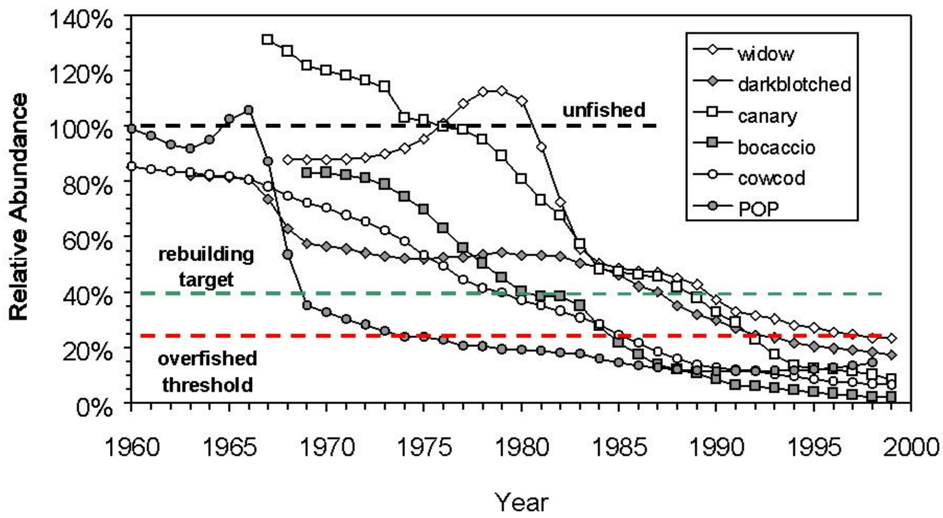

Figure 1. Declines of Rockfish Species in the U.S. West Coast Fisheries [3]

Because these rockfishes are long-lived species with variable and episodic recruitment, it will take a long time for these populations to return to a level managers consider healthy (Table 1).

Species	Population Estimate	Rebuilding Target
Cowcod	7%	2090 (2061-2098)
Bocaccio	7.4%	2023 (2018-2032)
Canary	8%	2074 (2057-2076)
Yelloweye	24%	2058 (2027-2071)
Darkblotched	11%	2030 (2011-2044)
Pacific ocean perch	28%	2027 (2014-2042)
Widow	22.4%	2038 (2028-2042)

Table 1. Population estimate (as a percentage of the estimated unfished biomass) and rebuilding targets for West Coast rockfishes [4]

On the West Coast, the rockfish harvest policy in the early 1980s was to cap the catch at historic levels, with harvests specified for species assemblages. This was viewed at the time by managers as a "do no harm" approach. This approach was later complemented by applying a constant fishing rate policy, based on theoretical results that indicated a fixed rate ($F_{35\%}$) would not reduce stock sizes to levels of concern. In retrospect, the National Oceanic and Atmospheric Administration (NOAA) scientists determined this fishing rate was barely leaving the rockfish stocks room to replenish.[5] Furthermore, harvest limits

[3] Ralston, Steve (2002). "The Groundfish Crisis: What Went Wrong?" (from Ecosystem Observations for the Monterey Bay National Marine Sanctuary)
[4] From Agenda Item F.4a, Attachment 2, March 2005 PFMC Briefing Book and the 2005-2006 ABC and OY groundfish management specifications FEIS.
[5] Ralston, Steve (2002). "The Groundfish Crisis: What Went Wrong?" (from Ecosystem Observations for the Monterey Bay National Marine Sanctuary)

applied to a stock assemblage sometimes allowed individual species within the assemblage to be overfished without violating the aggregate harvest limit.

The West Coast rockfish crisis could have been averted. A National Marine Fisheries Service (NMFS) scientist in 1984 warned that rockfishes

> *have such low rates of production and (relatively) high unexploited standing stocks that fisheries can develop and mature relying almost entirely on the standing stock (as opposed to surplus production) for their sustenance. These resources are ultimately harvested down to levels at which their fisheries productive capacities are destroyed.*[6]

Subsequent analysis confirmed that a default "one size fits all" fishery management approach simply does not work for rockfishes. The American Fisheries Society analysis explains that

> *[p]opulations have shown little response to the management measures used to date, mostly because these measures fail to consider the constraints that reproductive strategies of rockfish impose on the population's ability to recover from reductions in abundance.*[7]

Compounding a high fishing rate and a management strategy inappropriate for rockfish population dynamics, was the lack of basic fishery and biological data needed to adequately assess rockfish stocks. In a 1998 report to Congress, NMFS listed the status of 83% of the rockfish species on the West Coast as "unknown," meaning that it was not known whether these species were declining, increasing, or stable.[8] Concurrently, the knowledge of rockfish habitat was considered to be at "Level 1," the lowest tier in a hierarchal system that rates the understanding of the habitat needs of a species.

In retrospect, the collapse of both West Coast rockfish populations and associated fisheries may have been avoided by a more precautionary management system. Such a management approach is needed when fishery and biological information are limited, and for species whose life history and biological characteristics elevate their susceptibility to overfishing. Precautionary management implements proactive conservation measures for species when biological information is lacking and for which unique life histories and reproductive strategies limit the ability to rebound from low population levels.

In general, Alaskan rockfish populations are not yet in such dire straits, but there is cause for concern. Overfishing of Pacific ocean perch by Japanese and Soviet trawl fleets in the 1960s did lead to sharp population declines, and in 1977 catch per unit effort values dropped 90-95%. While cessation of this over harvest and rebuilding efforts have allowed Pacific ocean perch to rebound, the current Aleutian Islands spawning biomass estimate

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[6] Francis, R.C. NMFS. Fisheries Research and its Application to West Coast Groundfish Management. In: Fisheries Management: Issues and Options, University of Alaska Sea Grant Report. 85:2.
[7] American Fisheries Society Policy Statement #31d: Management of Pacific Rockfish
[8] NMFS 1998. Report to Congress: Status of fisheries of the United States, at 32-38.

is still below the peak fishery catch in 1965. Pacific ocean perch are also below the target $B_{40\%}$ level managers use to evaluate healthy stocks.[9] Similarly, current Gulf of Alaska Pacific ocean perch total biomass estimates are less than the catch taken in 1965.[10]

There is some evidence of recent overfishing of many of the longest-lived and most sensitive rockfish species in Alaska, such as Aleutian Islands rougheye, Gulf of Alaska shortraker, and Gulf of Alaska yelloweye. Other stocks, such as Gulf of Alaska northern rockfish are fished intensively in only a few areas, but assessments are indicating declining populations.[11]

While it has been recognized that Alaska has a more conservative management system, many of the deficiencies that led to the West Coast declines also exist in the Alaska management system. These include:

- High uncertainty in estimated biomass and abundance trends
- Catch levels that lack sufficient precaution
- Minimal information on habitat locations and quality
- Minimal biological information on juvenile rockfishes
- Habitat loss and degradation.

Existing scientific information on the status of Alaskan rockfishes compels immediate adoption of a risk-averse management policy that incorporates both the unique biological complexity of rockfishes and the lack of basic biological information. This management policy should be precautionary.

The National Marine Fisheries Service defines the precautionary approach as management that

> *implements conservation measures even in the absence of scientific certainty that fish stocks are being overexploited. In a fisheries context, the precautionary approach is receiving considerable attention throughout the world primarily because the collapse of many fisheries resources is perceived to be due to the inability to implement timely conservation measures without scientific proof of overfishing. Thus, the precautionary approach is essentially a reversal of the "burden of proof."* [12]

Efforts are underway to obtain the basic biological information needed to effectively manage stocks.[13] However, a commitment to the precautionary policy is paramount to

[9] NPFMC 2004. BSAI SAFE Introduction.
[10] NPFMC 2004. GOA SAFE Introduction.
[11] NPFMC 2003. GOA SAFE, at 412.
[12] NOAA 1998. NOAA Technical Memorandum: Technical Guidance on the Use of the Precautionary Approaches to Implementing National Standard One of the Magnuson-Stevens Fishery Conservation and Management Act.
[13] See, e.g., North Pacific Fisheries Management Council Non-Target Species Committee Minutes, March 14-15, 2005, Appendix: "Proposed AFSC rockfish research projects, FY 2005."

sustaining populations of these long-lived species during the time needed to acquire the appropriate biological data.

ECOLOGY, LIFE HISTORY, AND DIVERSITY OF NORTH PACIFIC ROCKFISHES

The following brief account of the ecology, life history, and diversity of North Pacific rockfishes is a simple synopsis of the unique characteristics attributable to all the individual rockfish species. Due to data gaps and a general lack of information, a complete description of the biology and ecology of each rockfish species is presently not available. A more complete account of current biological and ecological information is available in: The Rockfishes of the Northeast Pacific.[14] Here, we provide a fundamental look at the unique characteristics of rockfishes essential to understanding the conservation and management of these species.

Rockfish Diversity:

There are approximately 68 species of rockfishes in the genus *Sebastes* and three in the genus *Sebastolobus* found in the waters off the Pacific coast of North America. Approximately 36 species of *Sebastes* and all three *Sebastolobus* species have been documented by fishery observers in the waters off Alaska (Table 2).[15] This is greater than the 32 species of *Sebastes* and two *Sebastolobus* more commonly cited in other publications.[16] Rockfish diversity is highest in southern southeast Alaska and the number of species markedly declines west of the central Gulf of Alaska. Although thirty-four rockfish species have been documented in the Bering Sea and Aleutian Islands (BSAI) region in survey and/or observer data, only twelve of these have been documented in greater than 1% of fishery hauls.[17] The Bering Sea is the northernmost boundary for rockfishes.

Influencing the evolution and diversity of rockfishes are oceanographic boundaries such as temperature, coastal currents and gyres that physically isolate larvae or other life stages from their original population. Over the course of thousands of years, this physical isolation can lead to reproductively and genetically distinct species. Rockfish evolution may also occur through the reproductive isolation of a single population inhabiting the same area. Rockfishes have complex courtship rituals and mating behaviors including internal fertilization and perhaps the use of sound and pheromones.[18] Reproductive isolation can occur with slight alterations of these and the loss of mate recognition can eventually lead to speciation within the population.

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[14] Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.
[15] Fenty, B. 2005. An analysis of rockfish diversity and density in the North Pacific using available Groundfish Fisheries Observer data. Prepared for: The Ocean Conservancy (in press).
[16] See, e.g., Kramer, D.E., and V.M. O'Connell. 1995. Guide to Northeast Pacific Rockfishes. Alaska Sea Grant Marine Advisory Bulletin No 25.
[17] NPFMC 2003. BSAI SAFE, at 691.
[18] Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.

KEY

EBS - Eastern Bering Sea
EGOA- Eastern Gulf of Alaska
GOA- Gulf of Alaska
AI- Aleutian Islands

Pacific ocean perch (*Sebastes alutus*) *-all regions*
Rougheye rockfish (*Sebastes aleutianus*) *-all regions*
Shortraker rockfish (*Sebastes borealis*) *-all regions*
Northern rockfish (*Sebastes polyspinis*) *-all regions*
Sharpchin rockfish (*Sebastes zacentrus*) *-all regions*
Bocaccio (*Sebastes paucispinis*) *-all regions*
Widow rockfish (*Sebastes entomelas*) - *EBS, EGOA, GOA*
Black rockfish (*Sebastes melanops*) *-all regions*
Red-banded rockfish (*Sebastes babcocki*) *-all regions*
Rosethorn rockfish (*Sebastes helvomaculatus*) – *EBS, EGOA, GOA*
Silvergray rockfish (*Sebastes brevispinis*) *-all regions*
Dark blotched rockfish (*Sebastes crameri*) *-all regions*
Rosy rockfish (*Sebastes rosaceus*) - *EBS*
Greenstriped rockfish (*Sebastes elongatus*) - *EBS, GOA*
Canary rockfish (*Sebastes pinniger*) - *EBS, EGOA, GOA*
Splitnose rockfish (*Sebastes diploproa*) *-all regions*
Blue rockfish (*Sebastes mystinus*) - *AI, EBS, GOA*
Gray rockfish (*Sebastes glaucus*) - *AI, EBS*
Shortbelly rockfish (*Sebastes jordani*) - *GOA*
Blackgill rockfish (*Sebastes melanostomus*) - *EBS, GOA*
Yellowmouth rockfish (*Sebastes reedi*) *-all regions*
Yellowtail rockfish (*Sebastes flavidus*) *-all regions*
Yelloweye rockfish (*Sebastes ruberrimus*) *-all regions*
Harlequin rockfish (*Sebastes variegatus*) *-all regions*
Redstripe rockfish (*Sebastes proriger*) *-all regions*
Chilipepper rockfish (*Sebastes goodei*) - *AI, EBS, GOA*
Copper rockfish (*Sebastes caurinus*) - *AI, GOA*
Stripetail rockfish (*Sebastes saxicola*) - *EGOA, GOA*
Tiger rockfish (*Sebastes nigrocinctus*) - *EBS, EGOA, GOA*
Light-dusky rockfish (*Sebastes variabilis*) *-all regions*
Vermillion rockfish (*Sebastes miniatus*) *-all regions*
Aurora rockfish (*Sebastes aurora*) - *GOA*
Pygmy rockfish (*Sebastes wilsoni*) - *EGOA, GOA*
Chameleon rockfish (*Sebastes phillipsi*) - *AI*
Quillback rockfish (*Sebastes maliger*) - *EGOA, GOA*
Dark dusky rockfish (*Sebastes ciliatus*) *-all regions*
Shortspine thornyhead (*Sebastolobus alascanus*) *-all regions*
Broadband thornyhead (*Sebastolobus macrochir*) - *AI, EBS*
Longspine thornyhead rockfish (*Sebastolobus altivelis*) *–all regions*

Table 2. Rockfish species identified by the North Pacific Groundfish Observer program (1990-2003)[19]

Scientific understanding of rockfish species is steadily growing. Recent genetic investigations of rougheye rockfish, one of the largest and longest-lived rockfish species, indicate that there are two sibling species of rougheye (for now called type I and II).[20] It is unclear whether reproductive isolation or physical isolation has caused the divergence

[19] Fenty, B. (in press) An analysis of rockfish diversity and density in the North Pacific using available Groundfish Fisheries Observer data.
[20] Gharrett, A.J. et al (in press). Distribution and population genetic structure of sibling species of rougheye rockfish based on microsatellite and mitochondrial variation. Transactions of the American Fisheries Society.

of these sibling species. Initial studies indicate that the two rougheye species have different physical attributes, overlapping but different geographic distributions, and likely different habitat preferences.[21] Such complex population structures have serious implications for our current management scheme, in which distinct populations are often managed as single units across broad geographic ranges.

Similarly, a new taxonomic classification was recently given to dark and light dusky rockfishes which were previously considered separate color morphs of the same species.[22] These rockfishes are now recognized as genetically different species, dark rockfish (*Sebastes ciliatus*, formerly dark dusky) and dusky rockfish (*Sebastes variabilis*, formerly light dusky).

<u>Sex and Survival:</u>

Besides their often bright colors and sharp spines, rockfish in the genus *Sebastes* share the reproductive trait of being viviparous, meaning that the females' eggs are internally fertilized, nutrients are passed to the embryos, and they give birth to live young. This reproductive strategy maximizes egg fertilization and also ensures that the developing embryos are protected inside the female. In contrast, broadcast spawners like cod or pollock, release their eggs and milt into the water column, with reduced fertilization rates and increased risk of predation and other sources of mortality.[23] Ideally, rockfishes release their larvae during times of peak zooplankton abundance, which provides optimal conditions for the larvae to feed. Yet timing larval release with an abundant food supply and the right oceanic conditions is more a matter of chance. Many years may pass before the timing of larval release is combined with optimal oceanic conditions, including water temperature, food supply and upwelling, which encourage larval survival and successful recruitment.

The most sensitive life stage for rockfishes is the time spent as pelagic. Pelagic larvae typically live at depths shallower than 80 meters. An exception are the larvae of Pacific ocean perch (*Sebastes alutus*), which likely remain at the 500 – 700 meter depth of larval release for about one month, before moving to shallower water.[24] Rockfish larvae initially feed on larval copepods and invertebrate eggs, and as they mature, they feed on larger copepods, krill and other invertebrates. Many pelagic juveniles move deeper in the water column as they develop. At some point, these juveniles settle onto seafloor habitats that have some physical or biological relief. For example, while viewing rockfish from a submersible off the Aleutian Islands, marine researchers noted that virtually 100% of juvenile rockfishes were in close association with coldwater corals.[25]

[21] Id.
[22] Id. AND. NPFMC 2004. BSAI SAFE, at 822.
[23] Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.
[24] Id., at 42.
[25] R. Stone, NOAA Fisheries. AAAS 2004 Annual Meeting.

The survival and ensuing recruitment - recognized as the addition of new individuals to the population or to a size or age targeted by a fishery - of juvenile rockfishes is highly variable from year to year. Recruitment success relates to optimal ocean conditions at both local and broad spatial scales during the larval and juvenile life stages. Years of strong recruitment depend on the right combination of water temperature, food supply, and upwelling intensity. For some species, annual variability in recruitment follows a similar pattern over wide geographic regions, indicating that broad ocean conditions influence survival. Recruitment can, however, be highly patchy and localized within a small area. For example, high juvenile recruitment can occur to a particular reef, pinnacle or coral garden, while other nearby areas may be seemingly absent of rockfish.[26]

Being long-lived is likely a rockfish evolutionary strategy against rare recruitment success. These species must have long lives to encompass years that are optimal for successful reproduction. If older year classes are lost from the population due to fishing mortality, there is a reduction of reproductive potential and larval success when ocean conditions become favorable. For fisheries management, the annual recruitment variability means that to sustain rockfish populations, the spawning biomass needs to be large enough to produce strong year classes during those years when environmental conditions are favorable to high recruitment success. Moreover, sufficient nursery habitat, such as eelgrass, kelp forests, and coral gardens need to be preserved to support juvenile rockfishes settling out of the pelagic zone.

As adults, many rockfish species exhibit strong site fidelity, often residing in the same area for years and perhaps the remainder of their lives. In contrast, other species make seasonal movements. Female Pacific ocean perch move from summer feeding grounds at 150 – 400 meters to deep water habitats at 500 – 700 meters along the continental slope to release their larvae. Some rockfishes are territorial and individuals will actively guard their home range, whether it is a particular rocky reef, pinnacle or coral garden.

<u>The Importance of Old, Large Females:</u>

It has long been known that larger fishes produce more eggs than smaller ones. For example, a 7.5 inch splitnose rockfish (*Sebastes diplopra*) produces about 14,000 eggs per year, while a 14.6 inch splitnose produces about 255,000 eggs per year.[27] Yelloweye rockfish (*Sebastes ruberrimus*) up to 36 inches in length produce 2.7 million eggs per year. Recent research on black rockfish (*Sebastes melanops*), however, indicates that not only do larger female rockfishes produce more offspring, but the larvae of older rockfishes are more likely to survive to their next life stage.[28]

When studying growth and starvation resistance in larvae from black rockfish, researchers found that larvae from the oldest females had growth rates more than three

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[26] Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.
[27] Id at 162.
[28] Berkeley, S.A., C. Chapman, and S. Sogard. 2004. Maternal Age as a Determinant of Larval Growth and Survival in a Marine Fish, *Sebastes melanops*. Ecology. 85(5) 1258-1264.

times as fast and survived starvation for more than twice as long as larvae from the youngest females.[29] Larvae are able to feed immediately after birth but starvation during this initial feeding stage is thought to be major source of mortality for larval rockfishes. When female rockfishes release their larvae, the larvae carry with them an oil droplet that serves as a metabolic reserve. Larvae born from older black rockfish have significantly larger oil droplets than larvae born from younger females. This allows the larvae to grow faster and withstand starvation longer, giving them a better chance to survive. Faster growth of larval fish allows them to pass more quickly through their early and most vulnerable life stage, improving detection and capture of prey, avoiding predators, and surviving other environmental challenges.

Old Fish:

Some rockfish species are among the longest-lived vertebrates on earth, with rougheye and shortraker rockfishes being among the longest-lived fishes in the world. These are some of the largest rockfishes found off Alaska (38 to 48 inches) and they live in cold, deep-water seafloor habitats. Rougheye rockfish have been aged to 205 years and shortraker rockfish have been aged to 157 years of age.

Like annual growth rings on a tree, fish produce growth rings in a variety of their bones and scales. The ear bone, or otolith, is the standard calcified body part used to age rockfishes. Deep-water rockfishes tend to live longer than shallow-water rockfishes and rockfish species that live on the seafloor tend to live longer than mid-water species, and rockfishes living in colder, northern environments generally have longer life spans. In general, larger sized rockfish species live up to 100 years or more and small species can live several decades.

[29] Id.

Species	Approximate Maximum Age (years)	Maximum Size (inches)
Rougheye	205	38
Shortraker	157	48
Yelloweye	118	36
Redbanded	106	25.5
Darkblotched	105	23.2
Shortspine thornyhead	100	32
Pacific ocean perch	100	21.2
Quillback	95	24
Splitnose	86	18.4
Silvergray	82	29.2
China	79	45
Dusky	67	21.2
Widow	60	23.6
Northern	57	19.2
Black	50	27.6
Pygmy	26	9

Table 3. Maximum age recorded (years) and maximum size (inches) of select North Pacific rockfishes.[30]

FEDERAL MANAGEMENT

(A) Single Species and Management Assemblages:

Most North Pacific rockfishes are managed by the U.S. Department of Commerce through the National Marine Fisheries Service and the North Pacific Fishery Management Council. Managers determine annual allowable catches based on stock assessment information, and allocate the catch amounts by fishery and area. Allowable catch amounts are set for both individual populations and for species assemblages, which are groups of several species sharing similar characteristics. Over time, managers have broken out individual species when they determine that the level of information is high enough to effectively manage a species individually. Populations are generally managed spatially as either a Bering Sea/Aleutian Islands (BSAI) stock or a Gulf of Alaska (GOA) stock. This is done for management convenience, and biologists have noted that these boundaries most likely do not correspond to the proper spatial scale of rockfish populations.[31]

[30] Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.
[31] Rockfish Working Group. Alaska Fisheries Science Center. "Discussion Paper on Rockfish Research and Management." January 27. 2003.

Current Bering Sea and Aleutian Islands management categories include:[32]

- BSAI Pacific ocean perch
- BSAI northern rockfish
- BSAI shortraker rockfish
- BSAI rougheye rockfish
- BSAI "other" rockfish (shortspine thornyhead, dark rockfish, yelloweye rockfish, sharpchin rockfish, harlequin rockfish, redbanded rockfish, dusky rockfish, redstripe rockfish).

Gulf of Alaska (GOA) rockfish management categories:

- GOA Pacific ocean perch (eastern, western and central stocks)
- GOA northern rockfish (included with other slope rockfish in eastern GOA)
- GOA thornyhead rockfish (eastern, central/western)
- GOA shortraker rockfish
- GOA rougheye rockfish
- GOA "other" slope rockfish (aurora, blackgill, chillipepper, sharpchin, shortbelly, bocaccio, darkblotch, greenstriped, harlequin, silvergrey, splitnose, vermillion rockfish, yellowmouth rockfish, redstripe rockfish, redbanded rockfish, pygmy rockfish)[33]
- GOA demersal shelf rockfish (canary, China rockfish, copper, quillback, yelloweye, rosethorn, tiger)[34]
- GOA pelagic shelf rockfish (dark, dusky, widow, yellowtail).

While the question of whether quotas are set at appropriate levels remains open, Alaska managers do enforce the quotas that are set. When the overfishing level for an individual species or assemblage is reached, fishing is no longer allowed for those species or for fisheries that incidentally catch those species. Although this offers a certain level of protection for stocks managed as individual species, it does not prevent overfishing.

For those stocks managed as assemblages it is allowable to catch large numbers of species that comprise only a small percentage of the biomass. This overfishing would go undetected and would not trigger a management response until the cap for the entire assemblage is reached. It is also possible that localized overfishing may occur due to the large size of management areas. Both of these possibilities are increased by the use of non-selective trawl gear on assemblages of rockfish species that exhibit patchy distributions in microhabitats. Although the frequency of occurrence of less abundant or

[32] While the allowable biological catch and overfishing levels are set for some species at smaller areas, this list represents the area at which overfishing levels (OFL) are determined. Sometimes catch amounts greatly exceed allowable catch levels in their area apportionment but remain within the region wide OFL.
[33] In the Central and Western GOA, "other" rockfish includes demersal shelf rockfish.
[34] Demersal shelf rockfish are managed separately from "other slope" rockfish in Southeast Alaska.

rare species may be low, Sinclair et al. (1999) caution that "*the number of individuals caught when the species is encountered may be quite high*."[35]

Several species of extreme concern have likely experienced overfishing while part of an assemblage. These include Aleutian Island rougheye (explained below) and Gulf of Alaska shortraker.[36] Stock assessment authors have also noted assemblage concerns for Bering Sea and Aleutian Island "other" rockfish. For this assemblage, shortspine thornyheads make up 90% of the assemblage biomass, which places 27 other species at risk.[37]

(B) <u>Population Assessments:</u>

Effective quota-based fisheries management is dependent upon adequate assessments of fish populations. A good stock assessment provides not only information regarding the estimated number of fish in a stock, but also other important biological information about the managed stock. Key information includes estimates of natural mortality (what percentage of a population dies off naturally each year), estimates of spawning biomass, estimates of age at maturity, recruitment trends, and genetic differentiation among sub-stocks and distinct populations.

Basic information is lacking for nearly all Alaskan rockfish species. While species that are economically valuable receive the highest level of attention during the assessment process, adequate information for even these species is lacking. For example, the stock assessment for Pacific ocean perch, the dominant rockfish species fished off Alaska, which has been fished along its range in North America since 1940, states that there is:

- considerable uncertainty about the life history of the species
- extreme variability in estimates of population status from year to year
- little information on habitat requirements
- unclear stock population structure in the Gulf of Alaska, Bering Sea and Aleutian Islands.[38]

For species that are members of assemblages and those that are not commercially important, the lack of information and data gaps are even more severe. For example, vital information on many of the "other" rockfish in the Bering Sea and Aleutian Islands is lacking. Basic missing information for the BSAI "other" rockfish species include:

- a lack of reliable biomass estimates for all species except shortspine thornyheads
- no genuine natural mortality estimates (a single natural mortality estimate is provided for all BSAI "other" rockfishes based on information from other areas)

[35] Elizabeth H. Sinclair, Andrey A. Balanov, Tsunemi Kubodera, Vladimir I. Radchenko and Yury A. Fedorets. Distribution and Ecology of Mesopelagic Fishes and Cephalopods. In: Dynamics of the Bering Sea, T. R. Loughlin and K. Ohtani, eds. University of Alaska Sea Grant, AK-SG-99-03, 1999, pp. 485-505.
[36] NPFMC 2004. GOA SAFE, at 416.
[37] NPFMC 2004. BSAI SAFE, at 823.
[38] NPFMC 2003. GOA SAFE, Rockfish sections.

- minimal information on life history characteristics, population structure and spatial distribution.[39]

Information is so limited on the BSAI "other" rockfish category that only eight of the twenty-eight species comprising this group are actively managed as part of the complex. Even for the eight managed species, it is not possible to determine whether they are overfished or approaching an overfished condition.[40]

Alaskan rockfishes are surveyed with bottom trawl gear. The unique biology of rockfish species poses many obstacles to obtaining essential population information. Some rockfishes are patchily distributed, which can bias estimates both positively and negatively. Others are more evenly spread out, but live in rocky habitats with high vertical relief, which is difficult to survey with trawl gear. The combination of these factors yields population estimates that have been variously described by biologists as "unreliable,"[41] and "extremely variable,"[42] and scientists have indicated the need for a different survey approach to reduce variability.[43]

Some examples of the uncertainty in biomass estimates are listed in Table 4 for several members of the Gulf of Alaska "slope rockfish" assemblage. As seen here, biomass estimates are highly uncertain. For example, the biomass of sharpchin in 1987 was estimated to be 80,439 mt, but it could have been anywhere between 13,859 mt and 147,018 mt. Biomass estimates for harlequin rockfish jumped from 2,625 mt in 1984 to 72,405 in 1987, then back down to 14,480 in 2001. These wide fluctuations in biomass estimates do no seem reasonable given the slow growth and low natural mortality rates of rockfishes.[44] The uncertainty and variation in rockfish biomass estimates raises concern about catch levels based on these estimates.

[39] NPFMC 2004. BSAI SAFE, at 819.
[40] NPFMC 2004. BSAI SAFE, at 5-6 and 24-25.
[41] NPFMC 2004. BSAI SAFE, at 24.
[42] NPFMC 2003. GOA SAFE, at 433.
[43] NPFMC 2003. GOA SAFE, at 487.
[44] NPFMC 2003. GOA SAFE, at 538.

Year and Species	Biomass estimate (mt)	Lower 95% Confidence Int.	Upper 95% Confidence Int.
1984 **Sharpchin**	6,612	1,693	11,531
1987	80,439	13,859	147,018
2001	34,169	0	85,559
2003	7,064	0	14,338
1984 **Redstripe**	5,365	922	9,806
1987	26,519	0	53,639
2001	17,564	0	42,415
2003	8,025	2,109	13,942
1984 **Harlequin**	2,625	972	4,277
1987	72,405	28,945	115,865
2001	14,480	0	34,638
2003	3,545	313	6,776
1984 **Silvergrey**	4,817	1,336	8,298
1987	5,426	858	9,994
2001	24,032	13,742	34,321
2003	51,916	0	130,981
1984 **Redbanded**	1,430	531	2,330
1987	1,822	600	3,044
2001	6,409	0	15,063
2003	3,441	1,907	4,974

Table 4. Gulf of Alaska rockfish biomass estimates (metric tons) with lower and upper 95% confidence intervals.[45] Lower and upper confidence intervals represent the lower and higher end of the population estimates, sometimes representing a very large variation in population estimates.

Although Alaska Fisheries Science Center biologists and gear experts are exploring options to improve population assessments, enhanced information will not overcome the fact that we have little historic baseline data predating industrial trawl fisheries in the North Pacific. Population trend estimates for some species of concern are only available beginning in 1980.

Information is limited on the impact foreign fisheries had on rockfish species other than Pacific ocean perch, because foreign catch records did not identify rockfishes by species. During the years Pacific ocean perch were subjected to overfishing, it is likely that overfishing of other rockfish species was also occurring, since only a small percentage of rockfish bycatch in the foreign Pacific ocean perch fishery would have produced exceedingly large catches of other co-occurring rockfishes. Therefore, even theoretically exact assessments beginning in 1980 give us no picture of what population levels were like before and during the prior 20 years, when fishing levels were highly excessive and caused the documented collapse of Pacific ocean perch populations. The practical effect of this is a situation that scientists refer to as “shifting baselines,” which arises here when we use an already degraded 1980 population (having been subject to 20 years of intense fishing pressure) as the baseline for comparison for today’s populations. Gulf of Alaska northern rockfish, for example, were most likely caught in large numbers during the overfishing of Pacific ocean perch, but there is no data on how many were caught between 1965 and 1976.

[45] NPFMC 2003. GOA SAFE, at 557-558.

(C) Harvest Rates:

After population assessments are completed, stock assessment scientists calculate catch levels. The formal approach for determining overfishing levels and allowable catch levels is to begin with the assignment of the single species or species group into one of six Tiers, which is based on the available information for each stock. Tier 1 is assigned to those species with the highest level of data and biological information. Tier 6 is assigned to those species with very low data and biological information.

Reflecting the fact that rockfish information is lacking, most BSAI and GOA rockfish stocks have been historically placed in tiers 3-6. Those in Tier 3 are generally the most important commercial species and the species which receive the most attention during the assessment process. The majority of species are in Tiers 4 and 5, however, and information is so sparse that managers cannot determine whether these species are overfished or approaching an overfished condition.

Five stocks are currently managed under Tier 3:

- BSAI Pacific ocean perch
- GOA Pacific ocean perch
- GOA northern rockfish (in “other slope” category in Eastern GOA)
- GOA thornyheads
- GOA dusky rockfish.

Three stocks or assemblages are managed under Tier 4:

- GOA rougheye rockfish
- GOA sharpchin rockfish (in “other slope” category)
- GOA demersal shelf rockfish.

Seven stocks or complexes are currently managed under Tier 5:

- BSAI northern rockfish
- BSAI shortraker and rougheye rockfish
- BS “other” rockfish (although the stock assessment authors have indicated that all but shortspine thornyheads belong in Tier 6)
- AI “other” rockfish
- GOA shortraker rockfish
- GOA “other slope” rockfish excluding sharpchin rockfish
- GOA pelagic shelf rockfish excluding dusky rockfish.

The formulas for setting acceptable biological catches are based upon certain life history characteristics. For species in Tiers 3 and 4, the maximum catch level is based upon a fishing strategy that reduces reproductive output to an estimated 35% of that which would occur absent fishing pressure (the “$F_{35\%}$” strategy). For Tier 5 species, the maximum catch level is based upon a fishing strategy that doubles the estimated natural mortality (“M”) of a stock. For Tier 6 species, for which virtually no biological information is available, the maximum catch level is based upon a default value equal to the historic fishing levels from 1978-1995.

An independent review of this tier system, commonly known as the F40 report, concluded that several problems arise from the current tier strategy, including:

- The system may work for 'typical groundfish' but harvest rates are too high for rockfish, which exhibit different life-history traits (such as long life spans and rare recruitment).
- There is no systematic mechanism for reducing acceptable catches for species with less information (i.e., those in higher tiers, such as all rockfish stocks).
- There is no incentive to increase the level of information and move stocks to lower tiers.
- Tiers 3-6 do not have any provisions to accelerate rebuilding of stocks with lower biomass levels.
- Tiers 4-6 do not contain enough information to determine if species are being overfished.
- There is no explicit methodology for dealing with uncertainty.[46]

Of concern is that the overall harvest strategy explicitly allows reductions of rockfish spawning potential and biomass to be reduced to 35% of the estimated unfished biomass (Tiers 3 and 4) or allows fishing pressure to equal the rate of natural mortality (Tier 5). While in reality the North Pacific Fishery Management Council sets the target at either a reduction in spawning biomass to 40% of the estimated unfished biomass ($F_{40\%}$) or at 75% of natural mortality (0.75xM), the independent review concluded that these rates themselves are inappropriate and stated that

> *[l]ower rates, on the order of $F_{50\%}$ to $F_{60\%}$, may be more appropriate to balance yield and conservation objectives for such species. Another problem has to do with stock complexes. Because productivity of each species in the complex is likely to be different, a single $F_{\%spr}$[47] proxy will not perform equally well for all stocks in the complex.*[48]

The conclusions of the independent review are supported by numerous other scientific publications as well as a recently convened workshop panel that recommended an $F_{50\%}$ strategy for *Sebastes* and *Sebastolobus*.[49]

While the independent review found that rockfishes need a "considerably lower fishing mortality rate to avoid overfishing,"[50] they also noted that the current harvest policy for all groundfish only makes "possible" adjustments for ecosystem needs in an "ad hoc" fashion. While sometimes catch levels are adjusted downward for concerns about

[46] Goodman et al. 2002. Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Groundfish Fishery Management Plans. Goodman et al. Prepared for the North Pacific Fishery. Management Council. November 21, 2002.
[47] $F_{\%spr}$ is the fishing mortality rate at which the spawning biomass per recruit is at a certain percentage (i.e. 40%) of the unfished value.
[48] Goodman et al 2002. supra note 41, at 62.
[49] West Coast Groundfish Harvest Rate Policy Workshop, AFSC, Seattle, Washington: March 20-23, 2000; Sponsored by the Scientific and Statistical Committee of the Pacific Fishery Management Council
[50] Goodman et al 2002. supra note 41, at 7.

bycatch, protected species and general concerns about the ecosystem, the reviewers note, "*there are no grounds for believing the magnitude* [of the downward adjustment] *is enough for those purposes.*"[51]

The National Marine Fisheries Service, however, continues to contend that the current harvest strategy is appropriate for all Alaskan rockfishes.[52] The principle basis of this contention is that some studies of Gulf of Alaska and Aleutian Islands Pacific ocean perch suggest that the current harvest strategy is appropriate for these stocks. This statement relies heavily on a resiliency test of hypothetical rockfish stocks and a published study (Dorn 2002) to defend the current harvest strategy for all Alaska rockfish stocks. But while Dorn (2002) suggests that an $F_{35\%}$ harvest rate is likely appropriate for Gulf of Alaska and Aleutian Islands Pacific ocean perch, the study found that $F_{45\%}$ to $F_{50\%}$ would be more appropriate for Bering Sea Pacific ocean perch. Overall, the study concluded that an $F_{50\%}$ harvest strategy is a risk-neutral harvest rate for all North Pacific rockfishes and an $F_{55\%}$ to $F_{60\%}$ harvest rate would be a more "risk-averse" harvest rate.[53]

When discussing the apparent resiliency of Alaskan Pacific ocean perch, Dorn (2002) notes that what may be interpreted as high resiliency - the rebuilding from an overfished state in the '60s and '70s - could actually be biased by climate variation that created an oceanic environment favorable to high recruitment in the 1980s.

As noted in the 2004 stock assessment, the resiliency of Pacific ocean perch

> *is largely influenced by several strong year-classes in the early 1980s, and it is not clear whether this observed resiliency reflects an inherent density-dependent response of these stocks or climatic conditions during this time period in Alaskan waters. Dorn's meta-analysis focused primarily upon west coast rockfish stocks and found that resiliency for rockfish was lower than that observed for other taxonomic groups such as gadids and clupeids, although the recruitment declines for west coast rockfish also correspond to decreased productivity of the California current (McGowen et al. 1998). If rockfish stock-recruitment patterns are strongly influenced by environmental factors, the observations of Dorn (2002) that Alaskan POP show greater resiliency than many of the west coast rockfish may reflect the generally inverse relation between west coast and Alaskan oceanic production.*[54]

In other words, the regime shift in 1977-1978 may have favored conditions promoting population increases for Alaskan stocks. Since rockfishes exhibit highly variable and episodic recruitment, it is likely that oceanic conditions favorable to reproduction were

[51] Id.
[52] Alaska Fisheries Science Center. Comments on the 2002 Independent Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Groundfish FMPs. North Pacific Fishery Management Council. Agenda D-1(b)(4). February 2005.
[53] Dorn, M.W. 2002. Advice on west coast rockfish harvest rates from Bayesian-meta-analysis of stock-recruitment relationships. North American Journal of Fisheries Management 22:280-300.
[54] NPFMC 2004. BSAI SAFE 731.

occurring in Alaska at the same time of the observed poor reproduction of stocks off California, Oregon, and Washington. The Scientific and Statistical Committee of the North Pacific Fishery Management Council has expressed concern with basing conclusions about the effectiveness of harvest rates on several large recruitments of Pacific ocean perch in the late 1980s and they cautioned against extrapolating these results to other species.[55] Furthermore, such high levels of recruitment seem to not have continued into the early 1990s[56] and according to the stock assessment authors,

> *it is unclear how likely strong recruitments at low stock sizes will be in future years under differing environmental regimes.*[57]

NMFS' defense of current harvest strategies is thus premature at best and is proffered despite caveats presented in the SAFE documents, the independent F40 report, and warnings by the NPFMC scientific committee. While it may be plausible that the current harvest strategy is sufficient for Gulf of Alaska and Aleutian Islands Pacific ocean perch, it is a gross overgeneralization to apply this to all Alaska rockfish stocks.

Another concern with the tier system is how it functions when basic biological information is lacking. Catch levels based on natural mortality rates ("M") are dependent upon the estimates of M being correct. Estimates of M are difficult to acquire. For example, current estimates of natural mortality for Pacific ocean perch are one third what they were once thought to be.[58] If this estimate was not changed, allowable catch levels could be three times the current rate. Moreover, biologists often substitute natural mortality estimates from other regions and other species, which can lead to differing interpretations of acceptable catch levels. For example, although there is some indication that M for shortspine thornyheads may be as low as 0.0129, biologists for the Gulf of Alaska region recommend using 0.03, while those in the Bering Sea region recommend using 0.07.[59]

Finally, Tier 6, which uses no biological information to set catch levels, is unacceptable. This tier is similar to the strategy that allowed West Coast rockfishes to be overfished. As noted in the stock assessment for BSAI "other" rockfish, if Tier 6 was used, the catch level for 27 species would be nearly four times what is allowed when using Tier 5 and borrowing the natural mortality estimate from shortspine thornyheads.[60]

Participants at a groundfish harvest policy workshop discussed mechanisms used by Alaska fishery managers (setting targets either equal to M or 0.75xM) and some recommended that a more precautionary policy should be used for these long-lived species. The more prudent approach recommended was to use an exploitation rate of 0.5xM and to "*place the burden on whoever advocates a higher rate to demonstrate that*

[55] See, e.g., Draft NPFMC Scientific Statistical Committee Minutes, December 6-8, 2004, pg. 12.
[56] NPFMC 2004. BSAI SAFE, at 686.
[57] NPFMC 2004. BSAI SAFE, at 732.
[58] NPFMC 2004. BSAI SAFE, at 681.
[59] NPFMC 2003. GOA SAFE, at 663.
[60] NPFMC 2004. BSAI SAFE, at 826.

it is sustainable (by substantial direct analysis of historical stock-recruit data)."[61] For some species, this would mean cutting the allowable catch in half.

(D) Fisheries Impacts:

While fishing by definition impacts populations by reducing biomass, it also causes impacts to populations beyond direct reductions in biomass. These impacts include:

- Destruction of sensitive and valuable habitats
- Increased bycatch mortality
- Localized depletions caused by fishing intensely in areas that may harbor isolated subpopulations
- Age truncation caused by fisheries selecting the larger and older members of the population.

While no single one of these factors determines the success or failure of rockfish reproduction, scientists are beginning to note that current management strategies, which focus only on estimating population numbers over large regions, are likely inadequate for rockfishes. This need for a wide distribution of age-structured populations in intact habitats necessitates a more complex fisheries management approach that addresses all fishing impacts to rockfishes.

(1) Habitat Destruction

Numerous studies have been published describing the varying impacts of gear types, with most concentrating on the impacts of bottom trawling. Most studies have reached a consensus that bottom trawling has the largest impact on seafloor habitats.[62] The effects of bottom trawling can be extensive. Direct effects include smoothing of sediments, dragging rocks and boulders, resuspension and mixing of sediments, removal of seagrasses, damage to corals, and damage or removal of epibenthic organisms.[63] Studies in Alaska and elsewhere led the National Marine Fisheries Service to conclude that bottom trawls cause both short-term changes in infauna, epifauna, megafuana and substrates and persistent changes in megafauna communities.[64] NMFS also noted that dredges, longlines, pots, and pelagic trawls also cause damage to habitat, but at a lesser degree of intensity than compared to bottom trawls.

For example, an average of 152,000 pounds of corals and 777,000 pounds of sponges were caught annually as bycatch in the Bering Sea and Aleutian Islands from the years

[61] Pacific Fishery Management Council Supplemental SSC Report D.13(2), June 2000, at 3 (citing Walters, C., and A.M. Parma. 1996. Fixed exploitation rate strategies for coping with effects of climate change. Can. J. Fish. Aquat. Sci. 53:148-158).
[62] Morgan, L. and R. Chuenpagdee. 2003. Shifting Gears: Addressing the Collateral Impacts of Fishing Methods in U.S. waters. Washington: Island Press.
[63] NMFS 2005. Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. April 2005.
[64] Id.

1997-2001.[65] This ongoing bycatch, which includes species of coral never before taxonomically identified, prompted the federal scientists to conclude that

> *impacts to long-lived, slow growing species (i.e., coral) could cause long-term damage and possibly irreversible loss of living habitat, especially in the Aleutian Islands.*[66]

This damage is caused by bottom trawling for both rockfishes and other species.

Recognizing the importance of marine habitats to productive fisheries and healthy ecosystems, Congress amended the Magnuson-Stevens Act in 1996, requiring fisheries managers to designate essential fish habitat (EFH). Essential fish habitats are those needed by fish and crab populations to maintain and grow their populations. Essential fish habitat includes all the habitats necessary for spawning, breeding, feeding, and growth to maturity.

In addition to designating EFH, the National Marine Fisheries Service must also evaluate the scale of fishery impacts in light of where, when, and how long they occur, distinguishing between effects that are “minimal and temporary” versus those that are significant and long-lasting. Adverse impacts can be localized, like the damage of site-specific coral gardens that create habitat for a diversity of rockfishes, or region wide, like cumulative impacts along the Bering Sea slope or “greenbelt,” a productive habitat for many rockfishes. The EFH regulations further require that significant and long-lasting impacts be minimized with management tools such as fishing equipment restrictions, time and area closures, or harvest limits.

In May 2005, NMFS Alaska Region issued a Final Environmental Impact Statement (EIS) for the designation and conservation of Essential Fish Habitat. Evident in the agency analysis is the lack of information available to describe rockfish habitats off Alaska and to evaluate the connection between habitat and rockfish productivity. Using the best available information from fishery data, biological surveys, and field research, NMFS is only able to describe the general distribution of each managed rockfish species or assemblage, and only for some life stages. Based on the amount of information available, NMFS classifies data among four levels, with level 1 being minimal amounts of information and level 4 offering specific information correlating habitat to the productivity of the stock.

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[65] NMFS 2003. Draft Programmatic Supplemental Environmental Impact Statement, at A-T-535.
[66] NMFS 2003. Draft Programmatic Supplemental Environmental Impact Statement, at 4.1-5.

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Pacific ocean perch	x	1	x	1	1
Shortraker/ rougheye	x	1	x	x	1
Northern	x	1	x	x	1
Thornyhead	x	1	x	1	1
Yelloweye	x	1	x	1	1
Dusky	x	1	x	x	1

* x = no information available.

Table 5. Gulf of Alaska, Bering Sea and Aleutian Islands Rockfish Essential Fish Habitat Information Levels.[67]

As Table 5 indicates, specific habitat preferences for many rockfish life stages are either unknown or poorly known. While fishery and survey data indicate the presence or absence of rockfish species in certain habitat types, this provides little information about the nexus between rockfishes and the habitat features they utilize. In contrast, direct observations using SCUBA or research submersibles have produced remarkable insights. Observations using a manned submersible in the deep waters of the Gulf of Alaska continental slope indicate that adult shortraker and rougheye rockfishes prefer steep slopes and are often associated with boulders and coldwater corals.[68] Many late juvenile rockfishes live in the shallower waters of the Gulf of Alaska continental shelf and have been observed in rocky habitats, often closely associated with sponges growing on boulders.[69] Juvenile and adult rockfishes use these structurally complex and living habitat features as refuge from currents and predators and to feed on prey also living in these areas.

The scarcity of information about rockfish habitat associations available and presented in the Essential Fish Habitat EIS resulted in a great deal of uncertainty in the NMFS analysis of fishing impacts. While agency scientists found that fisheries using bottom trawls have lasting impacts on seafloor habitats, especially living habitats like corals and sponges that are slow to recover, they were unable to determine how those impacts affect rockfish populations. This lack of information resulted in 41% of the evaluations of fishing impacts on rockfish habitat concluding an "unknown" impact.

[67] NMFS 2005. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation., at Appendix D.
[68] Krieger, K.J. and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the GOA. Hydrobiologia 471: 83-90.
[69] Freese, J.L. and B.L. Wing. 2004. Juvenile red rockfish, *Sebastes* sp., associations with sponges in the GOA. Mar. Fish. Rev. 65:38-42.

Although little habitat information was presented for rockfishes, NMFS did estimate what percentage of habitat features would be permanently lost based on current levels of fishing. These include:

- a 29-46% reduction of hard coral in Gulf of Alaska deep shelf habitat estimated to provide 30-32% of Pacific ocean perch habitat
- a 8-13% reduction of hard coral in Aleutian Islands deep shelf habitat estimated to provide 22-36% of shortraker/rougheye habitat
- a 30-35% reduction of hard coral in Gulf of Alaska deep shelf habitat estimated to provide 57-60% of yelloweye rockfish habitat
- a 41-42% reduction of hard coral in Gulf of Alaska deep shelf habitat estimated to provide 26-37% of northern rockfish habitat
- a 31-46% reduction of hard coral in Gulf of Alaska deep shelf habitat estimated to provide 57-69% of dusky rockfish habitat.[70]

Despite these predictions, the agency jumped to the overall conclusion of no impact, not because there is no impact but because they could not "prove" an adverse impact based on the available scientific information. Noted a member of an independent panel of experts requested by NMFS to review the agency analysis:

> *With such an approach it will be extraordinarily difficult to prove productivity effects even in situations where spawning, feeding and/or growth are being systematically reduced. Thus, the conclusion that current fishing activities are having no effect on EFH is premature at best, and potentially dangerous for the long-term sustainability of Alaskan fisheries*.[71]

In February 2005, the North Pacific Fishery Management Council recognized the uncertainty between observed fishing impacts on habitat and potential consequences to the long-term sustainability of fisheries. Consistent with the precautionary approach, the Council voted to zone bottom trawling in the Aleutians Islands to designated open areas, close 10 areas along the continental slope of the Gulf of Alaska to bottom trawling, and protect identified coral gardens and seamounts from all bottom contact gear.

These actions will likely have some site-specific positive benefits for rockfish and the habitats they depend upon, but are based primarily on the strategy of preventing further expansion of bottom trawling into new areas. The decision did not adequately address existing impacts from bottom trawling and left open many areas where rockfishes and their habitat are persistently impacted (Figure 2). Furthermore, the levels of fishing estimated to cause long-term impacts remain unchanged.

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[70] NMFS 2005. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation, at Table B.3-3.
[71] Snelgrove, P. 2004. Center for Independent Experts, Review of the NMFS and NPFMC DEIS for EFH. July 2004.

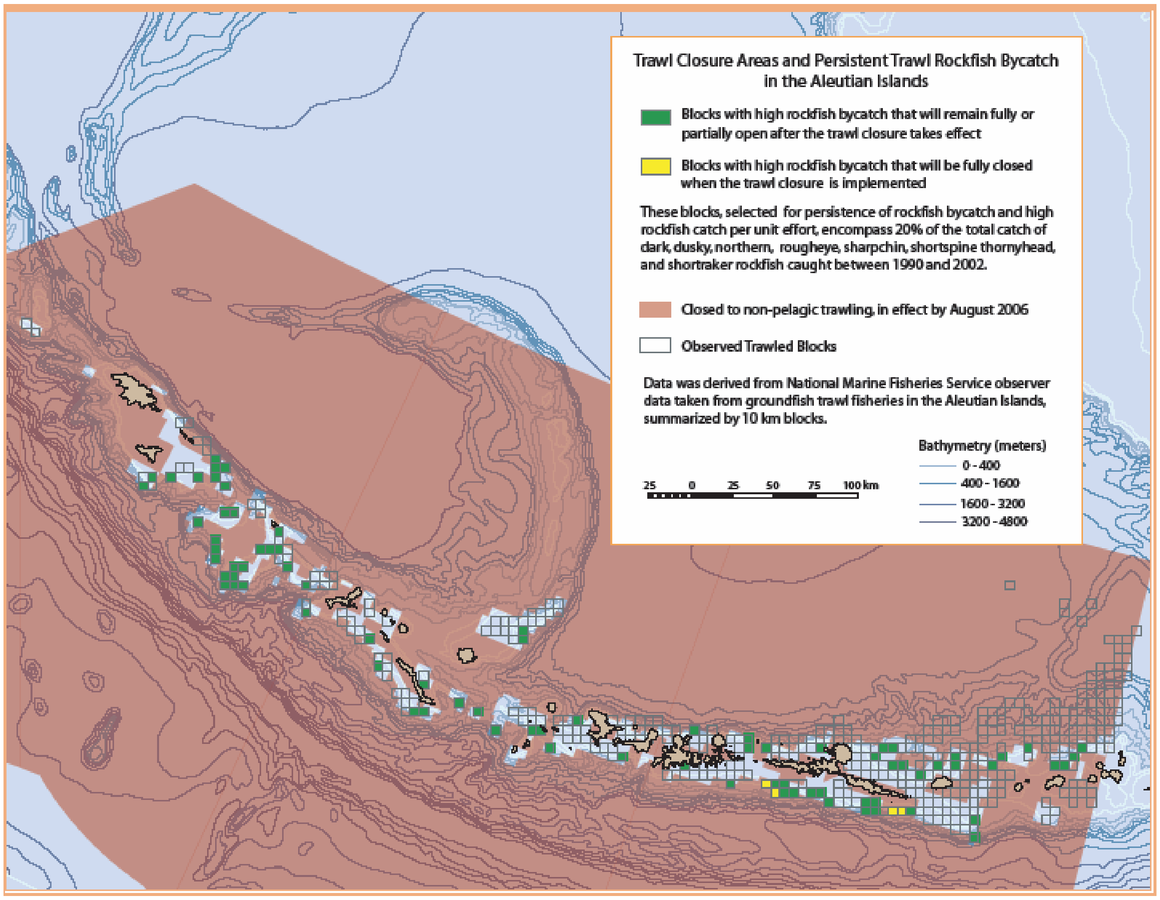

Figure 2. Trawl open/closed areas in the Aleutian Islands. Within 88 10x10 km blocks of highest Catch per Unit Effort (CPUE) and persistent rockfish bycatch, 84 blocks are partially or wholly open to bottom trawling.[72]

(2) Bycatch

Another fisheries impact is bycatch, which is the result of wasteful fishing practices that indiscriminately catch other marine life while targeting commercially important species. Bycatch normally means the incidental take and discard of marine life but sometimes species that are incidentally caught have value and are retained for personal or commercial use. While some bycatch can survive after being discarded, rockfishes have a closed swim bladder and suffer embolism mortality when brought to the surface from deeper water.[73] Hence, nearly 100% of rockfishes discarded are dead or dying.

The Aleutian Islands Atka mackerel bottom trawl fishery is the source of the largest amount of rockfish discards in the North Pacific. This fishery, conducted by 8-12 factory trawlers between 107 and 259 feet in length, is responsible for 90% of the northern

[72] Ecotrust 2005. Rockfish bycatch: spatial analysis using observer data in the Aleutian Islands and Bering Sea. Prepared for Alaska Marine Conservation Council. May 2005.
[73] NPFMC 2003. GOA SAFE, at 618.

rockfish catch and discarded over 9 million pounds of northern rockfish in 2003[74] and approximately 12 million pounds of northern rockfish in 2001. The percentage of northern rockfish discarded has historically been greater than 80%, with a high of over 97% in both 2001 and 2002.[75]

		2003			**2004**	
Gulf of Alaska Rockfish	Harvest	Discards	Discard Rate	Harvest	Discards	Discard Rate
Pacific ocean perch	22,443,000	3,589,000	16.0%	23,609,000	1,887,000	8.0%
Northern rockfish	11,746,000	1,080,000	9.2%	10,443,000	816,000	7.8%
Pelagic shelf rockfish	6,706,000	157,000	2.3%	5,375,000	194,000	3.6%
Shortraker/ rougheye	3,069,000	855,000	27.9%	2,163,000	597,000	27.6%
Thornyhead rockfish	2,551,000	291,000	11.4%	1,777,000	181,000	10.2%
Other slope rockfish	2,070,000	1,347,000	65.0%	1,801,000	1,118,000	62.1%
Demersal shelf rockfish	542,000	1,000	0.2%	573,000	0	0.0%

Table 6. Rockfish harvest, discards (lbs) and discard rate in the Gulf of Alaska groundfish fisheries, 2003 & 2005. [76]

		2003			**2004**	
Bering Sea/ Aleutian Islands Rockfish	Harvest	Discards	Discard Rate	Harvest	Discard	Discard Rate
Pacific ocean perch	30,618,000	5,818,000	19.0%	24,436,000	4,480,000	18.3%
Northern rockfish	10,238,000	9,795,000	95.7%	9,414,000	8,584,000	91.2%
Rougheye rockfish*	562,000	157,000	27.9%	414,000	227,000	54.9%
Shortraker rockfish*	//	//	//	366,000	110,000	30.1%
Other rockfish	1,380,000	547,000	39.6%	1,385,000	562,000	40.6%

Table 7. Rockfish harvest, discards (lbs) and discard rate in the Bering Sea and Aleutian Islands groundfish fisheries, 2003 & 2004. *Rougheye and shortraker rockfish harvest and discards are combined in 2003.

Bycatch also occurs when commercial fishermen decide to catch and keep economically valuable species of rockfish while they are targeting other species. An example is long-lived shortraker and rougheye in the Gulf of Alaska, which are not managed as target fisheries, but have a quota set for allowable bycatch. The majority of this bycatch is taken by vessels targeting Pacific ocean perch, that take advantage of "unnaturally high" bycatch allowances of shortraker and rougheye.[77] These bycatch allowances have essentially instituted a directed bycatch fishery for these sensitive species.

[74] DiCosimo, Jane. 2005. Draft Case Study for Bering Sea Rockfishes from NPFMC and NOAA Fisheries Service Sources.
[75] NPFMC 2004. BSAI SAFE, at 750.
[76] Harvest and Discard Data from NMFS Alaska Region "best blend" data, 2003 and 2004.
[77] NPFMC 2003. GOA SAFE, at 534.

(3) Age Truncation

Also of concern is the impact of fishing on the age structure of rockfish populations. Age truncation of fish populations is a common consequence of fishing because the longer a year class is exposed to fishing, the greater the likelihood the fish will be caught. Simply put, fishing removes young fish before they can become old fish. Age truncation can be extremely harmful to species with highly episodic recruitment such as rockfishes.[78] Recent research has concluded that

> *old-growth age structure, combined with a broad spatial distribution of spawning and recruitment, is at least as important as spawning biomass in maintaining long-term sustainable population levels.*[79]

The effects of failing to maintain an age-structured population is even more important in rockfish populations, which likely depend on older females for a disproportionate amount of long-term reproduction. As stated by Berkeley et al (2004):

> *[a]ge truncation induced by removing large fish via fishing, therefore, have a much greater impact on the reproductive capacity of a population than the simple reduction of biomass of mature females. Maintaining a significant proportion of older fish may be critical to long-term replenishment and stability in exploited fish populations.*[80]

Preliminary research on Gulf of Alaska Pacific ocean perch indicates that the proportion of old fish (greater than 40 years old) has been in decline over the last two decades.[81] The large observed decline in average age and proportion of old fish suggests that fisheries are targeting and depleting the oldest fish. After incorporating research demonstrating that older rockfishes produce more offspring with higher survival into stock assessment modeling, NMFS scientists found that Pacific ocean perch should be harvested at a lower rate.[82] If older Pacific ocean perch have higher larval success like research on black rockfish suggests, the NMFS analysis showed there should be a 3% decrease in biomass for the Gulf of Alaska population and a corresponding 15% reduction in allowable catch.[83] Age truncation may also be occurring in the demersal shelf rockfish assemblage, which exhibits a distinct decline in the log frequency of older fish.[84]

New scientific information suggests that age truncation induced by fisheries may have grave consequences for the long-term sustainability of fish populations. Further, analysis

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[78] Longhurst 2002, in NPFMC 2004 GOA SAFE, at 399.
[79] Berkeley, S.A., M.A. Hixon, R.J. Larson and M.S. Love. 2004. "Fisheries Sustainability via Protection of Age Structure and Spatial Distribution of Fish Populations." Fisheries 29(8): 23-32. p. 23.
[80] Berkeley, S.A., C. Chapman, and S M. Sogard. 2004. Maternal Age as a Determinant of Larval Growth and Survival in a Marine Fish, *Sebastes melanops*. Ecology. 85(5) 1258-1264
[81] NPFMC 2004. GOA SAFE, at 399-400.
[82] Id.
[83] Id.
[84] NPFMC 2003. GOA SAFE at 621.

of age data in Alaska is demonstrating that age truncation is occurring and in some cases the decline in average age may be quite large.

(4) Localized Depletion

Indiscriminate fishing can also cause marked reductions in populations over small spatial scales. This is referred to as localized depletion, and can have dire consequences for rockfish stocks exhibiting site fidelity and stock structure on fine spatial scales. An analysis of localized depletion for rockfish stocks requires a greater amount of information than is presently available. NMFS scientists note that

> *[t]he appropriate spatial and temporal scale at which localized depletion becomes problematic for rockfish is a subject for future research. The extent to which localized fishing becomes problematic for rockfish is dependent upon the ability of rockfish to replenish fished areas such that any potential local spawning populations are not eliminated. Considerations regarding localized depletion for rockfish should reflect the spatial scale characterizing fish movement within a year and the location and spatial extent of spawning populations and this information is largely unknown for rockfish.*[85]

As discussed in more detail below, genetic studies indicate that rougheye rockfish exhibit a much finer spatial scale than previously thought and are probably experiencing localized overfishing. Similarly, preliminary studies on Pacific ocean perch indicate population structure at fine spatial scales and that adult Pacific ocean perch do not migrate far from their natal grounds.[86] Demersal shelf rockfish, which are sedentary and exhibit habitat-specific residency, are experiencing declines in density in the Central Southeast Outside area which may be caused by localized overfishing.[87]

Although Alaska fishery managers have begun to assign catch levels for some species to management sub-areas in the Aleutian Islands and Gulf of Alaska, biologists have noted

> *[i]t is highly unlikely that the spatial boundaries of stock structure for a particular species will correspond to our current management boundaries or to other related rockfish species.*[88]

In 2004 catch levels of "other" rockfish (including demersal shelf rockfish) in the western Gulf of Alaska, exceeded the allowable biological catch by 606%. In the eastern Gulf of Alaska the allowable catch of "other" rockfish was exceeded by 176%.[89] While the

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[85] Spencer, P. and R. Reuter. Analysis of Localized Depletion for Bering Sea/Aleutian Islands Rockfish. Alaska Fisheries Science Center. National Marine Fisheries Service.
[86] NPFMC 2004. BSAI SAFE, at 678. and Withler et al. 2001.Co-existing populations of Pacific ocean perch, *Sebastes alutus*, in Queen Charlotte Sound, British Columbia. Mar. Biol. 139:1-12.
[87] NPFMC 2003. GOA SAFE, at 627.
[88] Rockfish Working Group. Alaska Fisheries Science Center. "Discussion Paper on Rockfish Research and Management." January 27. 2003.
[89] NMFS 2005. Gulf of Alaska Catch Report through December 31, 2004.

region-wide overfishing level for other rockfish was not exceeded, these exceedingly high catch levels may have detrimental impacts, particularly for rockfish species that exhibit distinct population structures at fine spatial scales.

Scientists have expressed concern about localized depletion of Gulf of Alaska northern rockfish and the pelagic shelf rockfish assemblage. These species are caught almost exclusively with bottom trawls at only a few specific sites. For northern rockfish, approximately 89% of the catch came from five small fishing grounds: Portlock Bank northeast of Kodiak Island, Albatross Bank south of Kodiak Island, Shumagin Bank, Davidson Bank, and the 'Snakehead' (which accounted for 46% of the catch).[90] Pelagic shelf rockfish catch was concentrated on the 'W' grounds west of Yakutat, Portlock Bank, and Albatross Bank.[91]

(E) Case Study – Rougheye Rockfish:

Aged to 205 years in Alaska, rougheye rockfish are likely one of the longest-lived fishes on Earth. Although important information on life history traits and habitat requirements are incomplete, recent genetic research indicates that rougheye rockfish are not one, but two genetically distinct species.[92] For now called Type I and II, these sibling rougheye species are extremely similar in appearance but are nonetheless reproductively isolated from one another.

Using genetic analyses, researchers have identified multiple distinct populations of both Type I and Type II rougheye. In the western Aleutian Islands (west of 175^0 west longitude) is a Type I rougheye population which is distinct from adjacent populations in the Bering Sea and western Gulf of Alaska. Meanwhile, there is a Type I population in the central Gulf of Alaska off Kodiak and two populations off British Columbia which are distinct from adjacent populations in the eastern Gulf of Alaska (Figure 3). Analysis of Type II rougheye has identified six distinct non-overlapping populations (Figure 4). Further, genetic divergence among distinct populations of rougheye rockfish appears strong in Type II fish, suggesting Type II rougheye have limited dispersal.

Type I and Type II rougheye appear to have different but overlapping geographic ranges. Type II rougheye have limited abundance west of Kodiak Island, while Type I rougheye can be found throughout the Gulf of Alaska, Bering Sea and Aleutian Islands. Even in regions where these species do overlap, however, it is likely they have different habitat preferences and spatial distributions.

[90] NPFMC 2004. GOA SAFE, at 484.
[91] NPFMC 2003. GOA SAFE, at 575-576.
[92] Gharrett, A.J., A.P. Matala, E.L. Peterson, A.K. Gray, Z. Li, and J. Heifetz. (in press) Distribution and population genetic structure of sibling species of rougheye rockfish based on microsatellite and mitochondrial variation. Transactions of the American Fisheries Society.

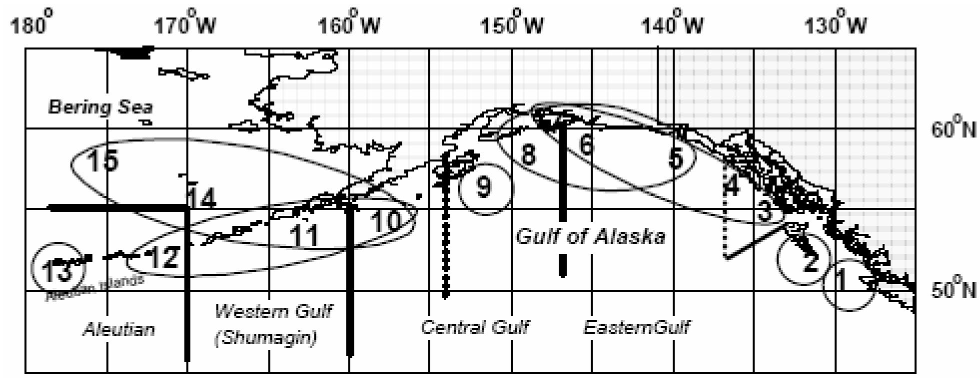

Figure 3. Ellipses delineate populations of Type I rougheye rockfish that are homogeneous and separate from adjacent populations based on microsatellite variation. Solid lines on the map indicate regulatory area boundaries. Courtesy of A.J. Gharrett.

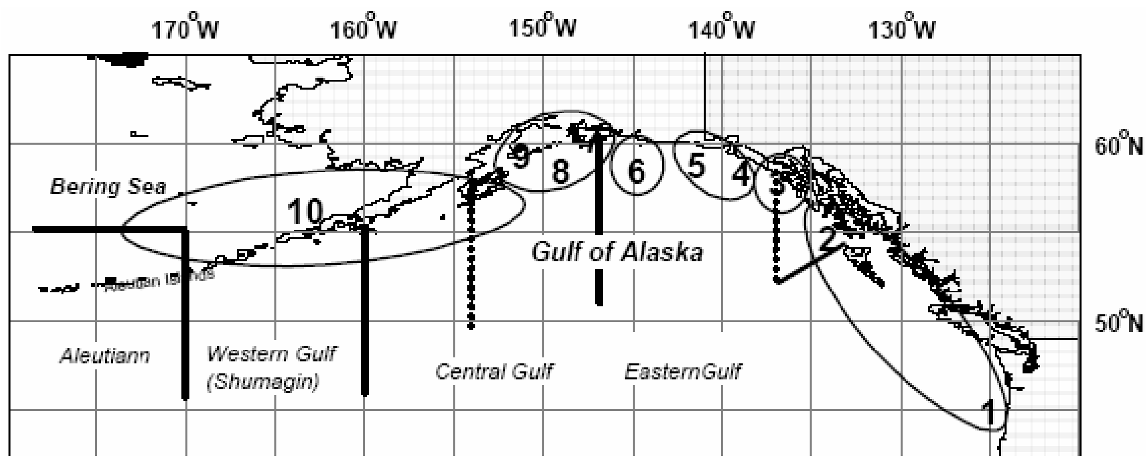

Figure 4. Ellipses delineate populations of Type II rougheye rockfish that are homogenous and separate from the adjacent populations based on microsatellite variation. Solid lines on the map indicate regulatory area boundaries. Courtesy of A.J. Gharrett.

How to manage rougheye rockfish populations in a way that is consistent with their unique life history and population structure has long vexed fisheries managers. For example, between 1991 and 2001, managers set the catch levels for Bering Sea and Aleutian Islands rougheye rockfish in aggregate with three other rockfish species. Then in 2001, they split rougheye into a smaller management group along with shortraker rockfish (*Sebastes borealis*). Starting in 2004, managers split rougheye out from this complex, but still manage Type I and II as one population.

The current imprecision of management boundaries may be exacerbating historic overfishing of rougheye. Recent work by stock assessment authors estimate that disproportionate rougheye rockfish catch when managed in an assemblage probably led to exceeding acceptable catch levels in the Aleutians Islands, "*sometimes by large amounts*."[93] Considering catch levels and high fishing mortality rates of rougheye in the

[93] NPFMC 2004. BSAI SAFE, at 793.

Aleutian Islands compared to acceptable biological and overfishing levels, it is clear that overfishing has occurred in this region multiple times in recent years (Figures 5 and 6).

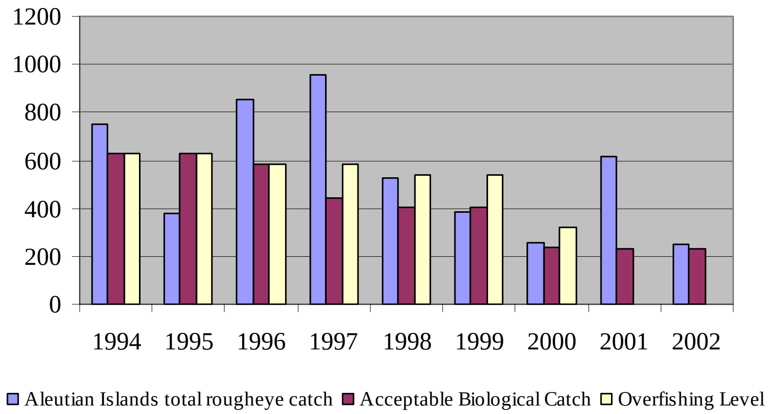

Figure 5. Catch of rougheye rockfish (metric tons) in the Aleutian Islands compared to the acceptable biological catch and overfishing level (not available for some years) for the Aleutian Islands region. Catch exceeded the acceptable catch seven out of nine years from 1994 to 2002.[94]

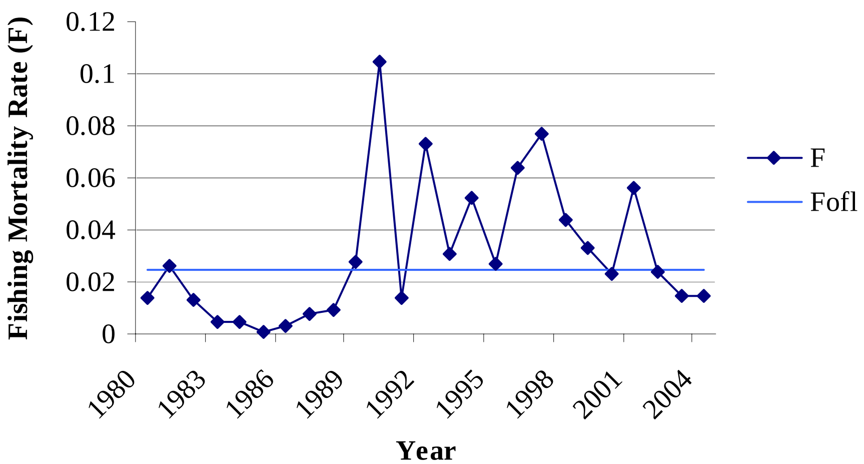

Figure 6. Estimated fishing mortality rate for Bering Sea and Aleutian Islands rougheye. The fishing mortality rate (F) has greatly exceeded the fishing rate that constitutes overfishing; Fofl for Rougheye = 0.025 (Fofl = fishing mortality rate which, if applied constantly, would constitute overfishing). [95]

While we are certain that overfishing of BSAI rougheye rockfish has occurred in recent years, we are unaware of historic trends prior to 1980 because catch information is unavailable. The decline of the species over the last 25 years may be worse due to prior fishing effort in which rockfish catch to the species level went undocumented, resulting in another "shifting baselines" scenario.

[94] NPFMC 2004. BSAI SAFE, at 810-811.
[95] NPFMC 2004. BSAI SAFE, at 815.

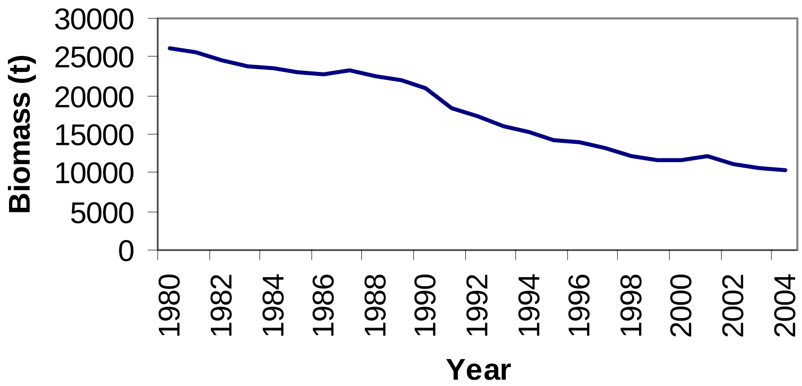

Figure 7. Estimated biomass of Bering Sea/ Aleutian Islands rougheye rockfish. [96]

Populations of rougheye rockfish are sensitive to overfishing and they are slow to rebuild, as is the case with many long-lived fishes. Fisheries managers, who continue to manage rougheye populations as one species across the entire Bering Sea and Aleutian Islands, have been reluctant to take concrete action to respond to the decline of rougheye rockfish and the discovery that they are multiple stocks. Management response is slow because a more refined management approach, such as setting separate allowable catch and overfishing levels for the Aleutian Islands region, would result in constraints on fisheries that incidentally catch these rockfish.[97]

STATE MANAGEMENT

The Alaska Department of Fish and Game (ADFG) manages sport and commercial rockfish fisheries inside state waters (zero to three miles from shore), plus black and blue rockfishes in both federal and state waters. In southeast Alaska outside waters (3- 200 miles), ADFG manages the demersal shelf rockfish assemblage jointly with the National Marine Fisheries Service. The demersal shelf assemblage includes seven species of rockfishes but the catch is primarily yelloweye rockfish.

In 1998 the NPFMC amended the Gulf of Alaska Fishery Management Plan by removing black and blue rockfishes from the pelagic shelf rockfish assemblage. Management responsibility for these species in federal waters defaulted to the State.[98] Black rockfish are both targeted and caught incidentally in sport and commercial fisheries throughout the Gulf of Alaska, including Cook Inlet, Prince William Sound and Southeast. Blue rockfish are less common with a northern geographic range likely near Sitka Sound. Any reports of blue rockfish in the western Gulf of Alaska or eastern Bering Sea, however, have likely been confused with the similar dusky rockfish.[99]

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[96] NPFMC 2004. BSAI SAFE, at 814-816.
[97] Balsiger, J.W. NOAA Fisheries Regional Administrator. November 12, 2004. Letter to the Stephanie Madsen, Chair, North Pacific Fishery Management Council. Agenda D-1(f)(3). December 2004.
[98] Trowbridge, C.E. and W.R. Bechtol. 2004. Cook Inlet Area Groundfish Report 2004. Alaska Department of Fish and Game. Special Publication, No. 04-11.
[99] Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.

After the State of Alaska gained management authority over black rockfish, the Alaska Board of Fisheries established a directed commercial rockfish fishery and restricted the legal gear type to jig gear. Mechanical jigs are used, typically rigged with 8-12 baited hooks off four wire lines with lead weights attached at the ends. Jig machines work on the same principle as hand jigging but are made less labor intensive by the use of electric or hydraulic motors which automatically move the line up and down and retrieve the line when fish are hooked. Jig gear was designated as the only legal gear type in the directed rockfish fishery in an attempt to focus the fishery on black rockfish, rather than yelloweye rockfish, which are considered more susceptible to overfishing and less likely to be caught with mechanical jig gear.

(A) Case Study – Rockfishes of the North Gulf Coast:

The North Gulf Coast District of the Cook Inlet Management Area, from Cape Douglas to Cape Fairfield along the outer Kenai Peninsula, supports active commercial and sport fisheries. In recent years fishermen, scientists, and managers have voiced conservation concerns about rockfish populations in this region, such as fewer older fish and possible localized depletion. As described elsewhere in this report, rockfish habitat preferences, physiology, longevity and late maturity are characteristics that make rockfishes susceptible to overfishing.

Compounding these traits that elevate conservation concerns is the lack of stock information for many nearshore rockfish species. There is no system currently in place to quantitatively assess either absolute or relative abundance for many nearshore rockfishes.[100] Additionally, at-sea discards are poorly estimated. While the directed commercial rockfish fishery closes when a guideline harvest level is reached, the recreational fishery is constrained only by bag limits and not by an overall harvest limit.

(1) Commercial Rockfish Fishery

Ninety-five percent of the Cook Inlet Management Area commercial rockfish catch occurs in the North Gulf Coast district.[101] The rocky and high relief habitat off the outer coast is more suitable habitat for nearshore rockfishes than the inside waters of Cook Inlet. Approximately 50% to 80% of the annual commercial rockfish harvest is comprised of black rockfish and 18% to 28% of the catch is yelloweye rockfish. Other harvested species include rougheye, shortraker, thornyhead, quillback, yellowtail, silvergray, dark, and dusky rockfishes. Along the North Gulf Coast, yelloweye rockfish are taken primarily as bycatch in fisheries using longline gear to target Pacific cod or halibut. Although jig gear is the only legal gear for the directed rockfish fishery, the reported yelloweye harvest by jig gear since 2000 exceeded the yelloweye bycatch in fisheries using longline gear. Landings dominated by yelloweye rockfish in the directed

[100] Meyer, S.C. 2000. Composition and Biomass of the Recreational Rockfish *Sebastes* Harvest in Southcentral Alaska, 1992-1995. Alaska Department of Fish and Game. Fishery Data Series, No. 00-6.
[101] Trowbridge, C.E. and W.R. Bechtol. 2004. Cook Inlet Area Groundfish Report 2004. Alaska Department of Fish and Game. Special Publication, No. 04-11.

fishery have raised concerns about the use of legal gear.[102] Because yelloweye do not school in high densities like black rockfish, they are normally not the target of jig fishermen that typically use “fish finders” or sonar to identify large schools of fish to target with their jigging machines.

Despite the lack of stock abundance estimates, the annual guideline harvest level in the Cook Inlet Management Area is capped at 150,000 lbs based on long-term average harvests. The directed rockfish fishery is allocated 130,000 lbs with 20,000 lbs reserved for anticipated bycatch in other directed fisheries. In addition there is a 4,000 lb/ five-day trip limit for the North Gulf Coast District. Starting in April 2005, full retention of all rockfish was required in all commercial fisheries to improve accounting of fishing mortality.[103]

Setting a guideline harvest level for the nearshore rockfishes without knowing the biomass of the different species being harvested is somewhat arbitrary and is similar to the approach employed by managers of the West Coast rockfish fisheries who set a constant fishing rate without having biomass estimates. It is also contrary to the Alaska Board of Fisheries *Guiding Principles for Fishery Management*, which states

> *Conservation of the groundfish resource to ensure sustained yield, which requires that the allowable catch in any fishery be based upon the biological abundance of the stock.*[104]

ADFG biologists are, however, actively working on developing new methods for assessing rockfish abundance, including dive and acoustic surveys. Unlike the West Coast rockfish fisheries, which collapsed, and current rockfish fisheries occurring in federal waters off Alaska, much of Alaska state waters including the North Gulf Coast are closed to bottom trawling.

(2) Sport Fisheries

Active recreational fisheries, including charter and non-charter operations, occur along the North Gulf Coast. Compared to other areas in the southcentral Alaska, including Prince William Sound, Cook Inlet, and Kodiak, the North Gulf Coast consistently experiences the largest recreational rockfish catch.[105] Rockfishes are often incidentally caught by anglers targeting halibut and lingcod, but anglers occasionally target rockfish.

Managers have set recreational bag limits in the North Gulf Coast District at five rockfish per day, only one of which may be a non-pelagic species such as yelloweye. Although there is a daily bag limit, this does not account for rockfish discards, which experience a

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[102] Id.
[103] ADFG Commercial Fisheries Regulations. 5AAC 28.310.
[104] ADFG Commercial Fisheries Regulations. 5AAC 28.089.
[105] Meyer, S.C. 2000. Composition and Biomass of the Recreational Rockfish *Sebastes* Harvest in Southcentral Alaska, 1992-1995. Alaska Department of Fish and Game. Fishery Data Series, No. 00-6.

high rate of mortality. Rockfishes taken at depths greater than 60 feet have a low likelihood of surviving due to decompression injuries.

Concerns about localized depletion and age truncation of black rockfish have been reported in the North Gulf Coast.[106] For example, an area off Cape Fairfield accounted for 43% of the charter boat rockfish harvest in 1993, but the area accounted for only 2.5% of the harvest in 1994 and 1995. When analyzing the age composition of black rockfish caught in the Seward area, Meyer states,

> *[a]lthough older fish are present in small numbers, the proportions appear to decrease faster than expected given the observed maximum ages. With relatively no growth after the age of maturity, it could be assumed that the natural mortality rate of mature fish is relatively constant. This may be an indicator of long-term growth overfishing, which is consistent with some anecdotal reports by long-time sport and commercial fishermen that abundance of black rockfish is much lower than historic levels.*[107]

In recent years, recreational fisheries in the North Gulf Coast have harvested significantly more rockfish than commercial fisheries (Figure 8). The high volume of rockfish catch taken in recreational fisheries is of concern when there is no overall limit to the amount of rockfish that can be taken, nor are there reliable biomass estimates. In Southeast Alaska, where biomass estimates for yelloweye rockfish are available, fisheries managers had to cancel the winter 2005 commercial yelloweye rockfish fishery because high amounts of yelloweye rockfish taken in the recreational fisheries threatened to exceed sustainable catch levels.[108] Because recreational fisheries do not have an overall harvest limit, managers currently have no authority to close these fisheries when harvest reaches high levels, which may result in impacts to other fisheries and to resource conservation.

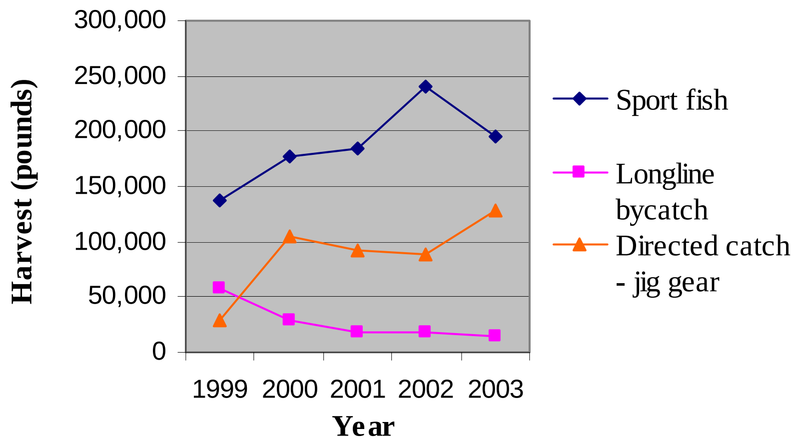

Figure 8. Harvest trend of rockfish catch in the sport, commercial longline bycatch, and directed jig fishery in the North Gulf Coast District, including the Cook Inlet Management Area, 1999-2003.

[106] Id.
[107] Id. at 61.
[108] V. O'Connell, ADFG, personal communication.

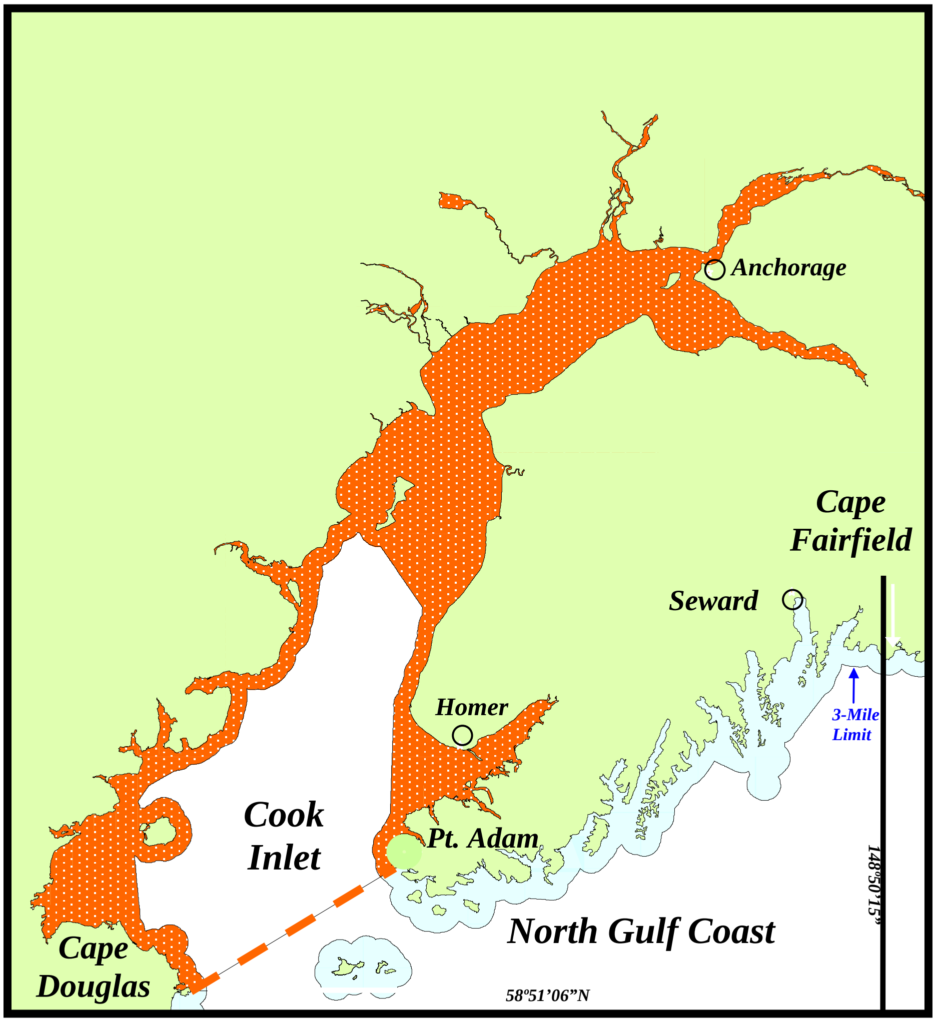

Figure 9. Alaska Department of Fish and Game Cook Inlet Management District, including the North Gulf Coast District from Cape Douglas to Cape Fairfield.

ROCKFISH REFUGIA

Rockfish refugia, or marine reserves, are increasingly being considered by scientists and stakeholders as effective tools for managing rockfishes. A comprehensive system of refugia can achieve multiple goals for rockfish conservation: (1) to serve as buffers against the large uncertainties in abundance estimates, (2) to reduce bycatch and guard against serial overfishing of substocks in patchily distributed locations of high abundance, and (3) to provide for fish habitat conservation.

Marine scientists have indicated that refugia are a necessary tool for maintaining the unique life history characteristics of rockfishes. Berkeley et al. (2004) stated that,

> *there is evidence that older, large female rockfishes produce larvae that withstand starvation longer and grow faster than the offspring of younger*

> *fish, that stocks may actually consist of several reproductively isolated units, and that recruitment may come from only a small and different fraction of the spawning population each year. None of these phenomena is accounted for in the current management programs. We examine alternative management measures that address these specific issues and conclude that the best and perhaps only way to ensure old-growth age structure and complex spatial structure of the populations of groundfish is through interconnected networks of marine reserves*.[109]

The National Research Council has further confirmed the growing recognition that protected areas are a promising component of ecosystem-based management.[110] The benefits of a system of protected areas are not limited to the issue of population preservation alone, but extend to many of the other difficulties concerning rockfish management. These include:

- protecting habitat
- minimizing bycatch
- conserving plants and animals living in protected habitat
- allowing depleted populations of fished species to recover
- spillover of species to surrounding unprotected areas
- providing insurance against environmental and management uncertainty
- providing ecosystem services
- protecting ecological baseline areas.[111]

While the scientific community has repeatedly highlighted the importance of protected areas for the conservation of rockfishes plus the broader enhancement and preservation of the marine environment, areas limiting fishing in part or total, remain highly controversial. To be successful, rockfish refugia must be carefully designed and their planning must include:

- The full involvement of coastal residents, fishermen, scientists, and other stakeholders in identification, creation, and management planning;
- The scientifically based selection and designation of refugia for the purpose of conserving marine biodiversity and fish habitat, and;
- Sufficient funding for necessary research, community involvement, and enforcement.

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[109] Berkeley, S.A., M.A. Hixon, R.J. Larson and M.S. Love. 2004. "Fisheries Sustainability via Protection of Age Structure and Spatial Distribution of Fish Populations." Fisheries 29(8): 23-32.
[110] NRC. 2001. Marine Protected Areas: Tools for Sustaining Ocean Ecosystems. National Research Council. National Academy Press, Washington D.C.
[111] PISCO 2002. The Science of Marine Reserves. The Partnership for Interdisciplinary Studies of Coastal Oceans.

CONCLUSION

Current state and federal fisheries management does not adequately account for the unique biological and ecological characteristics of rockfishes. Although Alaska fishery managers have a more conservative harvest system in place than existed when West Coast rockfish populations collapsed, many similar management and fishery information deficiencies are apparent in the Alaska region. Fisheries managers do incorporate a certain level of precaution in setting catch levels and protecting some habitat areas but there still remains substantial cause for concern with regards to the impacts fisheries are having on rockfish populations. As identified in the findings of this report, issues of greatest concern include:

- Inadequate biomass estimates
- Inadequate biological and genetic information
- Excessive harvest rates
- Overfishing of individual rockfish species managed in assemblages
- Localized depletion of sedentary or genetically distinct populations
- Age truncation
- Habitat loss and degradation.

Agency scientists have recommended removing individual species from assemblages or dividing catch and overfishing levels among smaller regions that more closely match the range of distinct populations. Managers have been reluctant to implement these recommendations or the recommendations made in the F40 report calling for reduced harvest rates[112] because of their implications for commercial fisheries. These measures would likely result in smaller total allowable catch and overfishing levels that would place constraints on commercial fisheries. Without implementation, however, distinct populations and species within assemblages can be overfished without triggering a management response. As signs of age truncation, habitat loss, localized depletion, and potential overfishing are becoming evident in the North Pacific, managers must address these issues and not simply fall back on status-quo management practices.

Recommendations

Based on this independent investigation, AMCC's recommendations for improving rockfish conservation and management in the North Pacific closely follow those already made by the American Fisheries Society in their policy statement for Pacific rockfish.[113] AMCC recommends that state and federal fisheries managers act without further delay to

[112] Goodman et al. 2002. Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Groundfish Fishery Management Plans. Goodman et al. Prepared for the North Pacific Fishery. Management Council. November 21, 2002.
[113] American Fisheries Society. 2000. Policy Statement #31d: Management of Pacific Rockfish.

reduce rockfish harvest rates, minimize and avoid rockfish bycatch, and protect sensitive habitat areas by:

- Reducing fishing mortality by establishing reduced harvest rates ($F_{50\%}$ -$F_{60\%}$) and designing management systems to reduce bycatch and discards.

- Developing mechanisms, including spatial management, to reduce the bycatch of rockfish in non-rockfish fisheries, and to reduce the capture of unmarketable sizes or species in all fisheries.

- Implementing measures that explicitly account for the importance of larger, older females when setting rockfish catch levels.

- Determining total mortalities by species, including mortalities associated with recreational and subsistence fishing to allow the total catch of each species to be monitored with high confidence.

- Establishing mechanisms to limit harvest to the targets established each year and set limits for each species, not groups of species, where weak stocks can be overfished. In recreational fisheries where there are only daily bag limits for individual fishermen, appropriate overall harvest levels should be evaluated and set.

- Collecting species-specific information on age, maturity, fecundity, and location of capture. Essential information includes stock structure and natural mortality estimates.

- Establishing adequate fishery-independent surveys and new survey techniques to monitor population abundance and promote accurate stock assessments.

- Buffering fishing pressure against variability in stock recruitment levels and unforeseen fishing mortality effects by protecting a portion of each population and its habitat through the use of refugia. Refugia should be implemented as part of an adaptive management framework to develop effective criteria for conserving rockfish populations. Furthermore, refugia should be designed to protect multiple species, their habitats, demographic and genetic structure, and community structure.

Success in carrying out this comprehensive strategy will require the commitment of fisheries managers, scientists, and stakeholders recognizing the vital need to improve upon present measures, and, as learned by neighboring fisheries to the south, the potentially devastating consequences of inaction. The Alaska Marine Conservation Council looks forward to working with these interests to realize the shared goal of maintaining healthy North Pacific rockfish populations for generations to come.