AGENDA D-3
DECEMBER 2008

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver
Executive Director

DATE: December 2, 2008

SUBJECT: Arctic Fishery Management Plan

ESTIMATED TIME
2 HOURS

ACTION REQUIRED

Review preliminary Arctic FMP and EA/RIR/IRFA and take action as necessary **(SSC only – Council if necessary)**

BACKGROUND

At its October 2008 meeting, the Council, SSC, AP, and Ecosystem and Enforcement Committees reviewed the preliminary draft Arctic Fishery Management Plan (FMP) and accompanying EA/RIR/IRFA. The SSC, AP, and Ecosystem and Enforcement Committees provided comments (Item D-3(a)). The Council requested that staff address all comments to the extent possible by the end of October, and then release the preliminary draft Arctic FMP and EA/RIR/IRFA for public review. The Council specified in its motion (Item D-3(b)) that it was particularly interested in public comments on Options 1 and 2 for setting conservation and management measures for future Arctic fisheries. The Council also requested that staff meet with the SSC in December 2008 to further discuss the Arctic FMP and remaining SSC concerns. The Arctic FMP and EA/RIR/IRFA were updated by incorporating most of the comments received from the SSC, AP, and Ecosystem and Enforcement Committees, and were posted on the Council's and NMFS Alaska Region's web sites in early November.

Since that time, staffs has continued to work on the Arctic FMP documents, including coordination with Alaska Fisheries Science Center staff to update the database used to inform the development of Options 1 and 2 and to address some of the remaining SSC comments. Also, NMFS reviewed the Arctic FMP documents, as did the office of NOAA General Counsel, and on November 26, 2008 a letter was sent to the Council from NMFS that transmitted these comments and a suggested Option 3 that would address legal and other issues with the other two options. Option 3 is a blend of elements from Options 1 and 2, and includes a suggested means for setting conservation and management measures consistent with the Magnuson-Stevens Act and the draft guidelines for National Standard 1. The NMFS letter with attached Option 3 language is attached as Item D-3(c).

Based on the NMFS letter, staff incorporated the suggested Option 3 into a revised draft Arctic FMP, and sent this document to the SSC in early December. The draft EA/RIR/IRFA was also updated based on the NMFS letter and the suggested Option 3; the EA/RIR/IRFA retains all of the background information used to develop Options 1 and 2, but also includes Option 3.

At this meeting, the SSC is scheduled to review the revised draft Arctic FMP, in particular the suggested Option 3. Staff will brief the SSC on how their comments on the previous draft documents were addressed, both in the FMP text and the EA/RIR/IRFA, and will discuss with the SSC any remaining issues associated with the Arctic FMP package.

The Council requested that a public review draft Arctic FMP and EA/RIR/IRFA be sent out for public review at the end of December 2008 or early January 2009. The Council is scheduled to pick its preferred alternative and take final action to adopt the Arctic FMP at its February 2009 meeting.

Excerpted comments from SSC, AP, and Ecosystem and Enforcement Committees on draft Arctic FMP and EA/RIR/IRFA – October 2008

DRAFT REPORT
of the
SCIENTIFIC AND STATISTICAL COMMITTEE
to the
NORTH PACIFIC FISHERY MANAGEMENT COUNCIL
September 29-October 1, 2008

C-5 Arctic FMP

Bill Wilson (NPFMC) and Grant Thompson (NMFS-AFSC) presented a draft Fishery Management Plan for Fish Resources in the Arctic and the accompanying EA. Melanie Brown (NMFS-AKR) presented the RIR/IRFA. Public testimony was provided by Chris Krenz (Oceana).

The SSC compliments the preparers of these documents for their excellent work. The EA/RIR/IRFA is well developed. The SSC comments on the previous draft reviewed in February 2008 have been addressed.

The SSC offers the following comments to be addressed before the documents are sent out for public review. Because our list of suggested changes is extensive, the SSC wishes to review the Arctic FMP and EA/RIR/IRFA one more time before it is released, preferably after response by NOAA General Counsel to legal questions about Option 2. Moreover, in scheduling a desired completion date for the revised draft FMP, it would be helpful if the timeline for revision did not coincide with the conclusion of the stock assessments. If completion of the Arctic FMP is not urgent, perhaps completion could be deferred until after the December Council meeting.

Much of the SSC discussion focused on the two options. Option 2 has much appeal, but it represents a new approach. At the time of our review, there was uncertainty about whether it is a legally valid approach. As noted by Option 2, there is too much uncertainty in the estimation of MSY to use these estimates for fishery management. Possibly, a simpler approach is to specify an MSY near 0 because no fisheries are established. Therefore, the SSC recommends adding a suboption to Option 2 that initially sets MSY near zero, leaving some room for subsistence harvest, bycatch in state fisheries and an allowance for exploratory surveys. At a minimum, the MSY estimates generated by comparison to the Barents Sea should be removed, as the SSC feels that differences between the Barents Sea and Arctic Ocean renders these estimates invalid. Baffin Bay in eastern Canada may be a more suitable comparison.

In Option 1, the procedures for estimating MSY are quite elegant and the preparers are to be commended for their ingenuity. However, many uncertainties lead to low confidence in these estimates, as well, including: (1) the number of assumptions to be made that are not informed by data, (2) the 1990 survey did not fully cover the region, so CPUEs were extrapolated to unsurveyed areas, (3) the Arctic has undoubtedly changed since the 1990 survey, so that the biomass estimate from 1990 likely does not reflect the current unfished biomass and B_0 is unlikely to be constant, and (4) biological parameters have not been estimated for Arctic cod, saffron cod, nor snow crab in this region. For instance, snow crabs do not grow as large as they do in the eastern Bering Sea and may not even attain maturity. Use of Bering Sea parameter estimates for snow crabs in the Chukchi and Beaufort Sea is likely to lead to overestimates of growth and productivity in the analysis.

For these reasons, the SSC recommends adding some text that qualifies the parameter estimates, including MSY. The text should also outline the expected steps by which uncertainty would be reduced in the future as new information becomes available. These include analyses of more recent (2008) survey data, which presumably will provide much better estimates of B_o, research on the included species to estimate area-specific biological parameters, and ultimate accumulation of survey time series and non-commercial fishery information, allowing the migration to age-structured analyses of the type applied in the GOA and BSAI.

The SSC recommends that the steps for designating a new target fishery listed in Option 2 should also be included in Option 1. Some of the more likely fisheries in the Arctic may be those on southern stocks (e.g., pollock), should range extensions occur. So, the document should indicate how fisheries may be developed on species at the northern tails of their geographic distribution. Likewise, the groundfish tier system of Option 2 should also be included in Option 1. The SSC notes that modified tiers have been developed for crab and these should be included in both Options 1 and 2. The crab tier system in both cases would need to be modified to include ABC determinations.

The SSC offers the following additional editorial comments on the draft Arctic FMP:

1. P. ES-3. Delete the last phrase in the box for permit pertaining to State of Alaska.

2. On p. 6 (item B), the list of those groups who may potentially provide a petition differs from the list provided on p. 23. The two should be reconciled.

3. On p. 7, several instances of "Alternative" should be changed to "Option" under Option 1. Note typos in first paragraph under Option 2.

4. Table 3-1, p. 12. The second sentence in the header for Table 3-1 should be deleted, as no ratio is provided. Also, the header should clarify whether the comparison between 1990 and 1991 pertains only to the 8 stations in common or the full set of stations.

5. Section 3.4.2.1.2 (p. 16). It might be noted that the estimate of B_{msy}/B_o (fraction of unfished biomass corresponding to maximum production) is equal to the fraction of unfished biomass at which fishery thresholds are typically set to close crab fisheries because of concerns about stock status.

6. P. 19-20. Revisit the section on non-consumptive use and consider expanding the discussion. Non-consumptive use may be valued more highly than indicated, particularly if the non-consumptive use of resources as a whole, rather than individually, are considered. Significant impacts will be difficult to define, given the lack of information on these populations.

7. P. 29, item a under 3.8.1. Define what "significant" means in the case of birds and mammals.

8. P. 31, under 3.15.1, no. 2. Include birds and mammals here. Also, consider adding references to ecosystem-based management.

9. P. 34, second paragraph, third sentence. Replace "although" with "because" and replace "can limit" with "limits".

10. P. 115. The section on likelihood of a large oil spill can be improved, perhaps borrowing from estimates and literature on other regions. The FMP cites an MMS report concluding that the threat of a spill is "very low". If the MMS report provides an estimate of the probability, that estimate should be included in the FMP. Although it is not the responsibility of the FMP to analyze threats from oil spills, both catastrophic and chronic spills can have cumulative effects. A discussion of how oiling could impact fisheries and their "ecosystem components" is warranted here.

The SSC offers the following comments on the EA/RIR/IRFA:

1. Comments offered above for the draft FMP should also be considered in the appropriate sections of the EA/RIR/IRFA.

2. Please clarify how management may differ if red king crabs were managed under the Arctic FMP versus the Crab FMP (i.e., Alternative 3 vs. 4). Also, clarify what is meant by "same size and scope" when referring to the purported historic red king crab fishery in the Chukchi Sea, and how these criteria will be quantitatively estimated.

3. For accuracy, replace "Alaska EEZ" with wording such as "EEZ off Alaska".

4. New information is now available on bearded seals, and the SSC will provide this information to the authors.

5. Mammal diets are provided in Table 7-4. Please point to this table earlier in chapter 7.

6. Consideration of non-consumptive value should be included in the RIR. In particular, it may be non-trivial, when considered in a cumulative manner.

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Ecosystem Committee Minutes

Tuesday, September 30, 2008 10am-1pm
Sheraton Hotel, Board Room 308, Anchorage, AK

Arctic FMP

The Committee received a presentation from Mr Wilson and Ms Brown, reviewing the EA/RIR/IRFA for the Arctic FMP, and the draft FMP itself.

The Committee recommends to the Council that the draft Arctic FMP and its EA/RIR/IRFA be released for public review, subject to some clarifications.

1. Address, insofar as it is possible, the comments of the SSC, in time to release the document for review by the end of October (in time for action at the December Council meeting). The comments are mostly editorial or technical, and Mr Wilson indicated that he should be able to address some of them in this timeframe, although he was not able to speak to the availability of staff from the Alaska Fisheries Science Center.
2. With respect to the SSC's comment about Alternative 3, about regarding more specificity about the historic red king crab fishery's size and scope, the Committee provides the following recommendation:
    - the size of the fishery should be no more than 1000 lbs annually,
    - the geographic scope of the fishery should be limited to the four statistical areas identified in the caption of page 203 of the EA, Figure 9-7: 646701, 646631, 646641, 636631.

3. Under Option 1, the Committee recommends editing the language describing the specifications process. The Committee recommends that annual catch limits be specified for a period of 3 years, and thus the Plan Team process that would support these catch limits would occur on a triennial cycle, unless new information is available, which would trigger a specifications process in that year. (The Committee noted that there is precedent for this procedure under the MMPA's marine mammal stock assessments).
4. Under Option 1, clarify that the procedures under Option 2, describing the criteria for moving a species into the target category, also apply under Option 1. The Committee noted that the procedures are also included in the draft FMP; it is important to clarify that the procedures are the focus of the Council's action at this time, as the fisheries would not open under any of the alternatives.

The Committee discussed the legal question which concerned the SSC, regarding Option 2, with Lisa Lindeman, NOAA GC. She confirmed that there is no legal impediment preventing the Council from sending this document out for public review. The Committee felt strongly that the document was ready for public review, that staff has prepared an excellent document, and that the edits suggested by the SSC and the Committee can be incorporated without holding up public review. The SSC agreed that both Option 1 and 2 have merit, and the advantage of releasing the document is that the public will have an opportunity to examine and consider these two options, and provide feedback to the Council for their decisionmaking. Releasing the document does not preclude the SSC providing further review or input the next time this issue is in front of the Council.

The Committee also suggested some other minor clarifications to staff. The draft FMP is written assuming that the Council chooses Alternative 3; this should be more clearly noted on the document. The document should put in perspective the calculated snow crab biomass in the Arctic, e.g., compared to the size and biomass of the eastern Bering Sea crabs and biomass. Under Option 2, a further clarification may be required to explain that MSY is calculated for individual species, not just for the ecosystem component as a whole. Under the description in Option 2, adding a heading on page 104 would highlight that the bulleted list represents the Council procedure for initiating a new target fishery, and clarify that the three suggestions of ways of calculating MSY are just examples that could be applied once the Council moves a fish stock into the target fishery category.

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ADVISORY PANEL MINUTES
North Pacific Fishery Management Council
September 29 – October 4, 2008
Anchorage Sheraton Hotel

C-5 Arctic FMP

The AP would like to note that Michelle Longo Eder, Commissioner, US Arctic Research Commission gave a presentation to the AP and noted that the Commission will continue to work with NPRB, Council, and NOAA to support necessary funding for research for the Arctic FMP.

The AP appreciates the outstanding efforts made by staff to develop a progressive and sophisticated analysis on Arctic Fishery Management. However, the AP recommends the Council delay sending out the document for Public Review until staff addresses the SSCs comments. This document should come back to the Council at the February 2009 meeting.

Motion passes 16/1.

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Enforcement Committee Minutes
September 30, 2008
Sheraton, Anchorage, Alaska

II. Update on the Arctic FMP analysis

Melanie Brown and Bill Wilson gave overview of the status of the Arctic FMP analysis. The Council proposes to develop an Arctic FMP that would (1) close the Arctic to commercial fishing until information improves so that fishing can be conducted sustainably and with due consideration of other ecosystem components; (2) determine the fishery management issues; and (3) implement an ecosystem based management policy that recognized the unique issues in the Alaska Arctic. Committee members recommend that the Arctic FMP enforcement plan might well include VMS as a monitoring tool. As noted in their February 2008 minutes, given the size of the area covered by the Arctic FMP and lack of suitable locations to logistically support enforcement assets which might operate in the area, the use of VMS as a tool to monitor fishing vessel activity in and around the area would be appropriate.

Council Motion – Arctic FMP – October 2008

The Council recommends the release of the draft Arctic FMP and draft EA/RIR/IRFA for public review at the end of October 2008 after staff addresses the SSC and Ecosystem Committee concerns to the extent possible. The Council requests that the Arctic FMP package, including public review comments, be brought back for final action in February 2009, with a December 2008 SSC review step.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

AGENDA D-3(c)
DECEMBER 2008

November 26, 2008

Chris Oliver
Executive Director
North Pacific Fishery Management Council
605 W. 4th Avenue, Suite 306
Anchorage Alaska 99501-2252

Dear Chris:

The North Pacific Fishery Management Council (Council) is currently considering four alternatives for fishery management in the Arctic. One alternative is no action (i.e., maintain status quo). The other three alternatives would establish an Arctic fishery management plan (FMP) and may amend the Bering Sea and Aleutian Islands King and Tanner Crab FMP to address various management scopes in the alternatives. For each of these three action alternatives, the Council also is considering two options, or a combination of these options, for setting maximum sustainable yield (MSY), optimum yield (OY), and other status determination criteria and reference points for the fisheries managed by the FMP.

In October 2008, the Council's Scientific and Statistical Committee (SSC) reviewed the draft Arctic FMP and the draft environmental assessment/regulatory impact review/initial regulatory flexibility analysis (EA/RIR/IRFA) and provided the Council with an extensive list of comments on these documents. One of the SSC's comments was whether Option 2 is a legally valid approach, and it asked that NMFS and NOAA GC provide some advice regarding this concern. NMFS and NOAA GC have reviewed Option 2 and have talked with Alaska Fisheries Science Center staff about the options. The following explains our concerns with certain aspects of Option 2, and presents a possible approach for addressing them.

Agency Concerns with Option 2

Option 2 would create four species categories for the Arctic FMP, listing a number of species in the ecosystem component category, and several species in the prohibited species category. No species would be listed under either the target category or the bycatch category. As explained in the draft EA/RIR/IRFA, Option 2 is based on a proposed rule that would amend the National Standard 1 Guidelines consistent with the current requirements of the Magnuson-Stevens Act (73 FR 32526, June 9, 2008). The proposed National Standard 1 Guidelines state that FMPs are required to contain "a description of the species of fish involved in the fishery" and that "all stocks listed in an FMP or FMP amendment are considered to be 'in the fishery' unless they are identified as ecosystem component species" (50 CFR § 600.310(d)(1) (proposed)).

Given the proposed National Standard 1 Guidelines, the species that would be "in the fishery" under Option 2 would be those species listed in the prohibited species category, and reference points, such as MSY, OY, and annual catch limits (ACLs), must be developed for these species. However, Option 2 does not specify reference points for species in the prohibited species category and explicitly states that the species in the prohibited species category are not part of the FMP.

Recognizing that the intent of Option 2 was not to have the Arctic FMP manage a fishery comprised of prohibited species, this problem could be resolved by moving the species listed in the prohibited species category to the ecosystem component category. However, this adjustment raises the question whether the Arctic FMP would have a fishery that is in need of conservation and management. The Magnuson-Stevens Act at section 303(a)(1) states that "Any fishery management plan which is prepared by any Council ... with respect to any fishery, shall contain the conservation and management measures ... which are necessary and appropriate for the conservation and management of the fishery ...." (See also 16 U.S.C. 1852(h)(1) (requiring the Council to prepare and submit an FMP "for each fishery under its authority that requires conservation and management.")) By placing all species in the ecosystem component category, the ability to identify the fishery that is in need of conservation and management, and therefore the authority for establishing an FMP, becomes less clear.

Another concern with Option 2 is that it sets OY at zero based on the fact that there are no target fisheries authorized by the FMP. It is not clear why Option 2 specifies an OY when the description of the option acknowledges that under the proposed National Standard 1 Guidelines, reference points such as MSY and OY are not required for species in the ecosystem component category. Because Option 2 lists all FMP species in the ecosystem component category, there is no requirement to establish OY. Additionally, the National Standard 1 Guidelines set forth the factors that must be considered and analyzed in establishing OY. The level at which OY is set provides a basis for additional decisions as to whether fishing for a species will be permitted. The fact that there would be no target fisheries authorized by the FMP does not dictate an OY of zero.

Possible Approach to Address These Concerns

The draft EA/RIR/IRFA notes that either Option 1 or Option 2 *or a combination of these options* must be chosen by the Council if the Council adopts Alternative 2, 3, or 4. Given our concerns with Option 2, we have developed and enclosed with this letter a possible third option for SSC, Advisory panel (AP), and Council consideration that would combine certain aspects of the two existing options. While we have determined that this third option is consistent with the proposed National Standard 1 Guidelines, we will have to review this determination after a final rule for the guidelines is published.

To briefly summarize, this third option would list the three species identified in Option 1 as target species and include the remaining finfish and invertebrate species as ecosystem component species. This third option would develop MSY, OY, maximum fishing mortality threshold (MFMT), and minimum stock size threshold (MSST) for each of the three target species, and establish methods to be used in determining levels of acceptable biological catch (ABCs) and ACLs, and measures to ensure that ACLs are not exceeded for the target species. Based on the best available information and the procedures detailed in this third option, the OY for the three target fisheries would be set equal to zero. Thus, the FMP would not authorize any commercial fishing for the three target species. Finally, this third option would allow the Council to revisit the initial placement of species in either the target species or ecosystem component species category, and would prescribe a method for determining whether to move species from one category to another.

All finfish and invertebrates, other than the target species, would be included in the ecosystem component category under this third option. Status determination criteria and reference points would not be established for these ecosystem component species. The third option would include management measures to prohibit commercial fishing for or retention of ecosystem component species. This would be consistent with the Magnuson-Stevens Act, including section 303(b)(12), which provides authority for FMPs to include management measures to conserve target and non-target species and habitats, considering the variety of ecological factors affecting fishery populations.

NMFS and NOAA GC staff will be available at the December Council meeting to answer questions concerning this letter and the enclosure.

Sincerely,

Robert D. Mecum

Robert D. Mecum
Acting Administrator, Alaska Region

Enclosure

Draft Option 3 for Arctic FMP conservation and management measures 11-26-08.

Criteria for Authorizing a Commercial Fishery in the Arctic

Until sufficient information exists to authorize a sustainable fisheries management program, commercial fishing is prohibited in the Arctic Management Area. The red king crab fishery described in Appendix A is exempt from the prohibition to commercial fishing. The Council will consider the following criteria for authorizing a commercial fishery in the Arctic Management Area:

A. The Council will initially require an FMP amendment for sustainably managing a commercial fishery ensuring resource conservation, minimize impacts on other users of the area, compliance with the Magnuson-Stevens Act and its National Standards and other applicable laws, and net positive benefits.

B. Any commercial fishing in the Arctic will be specified as one or more target fisheries. In most cases, the target would be a single species, though there may be situations where designating several species as a mixed species target may be more appropriate. Establishing a target fishery may require and FMP amendment that would transfer the species from the ecosystem component category to the target species category.

C. The Council will consider recommending authorizing commercial fishing on a target fishery in the Arctic Management Area upon receiving a petition from the public, or a recommendation from NMFS or the State of Alaska. The Council will initiate a planning process to evaluate information in the petition and other information concerning the proposed target fishery. The Council will require a fishery development analysis to ensure the best available science is used to move a species from unfished status to full fishery development. This analysis could be included in any NEPA and economic analysis required to support FMP amendments. The fishery development analysis will contain the following information.

:

- A review of the life history of the target species
- A review of available information on any historic harvest of the species, commercial, sport or subsistence
- An analysis of customary and traditional subsistence use patterns and evaluation of impacts on existing users
- Initial estimates of stock abundance (B_0) and productivity (M) sufficiently reliable to apply a Tier 5 control rule
- Evaluation of the vulnerability (susceptibility and productivity) of species that will be caught as bycatch in the target fishery.
- Evaluation of potential direct and indirect impacts on Endangered Species Act listed threatened or endangered species
- Evaluation of ecosystem/trophic level effects
- Evaluation of potential impacts on essential fish habitat, including biogenic habitat
- A plan for inseason monitoring of the proposed fishery
- A plan for collecting fishery and survey data sufficient for a Tier 3 assessment of the target species within a defined period
- Identification of specific management goals and objectives during the transition from unexploited stock to exploited resource
- Descriptions of proposed fishery management measures and justification for each

D. The analysis described above will be reviewed by the Council, and if appropriate the Council will initiate an environmental review consistent with NEPA and MSA and prepare an FMP amendment, including appropriate initial review, public review, and final review and rulemaking and completion of the FMP amendment process.

E. The Council may recommend the proposed fishing consistent with measures specified in the proposed FMP amendment and adopt additional measures it believes are necessary for stock conservation, fishery sustainability, and allocation considerations.

F. The Council may recommend onboard observers on fishing vessels, at shoreside processing facilities, or at harvest sites if non-vessel platforms (i.e., ice) are used for harvesting. The Council also may recommend additional research associated with the new fishery, other monitoring programs, recordkeeping and reporting requirements, and periodic review of the fishery's performance relative to requirements of the MSA and other applicable law.

Conservation and Management Measures Overview

Management Area

The FMP and its management regime govern commercial fishing in the Arctic Management Area described in Section 1.1, and for those stocks listed in Sections 1.1 and 3.4. Fishing by foreign vessels is not permitted in the Arctic Management Area because no TALFF or JVP is provided by this FMP.

The Arctic Management Area is all marine waters in the U.S. Exclusive Economic Zone of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the 1990 maritime boundary line and eastward to the U.S./Canada maritime boundary (Figure 1-1).

Two contiguous seas of the Arctic Ocean are referenced in this FMP, the Beaufort Sea and the Chukchi Sea. While oceanographically different, both are poorly understood and no clear boundary between these seas can be defined; therefore, this FMP does not divide the Arctic into subareas.

Definition of Terms

The following terms are definitions adopted by the Council for all fisheries in the Alaskan EEZ.

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions, and fishery technological characteristics (e. g. gear selectivity), and the distribution of catch among fleets.

Optimum yield (OY) is the amount of fish which–

a) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

b) is prescribed as such on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor; and

c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

Overfishing level (OFL) is a limit reference point set annually for a stock or stock complex during the assessment process, as described in Section 3.9, Overfishing criteria. Overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. Operationally, overfishing occurs when the harvest exceeds the OFL.

Acceptable biological catch (ABC) is an annual sustainable target harvest (or range of harvests) for a stock or stock complex, recommended by a Plan Team and the Scientific and Statistical Committee during the assessment process and established by the Council. It is derived from the status and dynamics of the stock, environmental conditions, other ecological factors, and the degree of scientific uncertainty, given the prevailing technological characteristics of the fishery. The target reference point is set below the limit reference point for overfishing.

Total allowable catch (TAC) is the annual harvest limit for a stock or stock complex, derived from the ABC by considering biological, social, and economic factors.

Identification of FMP fisheries

The FMP manages species in the fishery to attain optimum yield of such species on an ongoing basis. In the event that information emerges in the future to indicate interest in commercial fishing for some stock not currently in the fishery, the plan may be amended to include that stock in the fishery and ensure it is managed sustainably.

The following steps are used to identify stocks in the fishery.

1. From the most recent Economic Stock Assessment and Fishery Evaluation (SAFE) Report, tabulate ex-vessel price per pound from the most recent 5 years for the following groups: pollock, Pacific cod, flatfish, rockfish, and sablefish. Convert these to metric units (dollars/kg).
2. From the most recent surveys, tabulate mean CPUE (kg/ha) for each species in the above groups.
3. Calculate mean "revenue per unit effort" (RPUE) for each species encountered by the EBS survey that is also a member of one of the groups identified in Step 1 as (dollars/kg)×(kg/ha), where the average group-specific price from the most recent 5 years is used as the estimator of price.
4. Sort the RPUE series obtained in Step 3; determine the lowest RPUE associated with any target fishery, which is identified as the "cutoff" RPUE. This should not be taken to imply that an actual commercial vessel could operate profitably at such a rate or that an actual commercial vessel would locate its fishing activities independently of target species density (as the survey does); the minimum RPUE obtained here is simply a relative value.
5. Assess the CPUE for the species being considered for an Arctic target fishery using the best available information
6. Account for species at the extremes of their distribution. To focus on species that might actually have self-sustaining populations in the Arctic, eliminate all species that were

observed in fewer than 10% of the hauls and have total biomass estimates of less than 1,000 mt.

7. For each of the species identified in Step 6, assume that the true mean CPUE is equal to the upper 95% confidence interval of the mean. Then, for each species compute the "breakeven" price needed to achieve the cutoff RPUE value. Then, select all species with breakeven prices less than the highest price ever observed for the most recent 5 years for any groundfish listed in Step 1.
8. Of the species identified in Step 7, eliminate any for which markets appear to be nonexistent.

Based on the best available information at the development of the Arctic FMP, the results of the above algorithm are the target species shown in Table 0-1. Until information is available to support adding additional species to the fishery, the remaining Arctic fish, as defined by the Magnuson-Stevens Act, are in the ecosystem component category. Only target species are part of the fishery management unit for this FMP, requiring status determination criteria and essential fish habitat descriptions.

Table 0-1 Target Species and Ecosystem Component Species.

	Finfish	Invertebrates
Target Species	Arctic Cod and Safron Cod	Snow crab (*C. opilio*)
Ecosystem Component Species	All finfish other than Arctic cod and saffron cod	All marine invertebrates other than snow crab (*C. opilio*) and the red king crab fishery described in Appendix A

Specification of Maximum Sustainable Yield

MSY Control Rule

The MSY control rule for stocks in the fishery is of the "constant fishing mortality rate" form. MSY for each stock will be calculated as though the respective stock were exploited at a constant instantaneous fishing mortality rate.

Methods

In the simple dynamic pool model of Thompson (1992, using different notation), equilibrium biomass B is given by the equation

$$B(F|r) = \left[\left(\frac{h}{M+F}\right)\left(1+\frac{1}{(M+F)d}\right)\right]^{1/r} \quad ,$$

where F is the instantaneous fishing mortality rate, M is the instantaneous natural mortality rate, d is the difference between the age of maturity and the age intercept of the linear weight-at-age equation, h is the scale parameter in Cushing's (1971) stock-recruitment relationship (with recruitment measured in units of biomass), and $0 \leq r \leq 1$ is the amount of resilience implied by the stock-recruitment relationship (equal to 1 minus the exponent).

The ratio of equilibrium biomass to equilibrium unfished biomass is given by

$$Bratio(F|r) = \left[\left(\frac{M}{M+F}\right)^2 \left(\frac{(M+F)d+1}{(M+F)d}\right)\right]^{1/r} \quad .$$

Equilibrium (sustainable) yield is just the product of F and equilibrium biomass:

$$Y(F|r) = F\,B(F|r) \quad .$$

Likewise, the ratio of equilibrium yield to equilibrium unfished biomass is given by

$$Yratio(F|r) = F\,Bratio(F|r) \quad .$$

Equilibrium yield is maximized by fishing at the following rate:

$$F_{MSY}(r) = \left(\frac{M}{2(1-r)}\right)\left(1 - \frac{2-r}{M\,d} + \sqrt{\left(\frac{2-r}{M\,d}\right)^2 + \frac{4-6r}{M\,d} + 1}\right) - M \quad .$$

Determine the biomass information that provides the best representation of unfished biomass B_0. If it is assumed that the area-swept biomass estimate from the 1990 survey represents equilibrium unfished biomass B_0, an estimate of the MSY stock size B_{MSY} can be obtained as

$$B_{MSY} = Bratio(F_{MSY}(r)|r)\,B_0 \quad ,$$

and an estimate of MSY can be obtained as

$$MSY = Yratio(F_{MSY}(r)|r)\,B_0 \quad .$$

Application of the above equations requires an estimate of the resilience r. Typically, this parameter (or its analogue, depending on the assumed form of the stock-recruitment relationship) is very difficult to estimate in a stock assessment. In the case where no stock assessment even exists, it is necessary to assume a value on the basis of theory. As noted by Thompson (1993), in order for F_{MSY} and its commonly suggested proxies M, $F_{0.1}$, and $F_{35\%}$ all to be equal, a necessary (but not sufficient) condition is that r take the value 5/7 (≈0.714). Therefore, the value 5/7 will be taken as the point estimate of r for each species in the specification of MSY.

MSY for Target Species

The following descriptions of MSY for snow crab, Arctic cod, and saffron cod are based on the best available science at the time this FMP was developed. These values are examples of MSYs, which will be updated as necessary based on new information available during the stock assessment process described in Section 3.10.2. The values provided here are applicable until the FMP is amended based on new information in stock assessments sufficient to update these MSYs.

Snow crab: As implied by Turnock and Rugolo (2008, p. 40), the age at maturity for snow crab likely ranges between 7 and 9 years. The age at maturity will be estimated here as the midpoint of that range (8 years). Turnock and Rugolo also list 0.23 as the value for M in the Bering Sea. Together with the default estimate of r (5/7), and assuming that the age intercept of the linear weight-at-age equation is zero, these values give an F_{MSY} estimate of 0.36, a B_{MSY}/B_0 of 0.193, and an MSY/B_0 ratio of 0.069. The area-swept biomass estimate from the 1990 Arctic survey is 147,196 t, giving B_{MSY}=28,409 t and MSY=10,157 t.

Arctic cod: FishBase (Froese and Pauly 2008) reports that the age at maturity for Arctic cod likely ranges between 2 and 5 years. The age at maturity will be estimated here as the midpoint of that range (3.5 years). FishBase also lists a value of 0.22 for the Brody growth parameter K and a value of 7 years for maximum age. Using Jensen's (1996) Equation 7, an age of maturity equal to 3.5 years corresponds to an M of 0.47, while Jensen's Equation 8 implies an M of 0.33. Using Hoenig's (1983) equation, a maximum age of 7 corresponds to an M of 0.62. Taking the average of these three estimates (0.47, 0.33, 0.62) gives an M of 0.47, which is the estimate that will be used here. Together with the default estimate of r (5/7), and assuming that the age intercept of the linear weight-at-age equation is zero, these values give an F_{MSY} estimate of 0.70, a B_{MSY}/B_0 of 0.196, and an MSY/B_0 ratio of 0.136. The area-swept biomass estimate from the 1990 Arctic survey is 60,042 t, giving B_{MSY}=11,768 t and MSY=8,166 t.

Saffron cod: FishBase (Froese and Pauly 2008) reports that the age at maturity for saffron cod likely ranges between 2 and 3 years. The age at maturity will be estimated here as the midpoint of that range (2.5 years). FishBase also lists a value of 7 years for maximum age. Using Jensen's (1996) Equation 7, an age of maturity equal to 2.5 years corresponds to an M of 0.66. Using Hoenig's (1983) equation, a maximum age of 7 corresponds to an M of 0.30. (Need to check with Grant, should the maximum age be 15 or 7 here?) Taking the average of these two estimates (0.66, 0.30) gives an M of 0.48, which is the estimate that will be used here. Together with the default estimate of r (5/7), and assuming that the age intercept of the linear weight-at-age equation is zero, these values give an F_{MSY} estimate of 0.62, a B_{MSY}/B_0 of 0.207, and an MSY/B_0 ratio of 0.128. The area-swept biomass estimate from the 1990 Arctic survey is 10,195 t, giving B_{MSY}=2,110 t and MSY=1,305 t.

The main reference points derived above for the three stocks are summarized below. This is an illustration of the process for deriving MSY and is based on the information available during the development of the Arctic FMP. These values will be revised through FMP amendments as appropriate, based on new information provided during the stock assessment process.

Stock	F_{MSY}	B_{MSY}	MSY
Snow crab	0.36	28,409 t	10,157 t
Arctic cod	0.70	11,768 t	8,166 t
Saffron cod	0.62	2,110 t	1,305 t

Specification of Status Determination Criteria

The National Standard Guidelines require specification of two status determination criteria: the maximum fishing mortality threshold (MFMT) and the minimum stock size threshold (MSST). The guidelines suggest, but do not require, that an FMP specify overfishing limit (OFL).

Maximum Fishing Mortality Threshold

The National Standard Guidelines state the following in paragraph (2)(d)(i): "The fishing mortality threshold may be expressed either as a single number or as a function of spawning biomass or other measure of productive capacity. The fishing mortality rate must not exceed the fishing mortality threshold or level associated with the relevant MSY control rule. Exceeding the fishing mortality threshold for a period of 1 year or more constitutes overfishing."

The MFMT for Arctic fisheries is specified as F_{MSY}, the MSY control rule. If a future stock assessment results in an improved estimate of F_{MSY}, as determined by the Scientific and Statistical Committee, the FMP will be amended to improve the estimate of F_{MSY}. The overfishing limit for each fishery is specified as the catch that would result from fishing at the MFMT. (Is this consistent with discussion on determining overfishing under the tier system?)

Minimum Stock Size Threshold

The National Standard Guidelines state the following in paragraph (2)(d)(ii): "The stock size threshold should be expressed in terms of spawning biomass or other measure of productive capacity. To the extent possible, the stock size threshold should equal whichever of the following is greater: one-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the maximum fishing mortality threshold specified under paragraph (d)(2)(i) of this section. Should the actual size of the stock or stock complex in a given year fall below this threshold, the stock or stock complex is considered overfished."

Because no stock assessments have been conducted for the target stocks, it is impossible to determine the range of stock sizes over which rebuilding to B_{MSY} would be expected to occur within 10 years under an F_{MSY} exploitation strategy. In the absence of information indicating that such a rebuilding rate would be expected for any stock size below B_{MSY}, the MSST for these fisheries is therefore specified as B_{MSY}. If a future stock assessment results in an improved estimate of B_{MSY}, as determined by the Scientific and Statistical Committee, and it is appropriate to replace the B_{MSY} value listed in the FMP, the FMP will be amended. Also, if a future stock assessment enables estimation of rebuilding rates under an F_{MSY} exploitation strategy and it is appropriate to revise F_{MSY}, then the FMP will be amended to revise MSST according to the National Standard Guidelines definition.

Specification of Optimum Yield

The MSA states that optimum yield is to be specified "on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor." The recently proposed guidelines also suggest that OY be reduced from MSY to account for scientific uncertainty in calculating MSY. (73 FR 32526, June 9, 2008, 50 CFR 600.310(e)(3)(v), proposed). According to the National Standard Guidelines, OY is supposed to be specified by analysis, as described in §600.310(f)(6). Among other things, this section of the guidelines states, "The choice of a particular OY must be carefully defined and documented to show that the OY selected will produce the greatest benefit to the Nation and prevent overfishing." The following subsections analyze possible reductions from MSY as prescribed by relevant socio-economic and ecological factors; doing so one at a time to begin with, then in combination. The results shown are examples based on the information available during the development of the FMP and are applicable until the FMP is amended to incorporate new information from the stock assessment process described in Section 3.10.2.

Reductions from MSY prescribed by relevant socio-economic factors: Uncertainty

Methods

Decision theory can be used to compute the appropriate reduction from MSY resulting from consideration of uncertainty. This requires specification of a utility function. One of the simplest and most widely used utility functions is the "constant relative risk aversion" form (Pratt 1964, Arrow 1965), which will be assumed here. Given this functional form, it is also necessary to specify a value for the risk aversion coefficient. A value of unity will be assumed here. Finally, it is necessary to specify a measure of the nominal wealth accruing to society from the fishery. It will be assumed here that the nominal wealth accruing to society from the fishery is proportional to the equilibrium yield. Given these specifications, the decision-theoretic objective is to maximize the geometric mean of equilibrium yield.

It will also be assumed that the values of parameters M and d are known and that parameter r is a random variable, in which case geometric mean equilibrium yield is given by

$$Y_G(F) = Y(F|r_H) \quad ,$$

where r_H is the harmonic mean of r.

Geometric mean equilibrium yield is maximized by fishing at the constant rate $F_{MSY}(r_H)$. Similarly, the geometric mean of the ratio between equilibrium yield and equilibrium unfished biomass is given by

$$Yratio_G(F) = Yratio(F|r_H) \quad .$$

It will also be assumed that the area-swept biomass estimate from the 1990 survey represents equilibrium unfished biomass and that this estimate is lognormally distributed with

$$\sigma_B = \sqrt{\ln\left(1 + \frac{\mathrm{var}(CPUE)}{\mathrm{mean}(CPUE)^2 N}\right)} \quad .$$

Given the above, OY can be estimated as

$$OY = Yratio_G(F_{MSY}(r_H)|r_H)\, B_0 \exp\left(-\frac{\sigma_B^{\,2}}{2}\right) \quad .$$

Application of the above equation requires an estimate of the harmonic mean of the resilience r. Given that no assessments have been conducted of the stocks to which the plan applies, statistical estimates of this quantity (e.g., from a Bayesian posterior distribution) are not available. Therefore, it is necessary to use informed judgment to arrive at an estimate. Given the default value of 5/7 used in the estimation of MSY and the general lack of stock-specific information, it is reasonable to assume a logit-normal distribution for r with μ_r=ln(5/2) and σ_r=1. This distribution has a median value of 5/7 (the point estimate used in the MSY specifications), a coefficient of variation close to 0.27, and a harmonic mean close to 0.60.

If the distribution of r is logit-normal with a given median, no finite value of σ_r can reduce OY to zero. However, this result does not hold across all distributional forms. For example, if the distribution of r is beta with a given arithmetic mean, it is possible to find a coefficient of variation large enough that OY is reduced to zero.

Results

Snow crab: Together with the default distribution assumed for r, the parameters listed in the MSY section imply an OY/B_0 ratio of 0.046. The estimate of σ_B from the 1990 Arctic survey is 0.166, which, together with the biomass point estimate of 147,196 t, implies a geometric mean value for B_0 of 145,171 t. Considering the effects of uncertainty, then, OY would be 6,678 t, a reduction of 34% from MSY.

Arctic cod: Together with the default distribution assumed for r, the parameters listed in the MSY section imply an OY/B_0 ratio of 0.065. The estimate of σ_B from the 1990 Arctic survey is 0.192, which, together with the biomass point estimate of 60,042 t, implies a geometric mean value for B_0 of 58,944 t. Considering the effects of uncertainty, then, OY would be 3,831 t, a reduction of 53% from MSY.

Saffron cod: Together with the default distribution assumed for r, the parameters listed in the MSY section imply an OY/B_0 ratio of 0.064. The estimate of σ_B from the 1990 Arctic survey is 0.702, which, together with the biomass point estimate of 10,195 t, implies a geometric mean value for B_0 of 7,970 t. Considering the effects of uncertainty, then, OY would be 510 t, a reduction of 61% from MSY.

Reductions from MSY prescribed by relevant socio-economic factors: Non-consumptive value

Methods

In addition to the benefits derived from the consumptive uses of a stock, it is possible for society to derive value from non-consumptive uses. For example, society might prefer a higher biomass to a lower biomass irrespective of the use of that biomass to generate fishery yields. Non-consumptive values can be combined with consumptive values to generate a measure of equilibrium total gross value V as follows:

$$V(F|r) = B(F|r)(p_B + F p_Y) \quad ,$$

where p_B is the "price" per unit of biomass associated with non-consumptive use and p_Y is the price per unit of yield associated with consumptive uses.

The fishing mortality rate that maximizes sustainable value is given by

$$F_{MSV}(r) = \left(\frac{M}{2(1-r)}\right)\left((1-u) - \frac{2-r}{M\,d} + \sqrt{\left(\frac{2-r}{M\,d}\right)^2 + \left(\frac{4-6r}{M\,d}\right)(1-u) + (1-u)^2}\right) - M \quad ,$$

where $u = p_B/(M \times p_Y)$. Note that this expression is identical to the equation for F_{MSY}, except that the quantity 1 is replaced by the quantity $1-u$ in three places.

It is theoretically possible for u to be sufficiently high that the optimal fishing mortality rate (and thus OY) is zero. This value is given by

$$u_0 = \left(\frac{M\,d+1}{M\,d+2}\right)r \quad .$$

Results

There are no data on the value of p_B for any of the qualifying fisheries that would be covered by the FMP. However, available information from other fisheries indicates that p_B is likely to be very small. Based on the parameter values given in the section on MSY, the ratio of p_B to p_Y at which OY is reduced to zero for each of the three fisheries is as follows:

Snow crab:	0.12
Arctic cod:	0.24
Saffron cod:	0.24

It is very unlikely that the ratio of p_B to p_Y comes anywhere close to the above values for any of the three target fisheries covered by the FMP. The available information pertaining to non-consumptive value therefore does not support a reduction from MSY for any of the three potential commercial fisheries.

Reductions from MSY prescribed by relevant socio-economic factors: Costs

Methods

Costs of fishing can be viewed as including a fixed component, which is incurred at any level of fishing, and a variable component, which changes proportionally with the level of fishing. Equilibrium net wealth W can then be written as follows:

$$W(F|r) = B(F|r)F\,p_Y - c_F - F\,c_V \quad ,$$

where c_F is the instantaneous fixed cost rate and c_V is the instantaneous variable cost rate.

The fishing mortality rate that maximizes sustainable net wealth has no closed-form solution.

It is possible for fixed cost rate or the variable cost rate (or both) to be sufficiently high that the optimal fishing mortality rate is zero. In particular, if c_F>MSY×p_Y or if c_V>B_0×p_Y, the optimal fishing mortality rate, and thus OY, will be zero. It should be noted that these are sufficient, but not necessary, conditions for a zero OY.

Results

No significant commercial fishery currently exists for any of the three stocks to which the plan applies. Neither does there appear to have been significant commercial fisheries targeting these species, in this region, in the past. This implies that the expected costs of fishing outweigh the expected revenues, all else equal. These costs may include fuel use in remote locations, distance to processing facilities, very small CPUE in comparison to other fishing locations, lack of knowledge of profitable fishing locations, and small fish or crab size. Because any significant level of commercial effort evidently results in a net loss, the available information pertaining to costs would appear to prescribe something close to a 100% reduction from MSY for each of the three fisheries so long as current cost and expected revenue structures remain unchanged.

Reductions from MSY prescribed by relevant ecological factors

Methods

The MSFCMA requires that the specification of optimum yield take "into account the protection of marine ecosystems." Arctic cod is identified as a keystone species which needs to remain close to carrying capacity in order for the marine ecosystem to retain its present structure. No other keystone species are identified. Therefore, the OY for each of the three fisheries needs to be set at a level that limits impacts on Arctic cod to negligible levels. Available data pertaining to likely catches of Arctic cod in each of the three fisheries can be examined to determine if the respective fishery would be expected to have anything more than a negligible impact on the Arctic cod stock.

Results

Snow crab: Because snow crab are exclusively fished with pot gear, the relative catch rates of snow crab and Arctic cod from the 1990 Arctic survey are probably not a good indicator of the likely incidental catch rate in a future Arctic snow crab fishery. Therefore, the best available data on potential incidental catch rates in a future Arctic snow crab fishery come from the Bering Sea snow crab fishery. Incidental catch rates for gadids in that fishery are typically on the order of 0.5% (individual gadids caught per individual snow crab caught), which could reasonably be interpreted as a negligible value. Snow crab is also a prey species for marine mammal species that are either petitioned or currently under review for ESA listing. The removal of prey species may increase stress on these marine mammal species and may affect the predator/prey relationship in the Arctic. It is difficult to quantify the amount of MSY reduction to provide for this factor considering the variety of food these marine mammals consume. Until more information is known, it is not possible to quantify a reduction of MSY based on the relevant ecological factors in the snow crab fishery.

Arctic cod: By definition, any directed fishery for Arctic cod would have non-negligible impacts on the Arctic cod stock. Therefore, the relevant ecological factors prescribe something close to a 100% reduction from MSY in the Arctic cod fishery.

Saffron cod: In the 1990 Arctic survey, if the station-specific data are sorted in order of decreasing saffron cod CPUE and consideration is limited to the upper quartile (to approximate a fishery targeting on saffron cod), the median incidental catch rate of Arctic cod is just over 5 kg per kg of saffron cod. In other words, the best scientific information available indicates that a target fishery for saffron cod would likely take about five tons of Arctic cod for every ton of saffron cod, which could not reasonably be interpreted as a negligible value. Therefore, the relevant ecological factors prescribe something close to a 100% reduction from MSY in the saffron cod fishery.

Conclusion: OY Reductions from MSY prescribed by all relevant factors

The reductions from MSY resulting from the above analyses are summarized below:

Fishery	Uncertainty	Non-consumptive value	Costs	Ecosystem
Snow crab	34%	~0%	~100%	~0%
Arctic cod	53%	~0%	~100%	~100%
Saffron cod	61%	~0%	~100%	~100%

Interactions between the various factors were not considered in the analyses summarized in the above table, which could be problematic were it not for the fact that one factor (costs) prescribes something close to a 100% reduction from MSY for all three fisheries, and another factor (ecosystem) prescribes something close to a 100% reduction for all but the snow crab fishery.

On the basis of these analyses, OY would be an annual *de minimis* catch, sufficient only to account for bycatch in subsistence fisheries for other species. Because this FMP applies to the management of commercial fishing, the OY for each of the target species is zero based on the 100% reduction of MSY for each target fishery. In the event that new scientific information becomes available suggesting that the conditions estimated or assumed in the process of making this specification are no longer valid, a new analysis should be conducted and the FMP amended to change OY based on the new information.

Overfishing and Acceptable Biological Catch Determination Criteria

Overfishing is defined as any amount of fishing in excess of a prescribed maximum allowable rate. For finfish species in the Target Species category, this maximum allowable rate would be prescribed through a set of five tiers which are listed in section 4.7.3.3.1 in descending order of preference, corresponding to descending order of information availability. A similar tier process for crab species follows in section 3.8.2. The tier systems for specifications ares based on best available information (section 3.3). The tier system is used to specify ABC and OFL in a manner that accounts for uncertainty in the information used. Less information leads to more conservative setting of these values, resulting in more conservation management of stocks for which less information is available or reliable. .

If OY for the Arctic fisheries is reduced to zero through the process shown in section 3.7.5, no acceptable biological catches or total allowable catches would be specified. The process described in this section applies to the appropriate fishery that has been identified through the process described in sections 2.2 and 3.4.

The Council's Scientific and Statistical Committee (SSC) will have final authority for determining whether a given item of information is "reliable," and may use either objective or subjective criteria in making such determinations.

Finfish Tiers

For tier (1), a "pdf" refers to a probability density function. For tiers 1 and 2, if a reliable pdf of biomass at MSY (B_{MSY}) is available, the preferred point estimate of B_{MSY} is the geometric mean of its pdf. For tiers 1 to 5, if a reliable pdf of B is available, the preferred point estimate is the geometric mean of its pdf. For tiers 1 to 3, the coefficient α is set at a default value of 0.05. This default value was established by applying the 10 percent rule suggested by Rosenberg et al. (1994) to the ½ B_{MSY} reference point. However, the SSC may establish a different value for a specific stock or stock complex as merited by the best available scientific information. For tiers 2 to 4, a designation of the form "$F_{X\%}$" refers to the fishing mortality (F) associated with an equilibrium level of spawning per recruit equal to X% of the equilibrium level of spawning per recruit in the absence of any fishing. If reliable information sufficient to characterize the entire maturity schedule of a species is not available, the SSC may choose to view spawning per recruit calculations based on a knife-edge maturity assumption as reliable. For tier 3, the term $B_{40\%}$ refers to the long-term average biomass that would be expected under average recruitment and $F=F_{40\%}$.

Tier 1 Information available: Reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY} .

1a) Stock status: $B/B_{MSY} > 1$

$F_{OFL} = m_A$, the arithmetic mean of the pdf

$F_{ABC} \leq m_H$, the harmonic mean of the pdf

1b) Stock status: $a < B/B_{MSY} \leq 1$

$F_{OFL} = m_A \times (B/B_{MSY} - a)/(1 - a)$

$F_{ABC} \leq m_H \times (B/B_{MSY} - a)/(1 - a)$

1c) Stock status: $B/B_{MSY} \leq a$

$F_{OFL} = 0$

$F_{ABC} = 0$

Tier 2 Information available: Reliable point estimates of B, B_{MSY} , F_{MSY} , $F_{35\%}$, and $F_{40\%}$.

2a) Stock status: $B/B_{MSY} > 1$

$F_{OFL} = F_{MSY}$

$F_{ABC} \leq F_{MSY} \times (F_{40\%} /F_{35\%})$

2b) Stock status: $a < B/B_{MSY}$ # 1

$F_{OFL} = F_{MSY} \times (B/B_{MSY} - a)/(1 - a)$

$F_{ABC} \leq F_{MSY} \times (F_{40\%} /F_{35\%}) \times (B/B_{MSY} - a)/(1 - a)$

2c) Stock status: $B/B_{MSY} \leq a$

$F_{OFL} = 0$

$F_{ABC} = 0$

Tier 3 Information available: Reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$.

3a) Stock status: $B/B_{40\%} > 1$

$F_{OFL} = F_{35\%}$

$F_{ABC} \leq F_{40\%}$

3b) Stock status: $a < B/B_{40\%} \leq 1$

$F_{OFL} = F_{35\%} \times (B/B_{40\%} - a)/(1 - a)$
$F_{ABC} \leq F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$

3c) Stock status: $B/B_{40\%} \leq a$
$F_{OFL} = 0$
$F_{ABC} = 0$

Tier 4 Information available: Reliable point estimates of B, $F_{35\%}$, and $F_{40\%}$.
$F_{OFL} = F_{35\%}$
$F_{ABC} \leq F_{40\%}$

Tier 5 Information available: Reliable point estimates of B and natural mortality rate M.
$F_{OFL} = M$
$F_{ABC} \leq 0.75 \times M$.

Crab Tiers

Status determination criteria for crab stocks are calculated using a five-tier system that accommodates varying levels of uncertainty of information. The five-tier system incorporates new scientific information and provides a mechanism to continually improve the status determination criteria as new information becomes available. Under the five-tier system, overfishing and overfished criterion are formulated and assessed to determine the status of the crab stocks and whether (1) overfishing is occurring or the rate or level of fishing mortality for a stock or stock complex is approaching overfishing, and (2) a stock or stock complex is overfished or a stock or stock complex is approaching an overfished condition.

Overfishing is determined by comparing the overfishing level (OFL), as calculated in the five-tier system for the crab fishing year, with the catch estimates for that crab fishing year. For the previous crab fishing year, NMFS will determine whether overfishing occurred by comparing the previous year's OFL with the catch from the previous crab fishing year. This catch includes all fishery removals, including retained catch and discard losses, for those stocks where non-target fishery removal data are available. Discard losses are determined by multiplying the appropriate handling mortality rate by observer estimates of bycatch discards. For stocks where only retained catch information is available, the OFL will be set for and compared to the retained catch.

NMFS will determine whether a stock is in an overfished condition by comparing annual biomass estimates to the established MSST, defined as ½ B_{MSY}. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished. MSSTs or proxies are set for stocks in Tiers 1-4. For Tier 5 stocks, it is not possible to set an MSST because there are no reliable estimates of biomass.

If overfishing occurred or the stock is overfished, section 304(e)(3)(A) of the Magnuson-Stevens Act, as amended, requires the Council to immediately end overfishing and rebuild affected stocks.

The Council, Scientific and Statistical Committee, and Crab Plan Team will review (1) the stock assessment documents, (2) the OFLs and total allowable catches or guideline harvest levels for the upcoming crab fishery, (3) NMFS's determination of whether overfishing occurred in the previous crab fishing year, and (4) NMFS's determination of whether any stocks are overfished.

Five-Tier System

The OFL for each stock is estimated for the upcoming crab fishery using the five-tier system, detailed in Table 0-2 and

Table 0-3. First, a stock is assigned to one of the five tiers based on the availability of information for that stock and model parameter choices are made. Tier assignments and model parameter choices are recommended through the Crab Plan Team process to the Council's Scientific and Statistical Committee. The Council's Scientific and Statistical Committee will recommend tier assignments, stock assessment and model structure, and parameter choices, including whether information is "reliable," for the assessment authors to use for calculating the OFLs based on the five-tier system.

For Tiers 1 through 4, once a stock is assigned to a tier, the stock status level is determined based on recent survey data and assessment models, as available. The stock status level determines the equation used in calculating the F_{OFL}. Three levels of stock status are specified and denoted by "a," "b," and "c" (see Table 0-2). The F_{MSY} control rule reduces the F_{OFL} as biomass declines by stock status level. At stock status level "a," current stock biomass exceeds the B_{MSY}. For stocks in status level "b," current biomass is less than B_{MSY} but greater than a level specified as the "critical biomass threshold" (β).

Lastly, in stock status level "c," current biomass is below β * (B_{MSY} or a proxy for B_{MSY}). At stock status level "c," directed fishing is prohibited and an F_{OFL} at or below F_{MSY} would be determined for all other sources of fishing mortality in the development of the rebuilding plan. The Council will develop a rebuilding plan once a stock level falls below the MSST. The estimation of B_{msy}/B_0 is equal to the fraction of unfished biomass at which fishery thresholds are typically set to close crab fisheries because of concerns about stock status.

For Tiers 1 through 3, the coefficient α is set at a default value of 0.1, and β set at a default value of 0.25, with the understanding that the Scientific and Statistical Committee may recommend different values for a specific stock or stock complex as merited by the best available scientific information.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, are used in the calculation of the F_{OFL}.

In Tier 5, the OFL is specified in terms of an average catch value over an historical time period, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information.

OFLs will be calculated by applying the F_{OFL} and using the most recent abundance estimates. The Crab Plan Team will review stock assessment documents, the most recent abundance estimates, and the proposed OFLs. The Alaska Fisheries Science Center will set the OFLs consistent with this FMP and forward OFLs for each stock to the State of Alaska prior to its setting the total allowable catch or guideline harvest level for that stock's upcoming crab fishing season.

Tiers 1 through 3

For Tiers 1 through 3, reliable estimates of B, B_{MSY}, and F_{MSY}, or their respective proxy values, are available. Tiers 1 and 2 are for stocks with a reliable estimate of the spawner/recruit relationship, thereby enabling the estimation of the limit reference points B_{MSY} and F_{MSY}.

Tier 1 is for stocks with assessment models in which the probability density function (pdf) of F_{MSY} is estimated.
Tier 2 is for stocks with assessment models in which a reliable point estimate, but not the pdf, of F_{MSY} is made.
Tier 3 is for stocks where reliable estimates of the spawner/recruit relationship are not available, but proxies for F_{MSY} and B_{MSY} can be estimated.

For Tier 3 stocks, maturity and other essential life-history information are available to estimate proxy limit reference points. For Tier 3, a designation of the form "F_x" refers to the fishing mortality rate associated with an equilibrium level of fertilized egg production (or its proxy) per recruit equal to X% of the equilibrium level in the absence of any fishing.

The OFL calculation accounts for all losses to the stock not attributable to natural mortality. The OFL is the total catch limit comprised of three catch components: (1) non-directed fishery discard losses; (2) directed fishery discard losses; and (3) directed fishery retained catch. To determine the discard losses, the handling mortality rate is multiplied by bycatch discards in each fishery. Overfishing would occur if, in any year, the sum of all three catch components exceeds the OFL.

Tier 4

Tier 4 is for stocks where essential life-history, recruitment information, and understanding are lacking. Therefore, it is not possible to estimate the spawner-recruit relationship. However, there is sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries. The simulation modeling approach employed in the derivation of the annual OFLs captures the historical performance of the fisheries as seen in observer data from the early 1990s to present and thus borrows information from other stocks as necessary to estimate biological parameters such as γ.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, are used in the calculation of the F_{OFL}. Explicit to Tier 4 are reliable estimates of current survey biomass and the instantaneous M. The proxy B_{MSY} is the average biomass over a specified time period, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information. A scalar, γ, is multiplied by M to estimate the F_{OFL} for stocks at status levels a and b, and γ is allowed to be less than or greater than unity. Use of the scalar γ is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of γ is set at 1.0, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information.

If the information necessary to determine total catch OFLs is not available for a Tier 4 stock, then the OFL is determined for retained catch. In the future, as information improves, data would be available for some stocks to allow the formulation and use of selectivity curves for the discard fisheries (directed and non-directed losses) as well as the directed fishery (retained catch) in the models. The resulting OFL from this approach, therefore, would be the total catch OFL.

Tier 5

Tier 5 stocks have no reliable estimates of biomass or M and only historical data of retained catch is available. For Tier 5 stocks, the historical performance of the fishery is used to set OFLs in terms of retained catch. The OFL represents the average retained catch from a time period determined to be representative of the production potential of the stock. The time period selected for computing the average catch, hence the OFL, would be based on the best scientific information available and provide the appropriate risk aversion for stock conservation and utilization goals. In Tier 5, the OFL is specified in terms of an average catch value over a time period determined to be representative of the production potential of the stock, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information.

For most Tier 5 stocks, only retained catch information is available so the OFL will be estimated for the retained catch portion only, with the corresponding overfishing comparison on the retained catch only. In the future, as information improves, the OFL calculation could include discard losses, at which point the OFL would be applied to the retained catch plus the discard losses from directed and non-directed fisheries.

Table 0-2 **Five-Tier System for setting overfishing limits for crab stocks. The tiers are listed in descending order of information availability.**

Table 0-3 contains a guide for understanding the five-tier system.

Information available	Tier	Stock status level	F_{OFL}
B, B_{MSY}, F_{MSY}, and pdf of F_{MSY}	1	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = \mu_A$ =arithmetic mean of the pdf
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$ †
B, B_{MSY}, F_{MSY}	2	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = F_{msy}$
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$ †
B, $F_{35\%}$, $B_{35\%}$	3	a. $\frac{B}{B_{35\%^*}} > 1$	$F_{OFL} = F_{35\%}$ *
		b. $\beta < \frac{B}{B_{35\%}{}^*} \leq 1$	$F_{OFL} = F^*_{35\%} \frac{\frac{B}{B^*_{35\%}} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{35\%}{}^*} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$ †
B, M, $B_{msy^{prox}}$	4	a. $\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$
		b. $\beta < \frac{B}{B_{msy^{prox}}} \leq 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy^{prox}}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$ †
Stocks with no reliable estimates of biomass or M.	5		OFL = average catch from a time period to be determined, unless the SSC recommends an alternative value based on the best available scientific information.

*35% is the default value unless the SSC recommends a different value based on the best available scientific information.

† An $F_{OFL} \leq F_{MSY}$ will be determined in the development of the rebuilding plan for that stock.

Table 0-3 A guide for understanding the five-tier system.

- F_{OFL} — the instantaneous fishing mortality (F) from the directed fishery that is used in the calculation of the overfishing limit (OFL). F_{OFL} is determined as a function of:
  - F_{MSY} — the instantaneous F that will produce MSY at the MSY-producing biomass
    - A proxy of F_{MSY} may be used; e.g., $F_{x\%}$, the instantaneous F that results in x% of the equilibrium spawning per recruit relative to the unfished value
  - B — a measure of the productive capacity of the stock, such as spawning biomass or fertilized egg production.
    - A proxy of B may be used; e.g., mature male biomass
  - B_{MSY} — the value of B at the MSY-producing level
    - A proxy of B_{MSY} may be used; e.g., mature male biomass at the MSY-producing level
  - β — a parameter with restriction that $0 \leq \beta < 1$.
  - α — a parameter with restriction that $0 \leq \alpha \leq \beta$.
- The maximum value of F_{OFL} is F_{MSY}. $F_{OFL} = F_{MSY}$ when $B > B_{MSY}$.
- F_{OFL} decreases linearly from F_{MSY} to $F_{MSY} \cdot (\beta - \alpha)/(1-\alpha)$ as B decreases from B_{MSY} to $\beta \cdot B_{MSY}$
- When $B \leq \beta \cdot B_{MSY}$, $F = 0$ for the directed fishery and $F_{OFL} \leq F_{MSY}$ for the non-directed fisheries, which will be determined in the development of the rebuilding plan.
- The parameter, β, determines the threshold level of B at or below which directed fishing is prohibited.
- The parameter, α, determines the value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$ and the rate at which F_{OFL} decreases with decreasing values of B when $\beta \cdot B_{MSY} < B \leq B_{MSY}$.
  - Larger values of α result in a smaller value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$.
  - Larger values of α result in F_{OFL} decreasing at a higher rate with decreasing values of B when $\beta \cdot B_{MSY} < B \leq B_{MSY}$.

AFCS: Where is the ABC control rule for Crab? This is required to show how crab ABC would be set below OFL based on uncertainty.

Specification of ABC and TAC

How do you get to ABC and TAC for snow crab or can the same process be used for all species?

At the time information is available to support the management of a sustainable fishery in the Arctic Management Area, the following process would be used to provide harvest specifications for the management of the target fishery(ies).

The Secretary of Commerce (Secretary), after receiving recommendations from the Council, will determine up to 3 years of TACs and apportionments thereof for each stock or stock complex in the target species categories, by January 1 of the new fishing year, or as soon as practicable thereafter, by means of regulations implementing the FMP. Notwithstanding designated stocks or stock complexes listed by category in Table 0-1, the Council may recommend splitting or combining stocks or stock complexes in the "target species" category for purposes of establishing a new TAC if such action is desirable based on commercial importance of a stock or stock complex and whether sufficient biological information is available to manage a stock or stock complex on its own merits.

Prior to making final recommendations to the Secretary, the Council will make available to the public for comment as soon as practicable after its October meeting, proposed specifications of ABC and TAC for each target stock or stock complex, and apportionments thereof.

The Council will provide proposed recommendations for harvest specifications to the Secretary after its October meeting, including detailed information on the development of each proposed specification and any future information that is expected to affect the final specifications. As soon as practicable after the October meeting, the Secretary will publish in the *Federal Register* proposed harvest specifications based on the Council's October recommendations and make available for public review and comment, all information regarding the development of the specifications, identifying specifications that are likely to change, and possible reasons for changes, if known, from the proposed to final specifications. The prior public review and comment period on the published proposed specifications will be a minimum of 15 days.

At its December meeting, the Council will review the final SAFE reports, recommendations from the Groundfish and Crab Plan Teams, SSC, the Council's Advisory Panel (AP), and comments received. The Council will then make final harvest specifications recommendations to the Secretary for review, approval, and publication. New final annual specifications will supercede current annual specifications on the effective date of the new annual specifications.

Setting Total Allowable Catch

Once a commercial fishery is authorized by amendment to this FMP, the Council will recommend annual harvest levels by specifying a total allowable catch for each target fishery for a three year time period. The following generally describes the procedure that will be used to determine TACs for every target stock and stock complex managed by the FMP.

1. Determine the ABC for each managed stock or stock complex. ABCs are recommended by the Council's SSC based on information presented by the Plan Teams. ABC must be set less than OFL as provided in the tier process in section 3.8.
2. Determine a TAC based on biological and socioeconomic information. The TAC must be less than or equal to the ABC. The TAC may be lower than the ABC if bycatch considerations, socioeconomic considerations, or uncertainty regarding the effectiveness of management measures or accuracy of data used to inform inseason management cause the Council to establish a lower harvest. Does this work for crab?
3. Ensure TACs are at or below the OYs specified for the fisheries in the Arctic FMP. If the TACs are above the OYs, the TACs must be adjusted equal to or below OY or the FMP amended to increase OY based on the best available information.

Stock Assessment and Fishery Evaluation

For purposes of supplying scientific information to the Council for use in specifying ABC, OFLs, and TACs, an Arctic *Stock Assessment and Fishery Evaluation* report will be prepared every three years, or more frequently if new information or the development of a fishery indicates a shorter time period is needed.

Scientists from the Alaska Fisheries Science Center, the Alaska Department of Fish and Game, and other agencies and universities will prepare the Arctic *Stock Assessment and Fishery Evaluation* (SAFE) report every three years. This document is first reviewed by the Crab and BSAI Groundfish Plan Teams, and then by the Council's SSC and AP, and the Council. Reference point recommendations will be made at each level of assessment. Usually, scientists will recommend values for ABC and OFL, and the AP will recommend values for TACs. The Council has final authority to approve all reference points, but focuses on setting TACs so that OYs are achieved and OFLs are not exceeded.

The SAFE report will, at a minimum, contain or refer to the following:

1. current status of Arctic Management Area fish resources, by major species or species group;
2. estimates of maximum sustainable yield and acceptable biological catch;
3. estimates of Arctic fishery species mortality from commercial fisheries, subsistence fisheries, and recreational fisheries, and difference between Arctic target species mortality and catch, if possible;
4. fishery statistics (landings and value) for the current year;
5. the projected responses of stocks and fisheries to alternative levels of fishing mortality;
6. any relevant information relating to changes in Arctic target species markets;
7. information to be used by the Council in establishing any prohibited species catch limits with supporting justification and rationale; and
8. any other biological, social, or economic information that may be useful to the Council.

The Council will use the following to develop its own preliminary recommendations: 1) recommendations of the Plan Teams and Council's SSC and information presented by the Plan Teams and SSC in support of these recommendations; 2) information presented by the Council's Advisory Panel and the public; and 3) other relevant information.

Attainment of Total Allowable Catch

The attainment of a TAC for a species will result in the closure of the target fishery for that species. That is, once the TAC is taken, further retention of that species will be prohibited. Other fisheries targeting on other species could be allowed to continue as long as the non-retainable bycatch of the closed species is found to be non-detrimental to that stock.

Accountability Measures and Mechanisms

No commercial fishing in the Arctic Management Area is authorized by this FMP, and thus, no accountability measures and mechanisms are specified in the FMP. Under this FMP, catch and/or retention of species in the ecosystem component category for commercial purposes is prohibited. Under this FMP catch and/or retention of species in the target category for commercial purposes is prohibited and shall remain so until the FMP is amended to authorize commercial fishing. Accountability measures and mechanisms to ensure overfishing does not occur will be amended to the FMP and adopted in regulations before commercial fishing is authorized in the Arctic Management Area. These measures and mechanisms will be tailored to the commercial fishery to ensure sufficient information can be received in a timely manner to inform decisions for the sustainable management of the commercial fishery.

AGENDA D-3
Supplemental
DECEMBER 2008

WWF

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December 3, 2008

Mr. Eric Olson, Chair
North Pacific Fishery Management Council
605 W. 4th Street, Suite 306
Anchorage, AK 99501-2252

Mr. Doug Mecum, Acting Regional Administrator
NOAA Fisheries, Alaska Region
709 W. 9th Street
Juneau, AK 99802-1668

Re: Arctic Fisheries Management D-3

Dear Mr. Olson and Mr. Mecum,

On behalf of World Wildlife Fund (WWF), I am pleased to submit comments regarding the North Pacific Fishery Management Council's (Council) further consideration of the Arctic Fishery Management Plan (FMP). WWF supports the Council's Arctic FMP proposal, Agenda Item D-3. Among the highest priorities for WWF's Bering Sea program is achieving and maintaining sustainable management of the Arctic ecosystem. We view the Arctic FMP as an important step in keeping the Bering and Chukchi ecosystems healthy for the future.

Given the rapid changes underway in our marine environment, and particularly in the Arctic, taking a precautionary approach to managing our nation's fisheries is more important than ever. WWF believes that the Council's development of an Arctic FMP represents a critical precautionary step. Setting aside sensitive Arctic areas to allow for rigorous scientific studies on the resiliency and productivity of the ecosystem prior to commercial fishing activity sets an excellent example for other nations in the circumpolar region, and even in the high seas of the Arctic.

We underscore the importance of this action as it relates to the broader international perspective of fisheries in the Arctic. We have recently seen the Council's progressive approach reflected in documents distributed in the European Union. The actions of the Council on this issue could position the United States as a leader for establishing the kind of management necessary for the Arctic.

The Council's willingness to proactively address this issue is timely. As the United States National Snow and Ice Data Center recently reported, summer Arctic sea ice extent was the second lowest on record in 2008, following the record lowest Arctic summer sea ice extent in 2007. Thus, the Arctic environment may very soon see substantially increased cumulative impacts from shipping and mineral extraction activities in Arctic Seas as a consequence of diminishing ice cover.

The global community is escalating its interest in the Arctic for transportation and natural resource extraction, as demonstrated by Russia's recent move to increase its Arctic claims. Thus, it is important for the Council to move forward with its current planned schedule on the Arctic FMP. Moreover, it is important that the Council continue to provide the leadership example to stakeholders nationally and internationally of moving cautiously in the absence of science and great uncertainty with respect to activities that may have significant effects on a fragile ecosystem that is slow to change and slow to recover from disruptions or damage.

Therefore, WWF encourages the Council to continue forward with analysis of alternatives for the Arctic FMP Agenda Item D-3. Setting aside the Arctic will help protect the resilience of Arctic ecosystems, prevent additional pressure on currently-stressed wildlife and important marine habitat areas, and ensure the continued productivity of the Arctic's adjacent seas. More importantly, the implementation of the Arctic FMP would constitute a milestone in the history of fisheries management and exemplify the progressive and proactive reputation of the Council.

Thank you for your time and consideration of these comments.

Respectfully,

Alfred Lee "Bubba" Cook Jr.
Kamchatka/Bering Sea Ecoregion Senior Fisheries Program Officer
World Wildlife Fund

LENFEST OCEAN PROGRAM

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December 2, 2008

Robert D. Mecum
Acting Administrator
National Marine Fisheries Service
Alaska Region
P.O. Box 21668
Juneau, Alaska 99802

Re: Comments Concerning the Development of a Fisheries Management Plan for the Arctic Management Area

Dear Mr. Mecum:

Because of the critical role that adequate baseline data play in sustainable fisheries management, The Lenfest Ocean Program supported researchers from the University of British Columbia to estimate commercial and small-scale fisheries catches in arctic Alaska. This report indicates that more than half of the catches from this area between 1950 and 2006 were from small-scale fisheries.

These results fill an important gap – estimates of subsistence fishery use patterns – and emphasize the importance of a precautionary approach towards fisheries management in this area to minimize impacts on fishing communities. However, the study also points out that further studies are needed to complete the picture of subsistence fishing in this area.

I appreciate the attention that the North Pacific Fishery Council has given to precautionary management of fisheries in the Arctic and the importance of small-scale fisheries. I hope the enclosed report will provide useful baseline data for the upcoming Council decisions about a fishery management plan for the Arctic Management Area.

Respectfully,

Angela Bednarek
Program Officer, Lenfest Ocean Program

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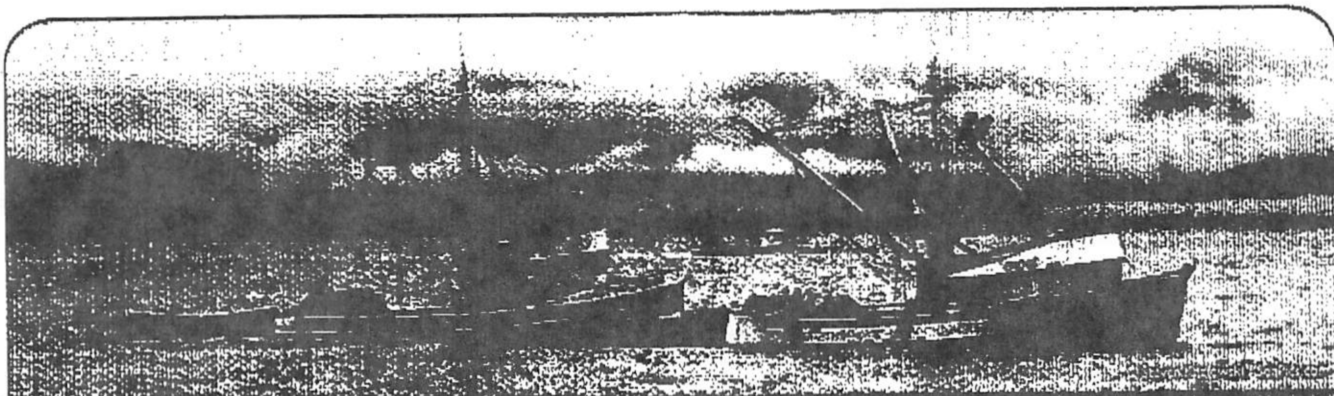

BASELINE STUDY OF MARINE FISHERIES CATCHES FROM ARCTIC ALASKA: 1950–2006

By

Shawn Booth, Dirk Zeller and Daniel Pauly

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A report supported by the

LENFEST OCEAN PROGRAM

BASELINE STUDY OF MARINE FISHERIES CATCHES FROM ARCTIC ALASKA: 1950-2006

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PREFACE

Sustainable fisheries management relies on sufficient baseline data and an understanding of the full range of different kinds of fishing activities. Yet a number of areas of the world lack this information, particularly for small-scale fisheries.

The huge area that makes up the Amerasian Arctic, from Novaya Zemlya Island and the Kara Sea off north-western Siberia in the west to the Canadian Arctic Archipelago and Hudson Bay in the east, is fully encompassed in the United Nations Food and Agriculture Organization (FAO) Statistical Area 18. This is one of the 19 large geographic statistical areas through which the FAO documents the marine fisheries catches of the world, based on reports filed since 1950 by FAO's member countries.

So far, however, the member countries of FAO Area 18 have reported limited or no catches. The USSR and later Russia have not reported catches to the FAO for the north of Siberia (perhaps because Russia did not join the FAO until 2006). Canada has reported only limited catches from its arctic waters. The United States has not reported any catches to FAO.

As this report shows, these data gaps may occur because the reporting systems at the national and international level in these countries do not document small-scale fisheries catches. This is a critical gap because these fisheries may actually constitute much of the fish caught in these areas. The present report provides an estimate of commercial and small-scale fisheries in the U.S. part of FAO Area 18 (i.e., arctic Alaska), and is based on a technical source document available as a University of British Columbia Fisheries Centre Research Report (available at www.fisheries.ubc.ca/publications/reports/fcrr.php). This technical document highlights potential underreporting in the United States - fisheries data collected and reported by the State of Alaska from their three nautical mile jurisdiction are not incorporated into national or international catch reports.

Not only will the data presented in this report and the underlying technical document help provide improved estimates of subsistence fishing, but they could also become important baselines for understanding ecosystem changes due to warming in the Arctic. For this reason, the bottom-up process (i.e., estimation method for small-scale fisheries) used to arrive at the catch data presented here is documented in great detail in the technical source document.

SUMMARY

The Food and Agriculture Organization of the United Nations (FAO) provides global data on fisheries catches based on reports by member countries. For FAO Statistical Area 18 (Arctic), however, the United States reports no fish catches to the global community. In Alaska, communities found north of Cape Prince of Wales fall within FAO Area 18. However, the State of Alaska's Department of Fish and Game has collected time-series of commercial data, and undertakes intermittent community fisheries subsistence studies. At the regional level in Alaska, the National Oceanic and Atmospheric Administration (NOAA) does not report on either of these fisheries, as they take place within state waters. The *Sea Around Us* Project (www.seaaroundus.org), at the University of British Columbia's Fisheries Centre, undertakes catch reconstructions to account for discrepancies between globally reported and likely total catches. Our catch reconstruction includes both subsistence and commercial fisheries of marine and anadromous (migrate between fresh and saltwater) species (excluding marine mammals) from 1950-2006 for 15 coastal and near-coastal communities in arctic Alaska. Total catches over this time period were estimated to be 89,000 tonnes (196.2 million lbs), with subsistence catches contributing 54% (48,200 tonnes or 106.4 million lbs), and commercial catches estimated at over 40,700 tonnes (89.8 million lbs). Subsistence catches averaged 847 tonnes·year^{-1} (1.8 million lbs·year^{-1}, range: 589-1,139 tonnes·year^{-1}). It is only since the late-1980s that subsistence catches have exceeded those from the 1950s, when there was a higher reliance on fisheries resources. While subsistence catches showed only a small increase, the human population has increased from approximately 3,550 to approximately 12,650, which resulted in *per capita* catch rates falling from 237 kg·person^{-1}·year^{-1} (523 lbs·person^{-1}·year^{-1}) in 1950 to 78 kg·person^{-1}·year^{-1} (171 lbs·person^{-1}·year^{-1}) in 2006. One of the main drivers for this was the decrease in the amount of fish used for dog feed, when the snowmobile replaced the dogsled as the main form of transportation. The holistic historical perspective of total reconstructed fisheries catches presented here suggest that subsistence fisheries continue to be important to food security in this area, and merit careful protection, especially in the face of climate change.

Introduction

Alaskan marine fisheries in the arctic area are those that operate north of Cape Prince of Wales on the Seward Peninsula (Figure 1). This area falls within the United Nations Food and Agriculture Organization's (FAO) Statistical Area 18. These statistical areas have been defined by FAO on a statistical, rather than ecosystem basis, to allow comparison of fisheries data among different regions of the world. The National Marine Fisheries Service's Alaska branch (NMFS-Alaska) does not report on fisheries in this area, because they take place within state waters. At the federal level, the National Marine Fisheries Service (NMFS-National) reports on Alaska's fisheries, but they do not include catches taken in the arctic. As a consequence, the United States currently reports zero catches to FAO for the arctic area. The state agency, the Alaska Department of Fish and Game (ADF&G), has collected time-series of commercial data and has also undertaken community subsistence studies that are intermittent in space and time. However, no complete time series of total marine catch estimates exist for the arctic coast of Alaska.

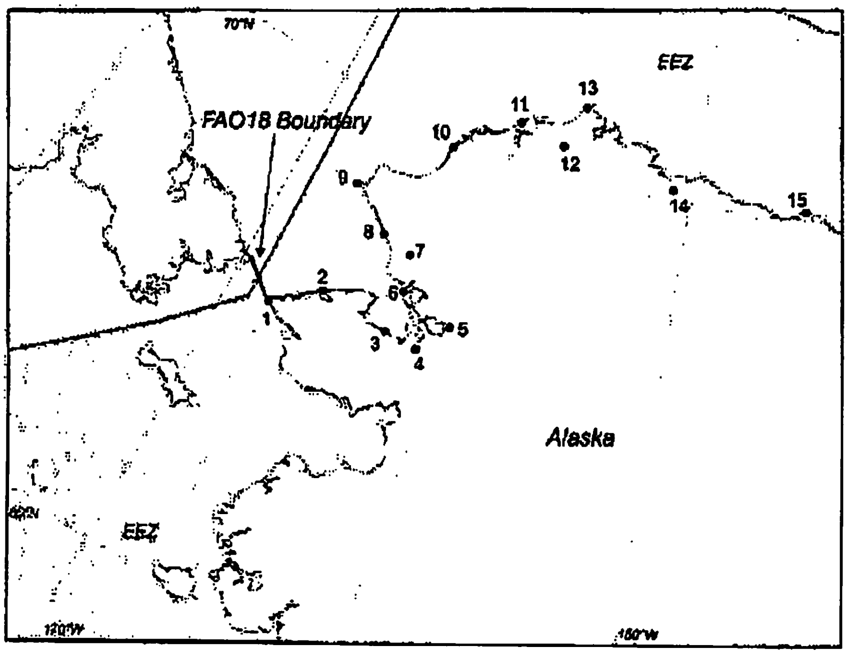

Figure 1. The U.S. state of Alaska, showing the 200 nm Exclusive Economic Zone (EEZ) and southern boundary of FAO Statistical Area 18 (Arctic). Indicated also are the arctic communities of 1) Wales, 2) Shishmaref, 3) Deering, 4) Buckland, 5) Selawik, 6) Kotzebue, 7) Noatak, 8) Kivalina, 9) Point Hope, 10) Point Lay, 11) Wainwright, 12) Barrow, 13) Atqasuk, 14) Nuiqsut and 15) Kaktovik.

Here, we present reconstructed estimates of total commercial and subsistence catches taken by the 15 coastal and near-coastal communities in Alaska's arctic waters that form part of FAO Statistical Area 18 for the years 1950 to 2006.

Fisheries in 1950 were under the mandate of the U.S. federal government. However, driven in part by the desire of Alaskans to have control over their salmon resources, statehood was achieved in 1959. At this point, the state of Alaska took control of its own fisheries management. With the implementation of the Magnuson-Stevens Act in 1976, the federal government gained responsibility of fisheries taking place from 3-200 nautical miles (nm) from shore and the state retained responsibility of the fisheries occurring within 3 nm of the coast. After Alaska gained statehood, its subsistence use of fish and wildlife was given priority over all other uses. However, in subsequent years the Alaska Board of Fisheries and Game created a rural subsistence priority, which was later ruled to be in violation of the state's constitution, and thus subsistence use and personal use fisheries are currently given priority. In 1999, the federal government also extended its jurisdiction to include fisheries on all public lands and waters under the Federal Subsistence Management Program (Woodby *et al.*, 2005).

The people of arctic communities have always relied on the Arctic Ocean for a large part of their sustenance. The area is sparsely populated, and the 15 communities represented in this study (Wales, Shishmaref, Deering, Buckland, Selawik, Kotzebue, Noatak, Kivalina, Point Hope, Point Lay, Wainwright, Barrow, Atqasuk, Nuiqsut, and Kaktovik; Figure 1) have an estimated total population of over 12,000 that grew at an average annual rate of 5.2% per year from 1950 to 2000. The total population has since slightly decreased (Figure 2). Two communities, Atqasuk and Nuiqsut, were founded in the 1970s by people moving from existing communities to traditional lands. These 15 communities form part of three Alaska Native Regional Corporations-the Bering Straits Native Corporation (Wales and Shishmaref), NANA Regional Corporation (Deering, Buckland, Selawik, Kotzebue, Noatak, and Kivalina) and the Arctic Slope Regional Corporation (Point Hope, Point Lay, Wainwright, Barrow, Atqasuk, Nuiqsut, and Kaktovik). Marine commercial fisheries are important in Kotzebue Sound with chum salmon (*Oncorhynchus keta*) the most important component of the catch, while marine subsistence fisheries are an important component throughout the area, and target a variety of species including chum salmon, whitefish (Coregonidae) and Dolly varden (*Salvelinus malma*).

The coastal communities in arctic Alaska have relied on a mixed economy since the late 19th century, when American government and business expanded into the territory and developed commercial industries (Wolfe, 2004). Whaling, reindeer herding, and fur-trapping were important early contributors. After World War Two, the building of military stations (e.g., DEW line) also provided the opportunity for people to earn wages. More recently, the discovery of oil on the North Slope in 1968 has enabled people to participate in a mixed economy with the cash income supplementing a subsistence lifestyle.

MATERIALS AND METHODS

Time series estimates of commercial catches were taken mainly from the 2004 and 2005 Annual Management Reports from the State of Alaska (Kohler *et al.*, 2005; Banducci *et al.*, 2007), and additional unreported catches were estimated using time series analysis (see 'Commercial fisheries data' below). The Annual Management Reports detail the catch in numbers of individuals taken and average weights that were used to convert numbers of fish to round (or live) weight. A time series average for weight was used to estimate the weight of the catch in years when the report did not detail average weights. Arctic cisco taken in the Colville River fishery were assigned an average weight of 1 pound (0.45 kg; Daigneault and Reiser, 2007). Estimates of subsistence catches were taken from a variety of sources (see 'Subsistence fisheries data' below) and were expanded using a range of approaches to incorporate communities and years when no data were available. Subsistence catches in Alaska are often reported in terms of edible weight. If the edible weight to round weight conversion factors were not given, a standard conversion factor of 1.3 was used (Anonymous, 2001)

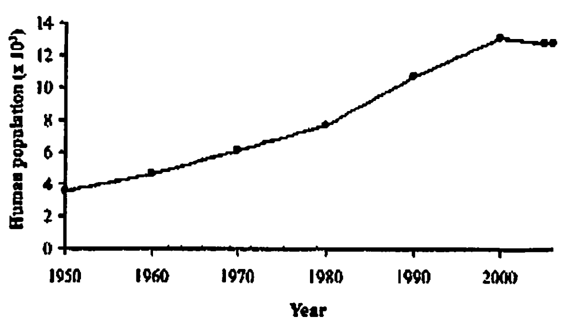

Figure 2. Human population for the fifteen communities of arctic Alaska 1950-2006. Solid circles indicate census data taken from the Division of Commerce, Community and Economic Development's website (www.dced.state.ak.us/). Intervening years are linearly interpolated. For individual community information, see Booth and Zeller (2008).

Human population data

The Alaska community database (Alaska Department of Commerce, Community and Economic Development) provides population data for the first year of every decade (www.dced.state.ak.us), and estimates for 2005 and 2006. We used linear interpolations between years of reported data. For Point Lay (no population data were reported between 1940 and 1980), we used Point Lay Biographies (Impact Assessment Inc., 1989) to estimate the population between 1950 and 1980. Total population for the 15 arctic communities grew from approximately 3,550 in 1950 to 13,000 in 2000 at an average rate of 5.2% per year, before declining to about 12,650 in 2006 (Figure 2).

Commercial fisheries data

Administratively, commercial fisheries for this area take place in the Arctic-Yukon-Kuskokwim region. This region encompasses the drainages of the Kuskokwim, the Yukon and Colville Rivers, and includes both Norton Sound and Kotzebue Sound. However, the areas of the region that coincide with FAO

Statistical Area 18 are Kotzebue Sound and the northern district of the Yukon-Northern area. Within these two areas, there are few commercial fishing opportunities, although a fishery that mainly targets chum salmon takes place in Kotzebue Sound, while another fishery in the Colville Delta targets whitefish. The commercial fishery for chum salmon in Kotzebue Sound is stated to have officially started in 1962 and the Colville River fishery officially commenced in 1967. Commercial catches were taken from the 2005 Annual Management Report and the 2007 Kotzebue Sound salmon season summary (Banducci *et al.*, 2007; Menard and Kent, 2007).

The commercial fishery in Kotzebue Sound for chum salmon, along with incidental takes of Dolly varden (*Salvelinus malma*), other species of salmon, and the fishery for sheefish (*Stenodus leucichthys*) is reported by the commercial fisheries department within ADF&G. Recent and historical data for these species were taken from the 2004 Annual Management Report (Kohler *et al.*, 2005) and the 2005 Annual Management Report (Banducci *et al.*, 2007). However, data for the commercial fishery that targets Arctic cisco largely in estuarine waters near the Colville River were taken from data supplied by Stephen Murphy (pers. comm.[1]). For the period 1974-1976 and 1981, unreported catches of Dolly varden were estimated using the respective average decadal catches.

However, although official documents report that the commercial fishery in Kotzebue Sound started in 1962, there were local commercial fisheries prior to this time. This earlier commercial fishery was informal: local people sold their catch for dog feed to people who ran dog-sled teams, the transportation link prior to the introduction of the snowmobile (C. Lean, pers. comm.[2]). Similarly, Stefanich (1973) reported that commercial fisheries in the Colville River prior to 1967 were taking approximately 64,000 whitefish and ciscos each year; Wilimovsky (1956) estimated that 10,000 pounds of whitefish were taken in one instance in 1952. Thus, these two commercial fisheries had unreported catches estimated for the period prior to their official reporting by ADF&G.

There was also a Japanese fishery in the Chuckchi Sea beginning in 1966, with most fishing effort taking place between 66-67° N and 166-169° W, an area largely within the current boundaries of the US Exclusive Economic Zone. This fishery's peak catches were similar to those for Kotzebue Sound, and thus, it may have been intercepting large numbers of Kotzebue area chum salmon. Commercial data for the Japanese fishery are reported for 1966 and 1967 (Anonymous, 1967, 1968).

Subsistence fisheries data

For the purposes of this study, the scope of subsistence fishing included those fisheries targeting species that rely on marine waters as part of their life history. Thus, subsistence fisheries include both anadromous and marine fish species that are taken in marine, estuarine or freshwater environments, but exclude fish species that are solely reliant on freshwater for their life-cycle. Anadromous species including chum salmon, sheefish, whitefish and Dolly varden, and marine species, including herring (*Clupea pallasii*) and cod (*Boreogadus saida* and *Eleginus gracilis*), are the main species of importance.

Catch data for subsistence fisheries come from a variety of reports that are spatially and temporally intermittent (for details of the sources used, see Booth and Zeller [2008], available at www.fisheries.ubc.ca/publications/reports/fcrr.php) and form the basis for data 'anchor' points (see Zeller *et al.*, 2007). Early studies such as those by Patterson (1974) quantify fisheries catches for several communities representing an average annual catch of important species. The state of Alaska, through its Community Profiles Database (www.subsistence.adfg.state.ak.us), maintains a database on subsistence fish catch and wildlife harvests that includes fisheries data for eleven of the fifteen communities, with most information derived from household surveys. Other studies mostly focus on a given community in a given year, although Burch (1985) presents data for Kivalina for two distinct time periods (1964-1965 and 1982-1983). The data sources used to derive estimates of non-commercial, subsistence catches also indicated that the reported catch totals incorporated catches used for dog-feed.

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[1] Stephen R. Murphy, ABR, Inc. P.O. Box 80410, Fairbanks, Alaska 99708-0410, (907)-455-6777 [information received on October 19, 2007].

[2] Charlie Lean, Norton Sound Fisheries Research and Development Director, P.O. Box 358, Nome, Alaska, 99762, 1-888-650-2477 [information received on January 24, 2008].

In order to account for catches that were not reported during these studies, yearly catches were estimated using several methods. The most common method involved interpolating between data anchor points via *per capita* catch rates. This method involves dividing reported catches of a year by the human population of the same year and then interpolating linearly between the *per capita* catch rates. Another method involved using average catches, whereby a community's catch for reported years was divided by the number of years of reported data to derive an average catch, which was applied to other years when no other data were reported. This method was used in those cases where there was known to be large variations, including zero catches, due to ice in lagoon areas (Burch, 1985). The third method was to use the same reported catch for other years that lacked reported data. This was mostly done in carrying catches forward in time from the last reported catch amount, but was also used in some cases to carry catches backwards in time from the earliest reported catches.

The two final methods involved scaling a community's catch to either another community's reported catch or to another species catch in the same community. Point Hope, Point Lay and Wainwright had only one reported anchor point for most species, and thus other anchor points in time were derived using reported changes for the same species in Kivalina. In Kotzebue, Dolly varden catches were estimated as a percentage of chum salmon catches, since there is some indication that higher catches of Dolly varden are associated with higher catches of chum. Chum salmon catches in Shishmaref were estimated by linearly interpolating the exploitation rate between two data anchor points (average 1971-1975 and 1989); for later years with missing data, the average exploitation rate was used. In Wales, chum catches were derived for 1971-1975 and 1989 using the reported change in catches for Shishmaref. For the intervening time periods, catches were estimated by linear interpolation of the exploitation rate. Eggers and Clark (2006) provide estimated total run sizes for Kotzebue District chum for 1962-2004. Catch data were converted into exploitation rates by dividing the number of chum salmon caught in reported years by the estimated total run size of that year. Average reported weights from the commercial fishery for chum in Kotzebue Sound were used to convert the number of salmon to live weights. Detailed, community-level data and all sources used are presented in the technical report of Booth and Zeller (2008) available at www.fisheries.ubc.ca/publications/reports/fcrr.php.

Human vs. dog feed component of subsistence catches

Prior to the introduction of the snowmobile in the early 1960s, dog-teams provided the main mode of transportation. The first snowmobiles were sold in Kotzebue in the early 1960s and by the winter of 1965-66 the first snowmobiles were brought into Noatak (Hall, 1971). Therefore, we assumed that for communities other than Kotzebue, the snowmobile was introduced in 1965 and for Kotzebue in 1963. Fish were one of the main sources of feed for the dog-teams in some communities. Abrahamson (1968) reported that a dog would need at least 2 pounds of dried fish per day over the winter. C. Lean (pers. comm.) indicated that in the past a dog would be fed half a chum salmon (approximately 4 lbs, given an average weight of 8 lbs per chum) during the winter, and during the rest of the year, they would be fed with other protein sources (e.g., caribou). Thus, we considered that, prior to the introduction of the snowmobile, each dog would be fed 4 pounds of fish each day over a 6 month period.

Raleigh (1957, in Mattson 1962), gave estimates for the number of dogs in the 1950s in each community excluding Wainwright, Barrow, Kaktovik, Selawik and Point Lay. Estimates of the number of dogs for communities lacking data were based on the average dogs-to-people ratio for those communities that had reported data. Patterson (1974) also provided an estimate for the total number of dogs in 1972 for the NANA region, which includes communities outside the scope of this work. However, Raleigh (1957 in Mattson 1962) also provided estimates for these communities and thus, the number of dogs in 1972 for each of the communities was based on the percentage decline of total dogs between 1957 and 1972. For 1957, we assumed that each dog was fed 4 pounds of fish per day over a 6 month period. For 1972, Patterson (1974) estimated that each dog was fed 327 pounds (round weight) of fish per year. Georgette and Loon (1993) estimated the amount of fish fed to dogs for the community of Kotzebue in 1986 and estimates are also provided for Noatak in 1999 (Georgette and Utermohle, 2000) and 2000 (Georgette *et al.* 2001). These data were transformed into anchor points based on the amount of fish used for dog-feed (as a percentage) in relation to the total estimated fish catch. The 1957 estimate of the amount of fish used for dog-feed (as a percentage of the total estimated fish catch) was held constant until the year the snowmobile was introduced (Kotzebue 1963, all others 1965) and then scaled linearly to the 1972 estimate. For the communities that did not have any data available past the 1972 estimate, we scaled the amount of fish used for dog feed on the percentage change for Noatak because Kotzebue, as a regional centre, has a much larger population. Thus, it was possible to estimate, for each community, what percentage of catch through time was fed to dogs by linearly interpolating between anchor points.

However, for some communities the estimates of fish used for dog-feed exceeded the reported catch for the anchor years of 1957 and 1972. On further investigation, it was found that these communities relied far less on fish as a protein source and relied more heavily upon land or marine mammals. Estimates of total protein availability for each community were based on the report of Patterson (1974), who provided estimates on the weight of caribou, deer/reindeer, moose, seals, walrus, beluga, bowhead whales and birds taken in each community. The estimated amount of fish caught was added to these amounts and a percentage contribution to the available protein by fish was determined. The communities of Wales, Shishmaref, Point Hope and Kaktovik were found to have a negative balance, and they also had fish contributing less than 15% to their protein availability; thus we assumed that they did not rely heavily on fish for dog-feed. Therefore, we were also able to determine that the communities of Wainwright and Barrow, which were missing information on the number of dogs, were not heavily dependent on fish as dog-feed because they had fish contributing 3% and 5%, respectively to their total protein availability. No data were available for Point Lay, quantifying the number of dogs or contributions to protein availability, although the community is known for its beluga harvest (B. White, pers. comm.[3]); therefore it was assumed that fish were not relied upon for dog-feed for the following communities: Barrow, Kaktovik, Point Hope, Point Lay, Shishmaref, Wainwright, and Wales.

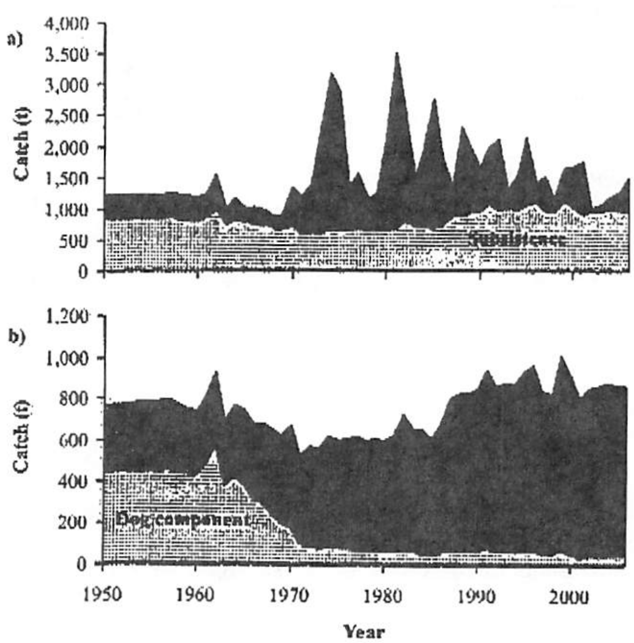

Figure 3. a) Estimated total marine and anadromous fisheries catches (excluding marine mammals) by fishing sector for fifteen coastal and near-coastal communities of Arctic Alaska, and b) breakdown of subsistence catch into estimated amounts destined for human consumption and for dog-feed.

Thus, for each community that was reliant upon fish for dog-feed (Deering, Buckland, Kotzebue, Noatak, Kivalina and Selawik) we were able to determine through time what percent of the estimated catch was used for dog-feed. For the communities of Atqasuk and Nuiqsut, which were established on traditional lands in the 1970s, the average percentage (excluding Kotzebue) was used to determine what proportion of fish was used for dog-feed in the first year that people re-settled traditional lands and the decline was based on changes represented by the community of Noatak. Although Deering in 1957 had a positive protein availability balance, the protein availability balance was negative in 1972, and therefore the change in the amount of fish fed to dogs was based on the average percent decline for the other communities, excluding Kotzebue.

[3] Bruce Wright, Senior scientist, Aleutian Pribilof Islands Association, 1131 East International Airport Rd., Anchorage Alaska 99518, (907)-276-2700 [information received on January 24, 2008].

RESULTS

Total catch time series

Prior to 1962, when commercial fisheries were part of the informal economy, total estimated catches averaged approximately 1,230 t·year⁻¹ (2.7 million lbs·year⁻¹; 1950-1961), with the informal commercial sector accounting for on average 31% of the yearly catch (Figure 3). For the first years, when the commercial fishery was considered part of the formal economy (1962-1969), total catches were estimated to average approximately 1,080 t·year⁻¹ (2.4 million lbs·year⁻¹). From 1970-1989, there were two peak periods of catches, 1974-1975 with catches of 3,178 and 2,909 tonnes (7.0 and 6.4 million lbs) respectively, and then in 1981-1982, with catches of 3,529 and 2,609 tonnes (7.8 and 5.8 million lbs), respectively. Catches for 1970-1989 averaged approximately 1,981 t·year⁻¹ (4.4 million lbs·year⁻¹). During the 1990s, catches averaged approximately 1,651 t·year⁻¹ (3.6 million lbs·year⁻¹) and in the early 2000s estimated total catches had declined to 1,355 t·year⁻¹ (3.0 million lbs·year⁻¹; Figure 3).

Total commercial and subsistence catches over the time period considered here amount to approximately 89,000 tonnes (196 million lbs). The most important species is chum salmon, which accounts on average for 55% of the total yearly catch. The whitefish complex (whitefish + ciscos) is the next most important group, accounting for on average 21%, while sheefish and Dolly varden account for 12% and 8% of the total yearly catch, respectively (Figure 4).

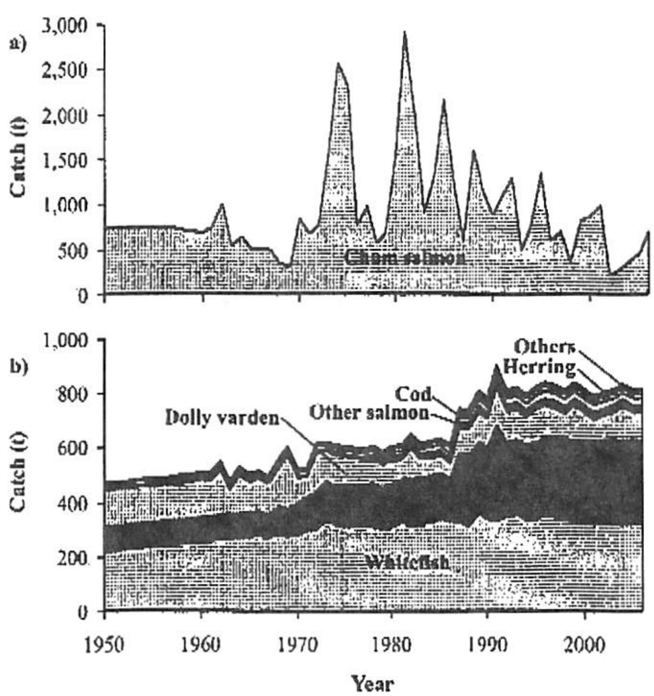

Figure 4. Taxonomic distribution of fisheries catches for the fifteen coastal communities of Arctic Alaska (by common names, marine mammals excluded) for 1950-2006 for a) chum salmon; and b) all other species. Note the difference in scale between the two panels. Whitefish includes both ciscos and whitefish; pink, coho, chinook, and sockeye salmon comprise the group 'Other salmon'; Cod includes both Arctic cod and saffron cod; while capelin, king crab, flounder and other Pleuronectidae (flatfishes), rainbow smelt, smelt and sculpin comprise the group 'Others'. See Booth and Zeller (2008) for all common, local and scientific names.

Subsistence catches

Subsistence catches account for approximately 54% of the estimated total catches (Figure 3a). From 1950-1965, prior to the Japanese high seas fleet fishing in the Chuckchi Sea, subsistence catches averaged 850 t·year⁻¹ (1.9 million lbs·year⁻¹), but declined to around 685 t·year⁻¹ (1.5 million lbs·year⁻¹) from 1966-1979. Catches increased to average 791 t·year⁻¹ (1.7 million lbs·year⁻¹) during the 1980s and it was only since the late 1980s that subsistence catches have consistently surpassed catches from the 1950-1966 time period. Since 1990, subsistence catches have averaged 1,000 t·year⁻¹. Despite increases in subsistence catches, subsistence *per capita* catch rates have declined from 237.0 kg·person⁻¹ (522.6 lbs·person⁻¹) in 1950 to 77.8 kg·person⁻¹ (171.5 lbs·person⁻¹) in 2006. The sharpest drop in subsistence *per capita* catch rates came from 1950-1971, with an estimated decline of approximately 60%. Between the 1950s and 1990s, there has been a 2.4-fold drop in subsistence *per capita* catch rates (Figure 5).

<u>Use of fish for dog-feed</u>

For the eight communities that we determined were reliant on fish for dog-feed, the percentage of fish for dog-feed accounted for 58% of the catch total in 1950 declining to 6% in 2006. Prior to the introduction of the snowmobile (1950-1962), it was estimated that the amount of fish fed to dogs averaged 459 t·year⁻¹ (1 million lbs·year⁻¹). From 1963 to 1975, the amount of fish required for feed dropped from an estimated 387 t·year⁻¹ (843,000 lbs·year⁻¹) to 82 t·year⁻¹ (181,000 lbs·year⁻¹) or from 56 to 14 % of the estimated total subsistence catches for the eight communities. Since 1976, catches for dog-feed have averaged 65 t·year⁻¹ (143,000 lbs·year⁻¹) and have declined from 13% to 6% of total catches (Figure 4).

Commercial catches

Commercial fisheries that were part of the informal economy from1950-1961 were estimated at 382 t·year⁻¹ (842,000 lbs·year⁻¹). Commercial fisheries catches in 1962 were estimated at 553 tonnes (1.2 million lbs), but did not reach that level again until 1970. From 1963-1969 commercial catches averaged 249 t·year⁻¹ (548,000 lbs·year⁻¹), during the 1970s reported catches averaged 1,097 t·year⁻¹ (2.4 million lbs·year⁻¹), rising to around 1,408 t·year⁻¹ (3.1 million lbs·year⁻¹) in the 1980s, before declining in the 1990s to average 621 t·year⁻¹ (1.4 million lbs·year⁻¹). In 2000-2001, catches averaged 732 t·year⁻¹ (1.6 million lbs·year⁻¹), but due to market conditions, recent commercial catches have been low, averaging 226 t·year⁻¹ (497,000 lbs·year⁻¹) from 2002-2006. Chum salmon are the main contributors to the commercial catch totals accounting for an average of 93 % of total commercial catches. Peak years for chum occur every 3 to 4 years (Figure 4).

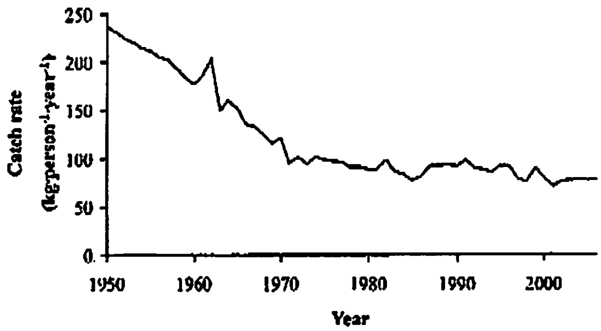

Figure5. Estimated subsistence *per capita* catch rates (total catches/total human population) for Arctic Alaska, 1950-2006 for fifteen communities.

DISCUSSION

The data presented in this report are estimates of commercial and small-scale fisheries catches for species that spend at least a portion of their life-cycle in marine waters (excluding marine mammals) taken from 1950-2006 by fifteen coastal and near-coastal communities in arctic Alaska. These data more likely represent total catches than those previously presented by reporting agencies, because they include both commercial and small-scale fisheries. Thus, they serve as useful baseline data for this area.

Furthermore, the catch reconstruction showed that more than half of the catches from 1950-2006 were from small-scale fisheries. These results underline the importance of subsistence fishing in this area and hence precautionary management to protect their livelihoods and culture. For example, it may be wise to heed the call for a ban on commercial fishing in this area to prevent fishing fleets from expanding into this area as the ice recedes (Biello, 2008) and allow the local people to maintain food security in the face of climate change and the associated ecosystem changes.

Currently, data collected at the state level on commercial and small-scale fisheries by the Alaska Department of Fish and Game are not reported to the National Marine Fisheries Service or to FAO. A more transparent catch reporting system, including data transfer information between state, regional, national, and international agencies, is needed so stakeholders can more easily access and understand available data and their limitations for policy and decision making processes. Having a baseline of information available on total fisheries catches is also important in light of global warming and impacts from ongoing developments, such as in the energy sector.

Although it appears that the commercial fisheries are well monitored by the state of Alaska, a more regular, systematic and comprehensive survey method would lead to a more complete picture of subsistence fisheries, and better track the potential impacts of global warming in this area. A subsistence survey design incorporating each community in a specified time interval, with abundance indices for species in non-survey years could assist in clarifying actual subsistence catches. Specific attention to all salmon species would benefit the efforts to track global warming effects because species' distributions will be affected (Cheung *et al.*, in press). Coho salmon in Norton Sound have been increasing in abundance over the last two decades, but tracking similar changes in northern areas is currently difficult because salmon species, besides chum, are often described as 'other' salmon in reports. That said, chinook salmon appear to have extended their historical distributions northwards because they have been appearing in Barrow since the mid-1990s and there is no local Inupiaq name for them (C. George, pers. comm.[4]). Previously, the furthest reported extent of this species was Wainwright.

This analysis may be underestimating catch data because of the necessary use of different data sources for different time periods. For example, early reported catches were observed amounts only and excluded any adjustments for non-reporting households, whereas later reports were mostly based on a household survey method, which included estimates for non-reporting households. However, these anchor points do allow an assessment of more likely catches for the years when no data have been collected at all. Regardless, the estimates of catches presented here are likely conservative, since no marine catches have been estimated for inland communities that may still have summer camps for fishing near marine waters or that fish for anadromous species further inland.

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