DRAFT
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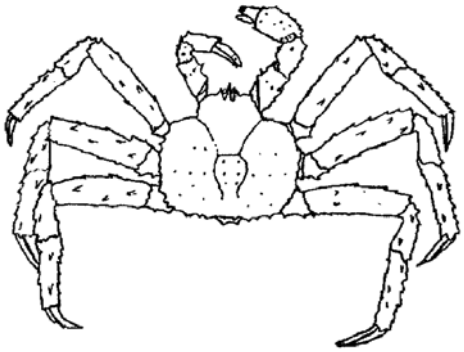
SECRETARIAL REVIEW

ENVIRONMENTAL ASSESSMENT
for
**AMENDMENT 7**
to the Fishery Management Plan for the Commercial
King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands
to

# 1. Revise Definitions of Overfishing, MSY, and OY
# 2. Update the BSAI Crab FMP



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## Executive Summary

This Environmental Assessment (EA) addresses alternatives for meeting the NMFS guidelines (50 CFR part 600) drafted to in response to the Magnuson-Stevens Act provisions for national standard 1 (§301 (a)(1)). National standard 1 states that conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry. The Act did not change the standard, but did change the definition of optimum yield and overfishing.

The Magnuson-Stevens Act also requires the Secretary of Commerce to establish advisory guidelines (which shall not have the force and effect of law), based on the national standards, to assist in the development of fishery management plans. This document examines alternative definitions of overfishing, maximum sustainable yield (MSY), and optimum yield (OY), for Bering Sea and Aleutian Islands (BSAI) king and Tanner crab in accordance with the national standard guidelines.

**Language from the Magnuson-Stevens Act 1996**.

Optimum Yield: The term 'optimum', with respect to the yield from a fishery, means 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 maximum sustainable yield 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 maximum sustainable yield in such fishery.

Overfishing: The terms "overfishing" and "overfished" mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.

This EA also examines potential impacts of updating the BSAI Crab FMP from its original 1989 version. Proposed updates to the FMP include general housekeeping and clarifying language on license limitation implementation schedule. A revised draft FMP is attached as Appendix 2.

Two alternatives were considered:

Alternative 1: Status Quo. No revisions to the current MSY, OY, and overfishing definitions would be made, and the FMP would not be updated.

Alternative 2: (Preferred) Redefine overfishing, OY, and MSY, and update the FMP. Updates to the FMP include general housekeeping as well as clarifying language on license limitation implementation schedule.

Alternative 2 would improve management of the BSAI crab fisheries by instituting the following conservation measures:

1. Requirement that OY take into account protection of marine ecosystems, that OY be no greater than MSY on a continuing basis, and the OY for an overfished fishery allow rebuilding to the MSY level.

2. Revised definitions for MSY based on prevailing ecological and environmental conditions;

3. Revised definitions of overfishing that include both fishing mortality and biomass thresholds; and

4. An updated and user-friendly BSAI King and Tanner Crab FMP.

Under Alternative 2, the following criteria definitions be established for estimation of optimum yield and overfishing of BSAI crab stocks. These definitions, as recommended by the BSAI Crab Plan Team, were based on species life history characteristics and trends in stock biomass estimates.

> MSY Control Rule = the natural mortality rate, M; M=0.2 for king crab and M=0.3 for *Chionoecetes* species.
> MSY Stock Size = the average mature biomass observed over the past 15 years, 1983-1997.
> Overfishing Rate = fishing rate > M.
> Minimum Stock Size Threshold = ½ MSY stock size.

Application of these definitions to each stock is shown in the following table. MSY and threshold estimates were derived from average of 1983-1997 survey data when possible. Values of M were estimated from longevity data (Hoenig 1982). Thresholds were calculated as one-half of the biomass level that produces MSY. Survey data were adjusted for catchability for king crabs, but not for *Chionoecetes* species.

**Table 1: Estimated values of recommending criteria to define optimum yield and overfishing of selected BSAI king and Tanner crabs. Biomass, MSY, and threshold levels reported in millions of pounds.**

| | 1997 Mature Biomass[1] | MSY Control Rule | MSY[1] | Minimum Stock Size Threshold[1] | Current Status (1997) |
|---|---|---|---|---|---|
| Red King Crab | | | | | |
| Bristol Bay | 89.0 | 0.2 | 17.9 | 44.8 | Above threshold |
| Pribilof Islands | 7.1 | 0.2 | 1.3 | 3.3 | Above threshold |
| Blue King Crab | | | | | |
| Pribilof Islands | 8.0 | 0.2 | 2.6 | 6.6 | Above threshold |
| St. Matthew I. | 22.5 | 0.2 | 4.4 | 11.0 | Above threshold |
| Tanner Crab (C. bairdi) | | | | | |
| Eastern Bering Sea | 64.2 | 0.3 | 56.9 | 94.8 | **Below threshold** |
| Snow Crab (C. opilio) | | | | | |
| Eastern Bering Sea | 994.3 | 0.3 | 276.5 | 460.8 | Above threshold |

Note that Tanner crab spawning biomass is below the minimum stock size threshold, and hence would be deemed 'overfished', based on the proposed rule. If adopted by the Secretary of Commerce, the Council will be required to develop a rebuilding plan for this stock within one year.

None of the alternatives contain implementing regulations and therefore the Regulatory Flexibility Act does not apply and review under E.O. 12866 is not required.

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

Table 2: MSY estimates for BSAI king and Tanner crab stocks. Estimated values are in millions of pounds. Long-term average catch represents MSY as it would have been calculated under the old FMP. Current average catch is that over the same years as the MSY estimate and may be taken as the average of OY determinations in the same period.

| | Long-term Average | | Current Average | | | |
|---|---|---|---|---|---|---|
| **Stock** | **Years** | **Ave. Landings** | **Years** | **Ave. Landings** | **MSY Estimate** | **Comments** |
| Adak red king | 1960-95 | 5.8 | 1983-95 | 1.2 | 1.8 | Closed 1996, 1997. |
| Bristol Bay red king | 1953-97 | 30.8 | 1983-97 | 10.6 | 17.9 | MSY from survey history; Closed 1983, 1994-95. |
| Dutch Harbor red king | 1961-82 | 11.3 | 1983-97 | 0.0 | NA | No current MSY; Fishery closed since 1982. |
| Pribilof Islands red king | 1980-97 | 0.9 | 1983-97 | 1.0 | 1.3 | MSY from survey history; No fishing or closed 1984-92 |
| Norton Sound red king | 1977-97 | 0.6 | 1983-97 | 0.3 | 0.5 | Closed 1991. |
| Pribilof Islands blue king | 1966-97 | 3.3 | 1983-97 | 0.8 | 2.6 | MSY from survey history; Closed 1988-94. |
| St Matthew blue king | 1977-97 | 3.0 | 1983-97 | 3.0 | 4.4 | MSY from survey history. |
| St Lawrence blue king | 1979-95 | <0.1 | 1983-95 | <0.1 | 0.1 | MSY provisional; Fished in 1979, 1983, 1989, 1995. |
| Aleutian Is. golden king | 1980-96 | 8.0 | 1983-96 | 8.8 | 17.9 | 1997-98 season in progress. |
| Pribilof Is. golden king | 1981-96 | 0.1 | 1983-97 | 0.1 | 0.3 | No fishing in 1984, 1990. |
| St. Matthew golden king | - | - | 1983-96 | 0.1 | 0.4 | MSY provisional; No fishing 1987-89, 1990-91, 1997. |
| Aleutian Is. scarlet king | - | - | 1992-97 | <0.1 | NA | MSY = 0.06 provisional |
| EBS scarlet king | - | - | 1995-96 | <0.1 | NA | MSY = 0.04 provisional |
| E. Aleutian Is. Tanner | 1974-95 | 0.5 | 1983-95 | 0.2 | 0.7 | No fishing 1996-97. |
| EBS Tanner | 1965-96 | 30.0 | 1983-96 | 13.9 | 56.9 | MSY from survey history; closed 1986-87, 1997. |
| W. Aleutian Is. Tanner | 1973-95 | 0.2 | 1983-95 | 0.1 | 0.4 | Closed 1976, 93-94, 96-97. |
| EBS snow | 1965-97 | 70.7 | 1983-97 | 136.6 | 276.5 | MSY from survey history. |
| E. Aleutian Is. angulatus | - | - | 1995-96 | 0.3 | 1.0 | MSY provisional; no fishing in 1997. |
| EBS angulatus | - | - | 1995-96 | 0.1 | 0.3 | MSY provisional; no fishing in 1997. |
| E. Aleutian Is. tanneri | - | - | 1993-96 | 0.5 | 1.8 | MSY provisional; no fishing in 1997. |
| EBS tanneri | - | - | 1992-96 | 0.5 | 1.5 | MSY provisional; no fishing in 1997. |
| W. Aleutian Is. Tanneri | - | - | 1992-96 | <0.1 | 0.2 | MSY provisional; no fishing in 1997. |

## 1.0 INTRODUCTION

The king and Tanner crab fisheries in the Exclusive Economic Zone (EEZ) (3 to 200 miles offshore) of the Bering Sea and Aleutian Islands off Alaska are managed under the Fishery Management Plan for King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands. This fishery management plan (FMP) was developed by the North Pacific Fishery Management Council (Council) under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). The BSAI King and Tanner crab FMP was approved by the Secretary of Commerce and became effective in 1989.

Actions taken to amend the FMP or implement other regulations governing the BSAI crab fisheries must meet the requirements of Federal laws and regulations. In addition to the Magnuson-Stevens Act, the most important of these are the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), Executive Order (E.O.) 12866, and the Regulatory Flexibility Act (RFA). None of the alternatives contain implementing regulations and therefore the Regulatory Flexibility Act does not apply and review under Executive Order 12866 is not required.

Section 1 contains a description of the purpose and need for the proposed action as well as a description of alternative actions which may address the problem. Section 2 contains information on the biological and environmental impacts of the alternatives as required by NEPA. Impacts on endangered species and marine mammals are also addressed in this section. Section 3 contains a brief analysis of the economic impacts of the alternatives considered.

This Environmental Assessment (EA) addresses alternatives for meeting the NMFS guidelines drafted to in response to the revised Magnuson-Stevens Act provisions for national standard 1.

### 1.1 Purpose of and Need for the Action

The Magnuson-Stevens Act was amended in 1996. Section 301(a) of the Magnuson-Stevens Act contains 10 national standards for fishery conservation and management, with which all FMPs and amendments prepared by the Councils and the Secretary must comply. Section 303(b) requires that the Secretary establish advisory guidelines, based on the national standards, to assist in the development of FMPs. One major provision of the Act necessitates significant revisions to the guidelines for national standard 1 (optimum yield). The national standard guidelines are intended as an aid to decision making, with responsible conservation and management of valued national resources as the goal.

**Language from the Magnuson-Stevens Act 1996**.

National Standard 1: Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

Optimum Yield: The term 'optimum', with respect to the yield from a fishery, means 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 maximum sustainable yield 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 maximum sustainable yield in such fishery.

Overfishing: The terms "overfishing" and "overfished" mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.

The new and revised national standards apply to all FMPs and implementing regulations, existing and future. However, as Congress recognized by allowing the Councils 2 years from enactment (i.e., until October 11, 1998) to submit FMP amendments to comply with the related new requirements in section 303(a), it will take considerable time and effort to bring all FMPs into compliance with the Magnuson-Stevens Act. Once issued

in final, NMFS will use these guidelines to review all new FMPs and amendments to determine whether they comply with the new and revised national standards. The Councils are required to submit necessary amendments to comply with the standards by October 11, 1998.

National standard 1 guidelines were last revised in July 1989; that revision focused on establishing a conservation standard, with the requirement that specific, objective, and measurable definitions of overfishing be established for each fishery managed under the Magnuson- Stevens Act (then called the Magnuson Act). By 1993, more than 100 such definitions had been approved by NMFS. At that time, NMFS convened a panel of scientists from inside and outside the agency to review the approved definitions, investigate their strengths and shortcomings, and standardize, as much as possible, the criteria and basis for future evaluations of overfishing definitions. The goal of the review was to develop a scientific consensus as to the appropriateness of the definitions and the criteria used in their evaluation. The resulting analysis and report (Rosenberg et al., 1994) provided a set of scientific principles for defining overfishing. However, these principles were not incorporated into the national standard guidelines. The SFA introduced or revised definitions for a number of terms and introduced several new requirements for contents of FMPs. As a consequence of the 1994 report and the statutory amendments, revisions to the national standard 1 guidelines are described below.

Overview of Issues

Revisions to the guidelines for national standard 1 center on the Magnuson-Stevens Act's definitions of ``overfishing," ``overfished," and ``optimum yield (OY);" the requirement for the establishment of objective and measurable criteria for determining the status of a stock or stock complex; and the requirement for remedial action in the event that overfishing is occurring or that a stock or stock complex is overfished.

The Magnuson-Stevens Act, in section 3(29), defines both ``overfishing" and ``overfished" as a rate or level of fishing mortality that jeopardizes a fishery's capacity to produce maximum sustainable yield (MSY) on a continuing basis. Neither term was defined statutorily, prior to passage of the SFA. The Magnuson-Stevens Act, in section 3(28), defines OY as the amount of fish that: (1) 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; (2) is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factors; and (3) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery. The main changes relative to the pre-SFA definition include the requirements that OY take into account protection of marine ecosystems, that OY be no greater than MSY, and that OY for an overfished fishery allow rebuilding to the MSY level. The Magnuson-Stevens Act, in section 303(a)(10), requires each FMP to specify objective and measurable criteria for identifying when the fishery to which the FMP applies is overfished (also referred to as ``criteria for overfishing"), with an analysis of how the criteria were determined and the relationship of the criteria to the reproductive potential of stocks of fish in that fishery. The Magnuson- Stevens Act also requires, in section 304(e), the Secretary to report annually to Congress and the Councils on the status of fisheries within each Council's geographical area of authority and identify those fisheries that are overfished or are approaching a condition of being overfished. For each fishery managed under an FMP or international agreement, the status is to be determined using the criteria for overfishing specified in that FMP or agreement. A fishery is to be classified as approaching a condition of being overfished if, based on trends in fishing effort, fishery resource size, and other appropriate factors, the Secretary estimates that it will become overfished within 2 years.

If the Secretary determines at any time that a fishery is overfished or approaching an overfished condition or that existing remedial action taken for the purpose of ending any previously identified overfishing has not resulted in adequate progress, the Secretary must notify the Council and request that remedial action be taken. Section 304(e)(3) of the Magnuson-Stevens Act requires that the Council then, within 1 year of notification,

prepare an FMP, FMP amendment, or proposed regulations for the purposes of ending (or preventing) overfishing and rebuilding (or sustaining) affected stocks of fish.

Overview of Approach

In developing the national standard guidelines, policy guidance was taken from the Magnuson-Stevens Act and other applicable law. Because the guidelines deal with technical subject matter, guidance was also taken from the scientific literature. In particular, the report by Rosenberg et al. (1994) was used to the extent that it is consistent with the Magnuson-Stevens Act and other applicable law.

Sustainability

Sustainable fisheries is a key theme within the Magnuson-Stevens Act. The idea of sustainability is inherent in MSY, a quantity that is central to the Magnuson-Stevens Act's definitions of both overfishing and OY. Closely related to the idea of sustainability is the phrase ``on a continuing basis," which is used both in the Magnuson-Stevens Act's definition of overfishing and in national standard 1. The appropriate interpretation of sustainability or the phrase ``on a continuing basis" is the one generally accepted in the fishery science literature, which relates to an average stock level and/or average potential yield from a stock over a long period of time.

It is important to distinguish between the theoretical concept of MSY as an unconditional maximum independent of management practice, and actual estimates of MSY, which are necessarily conditional on some type of (perhaps hypothetical) management practice. Specifically, the guidelines, in Sec. 600.310(c)(ii), describe the role of ``control rules" in estimating MSY, where an MSY control rule is any harvest strategy that, if implemented, would be expected to result in a long-term average catch close to MSY. A Council could choose an MSY control rule in which fishing mortality is held constant over time at an appropriate rate, one in which escapement is held constant over time at an appropriate level, or some other control rule, so long as that control rule is consistent with the Magnuson-Stevens Act.

Although the Magnuson-Stevens Act's definition of overfishing is expressed in terms of a stock's capacity to produce MSY on a continuing basis, nothing in the Magnuson-Stevens Act implies that such production, in the form of harvest, must actually occur. That is, a stock does not actually need to produce MSY on a continuing basis in order to have the capacity to do so.

Use of the Terms ``Overfishing" and ``Overfished"

The relationship between the terms ``overfishing" and ``overfished" can be confusing. As used in the Magnuson-Stevens Act, the verb ``to overfish" means to fish at a rate or level that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. ``Overfishing," then, occurs whenever a stock or stock complex is subjected to any such rate or level of fishing mortality. Interpreting the term ``overfished" is more complicated. In the Magnuson-Stevens Act, this term is used in two senses: First, to describe any stock or stock complex that is subjected to overfishing; and second, to describe any stock or stock complex for which a change in management practices is required in order to achieve an appropriate level and rate of rebuilding. (See, for example, section 303(a)(1)(A) and section 304(e)(1)) To avoid confusion, the guidelines use ``overfished" in the second sense only. Both terms would be defined in Sec. 600.310(d).

Status Determination Criteria

The Magnuson-Stevens Act, in section 303(a)(10), requires that each FMP specify objective and measurable criteria (status determination criteria) for identifying when stocks or stock complexes covered by the FMP are overfished. To fulfill the intent of the Magnuson-Stevens Act, such status determination criteria are

comprised of two components: A maximum fishing mortality threshold and a minimum stock size threshold (see Sec. 600.310(d)(2)). The maximum fishing mortality threshold should be set at the fishing mortality rate or level defined by the chosen MSY control rule. The minimum stock size threshold should be set at 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, whichever is greater. When data are insufficient to estimate any of these quantities, use of reasonable proxies would be required.

It is important to note that, even if no minimum stock size threshold were set, the maximum fishing mortality threshold would define a minimum limit on the rate of rebuilding for a stock that falls below its MSY level. The reason for requiring a minimum stock size threshold in addition to a maximum fishing mortality threshold is to define the point at which this minimum rebuilding rate is no longer prudent. For example, in the case of a slow-growing stock, a rebuilding rate that satisfies the statutory deadline of 10 years would be considered prudent management. However, for a fast-growing stock, it might be possible to fall to an extremely low level of abundance and still rebuild to the MSY level within 10 years, which would not be considered prudent management. Thus, the definition of the minimum stock size threshold includes a constraint, equal to one-half the MSY stock size, to ensure that the 10-year allowance is not abused in the case of fast-growing stocks.

Choosing an MSY control rule is thus key to satisfying national standard 1, because it defines the maximum fishing mortality threshold and plays a role in defining the minimum stock size threshold. Any MSY control rule defines a relationship between fishing mortality rate and stock size. This relationship is the maximum fishing mortality threshold, which may be a single number or a mathematical function. In addition, any MSY control rule defines a rate of rebuilding for stocks that are below the level that would produce MSY. The smallest stock size at which rebuilding to the level that would produce MSY is achieved within 10 years defines the minimum stock size threshold for that rule, unless such a stock size is less than one-half the MSY stock size. The MSY control rule also defines an upper bound on any OY control rule that might be specified.

The status determination criteria in Sec. 600.310(d)(2) would play a fundamental role in developing the Secretary's annual report to Congress and the Councils, as required by section 304(e) of the Magnuson-Stevens Act. Under the guidelines, the Secretary's annual report would list all stocks or stock complexes for which the maximum fishing mortality rate has been exceeded or for which the minimum stock size has not been achieved. Thus, the Secretary's decision as to whether a stock or stock complex is listed in the annual report of overfished stocks would be based on either the current rate of fishing mortality or the current condition of the stock, regardless of whether that condition is associated with either previous or current overfishing.

Preventing Overfishing

The Magnuson-Stevens Act is clear in its requirement to prevent overfishing. Except under very limited conditions, discussed below, this requirement must be satisfied. The Magnuson-Stevens Act's requirement to take remedial action in the event that a stock becomes overfished is not a substitute for the requirement to prevent overfishing in the first place.

Previous versions of the national standard guidelines have described limited conditions under which some amount of overfishing is permissible. Some of these conditions are retained in Sec. 600.310(d)(6) in the revision, but they are tightened considerably. Although the Magnuson-Stevens Act requires that OY and overfishing criteria be specified for each fishery, it does not require a one-to-one relationship between the fisheries for which OYs are specified and the fisheries for which overfishing criteria are specified. For example, in a mixed-stock fishery, overfishing criteria may be specified for the individual stocks, even if OY is specified for the fishery as a whole (see Sec. 600.310(c)(2)(iii)). Thus, it is conceivable that OY could be achieved for the fishery as a whole, even while overfishing of an individual stock is occurring.

## Ending Overfishing and Rebuilding Overfished Stocks

In the event that overfishing occurs or is projected to occur within 2 years, or in the event that a stock or stock complex is overfished or is projected to become overfished within 2 years, the Magnuson-Stevens Act, in section 304(e), gives detailed requirements for Council action that must be undertaken in response. As described in Sec. 600.310(e) of the national standard guidelines, if overfishing is occurring, Council action must be designed to reduce fishing mortality to a rate or level no greater than the maximum fishing mortality threshold. If a stock or stock complex is overfished, fishing at a rate or level equal to the maximum fishing mortality threshold will not meet the required rate and level of rebuilding. In such cases, Council action must go beyond that required for situations involving only overfishing.

Although the Magnuson-Stevens Act implicitly sets the rebuilding target equal to the MSY stock size, this constitutes a minimum standard only. In general, management practices should be designed to achieve an average stock size equal to the stock size associated with OY (or the average OY, in cases where OY is determined annually), and rebuilding plans should be consistent with this goal. Because OY cannot exceed MSY on average, the stock size that would produce OY will generally be greater than the stock size that would produce MSY. Remedial action should do more than merely assure that the stock reaches the target level; rather, the goal should be to restore the stock's capacity to remain at that level on a continuing basis, consistent with the stock's natural variability. For example, a stock should not be considered rebuilt just because its current size matches the target level, which could result from a single good year class, if the stock's condition would not likely be sustained by succeeding year classes. In order to conclude that a stock has fully recovered, it may be necessary to rebuild the age structure, in addition to achieving a particular biomass target. This generally requires keeping fishing mortality at an appropriately low level for several years (approximately one generation of the species).

Remedial action should be designed to make consistent and reasonably rapid progress towards recovery. ``Consistent progress'' means that no grace period exists beyond the statutory timeframe of 1 year for taking remedial action, and that such action should include explicit milestones expressed in terms of measurable improvement of the stock with respect to its status determination criteria. The Magnuson- Stevens Act, in section 304(e)(4), requires that the time period for rebuilding be as short as possible, but always less than 10 years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise.

## Optimum Yield

One of the most significant changes made by the SFA is a requirement that OY not exceed MSY on a continuing basis. Further, for overfished fisheries, OY must be based upon a rebuilding schedule that increases stock levels to those that would produce MSY. These changes are expressions of a precautionary approach, which should contain three features (see Sec. 600.310(f)(5)). First, target reference points, such as OY, should be set safely below limit reference points, such as the catch level associated with the maximum fishing mortality threshold. Second, a stock that is below its MSY level should be harvested at a lower rate or level of fishing mortality than if it were above its MSY level. Third, the criteria used to set target catch levels should be explicitly risk averse, so that greater uncertainty regarding a stock's status or productive capacity corresponds to greater caution in setting target catch levels. Because specification of a precautionary approach can be a complicated exercise, NMFS plans to supplement these guidelines in the near future with technical guidance for use in implementing such an approach. This additional guidance may be provided in a form similar to that developed to implement the 1994 amendments to the MMPA.

The Magnuson-Stevens Act is clear in its requirement that specification of OY take into account protection of marine ecosystems. This is reflected in the new provisions concerning the identification and description of essential fish habitat (EFH). Proposed guidelines for designation of EFH were published in the Federal

Register on April 23, 1997, at 62 FR 19723. Final Guidelines were published on May 1, 1998, at 63 FR 24212. Due to the complex nature of marine ecosystem structure and function, qualitative methods may be used to satisfy this requirement wherever data or scientific understanding are insufficient to permit use of quantitative methods.

NMFS recognizes the growing importance of non-consumptive uses of marine fishery resources. Such activities include ecotourism, fish watching, recreational diving, and marine education. The guidelines are intended to accommodate such uses in specifying OY.

## 1.2 Alternatives Considered

**1.2.1 Alternative 1: Status Quo**. No revisions to the current MSY, OY, and overfishing definitions would be made, and the FMP would not be updated.

**1.2.2 Alternative 2: (Preferred) Redefine overfishing, OY, and MSY, and update the FMP**. Updates to the FMP include general housekeeping as well as clarifying language on license limitation implementation schedule.

## 1.3 NMFS Guidance on National Standard 1

Below is the Final Rule guidelines on National Standard 1 (Section 600.310), published in the Federal Register on May 1, 1998.

Sec. 600.310 National Standard 1--Optimum Yield.

(a) Standard 1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the OY from each fishery for the U.S. fishing industry.

(b) General. The determination of OY is a decisional mechanism for resolving the Magnuson-Stevens Act's multiple purposes and policies, implementing an FMP's objectives, and balancing the various interests that comprise the national welfare. OY is based on MSY, or on MSY as it may be reduced under paragraph (f)(3) of this section. The most important limitation on the specification of OY is that the choice of OY and the conservation and management measures proposed to achieve it must prevent overfishing.

(c) MSY. Each FMP should include an estimate of MSY as explained in this section.

(1) Definitions.

(i) ``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.
(ii) ``MSY control rule" means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY.
(iii) ``MSY stock size" means the long-term average size of the stock or stock complex, measured in terms of spawning biomass or other appropriate units, that would be achieved under an MSY control rule in which the fishing mortality rate is constant.

(2) Options in specifying MSY.

(i) Because MSY is a theoretical concept, its estimation in practice is conditional on the choice of an MSY control rule. In choosing an MSY control rule, Councils should be guided by the characteristics of the fishery, the FMP's objectives, and the best scientific information available. The simplest MSY control rule is to remove a constant catch in each year that the estimated stock size exceeds an appropriate lower bound, where this catch is chosen so as to maximize the resulting long-term average yield. Other examples include the following: Remove a constant fraction of the biomass in each year, where this fraction is chosen so as to maximize the

resulting long-term average yield; allow a constant level of escapement in each year, where this level is chosen so as to maximize the resulting long-term average yield; vary the fishing mortality rate as a continuous function of stock size, where the parameters of this function are constant and chosen so as to maximize the resulting long- term average yield. In any MSY control rule, a given stock size is associated with a given level of fishing mortality and a given level of potential harvest, where the long-term average of these potential harvests provides an estimate of MSY.

(ii) Any MSY values used in determining OY will necessarily be estimates, and these will typically be associated with some level of uncertainty. Such estimates must be based on the best scientific information available (see Sec. 600.315) and must incorporate appropriate consideration of risk (see Sec. 600.335). Beyond these requirements, however, Councils have a reasonable degree of latitude in determining which estimates to use and how these estimates are to be expressed. For example, a point estimate of MSY may be expressed by itself or together with a confidence interval around that estimate.

(iii) In the case of a mixed-stock fishery, MSY should be specified on a stock-by-stock basis. However, where MSY cannot be specified for each stock, then MSY may be specified on the basis of one or more species as an indicator for the mixed stock as a whole or for the fishery as a whole.

(iv) Because MSY is a long-term average, it need not be estimated annually, but it must be based on the best scientific information available, and should be re-estimated as required by changes in environmental or ecological conditions or new scientific information.

(3) Alternatives to specifying MSY. When data are insufficient to estimate MSY directly, Councils should adopt other measures of productive capacity that can serve as reasonable proxies for MSY, to the extent possible. Examples include various reference points defined in terms of relative spawning per recruit. For instance, the fishing mortality rate that reduces the long-term average level of spawning per recruit to 30-40 percent of the long-term average that would be expected in the absence of fishing may be a reasonable proxy for the MSY fishing mortality rate. The long-term average stock size obtained by fishing year after year at this rate under average recruitment may be a reasonable proxy for the MSY stock size, and the long-term average catch so obtained may be a reasonable proxy for MSY. The natural mortality rate may also be a reasonable proxy for the MSY fishing mortality rate. If a reliable estimate of pristine stock size (i.e., the long-term average stock size that would be expected in the absence of fishing) is available, a stock size approximately 40 percent of this value may be a reasonable proxy for the MSY stock size, and the product of this stock size and the natural mortality rate may be a reasonable proxy for MSY.

(d) Overfishing--(1) Definitions.

(i) ``To overfish'' means to fish at a rate or level that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis.

(ii) ``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.

(iii) In the Magnuson-Stevens Act, the term ``overfished'' is used in two senses: First, to describe any stock or stock complex that is subjected to a rate or level of fishing mortality meeting the criterion in paragraph (d)(1)(i) of this section, and second, to describe any stock or stock complex whose size is sufficiently small that a change in management practices is required in order to achieve an appropriate level and rate of rebuilding. To avoid confusion, this section uses ``overfished'' in the second sense only.

(2) Specification of status determination criteria. Each FMP must specify, to the extent possible, objective and measurable status determination criteria for each stock or stock complex covered by that FMP and provide an analysis of how the status determination criteria were chosen and how they relate to reproductive potential. Status determination criteria must be expressed in a way that enables the Council and the Secretary to monitor the stock or stock complex and determine annually whether overfishing is occurring and whether the stock or stock complex is overfished. In all cases, status determination criteria must specify both of the following:

(i) A maximum fishing mortality threshold or reasonable proxy thereof. 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 threshold must not exceed the fishing mortality rate or level associated with the relevant MSY control rule. Exceeding the fishing mortality threshold for a period of 1 year or more constitutes overfishing.

(ii) A minimum stock size threshold or reasonable proxy thereof. 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.

(3) Relationship of status determination criteria to other national standards

(i) National standard 2. Status determination criteria must be based on the best scientific information available (see Sec. 600.315). When data are insufficient to estimate MSY, Councils should base status determination criteria on reasonable proxies thereof to the extent possible (also see paragraph (c)(3) of this section). In cases where scientific data are severely limited, effort should also be directed to identifying and gathering the needed data.
(ii) National standard 3. The requirement to manage interrelated stocks of fish as a unit or in close coordination notwithstanding (see Sec. 600.320), status determination criteria should generally be specified in terms of the level of stock aggregation for which the best scientific information is available (also see paragraph (c)(2)(iii) of this section).
(iii) National standard 6. Councils must build into the status determination criteria appropriate consideration of risk, taking into account uncertainties in estimating harvest, stock conditions, life history parameters, or the effects of environmental factors (see Sec. 600.335).

(4) Relationship of status determination criteria to environmental change. Some short-term environmental changes can alter the current size of a stock or stock complex without affecting the long-term productive capacity of the stock or stock complex. Other environmental changes affect both the current size of the stock or stock complex and the long-term productive capacity of the stock or stock complex.

(i) If environmental changes cause a stock or stock complex to fall below the minimum stock size threshold without affecting the long-term productive capacity of the stock or stock complex, fishing mortality must be constrained sufficiently to allow rebuilding within an acceptable time frame (also see paragraph (e)(4)(ii) of this section). Status determination criteria need not be respecified.
(ii) If environmental changes affect the long-term productive capacity of the stock or stock complex, one or more components of the status determination criteria must be respecified. Once status determination criteria have been respecified, fishing mortality may or may not have to be reduced, depending on the status of the stock or stock complex with respect to the new criteria.
(iii) If manmade environmental changes are partially responsible for a stock or stock complex being in an overfished condition, in addition to controlling effort, Councils should recommend restoration of habitat and other ameliorative programs, to the extent possible (see also the guidelines issued pursuant to section 305(b) of the Magnuson- Stevens Act for Council actions concerning essential fish habitat).

(5) Secretarial approval of status determination criteria. Secretarial approval or disapproval of proposed status determination criteria will be based on consideration of whether the proposal:

(i) Has sufficient scientific merit.
(ii) Contains the elements described in paragraph (d)(2) of this section.
(iii) Provides a basis for objective measurement of the status of the stock or stock complex against the criteria.
(iv) Is operationally feasible.

(6) Exceptions. There are certain limited exceptions to the requirement to prevent overfishing. Harvesting one species of a mixed- stock complex at its optimum level may result in the overfishing of another stock component in the complex. A Council may decide to permit this type of overfishing only if all of the following conditions are satisfied:

(i) It is demonstrated by analysis (paragraph (f)(6) of this section) that such action will result in long-term net benefits to the Nation.
(ii) It is demonstrated by analysis that mitigating measures have been considered and that a similar level of long-term net benefits cannot be achieved by modifying fleet behavior, gear selection/ configuration, or other technical characteristic in a manner such that no overfishing would occur.

(iii) The resulting rate or level of fishing mortality will not cause any species or evolutionary significant unit thereof to require protection under the ESA.

(e) Ending overfishing and rebuilding overfished stocks-- (1) Definition. A threshold, either maximum fishing mortality or minimum stock size, is being ``approached'' whenever it is projected that the threshold will be breached within 2 years, based on trends in fishing effort, fishery resource size, and other appropriate factors.

(2) Notification. The Secretary will immediately notify a Council and request that remedial action be taken whenever the Secretary determines that:

(i) Overfishing is occurring;
(ii) A stock or stock complex is overfished;
(iii) The rate or level of fishing mortality for a stock or stock complex is approaching the maximum fishing mortality threshold;
(iv) A stock or stock complex is approaching its minimum stock size threshold; or
(v) Existing remedial action taken for the purpose of ending previously identified overfishing or rebuilding a previously identified overfished stock or stock complex has not resulted in adequate progress.

(3) Council action. Within 1 year of such time as the Secretary may identify that overfishing is occurring, that a stock or stock complex is overfished, or that a threshold is being approached, or such time as a Council may be notified of the same under paragraph (e)(2) of this section, the Council must take remedial action by preparing an FMP, FMP amendment, or proposed regulations. This remedial action must be designed to accomplish all of the following purposes that apply:

(i) If overfishing is occurring, the purpose of the action is to end overfishing.
(ii) If the stock or stock complex is overfished, the purpose of the action is to rebuild the stock or stock complex to the MSY level within an appropriate time frame.
(iii) If the rate or level of fishing mortality is approaching the maximum fishing mortality threshold (from below), the purpose of the action is to prevent this threshold from being reached.
(iv) If the stock or stock complex is approaching the minimum stock size threshold (from above), the purpose of the action is to prevent this threshold from being reached.

(4) Constraints on Council action.

(i) In cases where overfishing is occurring, Council action must be sufficient to end overfishing.
(ii) In cases where a stock or stock complex is overfished, Council action must specify a time period for rebuilding the stock or stock complex that satisfies the requirements of section 304(e)(4)(A) of the Magnuson-Stevens Act.

(A) A number of factors enter into the specification of the time period for rebuilding:

(1) The status and biology of the stock or stock complex;

(2) Interactions between the stock or stock complex and other components of the marine ecosystem (also referred to as ``other environmental conditions'');

(3) The needs of fishing communities;

(4) Recommendations by international organizations in which the United States participates; and

(5) Management measures under an international agreement in which the United States participates.

(B) These factors enter into the specification of the time period for rebuilding as follows:

(1) The lower limit of the specified time period for rebuilding is determined by the status and biology of the stock or stock complex and its interactions with other components of the marine ecosystem, and is defined as the amount of time that would be required for rebuilding if fishing mortality were eliminated entirely.

(2) If the lower limit is less than 10 years, then the specified time period for rebuilding may be adjusted upward to the extent warranted by the needs of fishing communities and recommendations by international organizations in which the United States participates, except that no such upward adjustment can result in the specified time period exceeding 10 years, unless management measures under an international agreement in which the United States participates dictate otherwise.

(3) If the lower limit is 10 years or greater, then the specified time period for rebuilding may be adjusted upward to the extent warranted by the needs of fishing communities and recommendations by international organizations in which the United States participates, except that no such upward adjustment can exceed the rebuilding period calculated in the absence of fishing mortality, plus one mean generation time or equivalent period based on the species' life-history characteristics. For example, suppose a stock could be rebuilt within 12 years in the absence of any fishing mortality, and has a mean generation time of 8 years. The rebuilding period, in this case, could be as long as 20 years.

(C) A rebuilding program undertaken after May 1, 1998 commences as soon as the first measures to rebuild the stock or stock complex are implemented.

(D) In the case of rebuilding plans that were already in place as of May 1, 1998, such rebuilding plans must be reviewed to determine whether they are in compliance with all requirements of the Magnuson- Stevens Act, as amended by the Sustainable Fisheries Act.

> (iii) For fisheries managed under an international agreement, Council action must reflect traditional participation in the fishery, relative to other nations, by fishermen of the United States.

(5) Interim measures. The Secretary, on his/her own initiative or in response to a Council request, may implement interim measures to reduce overfishing under section 305(c) of the Magnuson-Stevens Act, until such measures can be replaced by an FMP, FMP amendment, or regulations taking remedial action.

> (i) These measures may remain in effect for no more than 180 days, but may be extended for an additional 180 days if the public has had an opportunity to comment on the measures and, in the case of Council-recommended measures, the Council is actively preparing an FMP, FMP amendment, or proposed regulations to address overfishing on a permanent basis. Such measures, if otherwise in compliance with the provisions of the Magnuson-Stevens Act, may be implemented even though they are not sufficient by themselves to stop overfishing of a fishery.
> (ii) If interim measures are made effective without prior notice and opportunity for comment, they should be reserved for exceptional situations, because they affect fishermen without providing the usual procedural safeguards. A Council recommendation for interim measures without notice-and-comment rulemaking will be considered favorably if the short-term benefits of the measures in reducing overfishing outweigh the value of advance notice, public comment, and deliberative consideration of the impacts on participants in the fishery.

(f) OY--(1) Definitions.

> (i) The term ``optimum," with respect to the yield from a fishery, means the amount of fish that 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; that is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor; and, in the case of an overfished fishery, that provides for rebuilding to a level consistent with producing the MSY in such fishery.
> (ii) In national standard 1, use of the phrase ``achieving, on a continuing basis, the OY from each fishery" means producing, from each fishery, a long-term series of catches such that the average catch is equal to the average OY and such that status determination criteria are met.

(2) Values in determination. In determining the greatest benefit to the Nation, these values that should be weighed are food production, recreational opportunities, and protection afforded to marine ecosystems. They should receive serious attention when considering the economic, social, or ecological factors used in reducing MSY to obtain OY.

(i) The benefits of food production are derived from providing seafood to consumers, maintaining an economically viable fishery together with its attendant contributions to the national, regional, and local economies, and utilizing the capacity of the Nation's fishery resources to meet nutritional needs.
(ii) The benefits of recreational opportunities reflect the quality of both the recreational fishing experience and non-consumptive fishery uses such as ecotourism, fish watching, and recreational diving, and the contribution of recreational fishing to the national, regional, and local economies and food supplies.
(iii) The benefits of protection afforded to marine ecosystems are those resulting from maintaining viable populations (including those of unexploited species), maintaining evolutionary and ecological processes (e.g., disturbance regimes, hydrological processes, nutrient cycles), maintaining the evolutionary potential of species and ecosystems, and accommodating human use.

(3) Factors relevant to OY. Because fisheries have finite capacities, any attempt to maximize the measures of benefit described in paragraph (f)(2) of this section will inevitably encounter practical constraints. One of these is MSY. Moreover, various factors can constrain the optimum level of catch to a value less than MSY. The Magnuson-Stevens Act's definition of OY identifies three categories of such factors: Social, economic, and ecological. Not every factor will be relevant in every fishery. For some fisheries, insufficient information may be available with respect to some factors to provide a basis for corresponding reductions in MSY.

(i) Social factors. Examples are enjoyment gained from recreational fishing, avoidance of gear conflicts and resulting disputes, preservation of a way of life for fishermen and their families, and dependence of local communities on a fishery. Other factors that may be considered include the cultural place of subsistence fishing, obligations under Indian treaties, and worldwide nutritional needs.
(ii) Economic factors. Examples are prudent consideration of the risk of overharvesting when a stock's size or productive capacity is uncertain, satisfaction of consumer and recreational needs, and encouragement of domestic and export markets for U.S.-harvested fish. Other factors that may be considered include the value of fisheries, the level of capitalization, the decrease in cost per unit of catch afforded by an increase in stock size, and the attendant increase in catch per unit of effort, alternate employment opportunities, and economies of coastal areas.
(iii) Ecological factors. Examples are stock size and age composition, the vulnerability of incidental or unregulated stocks in a mixed-stock fishery, predator-prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Also important are ecological or environmental conditions that stress marine organisms, such as natural and manmade changes in wetlands or nursery grounds, and effects of pollutants on habitat and stocks.

(4) Specification.

(i) The amount of fish that constitutes the OY should be expressed in terms of numbers or weight of fish. However, OY may be expressed as a formula that converts periodic stock assessments into target harvest levels; in terms of an annual harvest of fish or shellfish having a minimum weight, length, or other measurement; or as an amount of fish taken only in certain areas, in certain seasons, with particular gear, or by a specified amount of fishing effort. (ii) Either a range or a single value may be specified for OY. Specification of a numerical, fixed-value OY does not preclude use of annual target harvest levels that vary with stock size. Such target harvest levels may be prescribed on the basis of an OY control rule similar to the MSY control rule described in paragraph (c)(1)(ii) of this section, but designed to achieve OY on average, rather than MSY. The annual harvest level obtained under an OY control rule must always be less than or equal to the harvest level that would be obtained under the MSY control rule.
(iii) All fishing mortality must be counted against OY, including that resulting from bycatch, scientific research, and any other fishing activities.
(iv) The OY specification should be translatable into an annual numerical estimate for the purposes of establishing any TALFF and analyzing impacts of the management regime. There should be a mechanism in the FMP for periodic reassessment of the OY specification, so that it is responsive to changing circumstances in the fishery. (v) The determination of OY requires a specification of MSY, which may not always be possible or meaningful. However, even where sufficient scientific data as to the biological characteristics of the stock do not exist, or where the period of exploitation or investigation has not been long enough for adequate understanding of stock dynamics, or where frequent large-scale fluctuations in stock size diminish the meaningfulness of the MSY concept, the OY must still be based on the best scientific information available. When data are insufficient to estimate MSY directly, Councils should adopt other measures of productive

capacity that can serve as reasonable proxies for MSY to the extent possible (also see paragraph (c)(3) of this section).

(vi) In a mixed-stock fishery, specification of a fishery-wide OY may be accompanied by management measures establishing separate annual target harvest levels for the individual stocks. In such cases, the sum of the individual target levels should not exceed OY.

(5) OY and the precautionary approach. In general, Councils should adopt a precautionary approach to specification of OY. A precautionary approach is characterized by three features:

(i) Target reference points, such as OY, should be set safely below limit reference points, such as the catch level associated with the fishing mortality rate or level defined by the status determination criteria. Because it is a target reference point, OY does not constitute an absolute ceiling, but rather a desired result. An FMP must contain conservation and management measures to achieve OY, and provisions for information collection that are designed to determine the degree to which OY is achieved on a continuing basis--that is, to result in a long-term average catch equal to the long-term average OY, while meeting the status determination criteria. These measures should allow for practical and effective implementation and enforcement of the management regime, so that the harvest is allowed to reach OY, but not to exceed OY by a substantial amount. The Secretary has an obligation to implement and enforce the FMP so that OY is achieved. If management measures prove unenforceable--or too restrictive, or not rigorous enough to realize OY--they should be modified; an alternative is to reexamine the adequacy of the OY specification. Exceeding OY does not necessarily constitute overfishing. However, even if no overfishing resulted from exceeding OY, continual harvest at a level above OY would violate national standard 1, because OY was not achieved on a continuing basis.

(ii) A stock or stock complex that is below the size that would produce MSY should be harvested at a lower rate or level of fishing mortality than if the stock or stock complex were above the size that would produce MSY.

(iii) Criteria used to set target catch levels should be explicitly risk averse, so that greater uncertainty regarding the status or productive capacity of a stock or stock complex corresponds to greater caution in setting target catch levels. Part of the OY may be held as a reserve to allow for factors such as uncertainties in estimates of stock size and DAH. If an OY reserve is established, an adequate mechanism should be included in the FMP to permit timely release of the reserve to domestic or foreign fishermen, if necessary.

(6) Analysis. An FMP must contain an assessment of how its OY specification was determined (section 303(a)(3) of the Magnuson-Stevens Act). It should relate the explanation of overfishing in paragraph (d) of this section to conditions in the particular fishery and explain how its choice of OY and conservation and management measures will prevent overfishing in that fishery. A Council must identify those economic, social, and ecological factors relevant to management of a particular fishery, then evaluate them to determine the amount, if any, by which MSY exceeds OY. 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. If overfishing is permitted under paragraph (d)(6) of this section, the assessment must contain a justification in terms of overall benefits, including a comparison of benefits under alternative management measures, and an analysis of the risk of any species or ecologically significant unit thereof reaching a threatened or endangered status, as well as the risk of any stock or stock complex falling below its minimum stock size threshold.

(7) OY and foreign fishing. Section 201(d) of the Magnuson-Stevens Act provides that fishing by foreign nations is limited to that portion of the OY that will not be harvested by vessels of the United States.

(i) DAH. Councils must consider the capacity of, and the extent to which, U.S. vessels will harvest the OY on an annual basis. Estimating the amount that U.S. fishing vessels will actually harvest is required to determine the surplus.

(ii) DAP. Each FMP must assess the capacity of U.S. processors. It must also assess the amount of DAP, which is the sum of two estimates: The estimated amount of U.S. harvest that domestic processors will process, which may be based on historical performance or on surveys of the expressed intention of manufacturers to process, supported by evidence of contracts, plant expansion, or other relevant information; and the estimated amount of fish that will be harvested by domestic vessels, but not processed (e.g., marketed as fresh whole fish, used for private consumption, or used for bait).

(iii) JVP. When DAH exceeds DAP, the surplus is available for JVP. JVP is derived from DAH.

## 1.4 Draft Plan Team Recommendations on overfishing, OY, and MSY

Crab fisheries in the Bering Sea and Aleutian Islands (BSAI) area have been prosecuted quite differently compared to finfish fisheries. In the latter, the entire mature segment of a population or spawning biomass is typically vulnerable to fishing. Sustainable yield (SY) or its maximum (MSY) can be regarded for finfish as a biological parameter related to stock productivity and mortality. In contrast BS/AI crab fisheries have been subject to various constraints since their inception, restricting the fishery from harvesting substantial portions of the mature population. Paramount among these have been a prohibition against harvesting of females. Additionally minimum size limits were set to ensure that males would have at least one opportunity to breed before reaching legal size unless market preferences dictate acceptance of only crabs larger than legal size. Crab fisheries in the BSAI have been constrained by guideline harvest levels (GHLs) that are intended to promote stability in the face of variable recruitment.

The Crab Plan Team carefully debated interpretation of the Magnuson-Stevens Act Provisions; National Standard Guidelines during their discussions of optimum yield, maximum sustainable yield and overfishing. The team respectfully submitted comments on guidelines but proceeded in their definition of terms and evaluations of biological reference points for National Standard 1 in deference to the guidelines.

A suitable time period for MSY computations requires that environmental (including ecological) conditions remain reasonably constant over the period sustainable yields are considered. The team debated three definitions of the term “long-term” necessary for definition of terms; more than a life span, a life span, or a recruitment cycle. The team concluded the definition should depend on the species, the number of years of available catch data for a stock, and the length of environmental regimes. The team interpreted “prevailing” conditions as those at the current time implying the average yield may be based on something less than the longest available series of data. A period of 15 years from 1983 to 1997 was chosen to evaluate biological reference points as it was considered representative of the present ecological regime and environmental conditions. The Team considered the 15 years (1983-1997) as representative of current environmental conditions because: (1) many crab stocks seem to have declined until the early 1980s and then stabilized; (2) finfish populations that increased sharply during the late 1970s (regime shift) seem to have stabilized somewhat by 1983; (3) recruitment from the generally high crab populations of the 1970s would have been evident or have dissipated by 1983; and (4) conditions in crab populations (particularly red and blue king crabs) are relatively stable over this period. In choosing this time period the plan team recognized that MSY would be much lower, for many stocks, as compared to using a longer time series. The Team felt that it was extremely important to adhere to the available guidelines and select a time period that was representative of current environmental conditions. The Team recognized that MSY estimates have to be periodically evaluated as more information becomes available. The Team agreed to review estimates on a 5 year review cycle or in the event that environmental conditions signal a regime shift.

### 1.4.1 Proposed New Definitions

The definition of optimum yield, MSY, and threshold levels proposed by Alternative 2, are derived from definitions contained in the Magnuson-Stevens Act or based on the national standard guidelines. These definitions have been incorporated into the draft FMP update (see appendix).

<u>Optimum Yield</u>: The term ‘optimum’, with respect to the yield from a fishery, means the amount of crab 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 maximum sustainable yield 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 maximum sustainable yield in such fishery.

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. MSY was estimated from the best information available. Several BSAI crab stocks have insufficient scientific data to estimate biological reference points and stock dynamics are inadequately understood.

Overfishing: The term "overfishing "and "overfished " mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce MSY on a continuing basis. Overfishing is defined for king and Tanner crab stocks in the BSAI management area as any rate of fishing mortality in excess of the maximum fishing mortality threshold, $F_{msy}$, for a period of 1 year or more. Should the actual size of the stock in a given year fall below the minimum stock size threshold, the stock is considered overfished.

MSY control rule means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY. The MSY control rule for king and Tanner crabs is the mature biomass of a stock under prevailing environmental conditions, or proxy there of, exploited at a fishing mortality rate equal to a conservative estimate of natural mortality.

MSY stock size is the average size of the stock, measured in terms of mature biomass, or a proxy there of, under prevailing environmental conditions. It is the stock size that would be achieved under the MSY control rule. It is also the minimum standard for a rebuilding target when remedial management action is required.

Maximum fishing mortality threshold is defined by the MSY control rule, and is expressed as the fishing mortality rate. The MSY fishing mortality rate $F_{msy} = M$, a conservative natural mortality value set equal to 0.20 for all species of king crab, and 0.30 for all *Chionoecetes* species.

Minimum stock size threshold, is whichever 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. The minimum stock size threshold is expressed in terms of mature biomass.

### 1.4.2 Management of BSAI Crab Stocks Relative to MSY

The FMP establishes a State/Federal cooperative management regime that defers crab management to the State of Alaska with Federal oversight. The Alaska Department of Fish and Game (ADF&G) in consultation with the National Marine Fisheries Service recommends appropriate management measures for a given year and geographical area consistent with the Alaska Board of Fisheries (Board) policy on King and Tanner Crab Resource Management (Finding No. 90-04-FB; ADF&G 1992), the FMP, the Magnuson-Stevens Fishery Conservation and Management Act, and other State and Federal laws. Furthermore, the Board has adopted a harvest strategy for king and Tanner crab stocks that is to be consistent with the Board's policy on king and Tanner crab management (ADF&G 1997). The harvest strategy specifies ADF&G shall establish, if adequate data are available, threshold level of abundance and shall close the fishery during the entire fishing season on any stock that is below its threshold level of abundance. This harvest strategy controls the removal of legal male crabs from a stock by establishing a guideline harvest level (GHL) for the commercial fishery. Data used to determine GHLs and, if appropriate, exploitation rates, may include estimates of exploitable biomass, estimates of recruitment, estimates of threshold, estimates of accepted biological catch, historical fishery performance data, estimates of reproductive potential, and market or other economic considerations. The harvest strategy is set to minimize the risk of overfishing.

### 1.4.3 Adequacy of Current Overfishing Definition

Scientific review of the FMP definitions of overfishing for BSAI crab stocks was limited to the Bristol Bay red king crab (*Paralithodes camtschaticus*) stock and the Bering Sea Tanner crab (*C. bairdi*) stock (Rosenberg et. al. 1994). The overfishing definition for these two stocks was found neutrally conservative as a threshold rather than a target. The review pointed out that handling and discard mortality strongly affect the calculation of the maximum fishing mortality rate since only males greater than a specific size can be legally harvested. The scientific review stated that handling and discard mortality need to be investigated further. Several recent and current studies should provide guidance on the magnitude of handling mortality in the directed pot and bottom trawl fisheries (Murphy and Kruse 1995, Zheng et. al. 1995, Zhou and Shirley 1996, MacIntosh et. al. 1996, Tracy and Pengilly 1996, Heifetz 1997). The scientific review noted some ambiguity in the current overfishing definition because who should decide which tier to assign a stock to was not specified. All stocks were assigned to one of the three tiers by the NPFMC Crab Plan Team in its Environmental Assessment for Amendment 1 of the Fishery Management Plan (NPFMC 1990).

### 1.4.4 Analysis of OY, MSY and Overfishing

**Estimation of Optimum Yield**

Considering the history of regulations for BSAI crabs and in light of the MSFCMA, the catch history for the stocks actually reflects OY rule making. This is because the regulatory process considers social (e.g., desire for stabilized economy) and economic factors (e.g., marketability of females and small males) as well as biological (e.g., growth, mortality, abundance) factors. Under alternative two optimum yield is estimated for BSAI king crabs to be on average less than MSY. Crab in the BSAI are currently managed to optimize yield. As a result, a set of OY control rules is already in operation to reduce MSY by appropriate factors.

<u>OY Control Rules</u>

Sex restriction, no harvest of female crabs;
Size restriction, only crabs greater than or equal to a minimum size limit may be harvested;
Guideline Harvest Levels estimated from exploitation rate strategy or fishery performance data;
Non-retained catch of directed harvest;
Non-directed harvest including subsistence, sport, and bycatch.

Proposed OY ranges are shown in Table 2.

**Estimation of Maximum Sustained Yield**

Harvest strategies have evolved for stocks of Bering Sea and Aleutian Islands crab species as more data have been collected. Management of king crabs has varied from *size and sex (2-S), to size, sex and season (3-S)*, to *fishery performance management* to *exploitation rate management* (Kruse 1993). Integral to the type of management is the presence or absence of biomass estimates. The Bering Sea red and blue king crab stocks have a long history of surveys and been studied extensively allowing estimation of stock biomass. Harvests of Bering Sea red and blue king crab stocks have been determined using exploitation rates for some time. The Bering Sea Tanner and snow crab stocks have also been surveyed and studied for sufficient time to allow estimation of biomass. Harvests have been projected using exploitation rate management. Red king and Tanner crab stocks in the Aleutian Islands were first prosecuted with 2-S and 3-S management and once supported fisheries in the multi-million pound range but these fisheries are now closed. The remaining stocks of deep water king crab and *Chionoecetes* species have limited or no survey data precluding estimation of biomass. Harvest of golden king crabs began under 2-S management but more recently has been based on fishery performance as measured by average catch from the stocks. The harvest of scarlet king crabs and

*Chionoecetes* species has been by developing fisheries permit or incidental to harvest from other directed crab fisheries.

In the BSAI crab FMP, the mean harvest over the history of a fully developed fishery was considered MSY for a given stock (Alternative 1, status quo). Under Alternative 2 we depart from past practice and attempt to compute MSY on the basis of what is known of the biomass of the male and female portion of the mature population or total mature biomass (*MB*) of a stock. Note that *MB* is simply an estimate of the total biomass of individuals that are physiologically mature and makes no assumptions as to what proportion of them actually spawn.

Stocks that are not surveyed or only have limited years of survey data require different methods to estimate *MB* and MSY than stocks that are regularly surveyed. For data poor stocks, *MB* was estimated in part using a ratio of legal biomass to mature biomass and corresponding utilization rate for representative stocks. The Bristol Bay red, Pribilof Island red and blue, and St. Matthew Island blue king crab stocks were selected to estimate the proxy mature biomass and utilization rates for the Western Aleutian Islands stock of red king crabs. These stocks were also used as the proxy stocks for the deep water king crabs: Aleutian Islands and Bering Sea scarlet king crabs, and the Aleutian Islands, Pribilof Islands and St. Matthew Island golden king crab stocks. Both Bering Sea Tanner and snow crabs were chosen as being representative proxy stocks for the Eastern and Western Aleutian Islands Tanner crab stocks and deep water Tanner crabs *Chionoecetes tanneri* and *C. angulatus* crab stocks in the Eastern and Western Aleutians and Eastern Bering Sea.

A fraction of the *MB* is considered sustained yield (*SY*) for a given year and the average of the *SY*s over a suitable period of time is considered the MSY. In this approach, the assumed level of fishing mortality (*F*) that corresponds to MSY is equal to the natural mortality (M) of an unfished stock. This value of M was determined by taking the largest crab size observed during surveys or other sampling opportunities prior to the development of substantial fishing (Wallace et al 1949, NMFS unpublished), converting this roughly to age and then computing M from equations given by Hoenig (1983).

The longevity of Bristol Bay red king crab was considered as representative for all king crabs (*Paralithodes* and *Lithodes*) while that of the EBS Tanner crab (*C. bairdi*) as representative of all members of the genus *Chionoecetes*. The largest red king crab observed was 197 mm in carapace length (CL) (Wallace et al 1949) and the largest known from Bristol bay fisheries was 205 mm CL. Growth models (e.g. Balsiger 1974) indicate that a crab of 157 mm is about 14 years old while tagging studies indicate that a king crab of this size may be recovered as much as 6 years later. The maximum age of red king crab near Kodiak (ADF&G unpublished, news release) has been estimated at 24 years. For the purposes of computing MSY, values of 22 to 24 years were considered as maximum age and these correspond to *F* values of .20 and .19; *F*=0.20 was chosen for king crabs. During the 1969 and 1970 NMFS trawl surveys 20,117 Tanner crabs were measured and a maximum size of 199 mm carapace width (CW) was obtained. Using Somerton's (1981) growth model as well as tagging data, a Tanner crab of this size would be approximately 15 years of age which corresponds to *F*= 0.295. *F*=0.30 was chosen for Chionoecetes species.

<u>Estimation of MSY for Stocks Using Proxy Estimate of MSY</u>

Use of a proxy measure of *MB* requires assumptions be made for both the proxy stock and data poor stock. The procedure assumes the ratio of legal to mature crab biomass of the proxy stock reflects its' status given the environment and utilization over time. We also assumed population structure of a data poor stock responded similarly to the proxy stock under the same environmental regime. Since *MB* of the data poor stock is unknown, utilization rates could not be estimated and were assumed to equal those of the proxy stock. Given the ratio of legal to mature biomass is a function of the utilization rates for the proxy stock, then application of the ratio to data poor stocks assumes the same history of utilization rates was experienced.

$MSY = \Sigma SY_n/N$

$SY_n$ is the sustainable yield in year $n$
$N$ is the number of catch years ≅ 15 years (1983-1997)

$SY_n = MB_n * F_{msy}$

$MB_n$ is the average total mature biomass available for year $n$.
$MB_n = C_n * 1/U_{an} * 1/R_n$

$C_n$ is the harvest of legal male crabs landed in year n and expressed in millions of pounds.

$U_{an}$ is the assumed rate of utilization or fraction of the number of legal-sized male crabs landed in year $n$ for stocks with no estimates of mature biomass.
$U_{an}$ is the average of the utilization rates in year $n$ for $N_p$ representative or proxy stocks.
$U_{an} = \Sigma U_{anp}/N_p$

$U_{anp}$ is the ratio of the harvest of legal male crabs (in millions of pounds), $C_{np}$, in year $n$, from proxy stock $p$, to the total legal biomass, $LB_{np}$, of proxy stock $p$, in year $n$.
$U_{anp} = C_{np} /LB_{np}$

$N_p$ is the number of representative or proxy stocks.
1. $N_p$ = 4 for non-surveyed stocks of king crab. Designated proxy stocks include Bristol Bay red king crabs, Pribilof Islands red king crabs, Pribilof Islands blue king crabs, and St. Matthew Island blue king crabs.
2. $N_p$ = 2 for non-surveyed *Chionoecetes* stocks. Proxy stocks are Bering Sea Tanner and snow crabs.

$R_n$ is the average of the ratios $R_{np}$ of biomass of legal-sized male crabs, $LB_{np}$, to total mature female and male crab biomass $MB_{np}$ in year $n$ for $N_p$ representative or proxy stocks.
$R_n = \Sigma R_{np}/N_p$
$R_n = \Sigma (LB_{np}/ MB_{np})/ N_p$

$N_p$ is the number of representative or proxy stocks.
1. $N_p$ = 4 for non-surveyed stocks of king crab. Designated proxy stocks include Bristol Bay red king crabs, Pribilof Islands red king crabs, Pribilof Islands blue king crabs, and St. Matthew Island blue king crabs.
2. $N_p$ = 2 for non-surveyed *Chionoecetes* stocks. Proxy stocks are Bering Sea Tanner and snow crabs.

$F_{msy}$ is the instantaneous fishing mortality rate at MSY.
$F_{msy} = M$, a conservative estimate of the instantaneous rate of natural mortality.
$F_{msy} = 0.2$ for king crabs
$F_{msy} = 0.3$ for *Chionoecetes* species

Estimation of MSY for Stocks with Mature Biomass Estimates

The *MB* for surveyed king crab stocks was computed by considering the catchability or probability of capture in survey trawl of each 5 mm size group of crabs, the proportion mature, the mean weight, and unadjusted survey index of abundance for each size and sex group. The *MB* for surveyed Tanner and snow crabs was computed by considering the proportion mature, the mean weight, and unadjusted survey index of abundance for each size and sex group. The *MB* for a given year is taken as the sum of biomass over size and sex and

considered as the annual average biomass for a single annual cohort. Baranov's catch equation is then simplified to $C_n = F * MB_n$. This was done because the timing of fisheries relative to the survey or to recruitment is in part an optimum yield consideration and also varies from stock to stock.

$MSY = \Sigma SY_n/N$

$SY_n$ is the sustainable yield in year $n$.
$N$ is the number of catch years ≅ 15 years (1983-1997).

$SY_n = MB_n * F_{msy}$

$MB_n$ is the average total mature biomass available for year $n$.
$MB_n = B_{mn} + B_{fn}$

$B_{mn}$ is the sum of the biomass of mature male crabs of size $l$, in year n.
$B_{mn} = \Sigma((A_{mln} * P_{ml}) * W_{ml})/ q_{ml}$

$B_{fn}$ is the sum of the biomass of mature female crabs of size $l$, in year n.
$B_{fn} = \Sigma((A_{fln} * P_{fl}) * W_{fl})/ q_{fl}$

$A_{mln}$ and $A_{fln}$ are abundance of male and female crabs by 5 mm length category $l$, in year $n$, as estimated by area swept methods using annual NMFS survey data.

$q_{ml}$ and $q_{fl}$ are the probability of capture of male and female crabs by 5mm length category $l$.

$P_{ml}$ and $P_{fl}$ are the proportion of mature male and female crabs by 5mm length category $l$.

$W_{ml}$ and $W_{fl}$ are the factors for conversion of length $L$, to weight $W$, for male and female crabs by 5mm length category $l$.

$F_{msy}$ is the instantaneous fishing mortality rate at MSY.
$F_{msy} = M$, a conservative estimate of the instantaneous rate of natural mortality.
$F_{msy} = 0.2$ for king crabs.
$F_{msy} = 0.3$ for *Chionoecetes* species.

### 1.4.5 Definition of Available Data Tiers

Three tiers of data are characterized for evaluation of OY, MSY, and overfishing according to the data available to quantify biological reference points. Each of the 20 stocks of crab in the BSAI management area is assigned to one of the tiers.

Tier 1) Crab stock is not surveyed. Harvest data range from minimal due to exploratory fishing to continuous historic landings to developing fisheries with onboard monitoring of catch. Crab stocks in the BSAI with a developing fishery designation have not been surveyed, harvests are incidental to other directed fisheries or directed fishing has only recently developed. Catch, effort and biological data have been collected from fisheries on these stocks beginning in 1994 and will provide good data for estimation of biological reference points in the future since they are permit only fisheries requiring 100% observer coverage. Magnitude of catches from developing fisheries for BSAI crab are largely market driven and are therefore a function of both domestic and foreign harvest levels on stocks with developed fisheries. Fisheries on stocks of the deep water scarlet king crab, *Lithodes couesi*, and

deep water triangle and grooved Tanner crabs, *Chionoecetes angulatus* and *C. tanneri* are all managed as developing fisheries.

Alternative 1. Status Quo. Do not evaluate MSY.
Alternative 2. MSY is estimated from a proxy of the mature biomass and stock utilization rate.

Tier 2) Sporadic or limited years of survey data. Catch and effort data on each crab stock is well documented.

Alternative 1. Status Quo. Do not evaluate MSY.
Alternative 2. MSY is estimated from a proxy of the mature biomass and stock utilization rate.

Tier 3) Data available: Historical catch, continuous inseason catch and effort data, stock assessment, growth, maturity, limited natural mortality and stock recruitment relationship information.

Alternative 1. Status Quo. MSY equals the mean of the available year so harvest data.
Alternative 2. MSY equals the product of the estimated mature biomass and the instantaneous fishing mortality rate at MSY.

**Crab Stocks Characterized by Tier 1 Data**

Pribilof Islands golden king crab: This stock is characterized by tier 1 data as there is no survey of golden king crab in the area. Harvest of Pribilof Islands brown king crab is by permit issued by the Commissioner of ADF&G (ADF&G, 1997). No fishing mortality rate has been estimated for Pribilof Islands golden king crabs. The maximum fishing mortality threshold for this stock $F_{msy}$= M = 0.2.

Northern District golden king crab: This stock is characterized by tier one data because there is no survey of the stock. Harvest of Northern District golden king crab is by permit issued by the Commissioner of ADF&G (ADF&G 1997). Sporadic harvest of this stock has occurred since 1982 (Morrison et al. 1997). No fishing mortality rate has been estimated though as no landings were made in 1997. The maximum fishing mortality threshold for Northern District golden king crabs is $F_{msy}$= M = 0.2.

Adak *C. bairdi* Tanner crab (Western Aleutian): This stock is characterized by tier one data because there is no survey of Adak Tanner crabs. This stock of crabs has generally been harvested incidental to Adak red king crab (Morrison et al. 1997b). There have only been two confidential landings of Adak Tanner crabs since 1991.No fishing mortality rate has been estimated for this stock as there were no landings in 1997. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.3.

Saint Lawrence Island blue king crab: This stock is characterized by unique tier 1 data that should be considered to determine if OY, MSY and overfishing should be evaluated. The St. Lawrence Island blue king crab stock has been subject to limited intermittent harvest. The first and largest catch from the area occurred in 1983 when 52,557 pounds of blue king crab were taken near the southeast shore of the Island (Lean and Brennan 1997). The following year the waters within 10 miles of all inhabited Islands in the St. Lawrence Island area were closed to protect king crab stocks targeted by local fisherman and reduce impacts on subsistence marine mammals. Commercial harvest has occurred in only three years since closure of nearshore waters: total catches in 1989 and 1992 were 984 pounds and 53 pounds while catch in 1995 was 7,913 pounds. The combination of closed waters and sporadic catch suggest harvest in offshore waters is extremely limited. A nearshore winter fishery is allowed by regulation. However, local residents have decided not to export any of their winter catch for commercial sale. No fishing mortality rate has been estimated for this stock since there has been no commercial harvest since 1995. The maximum fishing mortality threshold for St. Lawrence Island blue king crabs should be $F_{msy}$= M = 0.2.

Aleutian Islands Scarlet king crab: This stock is characterized by tier 1 data. Scarlet king crabs in the Aleutian Islands are harvested as incidental catch in the Aleutian golden king crab fisheries (historic Dutch Harbor and Adak areas) and the Eastern and Western Aleutian Deep Water Tanner crab fisheries. In the Bering Sea, scarlet king crabs are harvested incidentally in the Bering Sea triangle Tanner crab and golden king crab fisheries. No fishing mortality rate has been estimated for this stock since there are no directed fisheries for Aleutian Islands scarlet king crab. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.2.

Bering Sea triangle Tanner crab: This stock is characterized by tier 1 data. Bering Sea triangle Tanner crabs were harvested as incidental catch in the grooved Tanner crab fishery until 1995 when the first landings from directed fishing for the species was reported. Catch data have been collected for 1995 and 1996. No fishing mortality rate has been estimated for this stock since there were no landings of triangle Tanner crab reported from the Bering Sea in 1997. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.3.

Eastern Aleutian Islands triangle Tanner crab: This stock is characterized by tier 1 data. Eastern Aleutian Islands triangle Tanner crab were harvested as incidental catch in the grooved Tanner crab fishery until 1995 when the first landings from directed fishing for the species were reported. No fishing mortality rate is estimated for this stock because no harvest was reported from the Eastern Aleutian Islands in 1997. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.3.

Eastern Aleutian Islands grooved Tanner crabs: This stock is characterized by tier 1 data. In the early 1980's grooved Tanner crabs were occasionally landed from the Eastern Aleutian Island waters incidental to the developing golden king crab fishery. No directed harvest of grooved Tanner crab in the area was reported until 1993. Catch peaked at over 880,000 pounds in 1995 was incidental to the golden king crab fishery again in 1996. No fishing mortality rate has been estimated for this stock since there were no landings of grooved Tanner crabs reported from the Eastern Aleutian Islands in 1997. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.3.

Western Aleutian Islands grooved Tanner crab: This stock is characterized by tier 1 data. Grooved Tanner crabs have been noted in catches of the Adak area golden king crab fishery since it began developing the 1970s. Harvest was first reported in 1992 but directed fishing effort for grooved Tanner crabs didn't occur until 1994. Catch history is confidential for three out of four years harvests have been reported. No fishing mortality rate is estimated for this stock. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.3.

Bering Sea grooved Tanner crab: This stock is characterized by tier 1 data. The first landing of grooved Tanner crab from the Bering Sea were reported in 1988 but no further harvest followed until 1994. Harvest peaked at over 1 million pounds in 1995, declined sharply in 1996 and no landings were made in 1997 (Morrison et. al. 1997c.). No fishing mortality rate has been estimated for this stock since there were no landings of grooved Tanner crabs reported from the Bering Sea in 1997. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.3.

**Crab Stocks Characterized by Tier 2 Data**

Aleutian Islands red king crab (Dutch Harbor and Adak red king crab stocks): The Dutch Harbor red king crab stock has unique tier 2 data as the stock has not been fished since 1983. As such the catch and effort data for this stock do not reflect the prevailing ecological and environmental conditions. A survey of the E. Aleutians in 1991 and 1994 indicated no significant improvement in stock status since the fishery was closed. A survey in 1995, indicated further reductions in the Dutch Harbor stock as no red king crab were caught. Based on these results rebuilding of the Dutch Harbor red king crab stock is not expected in the near future (Morrison et. al. 1997a., 1997b.). The Adak stock of red king crab is characterized by tier 2 data, however, the stock has not been surveyed since 1977. The fishery for Adak red king crab was closed in 1996.

Analysis of recent catch statistics indicates the population abundance is depressed and no commercial fishery is anticipated in the near future. The maximum fishing mortality threshold for these stocks of red king crab in the Aleutian Islands should be $F_{msy}$= M = 0.2.

Norton Sound red king crab: This stock is characterized by tier 2 data. Sporadic surveys using variable gear types have been conducted in Norton Sound to assess status of the red king crab stock. An abundance index was estimated for Norton Sound red king crab in 1996, the first, since it was last surveyed in 1991. The legal male crab abundance was estimated to have declined dramatically (Fair 1997). The maximum fishing mortality threshold for Norton Sound red king crab should be $F_{msy}$= M = 0.2. An overfishing mortality rate for Norton Sound red king crabs was evaluated by Kruse et. al. (1996) and $F_{0.3}$ was estimated to equal 0.27. The 1997 GHL was 80,000 pounds and 93,000 pounds were landed in the fishery. The 1997 fishing mortality rate was also below $F_{0.3}$. A length-based stock synthesis model is now available to estimate legal male crab abundance (Zheng et. al. MS).

Aleutian Islands golden king crab (Eastern Aleutians (Dutch Harbor) and Adak golden king crab stocks): These stocks are characterized by tier 2 data. Two surveys (1991and 1997) have been conducted in a portion of the area considered golden king crab habitat. The 1997/98 GHL for the Aleutians golden king crab stocks was set at 3.2 million pounds east of 174° W. longitude, and 2.7 million pounds west of 174° W. longitude. Total harvest in 1997 from the area east of 174° W. longitude was 3.56 million pounds. The fishery west of 174° W longitude is still open. The maximum fishing mortality threshold should be $F_{msy}$= M = 0.2.

Eastern Aleutian Islands *C. bairdi* Tanner crab: This stock is characterized by tier 2 data. Four surveys of the area since 1990 indicate the population has been in decline. No fishing mortality rate is estimated for this stock because the fishery has been closed since 1995. The maximum fishing mortality threshold for Eastern Aleutian Tanner crabs should be $F_{msy}$= M = 0.3.

**Crab Stocks characterized by Tier 3 Data**

Bristol Bay red king crab: This stock is characterized by tier 3 data. Despite stock improvements, the abundance of red king crab in Bristol Bay remains low relative to historic levels. The Length-based Analysis (LBA) estimate of effective spawning biomass was 31.4 million pounds in 1997, less than half the target rebuilding level of 55 million pounds but above the State's threshold level of 14.5 million pounds (Zheng et. al. 1997). The LBA estimate of mature female abundance was 10.2 million crabs also in excess of the threshold level of 8.4 million crabs. A GHL of 7.0 million pounds was set for 1997. Harvest exceeded the GHL by 1.4 million pounds but the total fishing mortality rate was below the proposed maximum fishing mortality threshold $F_{msy}$ = M = 0.2.

Pribilof Islands red king crab: This stock is characterized by tier 3 data. Historically red king crabs have not been abundant in the Pribilof Islands and landings were taken incidentally during the blue king crab fishery (Otto et. al. 1997). The series of survey indices of abundance and fishery catch data indicate a long-term population decline (Stevens et. al. 1998). Pribilof Islands red king crabs are harvested in a combined fishery for blue and red king crab in the Pribilof Islands District. The combined GHL in 1997 was 1.5 million pounds. Total harvest of red king crabs was estimated to be 685,000 pounds and the total fishing mortality rate was below the proposed maximum fishing mortality threshold $F_{msy}$= M = 0.2.

Pribilof Islands blue king crab: This stock is characterized by tier 3 data. The stock abundance index for Pribilof Islands blue king crabs has declined and is well below the historic average (Stevens et. al.1998). Mature male crab abundance was estimated at 1.1 million crabs using catch survey analysis (CSA) (Zheng et. al. 1997) and was above the threshold of 770,000 crabs (Pengilly and Schmidt 1995). Pribilof Islands blue king crabs are harvested in a combined fishery for blue and red king crab in the Pribilof Islands District. The

1997 GHL was 1.5 million pounds. Total harvest of blue king crabs was estimated to be 696,000 pounds and the total fishing mortality rate was below the proposed maximum fishing mortality threshold $F_{msy}$= M = 0.2.

Saint Matthew Island blue king crab: This stock is characterized by tier 3 data. The 1997 index of abundance for Blue king crabs in waters around Saint Matthew Island was relatively unchanged from 1996 at 10 million crabs. The abundance of mature male crabs was estimated to be 5.3 million crabs, greater than the threshold of 600,000 crabs (Zheng et. al. 1997, Pengilly and Schmidt 1995). The 1997 GHL for Saint Matthew Island blue king crab was 5.0 million pounds. The fishery was closed with an estimated total harvest of 4.7 million pounds. The fishing mortality rate was below the proposed maximum fishing mortality threshold $F_{msy}$= M = 0.2.

Bering Sea *C. bairdi* Tanner crab: This stock is characterized by tier 3 data. Total abundance of Bering Sea Tanner crab continues to decline. This trend is not expected to change for several years as little recruitment is apparent (Stevens et. al.1998). No GHL was set for Bering Sea Tanner crab in the 1997/98 fishing season. Furthermore, retention of incidentally harvested C. bairdi during the Bristol Bay red king crab fishery was prohibited. Bering Sea Tanner crab are considered overfished as the mature biomass as estimated from the 1997 survey is less than 50% of the MSY biomass.

Bering Sea *C. opilio* snow crab: This stock is characterized by tier 3 data. Total abundance of Bering Sea snow crab continues to decline. However, a strong year class that probably hatched in the period 1988-1990 has resulted in good recruitment to the fishery. Continued recruitment to the large size category should offset losses due to fishing and mortality in 1998 but the lack of very small crabs may indicate declining abundance over a longer term (Stevens et. al. 1998). The 1998 GHL for Bering Sea snow crab was set at 226 million pounds for large male crabs $\geq$ 4.0 in carapace width. Total harvest was estimated to be 245 million pounds and the fishing mortality rate was below the proposed maximum fishing mortality threshold $F_{msy}$ = M = 0.3.

**Evaluating overfishing**

In evaluating stock status relative to overfishing a number of factors are taken into account including: overall stock status; estimates of representative components of the stock biomass; previous fishing season performance; and projected total harvest for the upcoming season. For stocks lacking survey estimates of biomass, Tier 1 and Tier 2 stocks, methods of evaluating overfishing rely on fishery data, proxy estimates of biomass from surveyed stocks, and catch-length analysis. The methods for surveyed stocks, those with Tier 3 data, are well illustrated by the Bering Sea *C. bairdi* Tanner crab as described below. In either case, overfishing is evaluated prior to the fishing season using two approaches. First by comparison of the estimated mature biomass to the minimum stock size threshold and second by comparison of the expected utilization rate to the maximum fishing mortality threshold. The expected utilization rate is the projected guideline harvest level divided by the estimate of legal male abundance.

Tier 1 and 2 Stocks

For stocks without survey estimates of abundance, fishery data is relied upon to generate estimates of harvestable population size or biomass and to provide estimates of the harvest rate incurred in a previous and upcoming fishing season or fishery in progress. In increasing order of detail, fish tickets, dockside sampling, and on-board observers provide the principal sources of fishery data. The detail of data collected from a fishery season will depend upon the degree of coverage by dockside samplers and onboard observers. Fish tickets are available from each landing of each vessel and provide catch and effort data for each statistical area for a landing. Dockside samplers and observers onboard floating processors augment fish ticket data by obtaining size and shell condition data from delivered crabs and by interviewing skippers to obtain data on daily catch and effort by statistical area. Observers on board fishing vessels collect the same data as dockside samplers and observers onboard floating processors, but also randomly sample pot lifts during the commercial

fisheries to obtain data on directed catch, bycatch, (species-sex-size composition of incidental catch), soak time, and exact locations of pot lifts. The more detailed information provided by interview or, especially observer data can be used to assess and correct for the conditions assumed for use of the abundance estimator. Observer data from fishing vessels, for example, can provide an estimate of the distribution of the exploited portion of the stock, data on changes in the geographic distribution of fishery effort during or between seasons, information on localized depletion, and data on changes in catch composition during or between seasons. For Tier 1 stocks and for those Tier 2 stocks without recent survey or fisheries, depletion estimators of abundance using fisheries data must be relied upon. Catch-length analysis models (Zheng et al. 1995) have potential as abundance estimators for some Tier 2 stocks with long and unbroken time series of fishery catch and effort data. A triennial pot survey for the Aleutians golden king crab stock east of 174$^{o}$ W will provide abundance indices and data on stock distribution that is independent of fishery data that can be used to calibrate a catch-length analysis. For evaluating stock level and fishing mortality relative to overfishing criteria, spawning biomass estimates and the fishing mortality of mature males can be generated by applying estimates of legal male abundance to the "proxy" stock mature-to-legal biomass ratios (see Estimation of MSY for Stocks Using Proxy Biomass Estimate of MSY).

Tier 3 Stocks (e.g. Bering Sea *C. bairdi* Tanner Crab)

The total population abundance of Bering Sea Tanner crabs has declined steadily since 1989 when the strong cohort of crabs (apparently 1988-1992) recruited to the fishery then began decline due to natural mortality and fishery removals. As this cohort ages, the proportion of oldshell and very oldshell crabs has increased and that of newshell crabs decreased. Old shell crab are not expected to molt again in their life span which further contributes to lack of new recruits to the legal portion of the population. The abundance index of large male, pre-recruit male and large female crabs decreased over 60% from 1996 to 1997. This is the second lowest estimate of large male crabs and the lowest estimate of large female crabs in the history of the fishery. Low abundance of recruit size crabs suggests that the population will continue to decline for several years.

In 1996, the GHL for Bering Sea Tanner crabs was set at 6.2 million pounds based on a 40% exploitation of legal male crabs. A total of 1.8 million pounds of *C. bairdi* were harvested before the fishery was closed due to low catch per pot. This poor fishery performance coupled to depressed stock abundance was instrumental in the management decision to forego the 1997 fishery that had an estimated guideline harvest level of 3.4 million pounds. Stock conservation concerns particularly for potential overfishing were paramount in this decision.

Overfishing for Bering Sea Tanner crabs under alternative one (status quo) is defined as a fishing mortality rate in excess of $F_{MSY}$ estimated as $F_{0.1} = 0.34$ based on the size of first maturity for male crabs. Evaluating the fishing mortality rate based on the midpoint and 95% confidence interval of mature male abundance indicated that the forgone GHL for the directed fishery would not have risked overfishing. Fishing mortality from the anticipated Bering Sea Tanner crab PSC for 1998 (average of 1996 and 1997) would not approach $F_{0.1}$ either. Cumulatively, the opposite may have been true, an important fact that was considered in the 1997 decision to close the fishery.

Overfishing for Bering Sea Tanner crabs under alternative two is defined as a fishing mortality rate in excess of $F_{MSY}$ estimated as $F = M = 0.3$ based on longevity of Tanner crab. Alternative two definition of overfishing is more conservative than the status quo. The fishing mortality rate associated with either the foregone harvest in 1997 or the anticipated Bering Sea Tanner crab PSC for 1998 alone would not have risked overfishing. However, under alternative two a minimum stock size threshold (MSST) is specified for Bering Sea Tanner crabs to equal ½ the MSY stock size. Estimated spawning biomass of Tanner crabs from the 1997 survey was 64.2 million pounds below the MSST of 94.8 million pounds. Under alternative two, the Bering Sea *C. bairdi* Tanner crab stock would be designated overfished.

## 1.5 List of Housekeeping Changes to Crab FMP

The BSAI Crab FMP has never updated from the original draft of January 24, 1989. Since that time, six plan amendments have been approved, but the amendment language has not been incorporated. The current plan draft therefore, does not provide readers with a clear understanding of conservation and management measures that have been implemented for the BSAI crab fishery. In addition, additional catch data and other scientific information has become available in the past 10 years. Other changes have also occurred, including Magnuson-Stevens Act requirements and other Laws, a Russian/U.S. boundary agreement, and development of a Federal/State Action Plan.

Because the reasons stated above, the Crab Plan Team has revised the FMP to bring it up to date. These proposed changes were discussed and reviewed over the course of several public meetings that occurred in the period 1995-1998. A revised draft FMP is attached as an Appendix. A list of changes made from the January 24, 1989 draft are listed below.

1) Added amendment language changes
- Amendment 1 Overfishing definition
- Amendment 2 Norton Sound superexclusive
- Amendment 3 Research Plan
- Amendment 4: Moratorium
- Amendment 5: License Limitation Program
- Amendment 6: Repeal Research Plan / Implement Modified Observer Program
- NOTE: language was added to convey that Moratorium (Amd 4) is effective through Dec 31, 1998 unless replaced by components of the approved License Limitation Program (Amd 5) that have not all been implemented in regulation; or until the Council extends the Moratorium

2) Updated Figure
- Figure 2.1 (Annual decision making process flow chart)
- Figure 2.2 (Season opening dates)
- Figure 2.3 (Inseason management decision process flow chart)
- Revised Figure 5.1 to show Russian/U.S. boundary based on 1988 agreement.
- Figure E.3 (updated registration areas)
- Figure E.4 (Added map showing location of fisheries)

3) Updated/Revised Tables
- Table 8.1 (Management measures by category)
- Table D.1 (added life history summary table)
- Table D.2 (added habitat association summary table)
- Table E.1 (crab harvests through 1997)
- Table E.3 (stock structure)
- Table E.4 (size at maturity)
- Deleted Table showing Current Status of Stocks- refer to SAFE instead.
- Deleted Table showing catch of king crab by registration area - redundant info.
- Deleted Table showing catch of Tanner crab by registration area - redundant info.

4) Updated Appendix language
- Appendix E: Current Status of Stocks
  - Changed text to lead reader to Annual SAFE Report
  - Inserted Species Profiles section to summarize current fishery and management measures
  - Removed 1987 distribution maps

5) Other changes

- Changed name of FMP to clarify, updated NPFMC address
- Text printed single spaced with New Times Roman 11 point font and full justification
- Added an Executive Summary
- Include Federal State Action Plan
- Various minor typos and edits made
  - (e.g., “Magnuson Act” now Magnuson-Stevens Act; “Regional Director” now Regional Administrator)
- Removed references to foreign and joint venture management
- Revised definition of commercial fishing to reflect State definition.
- Added new BOF regulations on category 2 petitions
- Updated the summary of applicable Acts and Laws
- Added a section called Species Profiles to summarize recent information on the fisheries, regulations, gear used, revenues generated, etc.
- Added a section on coastal communities
- Revised section on nomenclature of crab to update and clarify.
- Added new and more recent references.

6) Added language relative to Magnuson-Stevens Act amendments

- Added new national standards
- Revised OY definition
- Added information on bycatch reporting and bycatch minimization measures
  - (e.g., noted that seasons could be modified to minimize bycatch)

Table 1. MSY estimates for BSAI king and Tanner crab stocks. Estimated values are in millions of pounds. Long-term average catch represents MSY as it would have been calculated under the old FMP. Current average catch is that over the same years as the MSY estimate and may be taken as the average of OY determinations in the same period.

| | Long-term Average | | Current Average | | | |
|---|---|---|---|---|---|---|
| **Stock** | **Years** | **Ave. Landings** | **Years** | **Ave. Landings** | **MSY Estimate** | **Comments** |
| Adak red king | 1960-95 | 5.8 | 1983-95 | 1.2 | 1.8 | Closed 1996, 1997. |
| Bristol Bay red king | 1953-97 | 30.8 | 1983-97 | 10.6 | 17.9 | MSY from survey history; Closed 1983, 1994-95. |
| Dutch Harbor red king | 1961-82 | 11.3 | 1983-97 | 0.0 | NA | No current MSY; Fishery closed since 1982. |
| Pribilof Islands red king | 1980-97 | 0.9 | 1983-97 | 1.0 | 1.3 | MSY from survey history; No fishing or closed 1984-92 |
| Norton Sound red king | 1977-97 | 0.6 | 1983-97 | 0.3 | 0.5 | Closed 1991. |
| Pribilof Islands blue king | 1966-97 | 3.3 | 1983-97 | 0.8 | 2.6 | MSY from survey history; Closed 1988-94. |
| St Matthew blue king | 1977-97 | 3.0 | 1983-97 | 3.0 | 4.4 | MSY from survey history. |
| St Lawrence blue king | 1979-95 | <0.1 | 1983-95 | <0.1 | 0.1 | MSY provisional; Fished in 1979, 1983, 1989, 1995. |
| Aleutian Is. golden king | 1980-96 | 8.0 | 1983-96 | 8.8 | 17.9 | 1997-98 season in progress. |
| Pribilof Is. golden king | 1981-96 | 0.1 | 1983-97 | 0.1 | 0.3 | No fishing in 1984, 1990. |
| St. Matthew golden king | - | - | 1983-96 | 0.1 | 0.4 | MSY provisional; No fishing 1987-89, 1990-91, 1997. |
| Aleutian Is. scarlet king | - | - | 1992-97 | <0.1 | NA | MSY = 0.06 provisional |
| EBS scarlet king | - | - | 1995-96 | <0.1 | NA | MSY = 0.04 provisional |
| E. Aleutian Is. Tanner | 1974-95 | 0.5 | 1983-95 | 0.2 | 0.7 | No fishing 1996-97. |
| EBS Tanner | 1965-96 | 30.0 | 1983-96 | 13.9 | 56.9 | MSY from survey history; closed 1986-87, 1997. |
| W. Aleutian Is. Tanner | 1973-95 | 0.2 | 1983-95 | 0.1 | 0.4 | Closed 1976, 93-94, 96-97. |
| EBS snow | 1965-97 | 70.7 | 1983-97 | 136.6 | 276.5 | MSY from survey history. |
| E. Aleutian Is. angulatus | - | - | 1995-96 | 0.3 | 1.0 | MSY provisional; no fishing in 1997. |
| EBS angulatus | - | - | 1995-96 | 0.1 | 0.3 | MSY provisional; no fishing in 1997. |
| E. Aleutian Is. tanneri | - | - | 1993-96 | 0.5 | 1.8 | MSY provisional; no fishing in 1997. |
| EBS tanneri | - | - | 1992-96 | 0.5 | 1.5 | MSY provisional; no fishing in 1997. |
| W. Aleutian Is. Tanneri | - | - | 1992-96 | <0.1 | 0.2 | MSY provisional; no fishing in 1997. |

**Table 2. Comparison of current and proposed MSY and OY estimates for BSAI king and Tanner crab stocks. Estimated values are in millions of pounds.**

| Stock | Current MSY | Current OY range | Proposed MSY | Proposed OY range | 1997/98 Catch |
|---|---|---|---|---|---|
| Adak red king | 7 | - | 1.8 | 0 - 1.8 | 0 |
| Bristol Bay red king | 35 | - | 17.9 | 0 - 17.9 | 8.8 |
| Dutch Harbor red king | 11.2 | - | NA | NA | 0 |
| Pribilof Islands red king | NA | - | 1.3 | 0 - 1.3 | * |
| Norton Sound red king | 1 | - | 0.5 | 0 - 0.5 | 0.09 |
| Pribilof Islands blue king | 4 | - | 2.6 | 0 - 2.6 | 0.7 |
| St Matthew blue king | 3 | - | 4.4 | 0 - 4.4 | 4.6 |
| St Lawrence blue king | NA | - | 0.1 | 0 - 0.1 | 0 |
| Aleutian Is. golden king | 8.8 | - | 17.9 | 0 - 17.9 | 4.1 |
| Pribilof Is. golden king | NA | - | 0.3 | 0 - 0.3 | 0.01 |
| St. Matthew golden king | NA | - | 0.4 | 0 - 0.4 | 0 |
| Aleutian Is. scarlet king | NA | - | NA | NA | * |
| EBS scarlet king | NA | - | NA | NA | 0.007 |
| **TOTAL king crab** | **70** | **0 to 200** | **47.2** | **0 - 47.2** | **18.3** |
| | | | | | |
| E. Aleutian Is. Tanner | 0.7 | - | 0.7 | 0 - 0.7 | 0 |
| EBS Tanner | 27 | - | 56.9 | 0 - 56.9 | 0 |
| W. Aleutian Is. Tanner | 0.2 | - | 0.4 | 0 - 0.4 | 0 |
| **TOTAL Tanner crab** | **27.9** | **0 to 108** | **58.0** | **0 - 58.0** | **0** |
| | | | | | |
| EBS snow | 35 | - | 276.5 | 0 - 276.5 | 240 |
| **TOTAL snow crab** | **35** | **0 to 333** | **276.5** | **0 - 276.5** | **240** |
| | | | | | |
| E. Aleutian Is. angulatus | NA | NA | 1.0 | 0 - 1.0 | 0 |
| EBS angulatus | NA | NA | 0.3 | 0 - 0.3 | 0 |
| E. Aleutian Is. tanneri | NA | NA | 1.8 | 0 - 1.8 | 0 |
| EBS tanneri | NA | NA | 1.5 | 0 - 1.5 | 0 |
| W. Aleutian Is. Tanneri | NA | NA | 0.2 | 0 - 0.2 | 0 |
| **TOTAL other Tanners** | **NA** | **NA** | **4.8** | **0 - 4.8** | **0** |

## 2.0 NEPA REQUIREMENTS: ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES

An environmental assessment (EA) is required by the National Environmental Policy Act of 1969 (NEPA) to determine whether the action considered will result in significant impact on the human environment. If the action is determined not to be significant based on an analysis of relevant considerations, the EA and resulting finding of no significant impact (FONSI) would be the final environmental documents required by NEPA. An environmental impact statement (EIS) must be prepared for major Federal actions significantly affecting the human environment.

An EA must include a brief discussion of the need for the proposal, the alternatives considered, the environmental impacts of the proposed action and the alternatives, and a list of document preparers. The purpose and alternatives were discussed in Sections 1.1 and 1.2, and the list of preparers is in Section 6. This section contains the discussion of the environmental impacts of the alternatives including impacts on threatened and endangered species and marine mammals.

### 2.1 Environmental Impacts of the Alternatives

The environmental impacts generally associated with fishery management actions are effects resulting from (1) harvest of fish stocks which may result in changes in food availability to predators and scavengers, changes in the population structure of target fish stocks, and changes in the marine ecosystem community structure; (2) changes in the physical and biological structure of the marine environment as a result of fishing practices, e.g., effects of gear use and fish processing discards; and (3) entanglement/entrapment of non-target organisms in active or inactive fishing gear.

### 2.2 Endangered Species Act

The Endangered Species Act of 1973 as amended (16 U.S.C. 1531 *et seq*; ESA), provides for the conservation of endangered and threatened species of fish, wildlife, and plants. The program is administered jointly by the NMFS for most marine mammal species, marine and anadromous fish species, and marine plants species and by the USFWS for bird species, and terrestrial and freshwater wildlife and plant species.

The designation of an ESA listed species is based on the biological health of that species. The status determination is either threatened or endangered. Threatened species are those likely to become endangered in the foreseeable future [16 U.S.C. § 1532(20)]. Endangered species are those in danger of becoming extinct throughout all or a significant portion of their range [16 U.S.C. § 1532(20)]. Species can be listed as endangered without first being listed as threatened. The Secretary of Commerce, acting through NMFS, is authorized to list marine fish, plants, and mammals (except for walrus and sea otter) and anadromous fish species. The Secretary of the Interior, acting through the USFWS, is authorized to list walrus and sea otter, seabirds, terrestrial plants and wildlife, and freshwater fish and plant species.

In addition to listing species under the ESA, the critical habitat of a newly listed species must be designated concurrent with its listing to the "maximum extent prudent and determinable" [16 U.S.C. § 1533(b)(1)(A)]. The ESA defines critical habitat as those specific areas that are essential to the conservation of a listed species and that may be in need of special consideration. Federal agencies are prohibited from undertaking actions that destroy or adversely modify designated critical habitat. Some species, primarily the cetaceans, which were listed in 1969 under the Endangered Species Conservation Act and carried forward as endangered under the ESA, have not received critical habitat designations.

**Listed Species**. The following species are currently listed as endangered or threatened under the ESA and occur in the BSAI:

**Endangered**

| | |
|---|---|
| Northern Right Whale | *Balaena glacialis* |
| Bowhead Whale | *Balaena mysticetus* |
| Sei Whale | *Balaenoptera borealis* |
| Blue Whale | *Balaenoptera musculus* |
| Fin Whale | *Balaenoptera physalus* |
| Humpback Whale | *Megaptera novaeangliae* |
| Sperm Whale | *Physeter macrocephalus* |
| Short-tailed Albatross | *Diomedia albatrus* |
| Steller Sea Lion | *Eumetopias jubatus* |

**Threatened**

| | |
|---|---|
| Spectacled Eider | *Somateria fishcheri* |

**Section 7 Consultations**. Because crab fisheries are federally regulated activities, any negative effects of the fisheries on listed species or critical habitat and any takings[1] that may occur are subject to ESA section 7 consultation. NMFS initiates the consultation and the resulting biological opinions are issued to NMFS. The Council may be invited to participate in the compilation, review, and analysis of data used in the consultations. The determination of whether the action "is likely to jeopardize the continued existence of" endangered or threatened species or to result in the destruction or adverse modification of critical habitat, however, is the responsibility of the appropriate agency (NMFS or FWS). If the action is determined to result in jeopardy, the opinion includes reasonable and prudent measures that are necessary to alter the action so that jeopardy is avoided. If an incidental take of a listed species is expected to occur under normal promulgation of the action, an incidental take statement is appended to the biological opinion.

With regard to crab fisheries, Section 7 consultations may affect determinations made for short-tailed albatross and spectacled eider. Consultations done for the groundfish fisheries may also apply to some extent for BSAI king and Tanner crab fisheries, so they are included here as well. Below are summaries of the consultations.

A summary of the effects of the annual groundfish harvests on the biological environment and associated impacts on marine mammals, seabirds, and other threatened or endangered species are discussed in the final environmental assessment for the 1999 annual groundfish total allowable catch specifications.

Pursuant to section 7 of the Endangered Species Act, NMFS has completed a consultation on the effects of the pollock and Atka mackerel fisheries on listed species, including the Steller sea lion, and designated critical habitat. The Biological Opinion prepared for this consultation, dated December 3, 1998, and revised on December 16, 1998, concludes that NMFS actions that authorize the pollock fisheries in the BSAI and the GOA jeopardize the continued existence of Steller sea lions and adversely modify their designated critical habitat. The Biological Opinion contains reasonable and prudent alternatives (RPAs) to mitigate the adverse impacts of the pollock fisheries on Steller sea lions. An emergency rule to implement the RPAs was published on January 22, 1999 (64 FR 3437) with an effective date of January 20, 1999, through July 19, 1999. NMFS anticipates extending this emergency rule for an additional 180 days with revisions to the provisions for the pollock B and C seasons consistent with the Biological Opinion. The Biological Opinion concluded that NMFS actions that authorize the Atka mackerel fisheries in the BSAI would not likely jeopardize the continued existence of Steller sea lions or adversely modify their designated critical habitat.

[1] the term "take" under the ESA means "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct" (16 U.S.C. ' 1538(a)(1)(B).

On December 22, 1998, NMFS completed a consultation on the effects of the 1999 BSAI groundfish fisheries on listed and candidate species, including the Steller sea lion and listed seabirds, and on designated critical habitat. The Biological Opinion concluded that this action is not likely to jeopardize the continued existence of the Steller sea lion or adversely modify its critical habitat. The opinion is contingent upon development and implementation of reasonable and prudent alternatives as outlined in the December 16, 1998, Biological Opinion.

Spectacled Eider (*Somateria fischeri*), a threatened seaduck, feed on benthic mollusks and crustaceans taken in shallow marine waters or on pelagic crustaceans. The marine range for spectacled eider is not known, although Dau and Kitchinski (1977) review evidence that they winter near the pack ice in the northern Bering Sea. Spectacled eider are rarely seen in U.S. waters except in August through September when they molt in northeast Norton Sound and in migration near St. Lawrence Island. The lack of observations in U.S. waters suggests that, if not confined to sea ice polyneas, they likely winter near the Russian coast (FWS 1993).

Since 1994, NMFS has consulted with the USFWS annually on the crab FMP, which includes the winter Bering Sea *C. opilio* fishery, pursuant to section 7 of the ESA (FWS 1996a, 1996b). In the past, section 7 consultations on this fishery have been formal because it was perceived that the fishery was likely to adversely affect spectacled eiders. This perception of a likelihood of an adverse effect resulted from: (1) a lack of knowledge concerning the at-sea range of spectacled eiders and; (2) a lack of knowledge of the species of eiders that have struck, or were likely to strike crabbing vessels.

Beginning in 1995, observers aboard crabbing vessels received training in bird identification and reporting. Observers were instructed to report all sightings of spectacled eiders to the USFWS either directly or through ADF&G. To date, no take of spectacled eiders associated with this fishery has been reported.

Since the initial determination that this fishery was likely to adversely affect spectacled eiders, the USFWS has learned much about the at-sea distribution of spectacled eiders. Satellite telemetry data and 3 years of late winter aerial surveys indicate that spectacled eiders spend the winter in exposed waters between St. Matthew and St. Lawrence Islands, or in open leads slightly west of the inter-island area. *C. opilio* crab fishing has been largely concentrated around the Bering Sea continental shelf, which in the Bering Sea, runs from Unimak Island to the northwest, passing well south and west of St. Matthew Island. Crabbing occurs along the shelf because this is where the greatest *C. opilio* crab concentrations occur, and not because of fishing ground access restrictions imposed by sea-ice conditions between January and March. Thus, even if sea ice conditions were to make it possible for crabbing vessels to venture into the waters used by wintering spectacled eiders, they would not likely do so, due both to the time and expense of vessels traveling that far and the relatively fewer number of *C. opilio* crabs present there.

Crab fishery observers will continue to be placed aboard the catcher-processor vessels participating in this fishery, and in the future, these catcher-processor vessel observers will continue to receive training and refresher training in seabird identification and seabird reporting procedures.

Therefore, USFWS concurred with NMFS's determination that the opilio crab fishery is not likely to adversely affect threatened or endangered species under the jurisdiction of the USFWS, including the threatened spectacled eider (FWS 1998).

**Conditions for Reinitiation of Consultation**. For all ESA listed species, consultation must be reinitiated if: the amount or extent of taking specified in the Incidental Take Statement is exceeded, new information reveals effects of the action that may affect listed species in a way not previously considered, the action is subsequently modified in a manner that causes an effect to listed species that was not considered in the

biological opinion, or a new species is listed or critical habitat is designated that may be affected by the action.

**Impacts of the Alternatives on Endangered or Threatened Species**. None of the alternatives under consideration would affect the prosecution of the crab or groundfish fisheries of the BSAI in a way not previously considered in the above consultations. The proposed alternatives are designed to improve the long-term productivity of BSAI crab stocks. None of the alternatives would affect takes of listed species. Therefore, none of the alternatives are expected to have a significant impact on endangered or threatened species.

## 2.3 Marine Mammal Protection Act

The king and Tanner crab fisheries in the Bering Sea/Aleutian Islands are classified as Category III fisheries under the Marine Mammal Protection Act. A fishery that interacts only with non-strategic stocks and whose level of take has an insignificant impact on the stocks is placed in Category III. An observer program has been in existence since 1988 for the Alaskan crustacean pot fisheries. No marine mammal species have been recorded as taken incidentally in the fisheries according to records that date back to 1990.

## 2.4 Coastal Zone Management Act

Implementation of each of the alternatives would be conducted in a manner consistent, to the maximum extent practicable, with the Alaska Coastal Management Program within the meaning of Section 30(c)(1) of the Coastal Zone Management Act of 1972 and its implementing regulations.

## 2.5 Conclusions or Finding of No Significant Impact

None of the alternatives in Amendment 7 to the BASI crab FMP are likely to significantly affect the quality of the human environment, and the preparation of an environmental impact statement for the proposed action is not required by Section 102(2)(C) of the National Environmental Policy Act or its implementing regulations.

_____ _____

Assistant Administrator for Fisheries, NOAA Date

## 3.0 ECONOMIC AND SOCIOECONOMIC IMPACTS

This section provides information to aid future analysis of the economic and socioeconomic impacts of the alternatives including identification of the individuals or groups that may be affected by the action, the nature of these impacts, quantification of the economic impacts if possible, and discussion of the trade offs between qualitative and quantitative benefits and costs.

The following tables present data summarizing the number of vessels by gear and area that harvested Alaska groundfish, scallops and crab in 1996. These data include some vessels with a gross annual revenue that exceeds $3 million, although the preponderance of vessels experience annual revenues less than this amount.

**Number of vessels that caught groundfish in the BSAI area in 1996, by vessel length class (measured by length overall (LOA) in feet), catcher type, and gear.**

| | <60' | 60-124' | >125' | Total |
|---|---|---|---|---|
| Catcher vessels | | | | |
| Fixed gear | 64 | 125 | 17 | 206 |
| Trawl gear | 6 | 91 | 31 | 128 |
| Catcher/processors | | | | |
| Fixed gear | 1 | 21 | 32 | 54 |
| Trawl gear | 0 | 7 | 55 | 62 |
| Total all vessels | 71 | 244 | 135 | 450 |

**Number of vessels that caught groundfish in the GOA area in 1996, by vessel length class (measured by length overall (LOA) in feet), catcher type, and gear.**

| | <60' | 60-124' | >125' | Total |
|---|---|---|---|---|
| Catcher vessels | | | | |
| Fixed gear | 1116 | 179 | 7 | 1302 |
| Trawl gear | 63 | 82 | 17 | 162 |
| Catcher/processors | | | | |
| Fixed gear | 4 | 13 | 11 | 28 |
| Trawl gear | 0 | 7 | 30 | 37 |
| Total all vessels | 1183 | 281 | 65 | 1529 |

**Number of vessels that landed scallops in Alaska in 1996 and 1997, by vessel length class (measured by length overall (LOA) in feet).**

| | <60' | 60-124' | >125' | Total |
|---|---|---|---|---|
| Cook Inlet | | | | |
| 1996 | 0 | 4 | 0 | 4 |
| 1997 | 1 | 2 | 0 | 3 |
| Outside Cook Inlet | | | | |
| 1996 | 0 | 4 | 0 | 4 |
| 1997 | 0 | 6 | 0 | 6 |

**Number of vessels that caught crab in the BSAI area in 1996, by vessel length class (measured by length overall (LOA) in feet), catcher type, and gear.**

| | Catcher vessels | | | Catcher/ |
|---|---|---|---|---|
| | <60' | 60-124' | >125' | proc.s |
| Bristol Bay red king | 0 | 130 | 62 | 4 |
| Bering Sea Tanner | 0 | 102 | 40 | 4 |
| Bering Sea Snow crab | 0 | 154 | 70 | 15 |
| Norton Sound red king | 41 | 0 | 0 | 0 |

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## 7.0 Appendix 1: Sources of Fishing Mortality on BSAI Crabs

The guidelines for national standard 1 specifies that all fishing mortality must be counted against the OY, including that resulting from bycatch, research fishing, and any other fishing activities.

Survival of juvenile crab after settlement until they reach maturity depends on natural mortality (due to predation, disease, and other sources) and fishing mortality. Natural mortality is estimated to be about 20% (M=0.2) for king crab, and about 25% (M=0.3) for Tanner crab and snow crab (NPFMC 1990). Fishing mortality due to crab fisheries occurs through fishery removals of large males, handling mortality, ghost fishing by lost pots, direct gear impacts, and unobserved mortality caused by cannibalism and predation inside pots. Fishing mortality attributed to groundfish and scallop fisheries include bycatch mortality, unobserved gear induced mortality, and indirect impacts of habitat alteration. Very few crabs are killed due to research fishing, and thus are not analyzed further in this section.

### Crab Harvests

Harvest policies set by the State of Alaska for major BSAI crab stocks are based on an exploitation rate strategy, with additional size, sex, and season regulations. Total amount of crab harvested in the directed fisheries is detailed in the FMP tables. Catch figures of crab harvested include "deadloss", which is the portion of the harvest that dies prior to processing and is wasted. In recent years, deadloss in Bering Sea king and Tanner crab fisheries has amounted to about 1%- 2% of the total harvest.

### Bycatch Mortality in Crab Fisheries

Another source of mortality is crab bycatch in directed crab fisheries. Crab bycatch includes females of target species, sublegal males of target species, and non-target crab. Numbers of crab taken as bycatch in recent major Bering Sea crab fisheries are listed in **Appendix Table 1**. Due to the difference in legal size versus market size for snow crab, a portion of the legal crabs are not retained as harvest, and are thus considered bycatch. For example, in 1994, over 57 million legal sized snow crab were discarded. Additional crab are bycaught in other fisheries for red king crab (Dutch Harbor, Adak), blue king crab (Pribilof Islands, St. Matthew), golden king crab (Dutch Harbor, Adak), Tanner crab (Aleutian Islands), and hair crab fisheries.

Some crabs taken as bycatch die due to handling mortality. Several laboratory and field studies have been conducted to determine mortality caused by handling juvenile and female crab taken in crab fisheries. There are a variety of effects caused by handling, ranging from sublethal (reduced growth rates, molting probabilities, decreased visual acuity from bright lights, and vigor) to lethal effects. Studies have shown a range of mortality due to handling based on gear type, species, molting stage, number of times handled, temperature, and exposure time (Murphy and Kruse 1995). Handling mortality may have contributed to the high natural mortality levels observed for Bristol Bay red king crab in the early 1980's (65% for males and 82% for females), that along with high harvest rates, resulted in stock collapse (Zheng et al. 1995). However, another study concluded that handling mortality from deck and temperature impacts was not responsible for the decline on the red king crab fishery (Zhou and Shirley 1995, 1996).

Byersdorfer and Watson (1992, 1993) examined red king crab and Tanner crab taken as bycatch during the 1991 and 1992 red king crab test fisheries. Instantaneous handling mortality of red king crab was <1% in 1991, and 11.2% in 1992. Stevens and MacIntosh (1993) found average overall mortality of 5.2% for red king crabs and 11% for Tanner crabs on one commercial crab vessel. Authors recommend these results be viewed with caution, noting that experimental conditions were conservative. Mortality for red king crab held 48 hours was 8% (Stevens and MacIntosh 1993, as cited in Queirolo et al. 1995). A laboratory study that examined the effects of multiple handling indicated that mortality of discarded red king crabs was negligible (2%), although body damage increased with handling (Zhou and Shirley 1995).

Delayed mortality due to handling does not appear to be influenced by method of release. In an experiment done during a test fishery, red king crab thrown off the deck while the vessel was moving versus those gently placed back into the ocean showed no differences in tag return rates (Watson and Pengilly 1994). Handling methods on mortality have been shown to be non-significant in laboratory experiments with red king crab (Zhou and Shirley 1995, 1996) and Tanner crab (MacIntosh et al. 1995). Although handling did not cause mortality, injury rates were directly related to the number of times handled.

Mortality of crabs is also related to time out of water and air temperature. A study of red king crabs and Tanner crabs found that crabs exposed to air exhibited reduced vigor and righting times, feeding rates (Tanner crabs), and growth (red king crabs) (Carls and Clair 1989). For surviving females, there was no impact on survival of eggs or larvae. Cold air resulted in leg loss or immediate mortality for Tanner crabs, whereas red king crabs exhibited delayed mortality that occurred during molting. A relationship was developed to predict mortality as the product of temperature and duration of exposure (measured as degree hours). Median lethal exposure was -8ºC for red king crab and -4.3ºC for Tanner crab. For example, if crabs were held on deck for 10 minutes and it was -23ºC or 10 degrees below zero (Fahrenheit) outside, about 15% of the king crab and 50% of the Tanner crab would die of exposure. Because BSAI crab fisheries occur from November through March, cold exposure could cause significant handling mortality to crabs not immediately returned to the ocean. Zhou and Shirley (1995) observed that average time on deck was generally 2 to 3 minutes, and they concluded that handling mortality was not a significant source of mortality.

Unobserved Mortality

Catching mortality is ascribed to those crabs that enter a pot and are eaten by other pot inhabitants before the pot is retrieved. Catching mortality likely occurs during the molting period, when crabs are more susceptible to cannibalism. Most crab fisheries are set to occur outside of the molting season, and catching mortality in these fisheries may be limited to octopus or large fish entering a pot. Because no evidence of crab is left in the pot, these mortalities remain unassessed.

Mortality is also caused by ghost fishing of lost crab pots and groundfish pots. Ghost fishing is the term used to describe continued fishing by lost or derelict gear. The impact of ghost fishing on crab stocks remains unknown. It has been estimated that 10-20% of crab pots are lost each year (Meyer 1971, Kruse and Kimker 1993). Based on skipper interviews, about 10,000 pots were estimated lost in the 1992 Bristol Bay red king, and Bering Sea Tanner and snow crab fisheries (Tracy 1994). Fewer pots are expected to be lost under pot limit regulations and shorter seasons. Bob Schofield, a major crab pot manufacturer, testified at the January 1996 Council meeting that he was making fewer pots since inception of the pot limit. He estimated that 6,461 pots were replaced in 1995. It is not known how long lost pots may persist and continue to fish, or just litter the bottom.

A sonar survey of inner Chiniak Bay (Kodiak, Alaska) found a high density of lost crab pots (190 pots) in an area of about 4.5 $km^2$ (Stevens 1995). Underwater observations indicated that crabs and fish were common residents of crab pots, whether or not the pot mesh was intact. Eight intact pots recovered from the Chiniak Bay study area contained an average of 4 crabs and 0.5 octopus (Stevens 1995). High (1985) and High and Worlund (1979) observed that 20% of legal sized male red king crab and 8% of the sublegals captured by lost pots failed to escape.

Crabs captured in lost pots may die of starvation or by predation. Captured crab are subject to cannibalism (Paul et al. 1993), and predation by octopus, halibut and Pacific cod (High 1976). Crabs also have limited abilities to withstand starvation. In a simulated field study, 39% mortality of Tanner crabs was observed after 119 days of starvation (Kimker 1992). In a laboratory study, 10% of the Tanner crabs tested died of starvation in 90 days. Of the 90% that had survived 90 days, all later died even though they were freely fed (Paul et al. 1993). To reduce starvation mortality in lost pots, crab pots have been required be fitted with degradable escape mechanisms. Regulations required #120 cotton thread from 1977-1993. Beginning in

1993, regulations required #30 cotton thread or 30-day galvanic timed release mechanisms. A #30 cotton thread section is also required in groundfish pots. The average time for #30 cotton twine to degrade is 89 days, and the galvanic timed release about 30 days to degrade. Pots fitted with an escape mechanism of #72 cotton twine had a fishable life of 3-8 years and documented retention of up to 100 crabs per lost pot (Meyer 1971). High and Wolund (1979) estimated an effective fishing life of 15 years for king crab pots. Pots without escape mechanisms could continue to catch and kill crabs for many years, however testimony from crabbers and pot manufacturers indicate that all pots currently fished in Bering Sea crab fisheries contain escape mechanisms.

Mortality of crab caused by ghost fishing is difficult to estimate with precision given existing information. Mortality caused by continuous fishing of lost pots has not been estimated, but unbaited crab pots continue to catch crabs (Breen 1987, Meyer 1971), and pots are subject to rebaiting due to capture of Pacific cod, halibut, sablefish, and flatfish. In addition to mortality of trapped crab by ghost pots, and predation by octopus and fish, pot mesh itself can kill crabs. Lost pots retrieved by NMFS trawl surveys occasionally contain dead crabs trapped in loose webbing (Stevens 1995). Pot limits and escape mechanisms may have greatly minimized ghost fishing due to pot loss in recent years.

Another minor source of human induced crab mortality is direct gear impacts. Direct gear impacts result from a pot landing on the ocean floor when it is being set, presumably damaging any crab on which it lands. With reasonable assumptions, direct gear impacts is only a very minor source of mortality, however. An estimate of the impact of pot bombing can be derived by multiplying the number of pot lifts, the area they occupy, and relative crab density within areas fished in the Bering Sea. Assuming that pots land on different areas after each lift, and crab pots are set non-randomly over areas with relatively high density of crabs in directed fisheries, the total number of crab impacted can be roughly estimated. For 1993 the red king crab fishery, assuming a density of 5,000 red king crab of all sizes per square mile (density data from Stevens et al. 1994), a maximum of about two thousand red king crab were impacted (NPFMC 1996). Similarly, a maximum of 9,000 Tanner crabs (assuming 10,000 crab/mile$^2$) and 110 thousand snow crabs (assuming 75,000 crab/mile$^2$) were impacted by direct gear impacts in respective crab fisheries in 1993. It is not known what proportion of these crab die when a crab pot lands on them.

**Bycatch of Crab in Groundfish Trawl Fisheries**

Crab bycatch is estimated by the National Marine Fisheries Service through the groundfish Observer Program. Observer coverage depends on vessel length; 100% observers on vessels > 125 feet, 30% coverage on vessels 60-125 feet, and 0% coverage on vessels <60 feet. Shoreside processors have 100% coverage. 100% coverage means that an observer is always onboard; it does not mean that every haul or landing is observed.

Bycatch data for crab are available for the 1992-1995 groundfish trawl fisheries in the BSAI by target fishery and regulatory areas. (NPFMC, 1996). The observer data base categorizes crab bycatch into king crab, Tanner crab (C. bairdi), and "other" crab categories. In the Bering Sea, the "other" crab category is comprised almost entirely of snow crab (C. opilio), whereas in the GOA, "other" crab consists mostly of C. tanneri and C. angulatus, with the bycatch of snow crab virtually nil.

Bycatch of red king crab in BSAI groundfish fisheries totaled 48,191 in 1995, which was down significantly from a recent high of 281,023 in 1994. Most red king crab bycatch is taken in the trawl fisheries (97%) and to a lesser extent in the longline (1%) and groundfish pot fisheries (2%). Although red king crabs are bycaught in nearly every trawl fishery, the rock sole/other flatfish fishery accounts for a majority of red king crab bycatch. Bycatch has been consistently highest in NMFS statistical areas 509 and 516. Bycatch of red king crab was significantly lower in 1995 due in part to the implementation of the Pribilof Islands Habitat Conservation Area and the Bristol Bay Red King Crab Savings Area. The recent level of red king crab

bycatch in trawl fisheries (1991-1995 average of 0.16 million) is low relative to the 1978-1989 average of 0.44 million red king crab. This reduction may be due in part to reduced crab abundance and increased regulation of the trawl fishery. Regulations in effect in 1989 and thereafter for domestic fisheries included current crab PSC limits and trawl closure areas.

A total of 2.3 million Tanner crab (C. bairdi) were taken as bycatch in the 1995 BSAI groundfish fisheries. Bycatch of Tanner crab has been reduced in recent years, down significantly from 4.3 million in 1992. Most Tanner crab bycatch is taken in the trawl fisheries (about 98%) and to a lesser extent in the longline (1.5%) and groundfish pot fisheries (0.5%). Although Tanner crabs are bycaught in nearly every trawl fishery, the yellowfin sole fishery takes the largest share, followed by the rock sole/other flatfish fisheries. Bycatch has been highest in NMFS statistical areas 509 and 513; and large numbers of Tanner crab area have also been consistently taken in areas 517 and 521. The recent level of Tanner crab bycatch in trawl fisheries (1992-1995 average of 3.06 million) is high relative to the 1978-1987 average of 2.06 million.

Bycatch of snow crab (C. opilio) in BSAI groundfish fisheries totaled 5.4 million crab in 1995. Bycatch has been drastically reduced since 1992, when 17.66 million snow crab were taken in groundfish fisheries. Most snow crab bycatch is taken in the trawl fisheries (99%) and to a lesser extent in the longline (0.7%) and groundfish pot fisheries (0.3%). Although snow crabs are bycaught in nearly every trawl fishery, the yellowfin sole fishery takes the vast majority (70% on average 1992-1994). Bycatch is highest in the areas north and east of the Pribilof Islands, corresponding to NMFS statistical areas 513, 514, and 521 (NPFMC 1996). Average snow crab bycatch in Zone 2 was about 10.8 million crabs, or about 0.11% of the NMFS total population index on average, 1992-1994. Bycatch of snow crab in 1995 was much lower than in previous years, totaling 5,395,788 crabs.

Bycatch Mortality

The effect of crab bycatch on crab stocks is somewhat tempered by survival of discarded crabs. There have been numerous studies conducted on crab bycatch mortality, with each study having different objectives, methodology, and results. A summary of these studies is provided below, but many questions remain unanswered. Stevens (1990) found that 21% of the king crabs and 22% of the Tanner crabs captured incidentally in BSAI trawl fisheries survived at least 2 days following capture. Blackburn and Schmidt (1988) made observations on instantaneous mortality of crab taken by domestic trawl fisheries in the Kodiak area. They found acute mortality for softshell red king crab averaged 21%, hard shelled red king crab 1.2%, and 12.6% for Tanner crab. Another trawl study indicated that trawl induced mortalities aboard ship were 12% for Tanner crab and 19% for red king crab (Owen 1988). Fukuhara and Worlund (1973) observed an overall Tanner crab mortality of 60-70% in the foreign Bering Sea trawl fisheries. They also noted that mortality was higher in the summer (95%) than in the spring (50%). Hayes (1973) found that mortality of Tanner crab captured by trawl gear was due to time out of water, with 50% mortality after 12 hours. Natural Resource Consultants (1988) reported that overall survival of red king crab and Tanner crab bycaught and held in circulation tanks for 24-48 hours was <22%. In other analyses, the estimated mortality rate of trawl bycaught red king crab and Tanner crab was 80% (NPFMC 1993).

Unobserved Mortality

Not all crab in the path of a trawl are captured. Some crab pass under the gear, or pass through the trawl meshes. Non-retained crab may be subject to mortality from contact with trawl doors, bridles, footrope, or trawl mesh, as well as exposure to silt clouds produced by trawl and dredge gear. Only two studies have been conducted to estimate catchability of crabs by trawl gear, and these studies are summarized below.

In one experiment to measure non-observable mortality, 169 red king crab were tethered in the path of an Aleutian combination trawl (Donaldson 1990). The trawl was equipped with a footrope constructed of 14 inch bobbins spaced every 3 feet, separated by 6.5 inch discs. Thirty-six crabs (21.3%) were recovered

onboard the vessel in the trawl. Divers recovered 46.2% of the crabs not captured by the trawl. Another 32.5% were not recovered but assumed to have interacted with the trawl. Of the 78 crab not retained in the trawl, but captured by divers, only 2.6% were injured. If all injured crabs die, the non-observable mortality rate for trawl gear on red king crab is estimated at 2.6% (Donaldson 1990). It should be noted that hard shelled crabs were used in this experiment; higher impacts would be expected if softshelled crabs were tested. Additionally, some areas have had higher intensity of bottom trawling than other areas, thus potentially exposing some crab to multiple interactions with trawl gear.

In 1995, NMFS used underwater video cameras to observe the interaction of trawl gear with king and Tanner crabs (Craig Rose, NMFS, unpublished data). The experiment was conducted in Bristol Bay in an area with large red king crabs and C. bairdi Tanner crabs. Three types of trawl footropes were examined and they are as follows: a footrope with 3-4 foot lengths of 6" discs separated by 10" discs (called disc gear), a footrope with 24" rollers (tire gear), and an experimental float/chain footrope with the groundgear suspended about 8" off the seafloor. For disc gear, preliminary analysis indicated that all red king crab encountered entered the trawl and about 76% of the Tanner crab were caught. Tire gear captured fewer king crab (42%) and Tanner crab (1%). The float/chain gear did not catch any of the crabs encountered. At the December 1995 Council meeting, excerpts of the NMFS video were shown to the Council and public. Trawl industry representatives testified that groundgear used to harvest finfish in this area depended on target species and bottom type, with tire gear type footropes used in hard bottom areas, and disc type gear used on smooth bottom areas. Testimony also indicated that there was also variability in groundgear used among vessels, but that on average, most gear used in Bristol Bay trawl fisheries would be comprised of groundgear with discs or rollers larger than the disc gear tested and smaller that the tire gear tested.

In order to compare the impacts of unobserved mortality caused by trawling with other sources of fishing mortality, it would be necessary to have reasonable estimates of retention rates and mortality of those crab not retained. At this time, however, there are too many uncertainties to generate valid estimates of unobserved crab mortality (C. Rose, NMFS, personal communication).

**Bycatch Mortality in Other Groundfish Fisheries**

Some crabs are caught incidentally by non-trawl gear in pursuit of groundfish, and a portion of these crabs die. No field or laboratory studies have been made to estimate mortality of crab discarded in these fisheries. However, based on condition factor information from the trawl survey, mortality of crab bycatch has been estimated and used in previous analyses (NPFMC 1993). Discard mortality rates for red king crab were estimated at 37% in longline fisheries and 37% in pot fisheries. Estimated bycatch mortality rates for Tanner crab were 45% in longline fisheries and 30% in pot fisheries. No observations had been made for snow crab, but mortality rates are likely similar to Tanner crab. In the analysis made in Section 5, a 37% mortality rate was assumed for red king crab taken in longline fisheries and an 8% rate for pot fisheries. Observer data on condition factors collected for crab during the 1991 domestic fisheries suggested lower mortality of red king crab taken in groundfish pot fisheries. Bycatch mortality rates used in the analysis of Amendment 37 (NPFMC 1996) for Tanner crab were 45% in longline fisheries and 30% in pot fisheries, based on previous analyses.

**Bycatch Mortality in the Scallop Fishery**

In 1993, the scallop fishery in the Bering Sea caught 6 red king crab, 276,000 Tanner crab, and 15,000 snow crab (D. Pengilly, ADF&G, unpublished data). Average sizes of crabs were 110 mm carapace length for red king crab, 100 mm carapace width for Tanner crab, and 100 mm carapace width for snow crab. The sex ratio was about 50:50 for red king and Tanner crab, but almost all snow crab taken were males. In 1994, 55 red king crab and 262,500 Tanner crab were captured incidental to scallop fishing in the Bering Sea (NPFMC 1995b). No fishery occurred in 1995.

Observations from scallop fisheries across the state suggest that mortality of crab bycatch is low relative to trawl gear due to shorter tow times, shorter exposure times, and lower catch weight and volume. For crab taken as bycatch in the Gulf of Alaska weathervane scallop fishery, Hennick (1973) estimated that about 30% of Tanner crabs and 42% of the red king crabs bycaught in scallop dredges were killed or injured. Hammerstrom and Merrit (1985) estimated mortality of Tanner crab at 8% in Cook Inlet. Kaiser (1986) estimated mortality rates of 19% for Tanner crab and 48% for red king crab bycaught off Kodiak Island. Urban el al. (1994) recorded that in 1992, 13-35% of the Tanner crab bycaught were dead or moribund before being discarded, with the highest mortality rate occurring on small (<40 mm cw) and large (>120 mm cw) crabs. Delayed mortality resulting from injury or stress was not estimated. Mortality in the Bering Sea appears to be lower than in the Gulf of Alaska, in part due to different sizes of crab taken. Observations from the 1993 Bering Sea scallop fishery indicated lower bycatch mortality of red king crab (10%), Tanner crab (11%) and snow crab (19%). As with observations from the Gulf of Alaska, mortality appeared to be related to size, with larger and smaller crabs having higher mortality rates on average than mid-sized crabs (D. Pengilly, ADF&G, unpublished data). Delayed mortality was not estimated. In the analysis made in Section 5, a 40% discard mortality rate was assumed for all crab species.

**Summary of Management Actions Taken to Control and Reduce Crab Bycatch Mortality**

The NPFMC, the ADF&G, and the Secretary of Commerce have taken numerous actions to control the incidental bycatch and mortality of crabs in BSAI fisheries. The State has adopted seasons, escape rings, biodegradable panels, mesh size, and maximum entrance size requirements to reduce bycatch and associated mortality of non-target crab in the directed crab pot fisheries. The NPFMC has adopted numerous area closures and bycatch limit regulations to control and reduce crab mortality due to trawling and dredging. These regulations are consistent with National Standard 9, which states that conservation and management measures shall, to the extent practicable, minimize bycatch and to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

Appendix Table 1. Catch (numbers of animals) of selected crab and fish species taken in recent Bering Sea crab fisheries. Source: Tracy 1994, 1995.

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## 8.0 Appendix 2: Revised Draft FMP