AGENDA D-5
APRIL 2006

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver
Executive Director

ESTIMATED TIME
2 HOURS

DATE: March 27, 2006

SUBJECT: Research priorities

ACTION REQUIRED

Review research priorities

In February 2006, the SSC received a staff report on revised research priorities that were prepared by the Groundfish Plan Teams (Item D-5(a)), NOAA and ADF&G staff for crab (Item D-5(b)) and Scallop Plan Team (Item D-5(c)). The last time the SSC made a comprehensive review of research priorities was in April, 2003 (attached as Item D-5(d)). Research priorities for fish and invetebrates identified in the NPRB's science plan are attached as Item D-5(e). The SSC reviewed the Council's 2003 research priorities and identified progress that had been made on those topics. An SSC working group was formed to draft an updated list of research priorities to be considered by the full SSC in April. SSC recommendations for research priorities will be submitted to the Council as part of the SSC minutes. The Council will review those recommendations and forward a final set of revised research priorities to NOAA for use in preparing its annual budget, as well as to the North Pacific Research Board, universities, USCG, ADF&G and other entities.

Research priorities

Bering Sea/Aleutian Islands and Gulf of Alaska Groundfish Plan Teams

Background

The U.S. Oceans Commission recommended that management decisions be based on sound science and that the SSCs should develop research priorities. The Plan Teams have historically been very active in preparing lists of Research Priorities and providing them for SSC review and acceptance. Due to the growing responsibilities for reviewing larger and more numerous stock assessments each year, the Teams have failed to update research priorities on a regular basis. Similar to the SSC's conclusions from 2002, the Teams also feel that prioritization is complicated by the fact that the Teams represent a broad spectrum of academic disciplines with a wide scope of research interests. Hence, the lists presented here are unranked, but are generally considered important enough to be included.

For clarity, the authors compiled a shorter list from the full one developed and revised by the Teams (Table 1). This table is intended to provide simpler presentation with fewer redundant activities between the main research areas. The Plan Teams have not reviewed this current draft though input from representatives from each thematic research area was solicited. The main themes for research areas are as follows:

A. Critical Assessment Problems
B. Stock survey concerns
C. Expanded Ecosystem Studies
D. Social and Economic research
E. Bycatch issues
F. Fishery monitoring

These are listed in the last column of Table 1 for cross reference purposes.

Appendix 1 presents the list of activities detailed by research theme. For reference, an excerpt from the previous SSC minutes (June 2002) is included in Appendix 2.

Table 1. Condensed list of groundfish Plan Teams research priorities (as summarized by authors). "Main" refers to FMP species, "All" refers to all species. The item number is for referencing in discussions. These research topics are currently unprioritized.

Item	Table 1. Research Topic	Affected species/system	Topic Theme
1	Disproportional harvesting	All	A, E, F
2	Alternative abundance indices	Rockfish, Other, all	A, B, C
3	Identification (survey and fishery)	Other, rockfish	A, E, F
4	Biological sampling	Rockfish, Other	A
5	Catch estimation	All	A, E, F
6	Age samples	Rockfish, Pacific cod	A, B, C
7	Stock structure	Pollock, crab, main	A,
8	Supplemental surveys	Pollock, all	A
9	Discard mortality	Crab, skates, halibut	A
10	Assessment model evaluations	Main	A
11	Model specification	Main	A
12	Age validation	Main	A
13	Maturity data	Rockfish, other flats	A
14	Recruitment studies	Pollock, sablefish, main	A
15	Prohibited species abundance, origins	All	A, E
16	Movement and migration	Main	A
17	Management Strategy Evaluations	Main	A, C
18	Uncertainty in stock assessments	Main	A
19	Effectiveness of management measures	Main	A, C
20	Survey comprehensiveness and continuity	All	A, B
21	Survey interactions	Sablefish	A, B
22	Observer coverage	All, Sablefish	A-F
23	Incorporating longline survey data	Rockfish	A, B
24	Submersible, ROV, and other methods for survey research	All	A, B
25	Survey gear performance	All	A, B
26	Seamount surveys	All	A, B
27	Effects of climate on the dynamics of marine populations	All	A
28	"Standardized" future scenarios for recruitment processes	Main	C
29	Improve information biological oceanography of region	All	C
30	Natural markers	All	C
31	Marine mammal/seabird observers onboard survey vessels	Birds, mar. mammals	C
32	Forage fish assessment	Ecosystem	C
33	Effect of harvesting and processing	Ecosystem	C
34	Trophic modeling	Ecosystem	C
35	Benthic studies/community assessments	Ecosystem	C
36	Bioenergetics of key predation interactions	Ecosystem	C
37	Projection modeling of multispecies management system (e.g., including constraints such as TACs, PSCs and OY)	Ecosystem	C
38	Essential habitat assessments	All	C
39	Seabird assessments	Ecosystem	C
40	Seabird diets	Ecosystem	C
41	Multivariate statistical analysis of survey data	Ecosystem	C
42	Factors affecting Steller sea lions	Steller sea lion	C
43	Fish distribution relative to fishing, seasonal changes	Steller sea lion	C
44	Steller sea lion population dynamics relative to pollock as prey	Steller sea lion	C
45	Direct fishery effects on Steller sea lions	Steller sea lion	C
46	Food requirements of Steller sea lions	Steller sea lion	C
47	Indicator species for trophic or interaction studies	Steller sea lion	C
48	Parasite fauna as ecosystem change signal	Ecosystem	C
49	Killer whale abundance and behavior	Sablefish, Ecosystem,	C

Table 1.

Item	Research Topic	Affected species/system	Topic Theme
		Steller sea lions	
50	Socio-economic data collection (10 projects)	Socio-economic	D
51	Harvest and processing cost analysis	Socio-economic	D
52	Fish product demand studies	Socio-economic	D
53	Net benefits and distribution	Socio-economic	D
54	Regional models of economic activity in fishing communities	Socio-economic	D
55	Integrated regional economic and ecosystem models	Socio-economic, Ecosystem	D
56	Bioeconomic models of multi-use fisheries	Socio-economic, Main	D
57	Cumulative efficiency and equity consequences of time/area management actions	Socio-economic	D
58	Net economic benefits of recreational and subsistence harvests	Socio-economic	D
59	Valuation of corals, seabirds, and marine mammals	Socio-economic	D
60	Fleet dynamics to alternative fishing opportunities	Socio-economic	D
61	Fishery exit and entry behavior by harvesters and processors	Socio-economic	D
62	Economics of reducing bycatch	Socio-economic	D
63	Develop methods for assessing the social costs of bycatch	Socio-economic	D
64	Individual and pooled bycatch quotas	Socio-economic	D
65	Models on effect of traceability, safety and product certification	Socio-economic	D
66	Cumulative efficiency and equity consequences of recreational halibut fisheries	Socio-economic	D
67	Risks of accidents associated with regulation changes.	Socio-economic	D
68	Fishery/community linkages	Socio-economic	D
69	Social assessments and impacts	Socio-economic	D
70	Statistical approaches to catch estimation	All	A-G
71	General enhancement of observer coverage	All	E
72	Bycatch in the halibut fishery	Skates, rockfish, crabs	E
73	Prohibited species abundance impacts	Prohibs	E
74	Gear technology for reducing bycatch	All	E
75	Area/time management closures	All	E
76	Logbook collection and analysis	Main	A, B, E, F
77	Fishery dependent abundance index	Main	A, B
78	Observer sampling procedures	All	A-F
79	Non-target species biological data collection	Non-target	A, E
80	IFQ sampling	All	A, E, F
81	Remote sensing/observing	All	A-F
82	Impact of new management categories	Specific	D, E, F

Appendix 1. Detailed November 2005 draft version

November 2005 Plan Team Draft Monday, 1700 (Revised)

Research Topic

A. Critical Assessment Problems

1. Some of our stocks may be disproportionately harvested across large areas of the GOA and BSAI due to area closures, other management actions, or fishery behavior. Additional analysis should be undertaken to examine potential effects of disproportional harvesting.
2. Improved stock assessment information is needed for the groups in the complex "other species." Stock assessments at the assemblage level for members of the other species complex (sharks, skates, squid, sculpins, and octopus) are already being reviewed by the Plan Teams. FMP amendment analyses have also been initiated for GOA "other species," so the following applies in that region as well. The information required differs by species group, and is summarized in each assessment, where priority species within each group are also identified. However, general needs include:
   a. Improved identification of priority species within each group in the fisheries by both processors and observers to avoid mis-identifications as well as categories containing large numbers of unidentified species.
   b. Improved identification of priority species on scientific surveys, including NMFS trawl and longline surveys, IPHC surveys, and ADF&G surveys.
   c. Improved biological data collection via scientific survey sampling, fishery port sampling and at sea observation, including collection of lengths and collection of age structures for priority species.
   d. Alternative sources for abundance and biomass estimates need to be developed where standard surveys have been found inadequate for species in these groups.
   e. Life history information (specifically, natural mortality (M), size at maturity, and other basic indicators of stock production) must be improved for many species in this complex to allow application of Tier 5 or Tier 4 assessment criteria. Studies for skates in the BSAI and GOA are already in progress, and limited information is available for some shark species, but sculpins, octopi, and squids have less information available.
   f. Improved catch histories for groups in this complex for more appropriate application of Tier 6 assessment criteria as well as for improved stock assessment. Group specific catch history can be estimated via analysis of foreign observer data, but this requires commitment of staff time.
3. Rockfish: There is a general need for better assessment data, particularly investigation of stock structure and biological variables.
   a. Supplement trawl survey biomass estimates with estimates of biomass or indices of biomass obtained from alternative survey designs.
   b. Obtain age and length samples from the fishery, especially for Pacific ocean perch, northern rockfish, and dusky rockfish.
4. Increase capacity for production ageing of rockfish so that age information from surveys and the fishery can be included in stock assessments in a timely manner.
5. Pacific cod: Research into methods of ageing Pacific cod has been completed and production ageing has begun. Working through the backlog of age structures should be given a high priority.

Research Topic

6. Walleye pollock: There is a continuing need for research on stock structure as it relates to assessments. There is a critical need for stock interactions studies and pollock recruitment patterns. We continue to emphasize the need for age-structured assessments of recognized stock units.
   a. The SSC believes that the magnitude of the catch, size and age structure of the EBS stock harvested in the Russian zone in the vicinity of the transboundary area is needed. It may be necessary to consider fishing removals from the Russian zone and their impact on EBS pollock mortality in the estimates of ABC and TAC.
   b. Assessment of the status of the Gulf of Alaska resource is critically dependent upon results of resource surveys. These surveys will be conducted every two years. While this is a positive development, various ways of supplementing the biennial survey data should be evaluated.
   c. More research should also be conducted on the movement of pollock between the GOA and BSAI and across regions within GOA and BSAI, (e.g., Bogoslof, Donut Hole, PWS, Shelikof, and SE inside).
   d. More research using acoustic data should be conducted.
7. Crab research: Research should be expanded on handling mortality, stock structure and life history parameters.
8. Age- and length-structured assessments: These assessments integrate several data sources using some weighting scheme. Little research has gone into evaluation of different weighting schemes, although the weight can have a large effect on the assessment results. Research is needed on which weighting schemes are robust to uncertainties among the different data sources.
9. Age structured assessments depend upon age determination techniques and ongoing age validation is needed.
10. Correct model specification is critical to stock assessment. Further research is needed on model performance in terms of bias and variability. In particular, computer simulations, sensitivity studies, and retrospective analyses are needed. As models become more complex in terms of parameters, error structure, and data sources, there is a greater need to understand how well they perform.
11. Life history information, e.g., growth and maturity data, is incomplete for a number of stocks. This information is essential for determination of ABC, OFL and preferred fishing mortality rates.
    a) Maturity data are lacking for: other flatfish, sablefish, and many species of rockfish.
    b) Life history and distributional patterns of Greenland turbot are lacking.
    c) To better understand sablefish recruitment variability, additional information on the geographical distributional and movement of juvenile sablefish is needed.
    d) More research should be done on sources of age-specific fish mortality.
12. Identification of the origin of chum and chinook salmon stocks captured incidentally in the groundfish fisheries is needed. The chum salmon stocks in particular are recognized as a mixture of Asian and North American origin. Resolution of stock origin is important in the consideration of bycatch management.
13. There is need for information about stock structure and movement of walleye pollock, Atka mackerel, Pacific cod, POP, and other rockfish. Specifically, we need information on temporal and spatial distributions of spawning aggregations of fish (especially Pacific cod). More research should be conducted into the delineation of stock boundaries/continuity and movements of groundfish populations - such as Pacific cod in the Western Gulf and Aleutians and sablefish in PWS vs. outside waters - to clarify issues associated with federal vs. state management and assessment.

Research Topic

14. Further research is needed about management strategies that provide for conservation of aquatic resources. Topics that need attention include: which measure of biomass should be used in biomass-based adjustment of ABC and OFL; what measure of average recruitment to use in B40%; the effect of seasonality in spawning, recruitment, and harvest on optimal harvest rate; adaptive management schemes which are designed to provide understanding of multispecies interactions and spatial population dynamics. One objective is to develop multispecies analysis of stocks.
15. Presentation of uncertainty in stock assessments is often lacking or incomplete. Further research is needed into which methods are most appropriate for capturing uncertainty in the status of populations. The use of Markov Chain-Monte Carlo (MCMC) methods appears to be a promising line of research and its use with AD Model Builder should be further explored.
16. Management measures such as time-area closures and other restrictions are frequently imposed, but rarely rescinded. Studies are needed to evaluate the effectiveness of management measures on conserving populations, achieving management goals and assessing other ecosystem effects.
17. The Groundfish Teams expressed concern regarding the lack of coverage by trawl survey in both the eastern GOA and in all deepwater strata during 2001 and strongly recommended continued coverage of deeper stations in future surveys.
18. Effects of the new **rockfish** rationalization program on the sablefish long line survey. Possibility of rockfish trawling affecting catch rates in the longline survey if fishing occurs on longline survey stations.
19. Need for improved observer coverage of vessels targeting sablefish especially in the BSAI. CPUE in the sablefish fishery is an important component in the apportionment computations for sablefish.
20. Under proposed NS1 guidelines, stocks will be managed as "core" (single species) or "assemblage" (complexes). Current assemblages of rockfish and flatfish will require reevaluation under new guidelines. Research should be expanded on the question of biological linkages among the components of "species assemblages" that justify this management approach. Further, are there other, unidentified groups of species that are ecologically related and could be managed as a unit?

B. Stock survey concerns

1. Conservation of aquatic resources in the North Pacific is critically dependent on a consistent time series of trawl, hydroacoustic, and longline surveys. The continuity of these series must remain one of the highest priorities of NMFS and the Council. Data analysis should be expanded to include non-target, non-FMP species.
2. Explore ways for inaugurating or improving surveys to assess rockfish (including nearshore pelagics), pollock, squid Atka mackerel and octopus, including surveys further west into the Aleutians and evaluating historical longline survey data to determine the value of using longline surveys to assess rockfish, particularly in the Aleutians.
3. Expand bottom trawl surveys in the Gulf of Alaska to include slope areas that encompass the population range of Greenland turbot, rockfish, thornyheads, and sablefish.
4. Improve surveys for Bering Sea crab complementary to the existing Bering Sea crab/groundfish survey (e.g. Norton Sound, Pribilof Islands, St. Matthew Island, and Bristol Bay).

Research Topic

5. Direct observation (e.g. submersible and dive surveys) offers unique opportunities to directly examine gear performance, fish behavior in the proximity of gear, gear related habitat impacts, and differences of fish density between trawlable and nontrawlable habitat.
6. There is a continuing need to perform gear calibration and fish observation studies to validate indices of abundance (e.g. fishing longline and trawl gear side-by-side, and fishing different baits on longline gear over the same stations).
7. Little scientific sampling has occurred of seamounts within the EEZ for groundfish, halibut, and crab abundance. Surveys that sample these seamounts may improve estimates of total abundance in the EEZ, particularly for sablefish and rockfish stocks.
8. Data from annual ADF&G crab surveys should be examined and their usefulness for assessing groundfish abundance in near-shore areas should be evaluated. Dialogue between ADF&G and NMFS assessment scientists regarding ways of gaining more useful groundfish data from this survey should be encouraged.
9. Encourage development of methods to measure fish density in habitats typically inaccessible to trawl survey gear.
10. Identify determinants of trawl survey selectivity, and confirm/improve estimates of selectivity, for Pacific cod.
11. Improve shark species survey sampling (pelagic sharks such as salmon sharks not effectively sampled by bottom trawl surveys; catchability of sharks in bottom trawl gear is unknown)
12. Increase the hydro-acoustic survey to broaden the number of species assessed and geographic area covered.
13. Perform trawl surveys, GOA and EBS, in other times of the year, especially fall and spring.
14. Continue to explore the use of alternative sampling designs that include hydroacoustics in assessing species with patchy distributions, i.e. certain rockfish species.
15. Work toward making integration seamless when combining data collected during different years from ADF&G, NMFS, and possibly other agencies (for example universities, USFW) from different surveys (trawl, long-line, hydroacoustic, etc), observer programs (groundfish, crab, etc), and fisheries (fish tickets, processor reports, etc).
16. Conduct **surveys** that focus on the early life history of groundfish (e.g., young of the year surveys), especially sablefish and rockfish to examine recruitment trends and habitat use.
17. Effects of the new rockfish rationalization program on the sablefish long line survey. Possibility of rockfish trawling affecting catch rates in the longline survey if fishing occurs on longline survey stations."

C. Expanded Ecosystem Studies

1. Considerable research is being conducted on the effects of climate on the biology and dynamics of marine populations. Research effort is required to develop methods to incorporate climate variability and its influence on processes such as recruitment and growth into our models of population dynamics. More specifically, considerable data has been collected and used for correlation analyses: while these should be continued, investigation should be directed at uncovering specific processes that govern dynamics (e.g. linking flatfish survival to wind via larval drift) and collecting data to test hypotheses developed through correlation (e.g. collecting data that would test the Oscillating Control Hypothesis).

Research Topic

2. A set of "standard" future scenarios should be obtained from current climate/ocean models that can be used to project recruitment in cases where process links have been developed; projections under these standard scenarios should become a part of stock assessments.
3. The Ecosystems Considerations SAFE chapter may be improved by addressing the following data gaps, which may include identifying new sources of data: nutrients and chlorophyll; harmful algal blooms; non-native species; and Gulf of Alaska zooplankton.
4. There have been considerable recent advances in using naturally occurring stable isotopes in diverse types of studies. Examples include identifying residence times and areas at various life stages; computing trophic levels and food web dynamics; examining ontogenetic changes and patterns of migration. Studies using these natural markers should be encouraged.
5. Works towards placing trained marine mammal/seabird observers onboard vessels conducting fishery surveys. Such observations contribute to abundance estimates, or provide indices of abundance and associations with oceanography and prey distributions. In particular, relationships among oceanographic conditions and animal condition and health should be explored.
    a. More research should be collected by placing trained marine mammal/seabird biologists on line transect surveys to begin an index of abundance for birds.
    b. Encourage development of at-sea programs by agencies (USFWS, NMFS, USGS) that will provide trained mammal/seabird observers and synthesize their data with the oceanographic and fisheries data.
    c. Encourage data exchanges between USFWS and NMFS RACE and NMML.
6. Effort is needed on status of stocks and distribution of forage fishes and shellfish, such as capelin, eulachon, sand lance, myctophids, and euphausids. The juvenile stages of commercial fish stocks should be included in this list, in particular juvenile (0 – 2 age classes) herring, rockfish, Pollock, and cod. Forage fish are an important part of the ecosystem , yet little is known about these stocks.
7. Studies of the effects of harvesting and processing activities on the ecosystem and habitat should be instituted. One example would be a study contrasting species diversity and abundance in the red king crab savings area with that in adjacent regions.
8. Current stock-scale trophic models (e.g. ECOPATH and MSVPA) synthesize considerable diet data into the stock assessment process, and include lower trophic levels, fish, birds, and marine mammals, although covering many species with a broad brush. Future work on trophic interactions should include: (1) extending data coverage to specific gaps, especially seasonal ; (2) determining key, strong interactions for detailed examination and separate modeling , e.g., Pacific cod and its prey (including shrimp and crabs); and (3) statistical examination of diet data to develop indicators of prey abundance. The inclusion of higher trophic levels (marine mammals/seabirds) should be reviewed and extended, especially with regard to differences in scales of data and models. Effort should be put into producing a common data format (e.g. between RACE, NMML, ADF&G, USF&W) to aid in timely updates of key species parameters and models for all species within ecosystems.
9. Trophic studies indicate the key role of benthos (e.g. clams and polychaetes) in the food of many groundfish and crabs. However, very few studies exist on the densities and changes of these important food components at times when their predators have fluctuated greatly: studies of benthic prey should be conducted.

Research Topic

10. Key predation interactions (such as arrowtooth eating pollock) are missing bioenergetics studies to properly estimate changes in predation that might occur with climate shifts; e.g., as temperature changes. A set of area-specific bioenergetics parameters for key predators should be pursued through laboratory and statistical analysis.
11. Examining OY caps via ecosystem modeling should be pursued, taking into account both the total cap and ecological distribution of TAC levels under the cap. This should include economic modeling of TAC tradeoffs and projections that include future changes in production and climate (note: link to CRITICAL ASSESSMENT section on disproportionate harvest).
12. Studies are needed to identify essential habitat for groundfish and forage fish species in the Gulf of Alaska and Bering Sea. This identification is required by the MSFCMA and would benefit from field studies conducted across a matrix of spatial, temporal, and life history stages. Mapping of nearshore and shelf habitat should be continued for FMP species.
13. Expand studies of distribution, abundance, and productivity of seabird populations and ensure that data are collected in ways that provide for rigorous analyses of seabird/marine mammal/oceanographic/fisheries interactions. Historic data on seabirds at-sea in Alaska was collected during the 1970s and 1980s (through OCSEAP); but the quantity of data collected in offshore waters afterwards has been insufficient to adequately examine trends in these interactions.
14. Most of the historic data prior to 1990 (i.e., OCSEAP) has been entered into the USFWS/USGS North Pacific Pelagic Seabird Database, however, work should continue to a) make the data widely accessible (i.e., web-based data retrieval); b) facilitate entry of new data; c) include all environmental data collected during the surveys.
15. More recent (1990's - present) data from inside and nearshore waters needs be consolidated and added to the pelagic database, to enable more complete analysis on seabird/fishery interactions and climate change effects.
16. New data on at-sea distribution of seabirds needs to be collected and entered into the NPPSD in association with oceanographic and fisheries studies, to enable comparison to historic data and determine long-term trends and changes in distribution.
17. Seabird diet needs to be described for more areas and species, including winter diet needs of seabirds. Existing and historic diet data needs to be consolidated and put into a format accessible and appropriate for examination of long-term trends. Very little is known about winter diets of birds.
18. Multivariate statistical analysis of the time series of annual survey data may identify which species regularly occur in assemblages. Mapping these assemblages through space and time may reveal changes in the distribution and abundance of the species of the Eastern Bering Sea. These mappings and trajectories may be applicable to adaptive management approaches suggested for exploring ecosystem concerns. Recent advances in spatial statistics may prove fruitful tools for re-examining these existing data.
19. Uncertainty about the relationship between the Steller sea lion population and groundfish fisheries has taken an elevated significance. With this uncertainty as to the extent of factors affecting Steller sea lions, it is critically important to investigate the effects of mitigation measures on the sea lions, seabirds, the fisheries, and the ecosystem. The monitoring must be based on an experimental design that provides information about the interaction of fisheries and Steller sea lions. Many of the same issues pertain to seabirds as well. Seven questions are central to future work:

Research Topic

a. What is the distribution of fish in relation to areas used for fishing, and what are the seasonal changes?
b. What is the distribution of fish in fishing areas before and after fishing?
c. How do Steller sea lions use pollock in relations to pollock distributions?
d. How does the Steller sea lion=s pollock feeding habits influence sea lion population dynamics?
e. Does the fishery affect Steller sea lions in other ways (e.g., behavioral disturbance)?
f. How much is needed per SSL compared to what is there seasonally and geographically B demand vs. availability, to address localized depletion?
g. How much is needed per SSL compared to what is seasonally and geographically available, i.e., demand vs. availability

20. Indicator species should be specifically linked to important commercial species through trophic or interaction studies (e.g. jellyfish abundance and its effects on pollock survival)
21. There is an apparent increase of a parasite occurrence in some flatfish stocks (flathead sole and Greenland turbot) in the Bering Sea. This may signal changes in the ecosystem and has important consequences for the fishery. Research on this should be pursued.
22. Killer whale depredation of sablefish catches has been a problem in the Bering Sea since the beginning of the survey. Additional information on the impacts of killer whale depredation on sablefish in the ecosystem and in the sablefish survey should be assessed, along with further consideration of sperm whale depredation of sablefish.

D. Social and economic research

There is a critical need for the development and continued maintenance of basic social and economic information databases on the fisheries and fisheries dependent communities of GOA and BS/AI. This information is required for establishing a baseline and assessing trends to be used in the evaluation of the impacts of alternative management measures.

1. There is a need to collect and improve longitudinal data on:
   a. domestic and international transaction-level observations of ex-vessel, wholesale, and retail prices;
   b. domestic and international production by species and product form;
   c. product inventories and trade volume by product form;
   d. employment and income of fishery participants;
   e. locus and magnitude of expenditures in support of harvesting and processing;
   f. nature and extent of fishery-regional economic linkages;
   g. tax receipts and transfer payments;
   h. socioeconomic and demographic data for fishery dependent communities (income levels and distributions, population levels and distributions; and
   i. spatial fishing information (e.g. VMS and the collection of trip-level observer information on time at sea).
   j. accidents and associated property losses, injury, and occupational mortality.
2. No data on fixed and variable harvesting and processing costs in GOA and BS/AI groundfish fisheries have been systematically collected due to an unwillingness of industry participants to provide cost and earnings data in voluntary surveys. There is a critical need to collect this information in order to estimate harvest and processing supply and demand behavior, and to characterize changes in the economic performance of the fishery resulting from alternative management measures.
3. There is a need for studies of:

Research Topic

a. the demand for fisheries products (exvessel, wholesale, international, and retail markets);
b. production and cost functions for catch and processing;
c. the producer and consumer surpluses associated with fisheries under current management regimes;
d. the net benefits and distribution of net benefits associated with changes in management regimes (e.g., changes in product markets, characteristics of quota share markets, changes in distribution of ownership, changes in crew compensation, as a consequence of the halibut/sablefish IFQ program or the pollock, crab, and salmon co-ops);
e. regional models of economic activity in fishery dependent communities;
f. integrated regional economic and ecosystem models;
g. bioeconomic models of multi-use fisheries;
h. the cumulative efficiency and equity consequences of management actions that apply time/area closures;
i. the net economic benefits of recreational and subsistence harvests;
j. the existence and option values associated with corals, seabirds, and marine mammals;
k. behavioral models of fleet response to alternative fishing opportunities to better predict how fishing effort will shift in response to possible management actions (e.g., time/area closures, marine reserves, bycatch restrictions, co-ops, IFQs);
l. models of fishery exit and entry behavior by harvesters and processors;
m. changes in catch efficiency and operating costs associated with gear modification and avoidance behaviors intended to reduce bycatch;
n. better methods for assessing the social costs of bycatch;
o. models of the relationship between sampling strategies and the confidence of bycatch estimates associated with individual and pooled bycatch quotas;
p. models of mechanisms for providing traceability, ensuring safety and certifying product and production process attributes of fishery products; and
q. the cumulative efficiency and equity consequences of management actions related to the recreational halibut charter fishery.
r. the impacts on risk of accidents associated with regulation changes.

4. Research pertinent to assessment of the social impacts of actions contemplated by the Council include:
   a. Fishery/community linkages: Field research aimed at capturing the full array of linkages between fisheries and social and economic life in fishery dependent communities.
   b. Social assessments: Selected community and industry assessments should be conducted to establish baseline conditions underlying social problems identified by the Council and the Advisory Panel. As appropriate, these projects can be extended to generate time series information.
   c. Social impacts: Social impact and policy research should be conducted regarding the identification and potential effects of alternative management actions.
   d. Economic efficiency considerations: Develop better methods for determining the social costs and benefits of management actions (e.g. through the use of non-market valuation techniques).

E. Bycatch issues

Estimation and data collection

Research Topic

Statistical approach to estimation: More rigorous statistical methods for catch estimation to species need to be implemented (e.g., that of Miller 2005). Specifically, identifying sources of variability in actual and estimated bycatch rates is needed. Research should be directed towards integrating the estimates of variance from the observed portion of the fisheries to the total catch estimates.

General enhancement of observer coverage, application of video monitoring, port sampling, or other direct methods is needed. Current logbook information is inadequate to quantify this bycatch. Specific bycatch issues requiring improved data collection programs are as follows:

Skate and other species (target and non-target) as bycatch in directed halibut fisheries: More than half of the skate catch every year is taken in the directed halibut fisheries. Quantifying level of groundfish (e.g., yelloweye rockfish, sablefish), shark, and crab bycatch in the halibut fishery is also a needed.

Other under-sampled fisheries: Sablefish longline fishery, skate fishery and Pacific cod pot and longline fishery (especially small vessels and the state pot fishery). Octopus bycatch estimates are non-existent for a number of these fisheries and is also needed.

Discard mortality rates: A better quantification by gear and fishery is needed, especially for crab and other species (e.g., skates, sharks, octopus).

Biological sampling of bycatch: Data on size/age and sex of crabs taken as bycatch are needed to assess impacts (lower priority, wait for crab researchers to comment on additional research needs here and adequacy of existing data collection protocols).

Management level research

Prohibited species abundance impacts: Investigate the effect prohibited species (e.g., salmon in BSAI and GOA, crab species in GOA) abundance levels have on bycatch rates. Also, the extent that bycatch levels affect these species' populations needs to be estimated for rational policy decisions.

Similarly, identification of the origin of chum and Chinook salmon stocks captured incidentally in the groundfish fisheries is needed. The chum salmon stocks in particular are recognized as a mixture of Asian and North American origin. Resolution of stock origin is important in the consideration of bycatch management.

Gear technology: Continued research on improving gear modifications (e.g. excluder devices for salmon and halibut bycatch, longline seabird bycatch mechanisms) for reducing bycatch

Area/time management closures: Comprehensive evaluations are needed of single and multiple time/area closures. These evaluations should examine the efficacy of the closure with respect to benefits for the bycatch species relative to impacts on target species. Studies could focus on the long-term effects of year-round and seasonal closures (e.g. for Kodiak red king crab) as well as the potential effects of short-term closures (e.g. hot spot closures in the BSAI pollock fishery for salmon bycatch). Innovative approaches to establish criteria for measuring the effectiveness of these closures should be encouraged.

Socio-economic factors: Develop better methods for assessing the social costs of bycatch.

F. Fishery Monitoring

1a. **Catch Estimation Precision:** Inseason management and stock assessment are critically are critically dependent on catch estimates. There is a need to conduct ongoing analyses of the accuracy and precision of catch estimates in all fisheries.

Research Topic

1b. **Logbook Data:** An analysis of the utility of fishery logbook information should be conducted. In particular, determine if it possible to gain insight into fleet performance from such information.

1c. **Fishery dependent abundance index:** Examine feasibility for developing a representative CPUE index and determine if it is proportional to stock size.

2a. **Observer Sampling procedures:** Evaluate sampling procedures used by observers and various catch estimation procedures (related to 1a).

2b. **Non-target species biological data collection:** Recent analyses have been conducted on efficient methods of collecting representative biological data from target species. Similar studies should be conducted on the collection of prohibited species data.

3. **IFQ sampling:** Development of catch and bycatch sampling procedures for individual vessel accounting programs. The focus should be shifted to sampling procedures of catch and bycatch, as well as the catch accounting system for IFQ and coop programs with catch and PSC limitations on a smaller scale.

4. **Remote sensing/observing:** Promote advance in video monitoring of otherwise unobserved catch for improved estimation of the species composition of total catch and the discrimination of retained and discarded catch.

5. **New management categories:** Improved monitoring of species catch under new, more specific management programs (Pilot Rockfish Program, Gulf and BSAI Rationalization). More extensive recordkeeping, computer programming, rulemaking, and observer training is required. Research is needed to evaluate the effectiveness of newly developed management groups or practices.

Appendix 2. Excerpt from the June 2002 SSC minutes on Research Priorities

"The SSC last revised it's "research priorities" in February 2000. Typically an annual endeavor, research priorities went unaddressed in 2001 due to pressing Council concerns over groundfish/SSL management measures. Historically, the SSC list of research priorities has been a vehicle to convey to the Council and parties interested in Council activities those areas of study the SSC deemed worthy of focused attention. The priority list is extensive and addresses six topical areas of research. Nevertheless, the list is not inclusive of all needed research nor is it prioritized.

In April 2002, Clarence Pautzke, Executive Director of the newly formed North Pacific Research Board (NPRB), requested the SSC's help in identifying topical areas of applied research that might be used to focus applicant proposals submitted to the Board for funding. Dr. Marasco, on behalf of the SSC, agreed to organize a working group to draft strawman thematic priorities to be reviewed and finalized by the SSC at the June 2002 NPFMC meeting. A draft set of 18 thematic areas of research was provided to the SSC for review. In addition, the SSC received public comment on research priorities from Ed Richardson representing the Pollock Conservation Cooperative.

Following lengthy discussion, the SSC chose to roll over, with minor edits, it previous research priority list as amended by the BSAI and GOA Plan Teams (Appendix I).

The SSC considered further numerical prioritization of the research list and editing of some items to sharpen the research focus. However, the SSC members represent a broad spectrum of academic disciplines and wide scope of research interests within their discipline and we recognized that numerical prioritization by a group as diverse as ours would be difficult if not impossible to achieve. Inevitably, the SSC decided that a shortened list would unnecessarily exclude from consideration legitimate areas of needed research and we reverted to the broader listing. Consequently, the SSC has not provided the narrowed research focus sought by the NPRB.

The goal of the SSC in developing its research priority list is to serve the Council by outlining areas of research that are most proximal to the Council's management actions. From this perspective, we view the request by the NPRB as periferal to that of the Council. Nevertheless, the SSC asks that our research priority list be made available to researchers seeking NPRB funding.

Finally, the SSC notes that it is important to understand the relationship between short-term issue-specific research projects and long-term monitoring projects. Short term projects tend to dominate the Council arena but they are often constrained by the lack of appropriate data. Long-term monitoring projects are essential to resolving the persistent data problems afflicting analyses across a broad spectrum of issues (i.e., biological, economic, and social). Data obtained from long-term monitoring provide the basic inputs for specific short term projects but short-term projects are unlikely to produce results that can simply be aggregated to form longterm data bases. The SSC believes that the NPRB has an excellent opportunity to provide funding for longterm monitoring projects that will ultimately provide critical inputs into the short-term projects often sought by the Council."

Bering Sea Crab Research needs

Compiled by B.J. Turnock and L.J. Rugolo, NMFS, January 2006.

1. Tagging for Tanner and snow crab mature males and females for longevity, verification of shell condition indices and shell hardness, estimation of natural mortality, movement, etc.

2. Need shell hardness (durometer readings) and shell condition relationship for snow, Tanner and king crabs. This is to calibrate shell condition indices which are important in stock assessment and harvest strategy modeling.

3. Egg sampling on the annual survey to determine the percent unfertilized eggs for snow, Tanner and king crabs.

4. Estimate growth for Bering Sea Tanner and snow crabs. A possible study would be to capture and hold in pots at time of molting or sample at molting time and return to lab and hold until they molt.

5. Selectivity of the survey net (underbag experiment). While this has been done for red King, Tanner and snow crab, sample sizes are small for Tanner and snow crab, especially females, and recent trawl samples by industry using a different need indicate selectivity could be less than estimated. Determine if selectivity is different for new and old shell animals.

6. Calibrate a new survey net (that has better sampling properties for crabs) with the existing survey net for use in future surveys.

7. Examine the possibility of a crab only survey (with a different net) every 2 years and a groundfish survey every two years with existing net.

8. Estimate mortality (long term and short term) of discarded crab in pot fisheries (historical and in the future under rationalization). Snow, Tanner and king crabs.

9. Determine if terminal molt occurs for morphometrically mature male Tanner crabs.

10. Need to determine methods of aging crabs. Radiometric aging and lipofuscin are two possibilities. Radiometric aging is being further investigated at the AFSC, however, may be too expensive and time consuming to do more than a few samples. A Lipofuscin pilot study has been completed. However, more study is needed to validate the method.

11. Need to analyze tagging data on red king crab to estimate growth and molting probabilities for the existing 1990's tagging data.

12. Estimate aging error for shell condition indices from Bristol Bay Tanner crab tagging data in 1970's and 1980's and snow crab 1980's (if possible). This has already been done for red king crab indicating a large bias. The errors in shell condition needed to be incorporated into stock assessment and harvest strategy modeling, since shell condition is important to determine mating males and relative age.

13. Spatial modeling of snow crab. Need to incorporate temperature in population dynamics models (north vs south spatial split) as an index of the fraction of females that are biennial vs annual spawners for snow crab. Split distribution of snow crab into southern and northern areas. Estimate catch quotas for total area and split by southern and northern management areas, so all the catch quota is not taken from southern area, to reduce the chance of localized depletion.

14. Pot surveys for un-surveyed crabs in the Aleutian Islands areas or to add more frequent pot surveys for triennially surveyed stocks.

15. Determine which males are effective at mating for Tanner, snow and king crabs, relative to shell condition, molting status, location relative to spawning areas, size relative to mature females, absolute size, etc.

16. Spatial distribution of fishery catch relative to distribution of mature and mating crabs. Does localized depletion occur? Has fishing concentrated in southern portions of the range of snow crab resulted in shifts of the distribution farther north to colder waters where biennial spawning occurs instead of annual spawning?

17. Survey sampling at various distances between tows (1-2 nm up to 10 nm) to estimate spatial correlation and patch size for Tanner and snow crab density. Sampling could be trawl or pots. Use to improve and design future surveys.

18. Management strategy evaluation modeling for major crab stocks. Possibly start with snow crab, then Bristol Bay red king crab, and Tanner crab.

19. Develop stock assessment models for other Bering Sea crab stocks.

Crab Research Priorities for Alaska – ADF&G, January 2006

The State of Alaska has drafted a list of crab research priorities (attached) that is an update of the priorities conceived by the region's crab researchers in the early to mid 1990s[1]. Based on the revised list, ADF&G has identified the following highest priority research needs as a balance between needs for stocks of high economic value and stocks considered overfished.

- Natural mortality (M) estimates. Estimates of M (obtained independently from models) are needed for all stocks (except Bristol Bay red king crab), with highest priority assigned to Tanner and snow crabs.

- Growth increment for Bering Sea Tanner and snow crabs. These parameters should be estimated independently from non-model sources, such as tagging and experimental data, to compare with parameters used or estimated by the models.

- Fertilization rate of egg clutches in relation to removals of mature males, including consideration of spatial dynamics of crab reproduction and contribution to reproduction by males as a function of size and time post molt. Primary emphasis is on snow and Tanner crabs, with secondary emphasis on red king crab.

- Survey catchability of snow crab, Tanner crab, and blue king crab with current trawl survey gear. There are multiple emphases: 1) differential catchability between males and females for Tanner and snow crab, 2) differential catchability between snow crabs near the shelf edge and in shallower shelf waters, and 3) the relationship between trawl survey catch and stock levels/trends for blue king crab, especially for the St. Matthew stock with second priority assigned to the Pribilof Islands stock.

- Recruitment dynamics for all FMP crab species. This is a very broad topic encompassing the need to identify and assess biological and environmental effects on egg production, egg hatching, and larval survival, as well as mechanisms controlling the abundance of juvenile crabs from settlement to recruitment into the fishery. Factors include larval transport, predation, competition, and habitat availability. Primary emphasis is on stocks currently declared overfished: eastern Bering Sea Tanner crab, St. Matthew Island blue king crab, eastern Bering Sea snow crab, and Pribilof Islands blue king crab.

- Stock structure of Bering Sea Tanner crab. Are the "Bristol Bay" and "Pribilof" components of the eastern Bering Tanner crab sufficiently distinct to be warrant designation as separate stocks?

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[1] Kruse, G. H. 1996. Crab research in Alaska, an interagency long-term plan. Pages 695-705 *in* High Latitude Crabs: Biology, Management, and Economics. Alaska Sea Grant College Program, Fairbanks, AK.

Long-term Alaskan Crab Research Priorities Preliminary Draft Update, 2005

ADF&G, Juneau

STOCK STRUCTURE

Genetics:

1) Continue and improve genetic stock identification (GSI) studies (allozymes) for all crabs.
2) Use nucleotide sequence analysis of mtDNA to infer demographic histories of crabs in Alaska.
3) Relate genetic structure to shoreline complexity, ocean currents, bathymetry, and geographic distance.

Tanner/Snow Crabs:

4) Develop a program to assess the contribution of Tanner-snow hybrids to the Bering Sea crab fishery integrating genetic studies and field identifications.

Other:

5) Evaluate the degree to which surveyed stocks overlap with fished stocks; e.g., develop a tag release and recapture program for investigating relationships of snow crabs in the northern Bering Sea to snow crabs on the fishing grounds.
6) Determine annual and long-term movements of crabs and how these migrations affect population structure.
7) Use morphological characteristics to distinguish species, hybrids, stocks, and instars; develop for field use, a weatherproof computer imaging system based on these characteristics.
8) Examine molecular genetic variability in newly exploited stocks to help define management areas.

POPULATION ESTIMATION

Surveys:

1) Implement or enhance surveys for crab stocks that are currently unsurveyed or have low survey precision.
    a. Southeast Alaska golden king crabs
    b. Gulf of Alaska Dungeness crabs
    c. Aleutian Islands red king crab

d. Aleutian Islands golden king crab west of 174
e. Grooved Tanner crab

2) Supplement trawl surveys with pot surveys or other data.
   a. Incorporate ADF&G Bristol Bay red king crab test fishery data and tag recoveries into current stock assessment.
   b. Reinstitute annual or biennial ADF&G Bristol Bay red king crab pot survey.
   c. Supplement Gulf of Alaska Tanner trawl database with pot surveys.
3) Develop methods to make existing surveys more efficient. Examples include electronic data collection and combining surveys for multiple species into combined surveys.
4) Evaluate the effectiveness of surveys and develop methods to improve surveys
   a. Use historic data to set sample size and establish sampling strata based on information such as depth and habitat.
   b. Assess the effect of timing of survey and crab distribution relative to fishery

Catchability:

5) Estimate crab pot catchability and selectivity coefficients. Highest priorities are Tanner and snow crabs and female red king crabs.
   a. Use a combination of tagging and fishing down the stock in a limited area.
   b. Assess the effects of the size, sex, and species of crabs already caught on catches of additional crabs.
   c. Assess the variability in catch over time for pots and understand what factors can effect the catch over time.
   d. Assess the role of different baiting techniques on catchability including the use of sonic bait.
6) Estimate relative catchability and selectivity of trawls. Possible methods of approach include depletion estimators, change in ratio estimators, visual estimates with trawl mounted cameras, further use of 'underbags' or tickler chains, remote operated vehicles (ROVs), LLSS, and mark-recapture methods.
   a. Bristol Bay red king crabs size and sex
   b. Westward survey for Tanner crab size, sex, and shell condition
   c. NMFS trawl for snow and Tanner size, sex, and shell condition

Database Management:

7) Complete historical data documentation and computer entry of state shellfish data.

Alternative Population Estimation Methods:

8) Apply recent advances in population estimation models to surveyed crab stocks. Potentially applicable models are catch-survey analyses (CSA), length-based analyses (LBA), and stock synthesis (SS).
    a. Southeast Alaska Dungeness crabs
    b. Southeast Alaska Tanner crabs
    c. Gulf of Alaska Tanner crabs
    d. Aleutian Island golden king crabs
9) Assess the cost effectiveness of PIT tag mark-recapture methods (dependent on improvements in cost effectiveness of the technology of recapture) to estimate exploitation rates and population sizes.
10) Develop spatial models and multi-species models for crab stocks.
11) Continue to develop and test analytical methods to estimate abundance of unsurveyed stocks, including the use of observer data.

STOCK PRODUCTIVITY

Natural Mortality:

1) Continue to estimate M for all Alaskan crab species, including examination of tag-recapture data.
2) Investigate the relationship of M to molting, spawning, and sex of crab.
3) Study potential relationships between shell condition and M.
4) Study the contributions of disease to M.
5) Estimate predation mortality on different life history stages of crabs.
6) Evaluate the effect of physical factors, such as temperature or salinity, on M
7) Assess the variation of M within and between years and evaluate the effect of this variation on population models.
8) Examine causes of high mortality of Bristol Bay red king crabs in the early 1980s.
9) Estimate contribution of cannibalism on juvenile mortality rates, especially for snow and Tanner crabs.

Growth:

10) For all species, verify shell aging criteria using independent methods of shell age (e.g., radiometric aging and the durometer) and develop consistent and meaningful criteria of shell aging in the field.
11) Develop a retainable tag for Tanner and snow crabs that is readily detectable.

12) Estimate the growth increment of crabs.
    a. Central Gulf of Alaska Dungeness crabs
    b. Southeast Alaska golden king crabs
    c. Bering Sea snow crabs
    d. Bering Sea Tanner crabs
    e. Other Tanner crab stocks
13) Estimate molt probabilities and molt timing of crabs
    a. Southeast Alaska golden king crabs
    b. Southeast Alaska Dungeness crabs
    c. Most Tanner crabs (except Kodiak)
    d. Blue king crabs (augment existing tag-recapture datasets to improve precision of current estimates)
14) Estimate annual variation in growth (molt increment and probability) and identify the causes of variation, particularly for stocks considered to be data-rich. Continue tagging experiments to obtain these data.
15) Evaluate the effects of individual characteristics (size, sex, maturity, and limb loss) on growth.
16) Evaluate the application of recent advances to age crabs such as lipofuscin density.
17) Determine meat fullness relative to last molt and assess factors that can affect meat fullness over time.

Reproduction:

18) Continue to study geographic and temporal changes in fecundity, egg predation, and size at maturity. Begin to understand the factors that cause these changes.
19) Continue to study the effects of body size, sex ratio, shell condition, and sperm storage on reproduction.
20) Examine the relationships among clutch fullness, exploitation rate, and mating ratio.
21) Evaluate and improve morphometric criteria for determination of male maturity and investigate spatial and temporal variation in these criteria.
22) Assess the effect of annual/biennial spawning and multiparous/primiparous females on reproductive potential of crab stocks.
23) Study the temporal and geographic distributions of mature and immature males and females in relation to mating seasons, surveys, and fisheries.
24) Examine environmental effects on gonadogenesis, embryo development rates, and hatching success.

Settlement and Recruitment:

25) Develop stock recruitment relationships for additional Alaskan crabs and evaluate factors that can lead to variation in the relationship.
26) Estimate age of recruitment of juvenile Tanner crabs to the fishable stock.
27) Continue to investigate the periodicity in the frequency of strong year classes.
28) Determine larval durations and assess factors that can affect both duration and survival (e.g., rearing temperature, advection, feeding success, predation).
29) Determine larval dispersal patterns. Potential methods include 3 dimensional ocean modeling accounting for larval behavior, using surrogate larvae (e.g. gastropods) that can be tracked using microchemical or genetic signatures, and direct larval observations.
30) Develop collectors that can sample larvae as they are settling from planktonic to benthic stages and use these to estimate settlement rates.
31) Identify and assess mechanisms that control juvenile abundance from settlement to recruitment to the fishery. Possible mechanisms include intra- and interspecific predation and competition, habitat availability, prey abundance, physical factors, and indirect effects.

Habitat:

32) Identify and map critical habitats for juvenile crabs from settlement to recruitment to the fishery. For some species (e.g., snow crabs), this may involve a combination of bottom habitat features and oceanographic conditions such as temperature.
33) Identify and map adult habitats including areas used during critical life stages such as molting and mating. Identify the key elements of these habitats to understand why crabs use those habitats.
34) Estimate the effects of pot fisheries on crab habitats, including long-lined pots in coral and sponge habitats.

Diseases and Parasites:

35) Continue to monitor and study crab diseases to determine life histories of these organisms, modes of transmission, crab mortality, and possible density-dependent relations to stock size. Evaluate appropriate harvest strategies for infected populations.
36) Devise strategies to minimize the spread and effect of diseases.

Fishing-related Effects:

37) Estimate bycatch and mortality due to trawling and dredging and ghost fishing.

38) Continue handling effects and bycatch mortality studies and include studies on the long-term effects sublethal injuries.

39) Continue to collect observer data on crab injuries and document handling methods used by the commercial fleet.

40) Document natural background levels of crab injuries in stocks for which new fisheries develop and in stocks that have not been fished for years or that are now closed.

    a. Some Kodiak Tanner crab districts
    b. Adak red king crabs
    c. Glacier Bay red king and Tanner crabs

41) Estimate the effects of crab injuries, such as limb loss, on predation rates by amphipods, fish, and other predators.

42) Estimate the effects of displacement of female and sublegal male crabs from their preferred habitats or home ranges, particularly for species living along the steep continental slope habitats (e.g., grooved Tanner crabs, golden king crabs)

43) Assess the effectiveness of current bycatch reduction measures (i.e. escape mechanisms) and ghost-fishing reduction measures (i.e. pot limits and biodegradable lines). Develop improvements to these measures.

44) Determine the effects on long-term stock productivity of fishery selection by location, size, and shell condition.

HARVEST STRATEGIES

Gear Studies:

1) Continue studies on types of degradable devices (e.g., galvanic timed-release mechanisms, cotton twine) and their placement in pots.
2) Study pot degradation rates *in situ*.
3) Continue study of pot and trawl gear modifications (e.g., mesh size, escape panels and rings, Tanner boards, or sex-specific bait) to reduce bycatch.
4) Study the effect of pelagic pollock trawls with large mesh lower panels that are fished on the seafloor in crab habitats less than 50 fathoms in the eastern Bering Sea.

Harvest Policy:

5) Evaluate alternative harvest strategies with respect to population dynamics and management implications. Alternative harvest strategies can include threshold spawning biomass, exploitation rate, constant catch, female harvest, minimum size limits, slot size limits (restrict pot tunnel entrances to prevent the largest crabs from entering the pot), multi-species harvesting, rotational harvests, and spatial closures.
6) Continue to estimate biological reference points for Alaskan crab stocks, especially for data-poor stocks.
7) Develop ecological modeling approaches to better understand how to implement ecosystem considerations in harvest policies.
8) Evaluate 3S management and develop new ways to manage unsurveyed stocks while preventing overfishing.
9) Consider development of harvest strategies and population modeling amenable to biennial, triennial, other infrequent survey schedules. Consider inclusion of auxiliary data, such as observer data.
10) Assess current harvest strategies and practices and implement new regulations and practices where necessary. This can include reevaluation of definitions, assessment of localized depletion, and review of stock thresholds as examples.
11) Evaluate the potential disproportionate benefits of large males and females with current harvest practices the remove the largest males from the population.

Scallop Research Priorities (Appendix E of the Scallop FMP)

This document reviews the results of a workshop on scallop biology and the effects of scallop dredging on benthic communities. The workshop was held in Kodiak, Alaska during 10-12 June 1999. A review of the history of the Alaskan weathervane scallop fishery was presented. Other speakers presented papers on scallop biology and fisheries in other cold water areas. Topics of the papers included physical and biological variables influencing distribution, impacts of suspended particles on energetics, modeling approaches to identify dredging impacts, effects of long-term dredging, benthic communities associated with scallops, and the importance of protecting areas from fishing. Following the first day of public presentations, a two-day workshop was convened to develop a viable study program for examining the effects of dredging on the scallop's life history, population dynamics, and associated benthic community. The workshop results were intended to be applied to the Alaskan fishery for weathervane scallops, but they are applicable to many scallop fisheries. The working groups identified ten research topics for which information needs to be gathered. Topics include the importance of spatial distribution on fertilization success, the reproductive output of individuals, the importance of nursery areas, scallop behavior and how it may be altered by dredging, factors that affect growth, fishery induced injury and mortality, causes and rates of natural mortality, long-term factors affecting recruitment, effects of scallop dredging on the benthos, and developing harvest strategies for scallops. Also, the working groups recommended that a monitoring program be established that included short- and long-term data gathering and they identified methods and tools that might be used for this task.

Question 1. How does spatial distribution (distance of its nearest neighbor) affect fertilization success?

Rational

A key factor in successful scallop recruitment is having a high egg-fertilization rate. Scallop gametes are broadcast into the water and rely on currents to mix sperm and eggs. Because of the dilution of the sperm, males and females need to be close to one another for successful fertilization. Therefore spatial distribution is critical.

Suggested Research Studies

- Laboratory fertilization trials to determine the effects of distance, dilution, and time to fertilization
- Measure fertilization success in the field
- Measure synchronization of spawning in the field
- Model fertilization probabilities and the effects of fisheries on them

Question 2. What is the reproductive output of individuals relative to weight, size and age?

Rational

The reproductive output of large females is considerably highly than that of recently matured females. Females curtail reproduction when they get to be very old. Thus, size and age structure

of the population is important for determining reproductive success. The currant harvest strategy removes the most fecund females by selecting for larger individuals. The consequence of harvesting these large females is not understood.

Suggested Research Studies

- Conduct laboratory studies that measure reproductive output relative to weight, size, and age
- Conduct field studies of reproductive cycle with size, age, and location components
- Construct models linking reproductive output with fertilization success in different areas
- Construct models linking reproductive output with fishing activity

Question 3. Where and when do spat settle, and what constitutes nursery areas?

Rationale

Protecting juveniles is critical to the survival of any harvested species. The spatial relationship between adult and juvenile distributions is unknown. Identifying and protecting nursery areas are commonly used management tools to preserve a resource.

Suggested Research Studies

- Collect information from population surveys and fishery observer programs including benthic and epibenthic species present, and geologic and biogenic structures where juveniles occur
- Identify habitat preferences through laboratory experiments (e.g., temperature, salinity, and food).
- Examine stomachs of potential scallop predators to identify mortality sources and relate to the timing of settlement
- Identify food type and size for larval survival
- Estimate larval duration and growth to determine when spat settle
- Identify oceanographic features that may retain larvae (e.g., fronts, gyres, eddies, currents)
- Develop a larval drift model

Question 4. After settling, what movement behaviors are critical for survival of juvenile and adult scallops, and are these behaviors altered by dredging?

Rationale

The distribution of scallops is critical to reproductive success. Dredge fishing alters the distribution of juvenile and adult scallops. The consequences of this redistribution are unknown, but in adults it may reduce fertilization success. Anecdotal evidence indicates large movements of scallop aggregations sometimes occur.

Suggested Research Studies

- Investigate the scallop's capacity for movement
- Measure the distance a scallop can swim per unit times as a function of size and season
- Is the scallop's capacity for movement altered by the effects of dredging?
- What are the effects of handling, aerial exposure, being discarded (e.g., righting response)?

- If juvenile and adult distributions differ, how and when do juveniles migrate into the adult areas?
- Observe movements relative to sediment type, predators, currents (velocities, direction, eddies, gyres), and fishing gear
- Determine if scallops move to re-aggregate after disruption

Question 5. What factors determine growth rates of scallops?

Rationale

Growth rates determine age of recruitment and potential yield to the fishery. There are geographical differences in growth rates that may be related to physical conditions, primary production levels, scallop densities, or genetic characteristics.

Suggested Research Studies

- Determine physical factors that affect growth: temperature/salinity, turbidity, seasonality, storm activity
- Determine biological factors that affect growth: metabolism, food, maturation, genetic (stock) effects on physiology, injury, age, and population density
- Develop a bio-energetic model for growth rates of weathervane scallops

Question 6. What are the effects of fishery-induced injuries and handling on mortality?

Rationale

Dredging can damage scallops, some of which are not brought to the surface. Management strategies need to incorporate this mortality but currently do not for lack of data.

Suggested Research Studies

- Fishery discards
- Injured or disturbed but uncaptured scallops (e.g., lethal versus sub-lethal, acute versus chronic)

Question 7. What is the natural mortality rate of scallops from recruitment into the fishery onward?

Rationale

Management plans predict natural mortality so sustainable harvest quotas can be set. For scallops natural mortality rates are poorly understood. Mortality rates probably differ with locality, age structure, local physical conditions, and benthic community structure.

Suggested Research Studies

- Specific locations at several fishery and closed areas
- Annual variability at several fishery and closed areas
- What are the factors influencing natural mortality?

Question 8. What factors affect recruitment of scallops?

Rationale

Viable fisheries depend on populations with abundance levels that allow harvest. Population abundance trends are dictated by recruitment. Inter-annual variability and recruitment depend on environmental processes, which are modified by fishing. In scallops, recruitment is periodic.

Suggested Research Studies

- Compare differences in recruitment between fished and unfished beds
- Identify sources and sinks, at the bed level, of recruiting scallops
- Consider indirect effects of fishing through enhanced settlement, predation, disease, and other factors
- Examine the member-vagrant theory and the ocean factors influencing it
- Develop age-structured models of the populations to estimate recruitment
- Develop methods to estimate juvenile scallop abundance using bottom-sampling devices, surveys of predator stomachs, submersibles
- How does the timing of dredging affect recruitment success (pre- and – post – settlement)?
- Contrast recruitment indices from different areas using age data

Question 9. What is the effect of scallop dredging on the benthos?

Rationale

Dredges alter the structure of the sediment and topography, kill some species, and displace others. Many species affected are commercially important or important prey of other commercially important species (e.g., shrimp, crabs, groundfishes). Dredging may lead to both short- and long-term detrimental consequences for scallops and associated species.

Suggested Research Studies

Geochemical studies need to be performed to:

- Determine how dredging affects geochemical (including organic content) and physical attributes (e.g. topography) of the bottom
- Determine how dredging affects water-column or interface turbidity
- Compare the effects of dredging to natural disturbance (e.g., tidal currents, storm events, runoff from land)

Ecological studies need to be performed to determine:

- Dominant infaunal and epifaunal benthic species and their relationships by bottom type
- How dredging affects benthic mobile epifauna and groundfish (e.g., crabs, flatfishes)
- How dredging affects sessile epifauna (e.g., hydroids, bryozoans, and long-lived species)
- How dredging affects the infauna community structure and successional events
- How dredging affects faunal patchiness within these communities
- What are the consequences of the frequency of dredging on benthic communities?
- What are the consequences of the amount of area dredged on benthic communities?
- Which species settle first into a disturbed area?
- Which predators benefit from dredging?

Question 10. What are the considerations for developing harvest strategies of scallops?

Rationale

In several scallop fisheries around the world overfishing and significant alterations of the benthic community have been demonstrated. The following suggestions may serve to avoid the mistakes in other fisheries and capitalize on successful harvest strategies. It is important to learn

from the worldwide experiences associated with various scallop species and the fisheries for these species.

Suggested Research Studies

Beyond the ecological considerations mentioned I this document the following should be addressed and understood in the development of harvest strategies for scallops:

- Stock size relative to the unfished population
- The scallop distribution and proportion of their habitats fished
- How many year classes support the fishery?
- What is the applicability of traditional harvest models for scallops?
- What harvest level or rate is sustainable?
- Is MSY (maximum sustainable yield) appropriate?
- Determine if there are several scallop beds with different abundances in a management area
- What is the appropriate unit for a management area? Is it at the level of a bed or larger?
- Need to consider the effect of scallop removals on spatial distribution relative to critical density
- Size versus age limit: What is optimum age or size of harvest given meat yield and reproduction?
- What are the effects of area closures and rotation on scallop recruitment?
- What is the unit stock, and where do the recruits come from?
- Should areas with persistent recruitment be set aside as nurseries?
- Can we set aside areas of broodstock for fishery enhancement?
- Do different year classes come from different parental sources?
- What is the heritability of growth, and does the fishery affect growth?
- What is the best season for fishing?

Reference:

Alaska Department of Fish and Game and University of Alaska Fairbanks. 2000. A workshop examining potential fishing effects on population dynamics and benthic community structure of scallops with emphasis on the weathervane scallop *Patinopecten caurinus* in Alaskan Waters. Alaska Department of Fish and Game, Division of Commercial Fisheries, Special Publication 14, Juneau.

Excerpt from Scientific Statistical Committee - March 31st - April 2, 2003

D-1(g) RESEARCH PRIORITIES

The SSC reviewed the list of research priorities as edited by the BSAI and Gulf Groundfish plan teams in November 2002. The SSC used this list to develop a short list of research topics needing immediate attention: The complete list of research priorities is attached in the Appendix.

A. Critical Assessment Problems

• For rockfish stocks there is a general need for better assessment data, particularly investigation of stock structure and biological variables.

a) Supplement triennial trawl survey biomass estimates with estimates of biomass or indices of biomass obtained from alternative survey designs.

b) obtain age and length samples from the commercial fishery, especially for POP, northern rockfish, and dusky rockfish.

c) Increase capacity for production ageing of rockfish so that age information from surveys and the fishery can be included in stock assessments in a timely manner.

• Further research is needed on model performance in terms of bias and variability. In particular, computer simulations, sensitivity studies, and retrospective analyses are needed. As models become more complex in terms of parameters, error structure, and data sources, there is a greater need to understand how well they perform.

• There is a need for life history information for groundfish stocks, e.g., growth and maturity data, especially for rockfish.

• There is a need for information about stock structure and movement of all FMP Groundfish species, especially temporal and spatial distributions of spawning aggregations.

B. Stock Survey concerns

• There is a need to explore ways for inaugurating or improving surveys to assess rockfish, including nearshore pelagics.

• There is a need to develop methods to measure fish density in habitats typically inaccessible to NMFS survey gear, i.e. untrawlable habitats

C. Expanded Ecosystem Studies

• Research effort is required to develop methods for incorporating the influence of environmental and climate variability, and there influence on processes such as recruitment and growth into population models, especially for crab stocks.

• Forage fish are an important part of the ecosystem, yet little is known about these stocks. Effort is needed on stock status and distribution for forage fishes such as capelin, eulachon, and sand lance.

• Studies are needed to identify essential habitat for groundfish and forage fish. Mapping of nearshore and shelf habitat should be continued for FMP species.

D. Social and economic research

- Development of time series and cross-sectional databases on fixed and variable costs of fishing and fish processing.
- Pre- and post-implementation economic analyses of crab and GOA groundfish rationalization.
- Identification of data needed to support analyses of community level consequences of management actions.
- Development of integrated multispecies - multifishery models for use in analyses of large scale management actions, such as PSEIS and EFH.

E. Bycatch

- Identify sources of variability in actual and estimated bycatch rates.

F. Monitoring

- Promote advance in video monitoring of other wised unobserved catch for improved estimation of species composition of total catch and discrimination of retained and discarded catch

G. **Research Priorities Identified by the NRC SSL Committee Steller**

The SSC held a brief discussion on the research and monitoring recommendations of the NRC Steller Sea Lion (SSL) Committee, as presented in the Executive Summary of their report. The SSC noted that their recommendations are consistent with recognized needs, but also that there is considerable ongoing SSL research. Among the NRC's recommendations, the SSC wishes to particularly identify their recommendation for a spatially-explicit, adaptive management experiment to definitively conclude whether fishing is playing a role in the current lack of SSL recovery. As noted in the SSC's February 2003 minutes, there are a number of scientific, economic, and ESA regulatory considerations that must be addressed before such a plan can be seriously considered for implementation. However, the SSC supports further exploration of the merits of this adaptive management approach.

APPENDIX 1

2003 Research Priorities

A. Critical Assessment Problems

1. Some of our stocks are disproportionately harvested across large areas of the GOA and BSAI due to area closures, other management actions, or fishery behavior. Additional analysis should be undertaken to examine potential effects of disproportional harvesting

2. More information is needed on "other species." Observer data should be collected and analyzed for individual species. Better estimates of abundance are needed. Lastly, life history data is limited for many species in this complex. Stock assessments at the assemblage level (sharks, skates, squid, sculpins, and octopus) are planned in the near future.

3. Rockfish: There is a general need for better assessment data, particularly investigation of stock structure and biological variables.
   a. Supplement triennial trawl survey biomass estimates with estimates of biomass or indices of biomass obtained from alternative survey designs.
   b. Obtain age and length samples from the commercial fishery, especially for Pacific ocean perch, northern rockfish, and dusky rockfish.
   a. Increase capacity for production ageing of rockfish so that age information from surveys and the fishery can be included in stock assessments in a timely manner.

4. Pacific cod: Research into methods of ageing Pacific cod has been completed and production ageing has begun. Working through the backlog of age structures should be given a high priority.

5. Walleye pollock: There is a continuing need for research on stock structure as it relates to assessments. There is a critical need for stock interactions studies and pollock recruitment patterns. We continue to emphasize the need for age-structured assessments of recognized stock units.

   The SSC believes that the magnitude of the catch, size and age structure of the EBS stock harvested in the Russian zone in the vicinity of the transboundary area is needed. It may be necessary to consider fishing removals from the Russian zone and their impact on EBS pollock mortality in the estimates of ABC and TAC.

   Assessment of the status of the Gulf of Alaska resource is critically dependent upon results of resource surveys. These surveys will be conducted every two years. While this is a positive development, various ways of supplementing the biennial survey data should be evaluated.

   More research should also be conducted on the movement of pollock between the GOA and BSAI and across regions within GOA and BSAI, (e.g., Bogoslof, Donut Hole, PWS, Shelikof, and SE inside).

   More research using acoustic data should be conducted.

6. Crab research: Research should be expanded on handling mortality, stock structure and life history parameters.

7. Age- and length-structured assessments: These assessments integrate several data sources using some weighting scheme. Little research has gone into evaluation of different weighting schemes, although the weight can have a large effect on the assessment results. Research is needed on which weighting schemes are robust to uncertainties among the different data sources. Age structured assessments depend upon age determination techniques and ongoing age validation is needed.

   Correct model specification is critical to stock assessment. Further research is needed on model performance in terms of bias and variability. In particular, computer simulations, sensitivity studies, and retrospective analyses are needed. As models become more complex in terms of parameters, error structure, and data sources, there is a greater need to understand how well they perform.

8. Life history information, e.g., growth and maturity data, is incomplete for a number of stocks. This information is essential for determination of ABC, OFL and preferred fishing mortality rates. Maturity data are lacking for: Pacific cod, Dover sole, other flatfish, sablefish, and many species of rockfish. Life history and distributional patterns of Greenland turbot are lacking. To better understand sablefish recruitment variability, additional information on the geographical distributional and movement of juvenile sablefish is needed. More research should be done on sources of age-specific fish mortality.

9. Identification of the origin of chum and chinook salmon stocks captured incidentally in the groundfish fisheries is needed. The chum salmon stocks in particular are recognized as a mixture of Asian and North American origin. Resolution of stock origin is important in the consideration of bycatch management.

10. There is need for information about stock structure and movement of walleye pollock, Atka mackerel, Pacific cod, POP, and other rockfish. Specifically, we need information on temporal and spatial distributions of spawning aggregations of fish (especially Pacific cod).

11. Further research is needed about management strategies that provide for conservation of aquatic resources. Topics that need attention include: which measure of biomass should be used in biomass-based adjustment of ABC and OFL; what measure of average recruitment to use in $B_{40\%}$; the effect of seasonality in spawning, recruitment, and harvest on optimal harvest rate; adaptive management schemes which are designed to provide understanding of multispecies interactions and spatial population dynamics. One objective is to develop multispecies analysis of stocks.

12. Presentation of uncertainty in stock assessments is often lacking or incomplete. Further research is needed into which methods are most appropriate for capturing uncertainty in the status of populations. The use of Markov Chain-Monte Carlo (MCMC) methods appears to be a promising line of research and its use with AD Model Builder should be further explored.

13. Management measures such as time-area closures and other restrictions are frequently imposed, but rarely rescinded. Studies are needed to evaluate the effectiveness of management measures on conserving populations, achieving management goals and assessing other ecosystem effects.

14. The Groundfish Teams expressed concern regarding the lack of coverage by trawl survey in both the eastern GOA and in all deepwater strata during 2001 and strongly recommended continued coverage of deeper stations in future surveys.

B. Stock survey concerns

1. Conservation of aquatic resources in the North Pacific is critically dependent on a consistent time series of trawl, hydroacoustic, and longline surveys. The continuity of these series must remain one of the highest priorities of NMFS and the Council. Data analysis should be expanded to include non-target, non-FMP species.

2. Explore ways for inaugurating or improving surveys to assess rockfish (including nearshore pelagics), pollock, squid and Atka mackerel.

3. Expand bottom trawl surveys in the Gulf of Alaska to include slope areas that encompass the population range of Greenland turbot, rockfish, thornyheads, and sablefish.

4. Improve surveys for Bering Sea crab complementary to the existing Bering Sea crab/groundfish survey (e.g. Norton Sound, Pribilof Islands, St. Matthew Island, and Bristol Bay).

5. Direct observation (e.g. submersible and dive surveys) offers unique opportunities to directly examine gear performance, fish behavior in the proximity of gear, gear related habitat impacts, and differences of fish density between trawlable and nontrawlable habitat.

6. There is a continuing need to perform gear calibration and fish observation studies to validate indices of abundance (e.g. fishing longline and trawl gear side-by-side, and fishing different baits on longline gear over the same stations).

7. Little scientific sampling has occurred of seamounts within the EEZ for groundfish, halibut, and crab abundance. Surveys that sample these seamounts may improve estimates of total abundance in the EEZ, particularly for sablefish and rockfish stocks.

8. Data from annual ADF&G crab surveys should be examined and their usefulness for assessing groundfish abundance in near-shore areas should be evaluated. Dialogue between ADF&G and NMFS assessment scientists regarding ways of gaining more useful groundfish data from this survey should be encouraged.

9. Encourage development of methods to measure fish density in habitats typically inaccessible to trawl survey gear.

C. Expanded Ecosystem Studies

1. Considerable research is being conducted on the effects of climate on the biology and dynamics of marine populations. Research effort is required to develop methods to incorporate climate variability and its influence on processes such as recruitment and growth into our models of population dynamics.

2. There have been considerable recent advances in using naturally occurring stable isotopes in diverse types of studies. Examples include identifying residence times and areas at various life stages; computing trophic levels and food web dynamics; examining ontogenetic changes and patterns of migration. Studies using these natural markers should be encouraged.

3. Explore the utility of placing trained marine mammal/seabird observers onboard vessels conducting fishery surveys. Such observations may contribute to abundance estimates, or to provide indices of abundance and associations with oceanography and prey distributions. In particular, relationships among oceanographic conditions and animal condition and health should be explored.
   a) More research should be collected by placing trained marine mammal/seabird biologists on line transect surveys to begin an index of abundance for birds.
   b) Encourage data exchanges between USFWS and NMFS RACE and NMML.

4. Effort is needed on status of stocks and distribution of forage fishes and shellfish, such as capelin, eulachon, sand lance and euphasids. Forage fish are an important part of the ecosystem , yet little is known about these stocks. The Lowell-Wakefield Symposium (October 1996) presented current research on forage fishes.

5. Studies of the effects of harvesting and processing activities on the ecosystem and habitat should be instituted. One example would be a study contrasting species diversity and abundance in the red king crab savings area with that in adjacent regions.

6. Trophic dynamics research should be undertaken on the relationships among critical species, e.g., Pacific cod and its prey (including shrimp and crabs). The feasibility of constructing multispecies models using ongoing collection of gut contents data should be investigated.

7. Groups of species in the rockfish and flatfish families are now managed as "species complexes." Research should be expanded on the question of biological linkages among the components of "species complexes" that justify this management approach. Further, are there other, unidentified groups of species that are ecologically related and could be managed as a unit?

8. Studies are needed to identify essential habitat for groundfish and forage fish species in the Gulf of Alaska and Bering Sea. This identification is required by the MSFCMA and would benefit from field studies conducted across a matrix of spatial, temporal, and life history stages. Mapping of nearshore and shelf habitat should be continued for FMP species.

9. Expand studies of distribution, abundance, and productivity of seabird populations and ensure that data are collected in ways that provide for rigorous analyses of seabird/marine

mammal/oceanographic/fisheries interactions. Historic data on seabirds in Alaska was collected during the 1970s (through OCSEAP); but the quantity of data collected afterwards has been insufficient to adequately examine trends in these interactions.

10. Historic (i.e., OCSEAP) data existing in the USFWS Pelagic Database needs be reformatted to update and make the data accessible, to enable analysis on seabird/fishery interactions.

11. More recent (1990's - present) data needs be consolidated and added to the pelagic database.

12. Seabird diet needs to be described for more areas and species, including winter diet needs of seabirds. Existing and historic diet data needs to be consolidated and put into a format accessible and appropriate for examination of long-term trends. Very little is known about winter diets of birds.

13. Multivariate statistical analysis of the time series of annual survey data may identify which species regularly occur in assemblages. Mapping these assemblages through space and time may reveal changes in the distribution and abundance of the species of the Eastern Bering Sea. These mappings and trajectories may be applicable to adaptive management approaches suggested for exploring ecosystem concerns. Although related analyses were started by NMFS in the late 1970's, they have not been conducted in recent years. Recent advances in spatial statistics may prove fruitful tools for re-examining these existing data.

14. Uncertainty about the relationship between the Steller sea lion population and groundfish fisheries has taken an elevated significance. With this uncertainty as to the extent of factors affecting Steller sea lions, it is critically important to investigate the effects of mitigation measures on the sea lions, the fisheries, and the ecosystem. The monitoring must be based on an experimental design that provides information about the interaction of fisheries and Steller sea lions. Five questions are central to future work:

15. What is the distribution of fish in relation to areas used for fishing, and what are the seasonal changes?
    a. What is the distribution of fish in fishing areas before and after fishing?
    b. How do Steller sea lions use pollock in relations to pollock distributions?
    c. How does the Steller sea lion's pollock feeding habits influence sea lion population dynamics?
    d. Does the fishery effect Steller sea lions in other ways (e.g., behavioral disturbance)?
    e. How much is needed per SSL compared to what is there seasonally and geographically – demand vs. availability, to address localized depletion?
    f. How much is needed per SSL compared to what is seasonally and geographically available, i.e., demand vs. availability

16. More research should be conducted to estimate jellyfish abundance trends because it may be an ecosystem indicator (it is a habitat for pollock).

17. There is an apparent increase of a parasite occurrence in some flatfish stocks (flathead sole and Greenland turbot) in the Bering Sea. This may signal changes in the ecosystem and has important consequences for the fishery. Research on this should be pursued.

18. Killer whale depredation of sablefish catches has been a problem in the Bering Sea since the beginning of the survey. Additional information on the impacts of killer whale depredation on sablefish in the ecosystem and in the sablefish survey should be assessed, along with further consideration of sperm whale depredation of sablefish.

D. Social and economic research

There is a critical need for the development and continued maintenance of basic social and economic information databases on the fisheries and fisheries dependent communities of GOA and BS/AI. This information is required for establishing a baseline to be used in the evaluation of the impacts of alternative management measures.

1. There is a need to collect and maintain longitudinal data sets that include:
   a. Domestic and International transaction level observations of exvessel, wholesale, and retail prices;
   b. domestic and international production by species and product form;
   c. product inventories and trade volume by product form;
   d. fixed and variable harvesting and processing costs;
   e. employment and income;
   f. locus and magnitude of expenditures in support of harvesting and processing;
   g. nature and extent of regional economic linkages;
   h. tax receipts and transfer payments; and,
   i. socioeconomic and demographic data for fishery dependent communities (income levels and distributions, population levels and distributions.
2. There is a need for economic analyses of:
   a. the demand for fisheries products (exvessel, wholesale, international, and retail markets);
   b. introduction and cost functions for catch and processing;
   c. estimates of the producers and consumers surplus associated with fisheries under current management regimes;
   d. prior and post-implementation studies of the net benefits and distribution of net benefits associated with changes in management regimes (e.g., changes in product markets, characteristics of quota share markets, changes in distribution of ownership, changes in crew compensation, as a consequence of the halibut/sablefish IFQ program or the pollock, crab, and salmon co-ops);
   e. Regional models of economic activity in fishery dependent communities;
   f. An assessment of the cumulative efficiency and equity consequences of management actions that apply time/area closures;
   g. estimates of the net economic benefits of recreation and subsistence harvests;
   h. bioeconomic models of multi-use fisheries;
   i. estimates of the existence and option values associated with corals, seabirds, and marine mammals;
   j. Behavioral models of fleet response to alternative fishing opportunities to better predict how fishing effort will shift in response to possible management actions (e.g., time/area closures, marine reserves, bycatch restrictions, co-ops, IFQs);
   k. changes in catch efficiency and operating costs associated with gear modification and avoidance behaviors intended to reduce bycatch;
   l. better methods for assessing the social costs of bycatch; and,

m. models of the relationship between sampling strategies and the confidence of bycatch estimates associated with individual and pooled bycatch quotas, and

n. Models of mechanisms for providing traceability, ensuring safety and certifying product and production process attributes of fishery products.

3. Research pertinent to assessment of the social impacts of actions contemplated by the Council include:

   a. Fishery/Community Linkages: Field research aimed at capturing the full array of linkages between fisheries and social and economic life in fishery dependent communities.

   b. Social Assessments: Selected community and industry assessments should be conducted to establish baseline conditions underlying social problems identified by the Council and the Advisory Panel. As appropriate, these projects can be extended to generate time series information.

   c. Social Impacts: Social impact and policy research should be conducted regarding the identification and potential effects of alternative management actions.

   d. Develop better methods for determining the social costs and benefits of management actions (e.g. through the use of non-market valuation techniques).

E. Bycatch problems

1. Research on gear modification and other methods for reducing bycatch should be expanded.
2. A better quantification of discard mortality rates is needed, especially for crab.
3. Data on size/age and sex of crabs taken as bycatch are needed to assess impacts.
4. Comprehensive evaluations are needed of single and multiple time/area closures and other bycatch management measures.
5. Develop better methods for assessing the social costs of bycatch.
6. Identify sources of variability in actual and estimated bycatch rates.
7. Collect bycatch information in the directed halibut fisheries using observer coverage. Current logbook information is inadequate to quantify this bycatch. Research efforts should also include development of video monitoring options.

F. Fishery Monitoring

1. Inseason management and stock assessment are critically dependent on catch estimates. There is a need to conduct ongoing analyses of the accuracy and precision of catch estimates in all fisheries. An analysis of the utility of fishery logbook information should be conducted. In particular, determine if it is possible to gain insight into fleet performance from such information. Examine feasibility for developing a representative CPUE index and determine if it is proportional to stock size.
2. Evaluate sampling procedures used by observers and various catch estimation procedures. Recent analyses have been conducted on efficient methods of collecting representative biological data from target species. Similar studies should be conducted on the collection of prohibited species biological data.
3. Development of catch and bycatch sampling procedures for individual vessel accountability programs.
4. Promote advance in video monitoring of otherwise unobserved catch for improved estimation of the species composition of total catch and the discrimination of retained and discarded catch.

Research Needs

There are many research needs for fish and invertebrates, spanning the full range of the Board's legislative mandate from pressing fishery management issues to marine ecosystem needs. Because fisheries extract living marine resources, understanding the effects of humans on the ecosystem is particularly important. Therefore, research needs for fish and invertebrates tend to be weighted more toward pressing fishery management issues. However, just as natural forces cause fluctuations of fishery resources, it is also important to consider the consequences of natural changes on how fisheries should be managed.

Identification of research needs on fish and invertebrates was motivated by several recent planning documents. First, the GOA and BSAI groundfish plan teams of the NPFMC developed a list of research needs that were prioritized by the NPFMC's Scientific and Statistical Committee in their April 2003 meeting minutes (see: http://www.fakr.noaa.gov/npfmc/minutes/ssc903.pdf). Second, research themes and approaches were identified in the Draft Bering Sea Ecosystem Research Plan (BSERP 1998). Third, information gaps and research needs were identified in the recent Alaska Groundfish Fisheries Final Programmatic Environmental Impact Statement (NMFS 2004b). Fourth, research approaches were outlined in the development of the Environmental Impact Statement for considerations of essential fish habitat (NMFS 2004c). Finally, several pressing research needs became apparent in the 2000 Biological Opinion in which NMFS considered the potential for groundfish fisheries to jeopardize the existence of Steller sea lions and to adversely modify their critical habitats (NMFS 2000). After considering these reviews, the North Pacific Research Board developed its own set of research needs for fish and invertebrates, discussed below, and summarized in Table 3-4. The list is not intended to be exhaustive, but instead attempts to identify some of the highest priority areas of research.

Stock Assessment Research and Development

Research and development of new stock assessment techniques and methods are needed. Whereas routine stock assessment surveys of exploited fish and invertebrates fall within the purview of state and federal management agencies, technical obstacles prohibit routine assessments for some species complexes. For instance, new methods or techniques are needed to assess the abundance and distribution of forage fish, rockfishes in untrawlable rocky habitats, and Greenland turbot in deep waters beyond the continental shelf. Also, it should be noted that even for well known species, many assumptions, sometimes very tenuous, are made in determining population status and trends. For example, routine stock assessments are questioned for some species owing to significant uncertainties about gear selectivity and catchability. These include selectivity curves for Pacific cod that imply a larger biomass of old/large fish than observed, catchability of snow and Tanner crabs in deep waters that may indicate larger abundances than currently estimated, and potential for herding of rockfish into survey trawl nets or capture of rockfish during gear deployment and/or retrieval, perhaps inflating abundance estimates. In effect, more information is needed on all species, not just little known ones.

Alternative Harvest Strategies

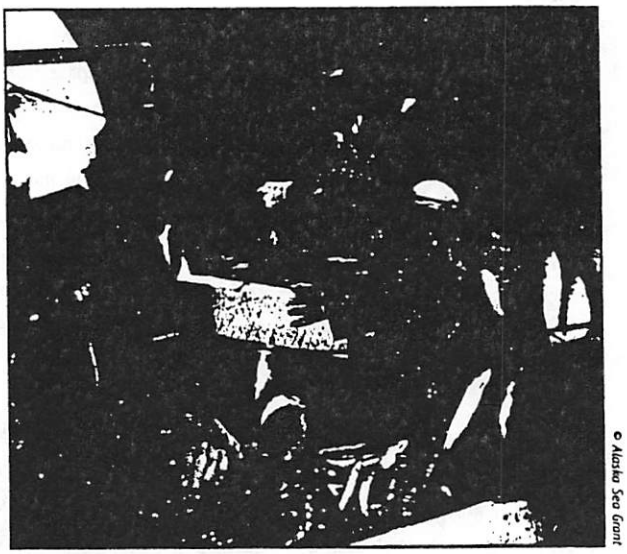
Future research may be needed on alternative harvest strategies. Many groundfish fisheries in Alaska are managed with spawning stock biomass per recruit (SSB/R) strategies, typically one based on F40%, the fishing mortality rate that reduces SSB/R to 40% of the unfished level. Further consideration needs to be given to whether F40% is appropriate for all species, including rockfishes, which have extreme longevity and other life history features that render them very vulnerable to overfishing (Goodman et al. 2002). Additionally, there are alternative strategies, used either instead of or in combination with SSB/R strategies, that account for other stock features, such as implications of truncated age and size distributions, potential for genetic selection and loss of genetic variability, effects of fishing on spawning schools and reproductive success, and effects of spatially and temporally disproportionate distributions of harvest, such as impacts of nearshore depletion on specific species (e.g., halibut) due to high recreational and/or commercial fishing effort.

Socio-economic Considerations

Fuller attention should be given to social and economic studies related to fisheries management. To perform meaningful analyses of the effects of fishery management measures on communities and on the individual and collective economics of fishing fleets, some way has to be found to develop time-series and cross-sectional databases on the fixed and variable costs of fishing. Notably, as a part of the crab rationalization program now being implemented, the industry agreed to make cost data available for purposes of assessing the "fairness" of the negotiated grounds price for crab. Other critical information would include the impact of rising cost of fuel or effect of a rationalized fishery on demand for supplies and services. Recent analyses of alternatives for essential fish habitat and habitats of particular concern have highlighted the difficulty of placing a meaningful value on fish habitats that can be compared to usual economic indices, such as exvessel and wholesale values and personal income. Therefore, estimation of aesthetic and non-market valuations of ecosystems is an area of needed research. Finally, whereas various federal laws require significant assessment of impacts of changes in management measures, there is seldom a conscious effort to develop baselines for conditions prior to implementation. Also, follow-up studies are needed to estimate the impacts of major regulatory decisions once they are implemented. For example, studies on the implementation of sablefish and halibut individual fishing quota (IFQ) programs would be highly valuable in consideration of potential future IFQ programs.

Reducing Catch of Unwanted Species

There are continuing needs to improve mitigation measures designed to reduce catch of unwanted species, or perhaps certain age groups of targeted species. Incidental catch of endangered (e.g., short-tailed albatross) or bycatch of prohibited species (e.g., red king crab, Pacific herring, Chinook and chum salmon) can lead to curtailment of fisheries and elevate concerns for the effects of fishing on other living resources. At a minimum, incidental catch of undesirable species can lead to increased costs of fishing operations. Priorities for research should include mitigation of seabird and marine mammal interactions with fisheries, new technologies and methods to reduce bycatch, and studies of survival rates of discarded fish to allow accurate estimation of total fishing mortality.



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Causes of Perturbations of Major Species

There are many ecosystem research needs, but investigations into the causes of perturbations of some major species are among the highest priorities. Understanding the role of natural and human causes on species declines (e.g., crab, shrimp, western Alaskan salmon, Greenland turbot, and halibut in IPHC Area 4C) and increases (e.g., arrowtooth flounder, other flatfish, sharks, skates) is important to developing management strategies that reflect their causes. Some species are particularly important owing to their high economic value (e.g., crab and shrimp), others for their cultural significance and local value (e.g., western Alaska salmon), and others for their perceived roles in restructuring the ecosystem (e.g., arrowtooth flounder, sharks). Much work has been done on recruitment and growth as affected by climate variability for groundfish and salmon, but relatively little attention has been paid in this regard to crab stocks. Yet the high value of crab makes it a worthy candidate for studies to better understand fishery management and environmental processes and their effects on crab stock abundance. Salmon are another species of special interest, particularly concerning their ocean migrations and intermingling of stocks on the high seas, effects of fisheries and environmental conditions on ocean survival, and the issue of overall ocean rearing capacity which is being stressed by increasing releases of young salmon from hatcheries around the Pacific Rim. High-seas capture of salmon bound for Alaskan watersheds also remains an area of continuing concern.

Implications of Ecosystem Change on Fishery Management

As with all other LME components, there are many research needs to investigate implications of ecosystem change on fishery management. Effects of fishing on fish habitats and fish productivity are poorly known for Alaska. There is a long history of research on these topics in other regions, such as the North Atlantic, and some studies have been conducted in Alaska in recent years, primarily by NMFS. Research needs for fish habitat were covered more thoroughly in the previous section on habitat.

Although harvest rates are set at levels estimated to be sustainable, removals are not evenly distributed within fish populations and the potential exists for competition between fisheries and other species for resources. To answer questions about competition, it is insufficient to know that a seabird or marine mammal eats the same species that is captured by a fishery. Rather, competition requires the use of the same resources that are in limited supply; resource limitation is rarely studied, so the existence of competition is almost always speculative.

Likewise, although harvest rates may be sustainable for single species, it is unclear what effects there may be on the ecosystem by harvesting some species and not others. One emerging challenge to fisheries management involves concerns that fishing has significant impacts on biodiversity at the complex, species, stock, and genetic levels. Another challenge at the complex level is the issue of "fishing down" food webs (Pauley et al. 1998). In the North Pacific, it appears that trophic levels in the food web are being maintained largely because of the dominance of pollock in the ecosystem (Boldt 2003).

In moving toward ecosystem-based fishery management, there is much discussion about identifying ecosystem indicators to assist in monitoring trends in the ecosystem. Shrimp have been proposed as one such indicator (Anderson and Piatt 1999), however, the entire topic of ecosystem indicators deserves considerable attention and was discussed in more detail in Chapter 2.

Most assessments of the potential role of climate on regime shifts consider statistical relationships between various climate indices (e.g., PDO, Aleutian Low Pressure Index) and time series of fish catches and recruitment. Although speculations about cause and effect have been offered, explicit mechanistic linkages between climate conditions and fish survival and growth remain largely uncertain. Most published correlations between fish and climate ultimately fail, because the true mechanisms have not been uncovered. Research into these processes would deepen our understanding of ecosystem function.

Regardless of causation, the implications of regime shifts require additional research, as well. For instance, forage fish abundance and distribution may have shifted in the late 1970s and perhaps more recently. Forage fish are an important component of the North Pacific ecosystem yet relatively little is known about forage fish species such as capelin, eulachon, and sand lance. Some progress has been made to understand the effects of changes in local availability of forage fish to some seabird colonies (e.g., Litzow et al. 2002), but ecosystem-wide implications of forage fish changes on other ecosystem components remain speculative. Likewise, the effects of large fluctuations of other species (e.g., crab, shrimp, flatfish, and sharks) on other ecosystem components through competition and predation are poorly known.

Ideally, development of new multispecies fishery management strategies should consider the full range of implications of ecosystem changes on fishery management. In such a new paradigm, the acceptable biological catch for a particular species would not be determined solely by that species biomass, but other considerations would be taken into account, as well, to determine an optimal harvest of a mix of species from the ecosystem. Although fisheries in the GOA and BSAI areas are managed very progressively under a suite of ecosystem considerations (Witherell et al. 2000b), development of a more integrated, formalized approach is likely to be more effective.

Research Needs

Table 3-4 General research needs for fish and invertebrates.

Pressing Fishery Management Issues

Stock Assessment Research and Development

- New methods to assess difficult species (e.g., forage fish, rockfish in untrawlable habitat, Greenland turbot in deep water)
- Catchability/selectivity studies for questioned assessments (e.g., Pacific cod, snow and Tanner crab, some rockfish)
- Incorporation of ecosystem indices in stock assessments
- Spatially explicit stock assessments

Alternative Harvest Strategies

- Effects of fishing on spawning aggregations and reproductive success
- Effects of truncated age/size distributions on stock productivity
- Potential for genetic selection and/or loss of genetic variation by fishing
- Effects of spatial-temporal disproportionate harvest rates on stock dynamics
- Applicability of spawning stock biomass per recruit harvest strategies

Socio-economic Considerations

- Estimates of fixed and variable costs of fishing
- Estimation of aesthetic and non-market valuation of ecosystems
- Socio-economic baselines for regulatory analyses and performance evaluations

Reducing Catch of Unwanted Species

- Mitigation of seabird and marine mammal interactions with fisheries
- New technologies/methods to monitor and reduce catch of unwanted species
- Survival studies of discards

Causes of Perturbations of Major Species

- Role of natural and human impacts on species declines (e.g., crab, shrimp, western Alaskan salmon, Greenland turbot)
- Role of natural and human impacts on species increases (e.g., arrowtooth flounder, other flatfish, sharks, skates)
- Migration, inter-mingling, carrying capacity, and ocean survival of anadromous salmonids
- Increased releases of Asian salmon, that may rear in U.S. waters and may impact Western Alaska salmon survival and production

Marine Ecosystems Information Needs

Implications of Ecosystem Change on Fishery Management

- Effect of habitat disturbance on fish populations
- Effects of disproportionate species removals on ecosystem function
- Potential for fisheries competition with fish, bird and mammal predators
- Biodiversity and implications for fisheries management
- Develop indicators of ecosystem conditions
- Mechanisms for climate-induced regime shifts of fish/invertebrate communities
- Role of pelagic and benthic forage species on upper trophic dynamics
- Ecosystem effects of large fluctuations in abundance and/or distribution of managed species (e.g., flatfish, crab, shrimp, sharks)
- Ramifications of large fluctuations in other ecosystem components (e.g., jellyfish, coccolithophores)