

**Northwest Fisheries Science Center
of the National Marine Fisheries Service
1999 Agency Report to the Technical Subcommittee
of the Canada-U.S. Groundfish Committee**

May, 2000

Review of Agency Groundfish Research, Assessments, and Management

A. Agency Overview

The Northwest Fisheries Science Center (NWFSC) provides scientific and technical support to the National Marine Fisheries Service (NMFS) for management and conservation of the Northwest region's marine and anadromous resources. The Center conducts research in cooperation with other federal and state agencies and academic institutions. It has positioned itself to provide the best possible science, anticipate solutions to emerging fishery resource challenges, and develop strong constituent relationships. Five divisions--Conservation Biology, Environmental Conservation, Fish Ecology, Resource Enhancement and Utilization Technologies, and Fishery Resource Analysis and Monitoring--conduct applied research to resolve problems that threaten marine resources or that deter their use. The Center's main facility and laboratories are located in Seattle. Other Center research facilities are located in Pasco, Big Beef Creek, Mukilteo, Manchester, Washington; Newport, Hammond, and Clatskanie, Oregon; and Kodiak, Alaska.

The Fishery Resource Analysis and Monitoring Division (FRAMD) is the focus for most of the research reported by the NWFSC to the Technical Subcommittee of the Canada-US Groundfish Committee. The FRAMD works in partnership with state and federal resource agencies, universities, and the groundfish industry to achieve a coordinated groundfish program for the West Coast.

The Division develops and provides scientific information necessary for managing West Coast marine fisheries, striving to provide useful, accurate, and reliable stock assessment data with which fishery managers can set ecologically safe and economically valuable harvest levels. It develops models for managing multispecies fisheries and designs programs to provide information on the extent and characteristics of bycatch in commercial fisheries as it looks at methods to reduce fisheries bycatch.

During 1999, West Coast groundfish research took on new urgency. Reduced harvest levels put in place for several highly valued and commercially important species meant economic disaster for segments of the fishing fleet and regional economies. In January

2000, after a particularly sharp decline in allowable catches to rebuild depleted stocks, Commerce Secretary William M. Daley determined a commercial groundfish fishery failure, the first step in the process of securing funds from Congress to assist fishermen.

Research facilities in Newport on the Oregon coast are particularly important for groundfish research. The Newport location provides opportunities for the FRAMD staff to work with and share information and ideas with researchers from Oregon State University, the Oregon Department of Fish and Wildlife, Alaska Fisheries Science Center, U.S. Environmental Protection Agency, and the fishing industry.

The Conservation Biology Division is responsible for characterizing the major components of biodiversity in living marine resources, using the latest genetic and quantitative methods. It also has responsibility for identifying factors that pose risks to these components and the mechanisms that limit natural productivity. The Division's multidisciplinary approach draws on expertise in the fields of population genetics, population dynamics, and ecology.

The Environmental Conservation Division (ECD) conducts nationwide research on the effects of chemical pollution and harmful algal blooms on habitat quality and fisheries resources. ECD is also a leader in NMFS' National Marine Mammal Health and Stranding Response Program's biomonitoring and quality assurances projects.

The Fish Ecology Division's role is understanding the complex ecological linkages among important marine and anadromous fishery resources in the Pacific Northwest and their habitats. The Division particularly places emphasis on investigating the myriad biotic and abiotic factors that control growth, distribution, and survival of important species and on the processes driving population fluctuations.

The Resource Enhancement and Utilization Technologies Division draws together multidisciplinary groups to address existing and developing challenges of captive rearing of salmon and other marine fish, improved hatchery practices, smolt quality, disease control, and developing technologies for full utilization of bycatch and fish processing waste.

For more information on Northwest Fisheries Science Center programs, contact Center Director Dr. Usha Varanasi at (206) 860-3200, usha.varanasi@noaa.gov.

B. Multispecies Studies

1. Research

Fishermen fishing strategies - Work progressed on defining fishing strategy and

catch assemblages in the commercial groundfish trawl fishery. The strategies and assemblages were defined using data collected by observers in 1985-1987. The strategies were based on selection of gear and depth of fishing. Logbook data collected in 1987 and 1996 were separated into groups based on those defined strategies. The logbook targets and catches in tows grouped by the defined strategies indicated some changes in the assemblages/ strategies between 1987 and 1996. Redefinition based on those changes made the strategy and assemblage definitions more applicable to the recent fishery.

For more information please contact Dr. Jean Rogers at jean.rogers@noaa.gov or at (541) 867-0153.

Juvenile groundfish - Further work was conducted on relating juvenile groundfish catch assemblages to environmental variables. In cooperation with the NMFS Tiburon Laboratory, assemblages of juvenile groundfish fish were defined using data collected by that laboratory off the coast of central California. Those assemblages were related to environmental variables in an attempt to understand differences in abundance over time. The environmental variables examined included invertebrate abundance; water temperature, salinity, and density; upwelling, wind turbulence, moonlight, and cloud cover.

For more information please contact Dr. Jean Rogers at jean.rogers@noaa.gov or at (541) 867-0153.

C. By species, by agency

2.) Shelf Rockfish

b.) Stock Assessment

An assessment of the canary rockfish (*Sebastodes pinniger*) population within the U.S. Vancouver through Columbia International North Pacific Fisheries Commission areas was completed in 1999. The age-based version of the Stock Synthesis model utilized to model the population. Fishery data included catches and length and age frequency distributions from the Oregon and Washington trawl fisheries. Fishery independent data included a biomass index and length and age frequency compositions from the NMFS triennial shelf survey.

The absence of older females (> 20 years of age) in all the age distributions were modeled based on two alternate hypotheses: 1) females die at an earlier age than males or 2) females are less 'vulnerable' to the fishing and sampling gears. The first hypothesis led to a model in which males had a natural mortality of 0.06, and females had natural mortality of 0.06 for ages 1-10 and mortality steadily increasing after age 10 to reach 0.20 for fish greater than age 25. Selectivity in the fishery and survey was

assumed to be time invariant and asymptotic for both sexes. The second hypothesis was expressed in a model in which natural mortality was a constant 0.06 for both sexes, selectivity in the fishery changed yearly after 1980, and selectivity in both the fishery and survey was dome-shaped for females and asymptotic for males. Both models results indicated that the 1999 spawning biomass was less than 30% of the spawning biomass at its unfished level.

Uncertainty in recent (1996-1998) recruitments also led to two alternate hypotheses. High recruitment was based on actual estimates of recruitment from the two models reflecting different assumptions regarding the absence of large females. Alternately, low recruitment was based on those estimates reduced by one-half. The two sets of recruitments were used in forecasting the allowable biological catches for 1999-2001. Those forecasts indicated that the catch needed to be reduced substantially, about 70% over those three years.

For more information please contact Dr. Jean Rogers at jean.rogers@noaa.gov or at (541) 867-0153.

D . Other related studies

1. Planning and Coordinating groundfish programs - In 1999, the NWFSC, in collaboration with the Southwest Fisheries Science Center and Alaska Fisheries Science Center, developed a draft comprehensive plan for West Coast groundfish research for the next three to five years. The research plan is designed to identify the scientific information and approach needed to achieve National Marine Fisheries Service stewardship objectives. Major elements of the plan are:

- Status of Stocks - to prevent overfishing, rebuild depleted stocks and obtain optimum yield from fisheries;
- Socio-Economics - to increase long-term economic and social benefits to the nation from living marine resources;
- Man-Made Stress - to understand and reduce impacts on fish habitat, including bycatch and gear impacts;
- Climate and Ecosystem - to understand the impact of ecosystem and climate factors on sustainable fisheries;
- Technological Innovations - to develop new tools for research and for conducting safe and valuable fisheries;
- Management Support - to integrate the above research knowledge into sound management advice.

Each area is addressed in the research plan's "action plan" in two ways. First is short-term progress that could be made on priority topics with current funding and staffing levels. Second is new research that could greatly improve the scientific basis for management decisions but which would require major new funding. The draft plan

recommends a high priority on conducting baseline assessments for all groundfish species, improving certainty in current assessments and improving socioeconomic analyses. Public meetings were planned for the first half of 2000 to gather comments to be incorporated into the plan.

For more information please contact Dr. Richard Methot at richard.method@noaa.gov, or at (206) 860-3365; or Cyreis Schmitt at cyreis.schmitt@noaa.gov, or at (541) 867-0127.

2. Electronic Fish Catch Logbook project - The Northwest Fisheries Science Center (NWFSC) of the NMFS is developing a prototype Electronic Fish Catch Logbook (EFCL) with funding by the Innovation Fund Committee of the National Performance Review. In the fall of 1997, the Center began development by conducting surveys of users of fisheries dependent data, including fishers, fisheries managers, fisher organizations, processors, marketers, port biologists and state and federal scientists who use or analyze the data. Systems currently in use for collecting fishery dependent data were also reviewed, as were potentially applicable technologies. A report was then distributed as a discussion draft for additional input. The project then requested proposals from private sector developers of software. Scientific Fisheries, Inc. of Anchorage was selected. Testing on the full system, including an on-board application, a web interface and a backend database, was undertaken in May 2000 with shore-based tests.

The project in part is an effort to be responsive to the Washington, Oregon and California trawl fleet, which, during a constituent meeting in 1996, requested the NWFSC develop a system to collect and analyze fish catch and logbook data. The industry was looking for opportunities to improve reliance on logbook data for fishery management because fishery managers appeared reluctant to use logbook data. Because the grant called for nationwide application, the system had to be developed based on needs for information in fisheries outside the west coast. Nonetheless, the project developers prototyped the system specifically for the WOC trawl fishery. Many concerns, primarily about data verification, have limited the use of logbook data in fishery management. Essentially, real-time or near-real-time reporting using an electronic logbook, like this one, has a significant potential to improve data verification, quantity, and timeliness. At present, primary verification of logbook data occurs by comparing it to landing data recorded by processors, a time consuming and nonstandard process. Optimal information collection would capture electronic data streams from fishers and from processors, and relate this data to spatio-temporal data collected on the vessel. An additional EFCL goal is to develop technology to use fishing vessels for collecting environmental data in relation to catch effort (for example: conductivity, temperature, and depth), and in relation to scientific data collection needs.

The on-board EFCL prototype, an application on a PC, will sample location data from a GPS. Fish catch data will be key entered into a custom application that will allow

integration with commercial charting packages. The design is modular, to allow, for example, different gear types to be used and to exploit emerging technology within an overall coherent design while allowing high levels of data security.

Bundled data will be transmitted to shore database/s via modem/cellular-phone or satellite device to a web accessed database. A research interface will allow access to central data and GIS analysis tools. Recording of CTD data from autonomous net mounted sensors during fishing events is also planned. Reconciliation and integration with fish ticket data will be a part of the system.

We completed the system design in two states. In July, 1998, a Draft System Design was prepared and distributed /presented to many data and system users. In October that same year an opportunity was offered for partners to join the NWFSC in a Cooperative Research and Development Agreement (CRADA). In February 1999 supplemental funding was made available to the project to add an observer module to the system. Following review of dozens of data collection systems and comments, the System Design was finalized in April.

For more information please contact Stewart Toshach at stoshach@noaa.gov, or at (206) 860-3200.

3. Chartered Coastwide Slope Surveys - Although resource surveys have been conducted on the West Coast continental slope periodically since 1984 to provide critical information to assess the status of the deep-water complex species, there is a scarcity of data on the size, age, maturity, and distribution of these and other species. These surveys also have often not had sufficient geographical coverage to resolve stock trends at the level of confidence desired for stock assessment and management. To help resolve this, the NWFSC began annual resource surveys of the continental slope species in 1998 using four chartered commercial fishing vessels. During fall 1999, the second survey was completed. The third survey will begin in summer of 2000.

Data obtained in this new survey series are being used to develop indices of relative abundance, for example, measures of catch-per-unit-effort (CPUE), to produce accurate results for stock assessment analyses and to provide additional insight regarding the biology and life history strategies of the slope species. Additional biological information about the slope species is being recorded, such as length frequency, sex, and age. Age estimations are made from examining otoliths or other age structures.

For these yearly events, the NWFSC is examining an area of the slope zone roughly from Cape Flattery, Wash. to Morro Bay, Calif. at depths of 100 to 700 fathoms. Through the exempted fishing permit process, participating boat owners have been reimbursed half in cash, the balance being paid by selling fish caught during the survey and in subsequent fishing trips.

West Coast crafts can take on board only two or three scientists, which limits the range of data that can be gathered. Thus, it provides narrowly focused research that cannot replace multi-project efforts handled by dedicated research vessels such as NOAA's *Miller Freeman*. The researchers approached this problem by employing new, off-the-shelf, high-technology gear for collecting and recording data. Primarily three electronic devices have been deployed, all linked to a single, portable computer: a compensating scale that adjusts to the roll, pitch and motion of the boat while weighing fish; an electronic fish measuring board that also allows the survey crew to record weight and species identification; and a device that tracks the trawl net as it moves along the bottom, allowing scientists to determine the success of the tow.

For more information, please contact Dr. Waldo Wakefield at waldo.wakefield@noaa.gov or at 541-867-0243; or contact Bill West at bill.west@noaa.gov or at 206-860-5619.

4. Summary of GIS program for West Coast Essential Fish Habitat-Groundfish - Available Base maps and baseline data.

Current base map data consists of two datasets

1. Coastline: West Coast state boundaries and coastline. National Ocean Service 1:250,000 coastline data.
2. Exclusive Economic Zone (EEZ): Northern boundary based on data received from NOAA-NOS; western and southern boundary from second-hand data sources. Created October 10, 1995.

Biological data

1. Slope and triennial survey data from RACEBASE: This dataset contains all data from survey fishing operations collected during NMFS, AFSC, RACE Division research surveys (bottom trawls, midwater trawls). Species point locations were generated from the latitude and longitude provided in the tabular data. Distribution of 44 species mapped from triennial surveys. Distribution of 37 species mapped from slope surveys. (35 of these species mapped with both surveys). The general geographic extent of the surveys is from Washington State to the Channel Islands, CA. Survey years, 1977-1995. We currently have the capability to directly query RACEBASE for more extensive data analysis, such as species catch rates, and for including data from more recent surveys (post-1995).
2. NMFS egg and larval data: Dataset provided by the UW Fish Collection. Point locations of egg and larval collection were generated from the latitude and longitude provided in the tabular data. Distribution of eggs and/or larvae for 20 species were mapped from this dataset. Geographic coverage is from Washington State (48° N latitude) to Northern California (~ 40° N latitude).

Neuston samplers were used to sample the surface layer. Bongo nets were used to sample the water column during oblique tows to a maximum of 200 m depth (as described in Doyle, 1992). Survey years, 1980-1987, primarily during spring.

3. CalCOFI egg and larval data: Dataset compiled by Jim Kellogg, Tierra Data Systems for NMFS, Southwest Fisheries Science Center. Distribution of eggs and/or larvae for 20 species mapped from this dataset. Survey years, 1951-1997.
4. Trawl logbook data: This is the catch data for commercial trawl fisheries. Data for 1996 has been summarized by trawl logbook blocks (generally, 10 minute latitude and longitude blocks). We currently have access to California, Oregon, and Washington logbook data (by 10 minute block) that has been submitted to the PacFin database. The years available vary by state, 1987-1998 are available for Washington and Oregon, 1981-1997 are available for California. Data includes total catch by pounds, fishing effort by hours, and catch for selected species or species groups by pounds
5. Hook and Line data: Dataset extracted from PacFin database. Data provided as number of landings, weight (metric tons) of landings, and number of vessels for 13 species (or species groups) based on nine generalized port groups. Exact locations of fish cannot be mapped. We have created graphs that show the proportion of each species and total weights for all landings. Geographic extent of this data is the entire west coast. The dataset provided to us includes monthly data for 1996 and annual data for 1994 and 1995.
6. NOAA West Coast Data Atlas. This is a digital atlas of generalized distribution maps for various life history stages of fourteen groundfish species. It was digitized from a hard-copy atlas, "West coast of North America coastal and ocean zones strategic assessment: Data Atlas", published in 1990 by NOAA, NOS.
7. Data for kelp bed distribution is currently being compiled for all west coast states.

8. Software

We are currently using Arc/Info and ArcView as our primary GIS software.

1. Bathymetric data sources

Bathymetry is provided by the Alaska Fisheries Science Center.

1. A fairly continuous, but undocumented set of bathymetry contours is used for small scale map output. This data set was found on the Burroughs machine at AFSC.
2. Additional bathymetry datasets include linear contours created from NOS multibeam data (from "Global Relief Data" CD-ROM - 15 second intervals) and from NOS survey data (from "Terrain Base" CD-ROM - 30 second intervals). Both data sets were created by Angie Greig, January 29, 1996. These data sets are more accurate than the Burroughs data, but do not have continuous coverage of the west coast.

3. The Southwest Fisheries Science Center has generated a coverage of bathymetry contours which incorporates the NOS bathymetry point data and data from Lamont-Doherty Lab which provides bathymetry by 2 minute lat/long cells. This data has not been quality-controlled.

For more information please contact Allison Bailey at allison.bailey@noaa.gov, or at (206) 860-6794.

5. Age readers - Age composition data are critical for studies of fish growth, recruitment patterns, bathymetric dispersion rates, and application of age-structured assessment methods. The group of four age readers--the fourth member being hired in 1999--that forms part of the cooperative ageing project continue to contribute to many projects. In 1998 the group produced ages for Dover sole and sablefish. In 1999 and during the first part of 2000, the technicians did production ageing on canary rockfish and petrale sole (1999), and bank rockfish and darkblotched rockfish (2000). In addition, some production reading for Pacific Ocean Perch (for the Alaska Fisheries Science Center) was completed. The readers contributed ages for two research projects (Depth Specific Sampling for the NWFSC, and Sablefish validation for the Southwest Fisheries Science Center) and began ageing the backlog of sablefish. The ageing lab has participated in a Dover sole ageing workshop and interagency otolith exchanges through the Committee of Age Reading Experts (CARE). In May, 2000, the ageing lab will participate in a CARE-sponsored Ageing Workshop to teach skills and learn new techniques between many labs along the West Coast. Ageing technicians also presented results of ageing research to the effects-of-ageing workshops at the Sitka meeting (2000).

For more information please contact Dr. Kevin Piner at kevin.piner@noaa.gov, or at (541) 867-0340.

6. Depth-specific sampling project - In 1999, the FRAMD implemented a depth-specific sampling project (DSSP) with the assistance of the commercial trawling industry and the Oregon Department of Fish and Wildlife (ODFW), in efforts to collect depth-specific biological data over a 12-month period. The objective of the project is to provide detailed information regarding the depth and seasonal migration habits of the deep-water complex species. These research data will also be used to:

- (a) examine the best times for conducting research surveys intended to produce accurate and precise estimates of abundance over time for groundfish populations;
- (b) objectively summarize logbook information routinely collected from the trawl fishery throughout the year;
- (c) improve critical assumptions regarding fish stock structure and life history strategies necessary when conducting stock assessments; and
- (d) provide information useful for developing workable and effective future cooperative research projects. Researchers expect it to provide depth-specific biological information on the deep-water complex species and benefit stock assessment

analyses by helping to document critical assumptions regarding stock structures.
During 2000, the sampling effort will be done with chartered vessels.

For more information please contact Cyreis Schmitt at cyreis.schmitt@noaa.gov, or at (541) 867-0127.

7. Economics research program - During 1999, the NWFSC began to develop an economics program that is focusing on providing economic analyses related to developing and implementing of fisheries management regimes that comply with the Sustainable Fisheries Act (SFA). The program also provides technical support for the Pacific Fishery Management Council and National Marine Fisheries Service's Northwest Region office. The program works with the Regulatory Flexibility Act and handles community impact analyses of proposed and alternative management options.

For more information please contact Dr. Richard Methot at richard.methot@noaa.gov, or at (206) 860-3365

8. Biology of West Coast Sablefish - This is a cooperative pilot project with Oregon State University to develop a recruitment index for sablefish from a survey of pelagic juveniles. In the past year, we prepared a draft manuscript summarizing the results of our study on bathymetric variation in sablefish reproduction and fecundity. Sablefish living in shallow water (< 400 fm) are significantly younger but larger and more fecund (124 eggs/g vs 93 eggs/g) than deep living sablefish. Ovaries of adult sablefish collected during the previous two winters (prior to spawning) were analyzed. The data generally suggest that spawning in sablefish does not proceed sequentially by age-class, contrary to our hypothesis. However, we do not believe that the question has been definitively answered because of inadequate temporal coverage of samples and possible confusion due to pooling of samples from a variety of depths. Otoliths of pelagic juveniles collected in 1998 are being prepared for birthdate analysis. We began our pelagic juvenile survey in April, 1999. We completed five sampling trips along transect lines off northern California (40° 50' N), Oregon (44° 50' N), and Washington (47° 00' N). More trips were scheduled. Pelagic juveniles are being collected by simultaneously towing a 1 m manta net and a 3.7 m neuston trawl net at night at stations spaced 2.5 mn apart beginning in 60 fin. We have found juvenile sablefish as far offshore as we have sampled (- 55 nin; > 1,000 fin).

For more information please contact Dr. Richard Methot at richard.methot@noaa.gov, or at (206) 860-3365

9. Pot/longline survey - Collaborating with the NWFSC FRAM Division during 1998 and 1999, the Oregon Department of Fish and Wildlife (ODFW) completed a three-part project with pot and longline gear that may provide a new survey tool for sablefish off the Oregon coast. The experiments were conducted aboard two commercial vessels and looked at the effectiveness of pot and longline gear in catching sablefish. During

the first year they attempted to measure the presence or absence of sablefish at deeper ranges—between 600 to 800 fathoms, and between 800 to 1000 fathoms—outside the current limit of the NMFS trawl resource surveys. During 1999, they subjected both gears to a more rigorous testing, and it appears fixed gear surveys could be used for depths where current NMFS trawl surveys do not sample.

For more information please contact Cyreis Schmitt at cyreis.schmitt@noaa.gov, or at (541) 867-0127.

APPENDIX 1

Recent Publications and Reports Pertaining to Groundfish and Marine Habitats by Authors at the Northwest Fisheries Science Center

Arkoosh, M. R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J. E. Stein, and U. Varanasi. Increased susceptibility of juvenile chinook salmon (*Oncorhynchus tshawytscha*) from a contaminated estuary to the pathogen *Vibrio anguillarum*. Transactions of the American Fisheries Society.

Arkoosh, M. R., E. Clemons, A. N. Kagley, R. Olson, P. Reno, E. Casillas, and J. E. Stein. Effect of pollution on fish diseases: Potential impacts on salmonid populations. Journal of Aquatic Animal Health. (In press).

Cailliet, G. M., A.H. Andrews, W. W. Wakefield, G. Moreno, and K.L. Rhodes. Fish faunal and habitat analyses using trawls, camera sleds and submersibles in benthic deep-sea habitats off central California. Oceanol. Acta 22: 579-592.

Casillas, E., B. B. McCain, M. Arkoosh, J. Stein and U. Varanasi. 1997. Estuarine pollution and juvenile salmon health: Potential impact on survival. In Emmett, R. L. And M. H. Schiwe (eds). Estuarine and ocean survival of Northeastern

Clemons, E., M. R. Arkoosh, and E. Casillas. Enhanced Superoxide anion production in act-

Collier, T. K., L. L. Johnson, M. S. Myers, C. M. Stehr, M. M. Krahn, and J. E. Stein. 1997.

Collier, T. K., L. L. Johnson, C. M. Stehr, M. S. Myers, and J. E. Stein. 1998. A comprehensive assessment of the impacts of contaminants on fish from an urban waterw-

Collier, T. K., L. L. Johnson, M. S. Myers, C. M. Stehr, M. M. Krahn, and J. E. Stein.

1998. Fish injury in the Hylebos Waterway of Commencement Bay, Washington.
NOAA Tech Memo. NMFS-NWFSC-36.

Crone, P. R., R. D. Methot, R. J. Conser, R. R. Lauth, and M. E. Wilkins. 1997.
1998: Stock assessment and fishery evaluation. Pacific Fishery Management
Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon. 135 p.

Status of the

Crone, P. R., D.B. Sampson, and 8 other authors. 1998. Evaluation of assumed error
Society publication.

Greene, H. G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E.

Sullivan, J.E.

Huffman, P. A., M. R. Arkoosh, and E. Casillas. Characteristics of peripheral

blood cells fro

Hunt, S. L., T. J. Mulligan and Kenichiro Komori. 1999. Oceanic feeding habits of
chinook salmon, *Oncorhynchus tshawytscha*, off northern California. Fish. Bull.
97(3): pages?

Johnson, L. L., B. Norberg, M. L. Willis, H. Zebrowski, and P. Swanson. 1997.

Isolation, cha

Johnson, L. L., S.-Y. Sol, D. P. Lomax, G. Nelson, and E. Casillas. 1997. Fecundity
and egg weight in English sole (*Pleuronectes vetulus*) from Puget Sound, WA:
Influence of nutritional status and chemical contaminants. Fish. Bull. 92:
232-250.

Johnson, L. L., D. Misitano, S. Sol, G. Nelson, B. French, G. Ylitalo, T. Hom. 1998.
Contaminant effects on ovarian development and spawning success in rock-sole
(*Lepidopsetta bilineata*) from Puget Sound, WA. Trans. Am. Fish. Soc.
(In press).

Johnson, L. L., D. Misitano, S. Sol, G. Nelson, B. French, G. Ylitalo, T. Hom.

1997. Conta

Johnson, L. L., J. T. Landahl, L. A. Kubin, B. H. Horness, M. S. Myers, E. Casillas, T. K.
Collier, and J. E. Stein. 1997. Assessing the effects of anthropogenic stressors
on Puget Sound flatfish populations. Neth. J. Sea Res. (In press).

Kope, R. G. 1999. Pacific Coast Salmon. In Our Living Oceans: Report on the status of
U. S. living marine resources. Unit 12, p. 149- 155. U.S. Dept. Commerce,

NOAA Tech.

Landahl, J. T., L. L. Johnson, T. K. Collier, J. E. Stein, and U. Varanasi 1997.

Marine pollutio

Livingston, P. and R.D. Methot. 1998. Incorporation of predation and cannibalism into
assessment models.

McCrea, J.E., Jr., H.G. Greene, V.M. O'Connell, and W.W. Wakefield. 1999. Mapping marine habitat

- Methot, R. D. 1998. Application of Stock Synthesis to NRC test data sets. In V. Restrepo (ed)
- Myers, M. S. L. L. Johnson, T. Hom, T. K. Collier, J. Stein, And U. Varanasi. 1998. Toxicopathic
45(1): 47-67.
- Rogers, J. B. and T. L. Builder. 1999. Pacific Coast Groundfish Fisheries. In Our Living Oceans: Rep
- Rogers, J. B., M. Wilkins, D. Kamikawa, F. Wallace, T. Builder, M. Zimmerman, M. Kander, and B. Culver. 1996. Status of the remaining rockfish in the Sebastes complex in 1996 and recommendations for management in 1997. Appendix E in Appendix volume II to the status of the Pacific coast groundfish through 1996 and recommended acceptable biological catches for 1997. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon. 59 p.
- Roubal, W., D. Lomax, M. Willis, and L. Johnson. 1997. Purification and partial characterization of English sole vitellogenin. Comp. Biochem. Physiol. Vol. 118B, No. 3, pp 613-622.
- Wainwright, T.C. and R. G. Kope. 1999. Short communication: methods of extinction risk assessment