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The 1997 Pacific West Coast Upper Continental Slope Trawl Survey of Groundfish Resources off Washington, Oregon, and California: Estimates of Distribution, Abundance, and Length Composition

by
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U.S. DEPARTMENT OF COMMERCE
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The 1997 Pacific West Coast Upper Continental Slope Trawl Survey of Groundfish Resources off Washington, Oregon, and California: Estimates of Distribution, Abundance, and Length Composition

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ABSTRACT

The Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering Division (RACE) conducted a groundfish bottom trawl survey of the West Coast upper continental slope (WCUCS) in 1997. The survey area stretched from the U.S.-Canada border (near Nitinat Canyon) to 34°50'N lat. (near Pt. Arguello) in waters from 183 to 1,280 m deep. This was the tenth survey in an ongoing series to monitor long-term trends in the distribution and abundance of WCUCS groundfish populations. The spatial coverage of the WCUCS groundfish trawl survey was expanded in 1997 to include all of the International North Pacific Fisheries Commission statistical areas between Point Conception (34°30'N lat.) and the U.S./Canada border. Sampling density was reduced to one-third the density of previous surveys so that the expanded area could be surveyed within a 5-week period. Sampling was conducted aboard the NOAA ship *Miller Freeman*. We successfully sampled 182 of the 200 stations that we had previously established. Catches included 149 different species of fishes from 55 fish families. Two-hundred and twelve different invertebrates representing 10 phyla and 18 classes were caught but only 125 of these invertebrates were identified to the species level. With all depth strata combined and when all INPFC areas and depths were combined, Pacific whiting (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) had the highest catch rates in the U.S.-Vancouver, Columbia, and Eureka INPFC areas. In the Monterey and Conception INPFC areas, Dover sole (*Microstomus pacificus*), longspine thornyhead (*Sebastoblobus*

altivelis), Pacific whiting, and sablefish (*Anoplopoma fimbria*) had the highest catch rates when all depths were combined. The biomass estimates for the Dover sole, sablefish, longspine thornyhead, and shortspine thornyhead (*Sebastolobus alascanus*) varied by stratum and INPFC area. The total biomass estimates for all INPFC areas and strata combined were 109,858 t, 71,019 t, 101,636 t, and 26,393 t for Dover sole, sablefish, longspine thornyhead, and shortspine thornyhead, respectively

The survey design and the methods used are described, the data collected are summarized, and the results of analyses of distribution, abundance, and biological parameters are presented. Data on water temperature, catch composition, relative abundance, and geographic distribution are reported. Estimates of biomass, population abundance, and length composition are also presented. Appendices include position and catch listings for each haul, catch rates of fish and invertebrates, and population size compositions.

CONTENTS

INTRODUCTION

Fishery-independent data obtained from the Alaska Fisheries Science Center's (AFSC) West Coast upper continental slope (WCUCS) groundfish trawl surveys are used by fishery managers to assess stock conditions and to establish annual harvest guidelines for the commercially valuable fish species inhabiting the WCUCS. These species, referred to as the deepwater complex (DWC), include sablefish (*Anoplopoma fimbria*), shortspine thornyhead (*Sebastolobus alascanus*), longspine thornyhead (*S. altivelis*), and Dover sole (*Microstomus pacificus*). The Resource Assessment and Conservation Engineering (RACE) Division of the AFSC conducted its first groundfish assessment survey of the WCUCS in 1984 and has done so annually since 1988. The WCUCS covers habitat 183-1,280 m deep from the U.S.-Canada border to 34°30'N lat. and is divided into five International North Pacific Fisheries Commission (INPFC) statistical areas including the U.S.-Vancouver, Columbia, Eureka, Monterey, and Conception areas (Fig. 1).

The spatial coverage of annual slope surveys has varied. Prior to 1997, WCUCS groundfish bottom trawl surveys were limited in their spatial coverage of INPFC areas because of limited vessel time and other logistic considerations. The 1996 survey was the most extensive and covered the U.S.-Vancouver and Columbia INPFC areas (Lauth 1997a). The U.S.-Vancouver INPFC area was surveyed once before in 1993 in addition to the northern portion of the Columbia INPFC area (Lauth et al. 1997). Central and/or southern sections of the Columbia INPFC area (45°30' to 43°00'N lat.) were also surveyed in 1984, 1988, 1989, and 1992 (Raymore et al. 1990, Parks et al. 1993, Lauth et al. 1997). The Eureka INPFC area was surveyed in 1990 (Lauth et al. 1997) and again in 1995 (Lauth 1997b), and the northern section of the Monterey INPFC area (38°20' to 40°30'N lat.) was surveyed in 1991 (Lauth et al. 1997). The Southwest Fisheries Science Center (SWFSC) conducted two other groundfish bottom trawl surveys in 1987 and 1988 which covered parts of the Conception and Monterey INPFC areas between 34°30' and 36°30' N lat. (Butler et al. 1989).

During the 1993 AFSC survey, concerns were raised about the poor performance of the slope survey trawl and, consequently, the validity of slope survey data. These concerns prompted an external review of the slope survey by a panel of fishery scientists in July 1995. The panel criticized the lack of synopticity in survey coverage and the performance of survey gear (Parma et al. 1995). Survey gear performance was investigated during an experimental gear cruise aboard the NOAA ship *Miller Freeman* in 1994. During that cruise, we experimented with ways to stabilize the sampling trawl, learned more about how to evaluate trawl performance, and investigated alternative methods of surveying groundfish resources using a video camera sled. Regular survey work resumed in 1995 after several changes were made to the sampling trawl and to towing protocol. The changes stabilized the slope trawl and resulted in more consistent trawl performance (Lauth et al., 1998).

The spatial coverage of WCUCS groundfish trawl surveys was expanded in 1997 to include all of the INPFC areas between Point Conception (N. 34°30' lat.) and the U.S.-Canada border. Sampling density was reduced compared to previous surveys so that the expanded area could be surveyed within a 5-week period.

The objective of this report is to document the survey design and field procedures, summarize the survey data, and present the results of the standard RACE analyses for the 1997 WCUCS survey for each of the INPFC statistical areas. Included are summaries of catches, distribution, abundance, and size composition for major components of the community, as well as analyses of age-length and length-weight relationships of selected species.

SURVEY METHODS

Survey Period and Sampling Area

The U.S.-Vancouver, Columbia, Eureka, Monterey, and Conception INPFC statistical areas (U.S.-Canada border to 34°30'N lat.) were surveyed between 20 October and 25 November. Survey sampling began near Cape Arguello (34°50'N lat.) and progressed northward to Nitinat Canyon (48°05'N lat., Fig. 1). Water depth at survey stations ranged between 183 and 1,280 m (100-700 fm).

Vessels and Sampling Gear

The NOAA Ship *Miller Freeman* is a 65.5 m stern trawler powered by a 2,300 continuous horsepower engine. The ship is equipped with dual net reels, a Rapp-Hydema warp tensioning system, Wesmar Fish Eye net sonar system, Furuno netsonde, EQ-50 depth sounder, and Global Positioning System (GPS) navigational aids. A high-opening Nor'eastern trawl (Fig. 2) constructed of polyethylene mesh and equipped with mudsweep roller gear (Fig. 3) was used to collect all samples. This trawl, built and rigged to RACE Division gear standards, has a 27.2 m headrope and a 37.4 m footrope. The body is constructed of 127 mm stretched-mesh polyethylene netting, 89 mm stretched-mesh web in the codend, and a 32 mm stretched-mesh codend liner. Three 55 m dandylines made of 16 mm galvanized steel cable lead from each wing to a pair of

1.8 x 2.7 m steel V-doors weighing 1,000 kg each. Each door has a 4-point bridle on its backside made with 13-mm long-link chain having 33 links forward and 22 links aft in both the top and bottom. Instruments attached to the trawl gear to monitor gear performance included the SCANMAR equipment for measuring net dimensions, a Furuno wireless netsonde for real-time monitoring of the headrope height, and one bottom contact sensor on the footrope. A Wesmar net sonar was attached to the net headrope and used to assure that the trawl gear was performing to engineering specifications during the wire marking procedure and during the initial gear calibration. A Richard Brancker XL-200 submersible data logger was attached to the trawl and used in conjunction with a Trimble Global Positioning System (GPS) unit to record data on the time, depth, water temperature, and geodetic position during each trawl. These data were combined with fishing dimensions of the net, producing a comprehensive set of haul data describing gear performance in space and time.

Trawl Station Allocation

There were 200 stations along 31 east-west tracklines spaced 50 km apart between the U.S.-Canada border and 34°50'N lat. near Cape Arguello. Stations south of Bodega Head (38°20'N lat.) were new and those to the north were a subset of the stations already sampled during previous WCUCS surveys (Lauth 1997a and Lauth 1997b, Lauth et al. 1997, Parks et al. 1993). A combined systematic and random design was used for selecting the survey bottom trawl stations. Sampling was conducted between 183 and 1,280 m in six strata of 183 m (100 fm) depth intervals (183-365 m, 366-547 m, 548-730 m, 731-913 m, 914-1,095 m, and 1,096-1,280 m). The number of sampling stations within each depth stratum were allocated proportional to the trackline length across each depth interval at the rate of one station per 13.0 km of linear trackline length (e.g., a stratum with a trackline length of 30 km would be allocated 3 stations). Tracklines were 50 km apart and positioned roughly perpendicular to the coastline. To assure even depth coverage within a stratum, the depth range of each stratum was divided into a number of bins equal to the number of stations scheduled to be surveyed that year. Nominally, a bin was identified by its midpoint target depth. Stations were then randomly assigned to tracklines by picking target depths without replacement.

Trawling Procedures

Sampling was done on a 24-hour basis. Stations were located by GPS and echosounder and then surveyed prior to towing. If the terrain was determined to be too rough or too steep to allow the successful completion of a tow, we searched for an alternate site with a similar target depth within a 10 km radius of the original. If no favorable ground was located the station was declared untrawlable and abandoned. If the gear was damaged during the tow severely enough to affect catch composition, or if the gear performance was in any way judged to be unacceptable (e.g., mud, large trap entangled in the net), the haul was considered unsatisfactory and the station was either repeated or abandoned. Unsuccessful tows were not used in the analyses.

Scientists, officers, and deck crew worked together to standardize fishing procedures. A scientist familiar with trawling was always present in the trawl house during fishing operations to monitor adherence to standardized protocols. Also, AFSC gear experts participated in the cruise to ensure that the trawl gear and associated rigging were properly maintained. The scope ratio varied with depth and ranged from 2.5:1 at shallower depths to 1.6:1 at the deepest depths (Table 1). Vessel speed while the trawl was being set was between 5.5 and 6.5 km/hr. Vessel speed gradually decreased to 4.3 km/hr (2.3 knots) at brakeset and this speed was maintained as closely as possible throughout each haul. The target duration of a trawl sample was 30 minutes. A haul began when the ground-gear first touched bottom and ended when it lost contact with the bottom. The Furuno netsounder was used to monitor ground-gear contact during a haul, but actual bottom time was determined from the bottom contact sensor data upon completion of the tow. Position data were collected at 2-sec intervals for each haul using a Global Positioning System (GPS) receiver. The position data were used to monitor ground speed, track the trawl's path, and estimate distance fished. Average vessel speed over ground and distance-fished were calculated from the position data and the trawl's actual bottom time.

Catch Sampling Procedures and Biological Data Collection

Standard RACE catch sampling procedures were followed as described by Smith and Bakkala (1982). Catches less than 1 metric ton (t) were dumped directly onto a sorting table for processing. Catches larger than 1 t were weighed by an electronic load cell and then dumped onto the deck, into the fish bin, onto the sorting table, or any combination of the three. In all cases, the entire catch was processed. Large catches were made more manageable for processing by weighing and measuring a random subsample of the dominant fish species (e.g., Pacific whiting or spiny dogfish) and discarding the remainder of that species overboard. The non-subsample catch weight for that species was the difference between the sum of the subsample weight for that species and the catch weights for all other species and the total catch weight measured by the electronic load cell. Fishes and invertebrates were identified to species as time and expertise permitted. After the catches were sorted by species, weighed, and enumerated, biological data and specimens were collected. Samples of all fish species were measured to characterize their size composition. Sex determination and fork length measurements were done for up to 200 specimens of each of the primary target species, rockfishes, and flatfishes from each haul. The same was done for grenadiers except they were measured from the tip of their snout to the insertion of the anal fin ray. Other non-target species were measured as unsexed and all skates and rays were measured from wingtip-to-wingtip. Otoliths were collected for age determination from arrowtooth flounder (*Atheresthes stomias*), darkblotched rockfish (*Sebastes crameri*), Dover sole, Pacific grenadier (*Coryphaenoides acrolepis*), sablefish, shortspine thornyhead, splitnose rockfish (*S. diploproa*), and longspine thornyhead. Otolith collections were depth-, area-, and size-stratified so that sampling effort was more evenly spread over the entire survey area. There were three depth zones (183-549 m, 550-914 m, and 915-1,280 m) and three geographical areas. Geographical areas were separated into southern (to 38°50'N lat.), central (to 43°20'N lat.), and northern areas (to U.S.-Canada border). Otoliths were collected from size-stratified samples of 5 fish per sex/centimeter interval in each depth zone and geographical area.

Additional biological collections were made at the request of other scientists from a number of laboratories, agencies, and universities interested in West Coast fishery resources. These collections were taken for studies involving age and growth, genetics, and other fish life history parameters.

Oceanographic Data Collection

Sea surface temperatures were taken at all stations using a bucket thermometer. Bottom temperatures were measured using a Richard Brancker XL-200 data logger mounted to the trawl headrope. Additional information on temperature profiles from this cruises is available on request from the author.

Data Analysis

Several analyses are performed routinely on RACE survey data. These include:

1) estimation of relative abundance,
2) estimation of population biomass,
3) estimation of population numbers, and
4) estimation of the population's size composition.

We used the area-swept method as described by Gunderson and Sample (1980) to estimate population biomass and numbers. Briefly, this method entails standardizing samples from each station into catch per unit of effort (CPUE) in terms of either kilograms or numbers per hectare (kg/ha, no./ha) and calculating the arithmetic mean for each sampling stratum. Length-frequency data were weighted by CPUE (no./ha) and expanded to the total estimated population abundance to estimate the population size composition for each species. Sablefish age data were available for this report so size composition estimates were applied to age-length keys to obtain estimated age compositions. Sablefish age-length keys were made by combining ages from all depths, areas, and sexes to increase the sample size. Since sablefish lengths at age were different between the sexes, and were more variable at greater depths, further analyses was done using three depth-specific (the same depth zones listed on p. 9) and sex-specific age-length keys.

RESULTS

Haul, Catch, and Biological Data

One-hundred-ninety tows were attempted during the survey. Out of 200 possible stations, 182 stations were sampled successfully (Fig. 1). Eighteen of the possible 200 stations were abandoned because the bottom was too rough or too steep. The remainder of the attempted tows were unsuccessful due to trawl hang-ups, net rips, bad bottom, excessive mud in the tows, crossing into an adjacent depth stratum, or gear deployment problems. SCANMAR net mensuration data were obtained from 142 tows, submersible bathythermograph data from 186 tows, bottom contact sensor data from 188 tows, and GPS course and position data from 190 tows. Sampling densities ranged from 2.0 hauls/1,000 km^2 in the U.S.-Vancouver INPFC area to 4.1 hauls/1,000 km^2 in the Monterey INPFC area (Table 2).

Mean net widths were calculated for each trawl haul. The relationship was linear between mean net width and gear depth, and mean net width and wire length (Fig. 4). An overall mean path width of 16.81 m was calculated for the entire survey using 142 of the 182 tows with good performance. The range of mean net widths for these 142 tows was 13.14 m to 19.01 m and the standard deviation was 0.85 m. The overall mean path width was used in area-swept calculations for hauls where actual width measurements were unavailable.

Table 3 summarizes the biological data collected from fish species. Specimen ages from collected otoliths were determined by researchers from the Pacific States Marine Fisheries Commission and Oregon Department of Fish and Wildlife. Results from collected data and specimens for several special studies requested by colleagues in other agencies or institutions will be reported elsewhere.

A total of 149 fish species representing 55 fish families were identified over the course of the survey. Table 4 lists the frequencies of occurrence, depth range, and the latitudinal range for all fishes identified in trawl samples. Similarly, Table 5 shows ranges and frequencies of occurrence for invertebrates representing 10 phyla and 18 classes. Of the 212 invertebrates listed, 125 were identified to species. Appendix A presents detailed station information for each haul and catch weights of the major fish and invertebrate species caught in each haul. The number of individual fish length observations of each fish species are reported in Tables 6 to 11 by depth stratum and INPFC area.

Temperature Data

Sea surface temperatures ranged from 11.7° to 18.9°C and bottom temperatures ranged from 3.1° to 10.3°C (Fig. 5). Mean sea surface temperature was 14.7°C and mean bottom temperature was 5.4°C. Sea surface temperatures generally decreased and were more variable with increasing latitude.

Bottom temperatures generally decreased with increasing depth within the survey area.

Relative Density and Distribution of Species

The 20 most abundant groundfish and selected crab species are presented with all depth strata combined by INPFC area (Table 12), with all INPFC areas combined by depth stratum (Table 13), and by INPFC area and depth stratum (Tables 14-18). Pacific whiting (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) had the highest catch rates in the U.S.-Vancouver, Columbia, and Eureka INPFC areas with all depth strata combined and when all INPFC areas and depths were combined (Table 12). In the Monterey and Conception INPFC areas, Dover sole, longspine thornyhead, Pacific whiting, and sablefish had the highest catch rates when all depths were combined (Table 12). With all INPFC areas combined by depth stratum, Pacific whiting and spiny dogfish had the highest catch rates in the shallowest two strata (Table 13). The fishes with the highest catch rates in successively deeper strata were Dover sole, sablefish, longspine thornyhead, and Pacific grenadier, respectively.

Catch rates by depth stratum varied among the INPFC areas (Tables 14-18). In general, Pacific whiting were the dominant species in shallower strata in the U.S.-Vancouver, Columbia, and Eureka INPFC areas, and stripetail rockfish (*Sebastes saxicola*), Pacific whiting, or Dover sole had the highest CPUE in the same two strata in the Monterey and Conception INPFC areas. For the deeper strata, the CPUE of longspine thornyhead was among the highest catch rate for all INPFC areas, and either Pacific or giant grenadier (*Albatrossia pectoralis*) had among the top three or four CPUEs in the deepest stratum.

Complete listings of the relative abundance of all fish and invertebrate species ranked by mean CPUE, depth stratum, and INPFC area are presented in Appendix B.

Maps of the geographical distribution and relative catch rates of selected important groundfish species and true Tanner crab (*Chionoecetes tanneri)* are presented in Figures 6-19 in alphabetical order. These maps show the locations of hauls where these species were caught. Catch rates were categorized as: 1) greater than zero and less than or equal to the mean CPUE; 2) greater than the mean CPUE and less than or equal to one standard deviation from the mean; 3) between one and two standard deviations greater than the mean CPUE; and 4) over two standard deviations greater than the mean CPUE.

Biomass and Population Estimates

Abundance estimates of biomass in metric tons (t) and associated coefficients of variation (CV) are presented for selected taxa by stratum and area in Tables 19 through 24. Similarly, estimates of population numbers with associated CVs are presented for important species groups in Tables 25 through 30. The total number of hauls and hauls with catch weight, catch number, and length data by stratum and area for the various taxa are represented in Tables 31 through 36.

The biomass estimates for the DWC (see p. 1) varied by species, stratum, and INPFC area. The total biomass estimates for all INPFC areas and strata combined were 71,019 t, 109,858 t, 101,636 t, and 26,393 t for sablefish, Dover sole, longspine thornyhead, and shortspine thornyhead, respectively (Table 19). The stratum with the greatest estimated biomass for each DWC species was Stratum 3 for sablefish (22%), Stratum 2 for Dover sole (39%), Stratum 4 for longspine thornyhead (35%), and Stratum 5 for shortspine thornyhead (23%). The INPFC area with the highest proportion of total estimated biomass for each DWC species was the Columbia area for sablefish (34%), and the Monterey area for Dover sole (35%), longspine thornyhead (30%), and shortspine thornyhead (29%).

Readers should be aware that the biomass and population estimates presented here are not absolute estimates since herding by doors and bridles and escapement underneath the trawl's footrope, around the net's opening, and through the net's meshes can affect the bottom trawl catches (Gunderson 1993). For lack of data on species-by-species catchability, abundance calculations are based on the assumption that all fish in front of the trawl and between the wingtips are captured. The degree of bias introduced by this assumption probably varies among species. For instance, the ability of a fish to avoid the net will depend on the fish's shape, size, speed, and its reaction to the part of the net encountered. Furthermore, the survey covers limited portions of the depth and geographic range of some of these species. As mentioned previously, this survey targets many species and provides general information where it lacks in specific information. These surveys are the only fishery-independent source of information on the abundance, distribution, and length and age-composition for many of these species. Stock assessment scientists utilize our survey results, along with commercial catch data, in order to estimate acceptable biological catch levels.

Size and Age Composition

Estimated population length compositions for several groundfish species are presented in Figures 20-73 by species and by depth stratum.

At the time this report was prepared, the only age data available for analyses were those for sablefish. Population estimates by age group and mean length at age are presented in Tables 37-43 by INPFC area and all INPFC areas combined using an age-length key for all depths, sexes, and areas combined. Lengths at age were different between the sexes and were more variable at greater depths for sablefish, so further analyses were done using three depth-specific and sex-specific age-length keys. The depth strata used for the age-length keys were the same as the biological sampling strata except that sablefish from all INPFC areas were combined to increase the sample size. Results from these analyses are presented in Figures 68-73.

Sablefish age data and results of growth rate, population age composition, and biomass-at-age analyses can be obtained upon request from the author in either printed or digital form. Age data and results from other species can be obtained as it becomes available.

Length-Weight Relationships

From the individual fish weight samples, we determined length-weight relationships for arrowtooth flounder, Dover sole, sablefish, shortspine thornyhead, longspine thornyhead, Pacific grenadier, and splitnose rockfish using a non-linear least squares regression model. Table 43 summarizes the length-weight relationships by sex and for all INPFC areas and sexes combined (including unsexed fish).

Requests for Other Data Analyses

To avoid unnecessary detail and excessive printing costs, appendices listing estimated length compositions for major species and abundance estimates for less commercially important species were not included in this report. However, if the reader requires these or other more detailed analyses, they can be obtained as either printed pages or as computer files upon request from Robert Lauth at (206) 526-4121 (phone) or bob.lauth@noaa.gov (email).

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TABLES

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CITATIONS

Butler, J.L., C.A. Kimbrell, W.C. Flerx, and R.D. Methot. 1989. The 1987-88 demersal fish surveys off central California (34°30'N to 36°30'N). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFC-133, 44 p.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific Coast fishes of North America. Houghton Mifflin Co., Boston, MA., 336 p.

Gunderson, D.R. 1993. Surveys of fisheries resources. John Wiley and Sons, Inc., New York, NY, 248 p.

Gunderson, D.R., and T.M. Sample. 1980. Distribution and abundance of rockfish off Washington, Oregon, and California during 1977. Mar. Fish. Rev. 42(3-4):2-16.

Hughes, S.E. 1976. System for sampling large trawl catches of research vessels. J. Fish. Res. Board Can. 33:833-839.

Lauth, R.R., M.E. Wilkins, and P.R. Raymore Jr. 1997. Results of trawl surveys of groundfish resources of the West Coast upper continental slope from 1989 to 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-79, 342 p.

Lauth, R.R. 1997a. The 1996 Pacific West Coast upper continental slope trawl survey of groundfish resources of Washington and Oregon: Estimates of distribution, abundance, and length composition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-81, 156 p.

Lauth, R.R. 1997b. The 1995 Pacific West Coast upper continental slope trawl survey of groundfish resources off southern Oregon and northern California: Estimates of distribution, abundance, and length composition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-80, 110 p.

Lauth, R.R., S.E. Syrjala, and S.W. McEntire. 1998. Effects of gear modifications on the trawl performance and catching efficiency of the West Coast upper continental slope groundfish survey trawl. Marine Fisheries Review 60(1):1-26.

Nelson, J.S. 1984. Fishes of the world, 2nd edition. John Wiley & Sons, New York, NY, 523 p.

Parks, N.B., F.R. Shaw, and R.L. Henry. 1993. Results of a 1988 trawl survey of groundfish resources of the upper continental slope off Oregon. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-23, 164 p.

Parma, A., R. O'Boyle, J. Maguire, D. Amos, A. Smith. 1995. West Coast groundfish assessments review. Supplemental Attachment F.4. Pacific Fishery Management Council, Portland, Oregon. 35 p.

Raymore, P.A., Jr., and K.L. Weinberg. 1990. 1984 spring and autumn surveys of Pacific West Coast upper continental slope groundfish resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-179, 196 p.

Robins, C.R. 1991. Common and scientific names of fishes from the United States and Canada, Fifth Edition, Am. Fish. Soc., Special Publ. 20, 183 p.

Smith, G.B., and R.G. Bakkala. 1982. Demersal fish resources of the eastern Bering Sea: Spring 1976. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-SSRF-754, 129 p.

APPENDIX A

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97 HILL, P. S., and D. P. DEMASTER. 1998. Alaska marine mammal stock assessments, 1998, 166 p. NTIS number pending.

96 WING, B. L., M. M. MASUDA, C. M. GUTHRIE III, and J. H. HELLE. 1998. Some size relationships and genetic variability of Atlantic salmon (Salmo salar) escapees captured in Alaska fisheries, 1990-95, 32 p. NTIS No. PB99-118697.

95 ORR, J. W., M. A. BROWN, and D. C. BAKER. 1998. Guide to rockfishes (Scorpaenidae) of the genera Sebastes, Sebastolobus, and Adelosebastes of the northeast Pacific Ocean, 46 p. NTIS No. PB99-114217.

94 THROWER, F., R. MARTIN, and R. HEINTZ. 1998. Effect of seawater entry date on 24-hour plasma sodium concentration and survival of juvenile spring chinook salmon (Oncorhynchus tshawytscha) reared in marine net-pens, 18 p. NTIS No. PB98-173545.

93 MURPHY, J. M., N. E. MALONEY, and B. L. WING. 1998. Distribution and abundance of zooplankton in the north Pacific Subarctic Frontal Zone and adjacent water masses, 31 p. NTIS No. PB98-159163.

92 FRITZ, L. W., and S. A. LOWE. 1998. Seasonal distributions of Atka mackerel (Pleurogrammus monopterygius) in commercially-fished areas of the Aleutian Islands and Gulf of Alaska, 29 p. NTIS No. PB98-153703.

91 WING, B. L., and J. J. PELLA. 1998. Time series analyses of climatological records from Auke Bay, Alaska, 90 p. NTIS No. PB98-149206.

90 PACUNSKI, R. E., P. A. LIVINGSTON, and B. S. MILLER. 1998. Food of flathead sole Hippoglossoides elassodon in the eastern Bering Sea, 27 p. NTIS No. PB98-148679.

89 WILKINS, M. E., M. ZIMMERMANN, and K. L. WEINBERG. 1998. The 1995 Pacific west coast bottom trawl survey of groundfish resources: Estimates of distribution, abundance, and length and age composition, 138 p. plus Appendices. NTIS No. PB98-136252.

88 FRITZ, L. W., A. GREIG, and R. F. REUTER. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands, and Gulf of Alaska regions based on groundfish fishery observer data, 179 p. NTIS No. PB98-139298.

87 SINCLAIR, E. H. (editor) 1997. Fur seal investigations, 1996, 115 p. NTIS No. PB98-131790.

86 SINCLAIR, E.H. (editor). 1997. Fur seal investigations, 1995, 188 p. NTIS No. PB98-131808.

85 KINOSHITA, R. K., A. GREIG, and J. M. TERRY. 1998. Economic status of the groundfish fisheries off Alaska, 1996, 91 p. NTIS No. PB98-126170.

84 LAAKE, J., D. RUGH, and L. BARAFF. 1998. Observations of harbor porpoise in the vicinity of acoustic alarms on a set gill net, 40 p. NTIS No. PB98-117641.

83 RUTECKI, T. L., M. F. SIGLER, and H. H. ZENGER JR. 1997. Data report: National Marine Fisheries Service longline surveys, 1991-96, 64 p. NTIS No. PB98-108822.

82 MARTIN, M. H. 1997. Data report: 1996 Gulf of Alaska bottom trawl survey, 235 p. NTIS No. PB98-103930.