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Inshore Rockfish Stock Assessment for the West Coast of Canada in 1998 and Recommendations for 1999/2000

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ABSTRACT

This document contains an interim update on the status of inshore rockfishes. Time series of commercial catch and effort in the directed fishery and bycatch in other fisheries are updated. Recreational landings are updated where data are available. Ongoing work to collate and archive inshore rockfish data is described. The status of research projects undertaken in collaboration with industry is reported. There are no new data or analyses sufficient to identify sustainable harvest targets for inshore rockfishes. Because harvest targets have not been identified or estimated there is no basis for quantifying risk or for providing yield options. Hence, the ability to assess the status of inshore rockfishes remains poor. Reasons for this situation are reviewed, and recommendations are provided for inshore rockfishes subject to constraints on assessment capabilities.

RÉSUMÉ

Le présent document constitue une mise à jour provisoire de l'état des sébastes côtiers. On y trouve une mise à jour des séries chronologiques des captures et de l'effort de la pêche dirigée et des prises accidentelles faites par d'autres pêches. Les captures de la pêche récréative sont aussi mises à jour, du moins pour les données disponibles. Les travaux en cours sur l'obtention et l'archivage des données sur les sébastes côtiers sont présentés et l'on fait rapport de l'état d'avancement des projets de recherche entrepris en collaboration avec l'industrie. Il n'existe pas de données ou d'analyses nouvelles permettant de préciser des cibles de récolte durable pour les sébastes côtiers. Comme il n'a pas été procédé à la détermination ou à l'estimation de cibles de récolte, on ne peut quantifier les risques ou formuler des options de rendement. Par conséquent, nos capacités à évaluer l'état des sébastes côtiers demeurent faibles. Cette situation est examinée et des recommandations, limitées par les contraintes de l'évaluation, sont formulées.

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1 Introduction

This working paper is an interim report on the status of inshore rockfishes. Time series of commercial catch and effort in the directed fishery and bycatch in other fisheries are updated. Recreational landings are updated where data are available. Ongoing work to collate and archive inshore rockfish data is described. The status of research projects undertaken in collaboration with industry is reported. The ability to assess the status of inshore rockfishes remains poor. Reasons for this situation are reviewed, and recommendations are provided for inshore rockfishes subject to constraints on assessment capabilities.

The designation "inshore" is meant to include rockfish (*Sebastes*) species that are primarily caught by commercial and recreational fishers using hook and line gear. Many species occupy reef habitat in relatively shallow, nearshore waters. This assessment has traditionally focussed on five species: yelloweye (*S. ruberrimus*), quillback (*S. maliger*), copper (*S. caurinus*), china (*S. nebulosus*), and tiger (*S. nigrocinctus*) rockfishes. In total, at least twenty species (Table 1) of rockfishes are landed in the directed rockfish hook and line fishery, including significant quantities of redbanded (*S. babcocki*), rougheye (*S. aleutianus*), and silvergray (*S. brevispinis*) rockfishes.

Interpretation of the stock impacts of the directed Zn fishery is complicated by removals incurred by several other fisheries. Other removals of inshore rockfishes can be attributed to bycatch and discarding in the halibut (*Hippoglossus stenolepis*), salmon (*Oncorhynchus* sp.), dogfish (*Squalus acanthias*), and lingcod (*Ophiodon elongatus*) hook and line fisheries. Based on creel survey estimates, recreational catch in the Strait of Georgia may be equal to that of the commercial fishery (Yamanaka and Richards 1992). Recreational catch data based on creel surveys are unavailable outside of the Strait of Georgia, except for Barclay Sound on the west coast Vancouver Island and various surveys in statistical area 12. First Nations groundfish allocations are significant, but the actual utilization of rockfishes is unknown (Kronlund 1997). The various fisheries are managed under different licenses, each with a suite of associated management tactics. Thus, management tactics applied to the directed Zn fishery alone do not restrict total fishery removals of inshore rockfishes.

Recent working papers on inshore rockfishes include the 1996 and 1997 assessment documents (Yamanaka and Kronlund 1997a,b). Analyses of logbooks were prepared for the west coast Vancouver Island (Yamanaka and Kronlund 1997c) and the Strait of Georgia (Kronlund and Yamanaka 1997) management regions. Also, Kronlund (1997) reviewed in detail the assessment and management problems for inshore rockfishes. These documents may be used as background information for this working paper.

2 Management

The management history of the directed Zn fishery was described in detail by Kronlund (1997), Yamanaka and Kronlund (1997c), and Kronlund and Yamanaka (1997). Briefly, the directed fishery has been area licensed ("Inside" or "Outside" of the Strait of Georgia) with catch quotas set for five management regions since 1991. The statistical areas that comprise each management region are listed Table 2.

Prior to 1995, annual quotas had been assigned to the "red snapper" (yelloweye rockfish) and "other rockfish" species categories. Beginning in 1995, the number of species categories was increased to include yelloweye rockfish (YE) and 6 additional species aggregates (A1 to A6). The number of aggregates was again increased in 1997 to a total of 7 groups (Table 3). The 1998/1999 Zn quotas by management region and aggregate are listed in Table 4. Beginning in 1995, fishers outside the Strait of Georgia could select one of three fishing options, each with different fishing period catch limitations. The fishing options currently include a live fish option (A), a yelloweye rockfish option (B), and a rougheye and shortraker rockfish option (C) (Fisheries and Oceans 1998a). There has been only a live fish option (I) within the Strait of Georgia management region. As an example, fishing period (about one month in duration) limits from 1995 to 1998 for the Strait of Georgia management region are shown in Table 5.

From 1986 to 1996, total allowable catches were allocated for a fishing year that coincided with a calendar year. In 1997, the fishing year was extended to take place from January 1, 1997 to March 31, 1998. The Zn fishing year now runs between April 1 and March 31, and coincides with the trawl fishing year. Fish landed between January 1 and March 31, 1998 were not applied against total allowable catches (TACs) allocated for the 1998/99 fishing year.

The groundfish trawl sector does not target yelloweye rockfish and aggregate 1 and 2 species. However, a bycatch of 2.3 percent by weight is permitted. Allocation of rockfishes to the trawl and hook and line sectors was specified in the Halvorson Decision (1997); minor variations in allocation are described by the current Conditions of License for each sector (Groundfish Management Unit, Fisheries and Oceans Canada).

Bycatch of rockfishes in the halibut fishery is restricted to a percentage by weight of the halibut quota. The permitted allowance ranged from 15 to 20 percent from 1991 to 1996, and was 10 percent in 1997. In 1998, halibut fishers were permitted to retain rockfishes up to 8 percent of the total net weight of halibut onboard, subject to the restriction that up to 1 percent of the rockfishes may be quillback, copper, china or tiger rockfishes (Fisheries and Oceans 1998b).

There is a daily bag limit tactic for recreational catch of rockfishes as described in the British Columbia Tidal Waters Sport Fishing Guide 1998/1999. There is no total allowable catch limitation for the recreational fishery.

3 Data Sources

Inshore rockfish catch, effort, and biological data are collected from various fishery monitoring program, logbooks, creel surveys, and research surveys:

1. Dockside monitoring programs
   - Zn rockfishes
   - dogfish
   - lingcod
   - halibut
   - groundfish trawl
2. Fish slips
   - hook and line fisheries (1954 to 1995)
   - salmon hook and line (1954 to present)
3. Logbooks
   - Zn rockfishes
   - Halibut
4. Trawl onboard observers
5. Recreational creel surveys
   - Strait of Georgia creel survey (GSCS)
   - Barclay Sound creel survey
   - North Vancouver Island creel survey
6. Biological sampling
   - commercial
   - research
7. Miscellaneous
   - Shrimp beam trawl
   - mid-water hake and pollock
   - flatfish Option B trawl in the Strait of Georgia

The data exist in a wide variety of formats; some data are maintained in formal databases. Resolution of species, time periods, and geographic areas is highly variable. Graphical and tabular summaries of catch statistics for inshore rockfishes were last updated by Yamanaka and Kronlund (1997a, 1997b) and Kronlund (1997). Catch and effort statistics for the trawl fishery were last summarized for 1993 by Rutherford (1996). Selected data sources are described below and updated in this working paper.

3.1 Dockside Monitoring Program

Dockside validation of landings for the Zn fishery was initiated in 1995. The dockside monitoring program (DMP) is conducted by contract under the authority of the Groundfish Management Unit, Fisheries and Oceans Canada. In 1995, all landings of

fish caught under the category Zn license were monitored for species composition and landed weight, *i.e.* rockfishes (*Sebastes*), thornyheads (*Sebastolobus*), and greenlings (*Hexagrammos*). Hook and line landings of dogfish and lingcod caught under Schedule II, Part II Species License (category C) conditions were included in 1996. In 1997 and 1998, all dogfish, lingcod, Pacific cod (*Gadus macrocephalus*), sole, flounder, and skate landed by hook and line were included. Landings of these species are not included under the category Zn license, and are exempt from dockside monitoring when caught and landed in conjunction with salmon. The characteristics of the hook and line dockside monitoring database are summarized in the following table.

Fisheries	Hook and line category Zn, directed dogfish and lingcod.
Landings	Landings recorded by weight (kg) to species by dockside validation.
Gear type	Not recorded, could be resolved by comparison with logbooks.
Time period	1995 to 1997, 1998 ongoing.
Effort	No direct measure of effort, could be resolved by comparison with logbooks.
Location	Landings assigned to major statistical area for Dover, rock and English soles, Pacific cod, lingcod and dogfish. Landings of yelloweye and Aggregate 1 and 2 rockfishes assigned to management region but not by species. Fishing location for remaining rockfishes unknown when fished outside the Strait of Georgia, could be inferred by comparison with logbooks.
Summary	Dockside monitoring provides good estimates of landed weight by species for each landing. Linkage with logbooks via a relational database could increase spatial resolution.

The species composition of rockfish landings for a management region can be unambiguously assigned only in the case of the Strait of Georgia. However, suppose a fishing trip occurred in both the CC and PR management regions. In this situation the fishing location is identified to management region for YE, A1, and A2. There is no direct means of determining the weight of each species by region, or of species not in the YE, A1, and A2 aggregates.

No detailed analysis of the halibut dockside monitoring data has been described by DFO assessment biologists.

3.2 Commercial Fish Slips

Commercial fish slip information is compiled and maintained by the Statistics Unit, Operations Branch. Prior to 1994, the majority of rockfish taken on hook and line gear were recorded as red snapper (primarily yelloweye rockfish) and other rockfish. In 1994, the database was upgraded to allow the entry of fish slip data by species, however, entry of Zn catch data ceased after the 1995 fishing year. The characteristics of the commercial fish slip data can be summarized as follows:

Fisheries	Groundfish hook and line, halibut, salmon troll.
Catch	Round fish weight to species category (red snapper and "other rockfish"), resolved to species in 1994 and 1995 only.
Gear	Longline, hand line, salmon troll, freezer troll.
Time period	1954 to 1995.
Effort	(1) Fishing day as recorded on a fish slip with a rockfish landing, and (2) the number of vessels in a year landing rockfish species.
Location	Catch assigned to major statistical area, no distinction between statistical areas inside and outside the surf-line.
Summary	Provides catch and effort measures to statistical area only for red snapper and other rockfish species categories (except 1995). Currently the only source of rockfish landings from salmon fisheries.

3.3 Logbooks

Fishers operating under Zn rockfish or halibut L licenses are required to complete logbooks as a condition of license. Haigh and Richards (1997) described the Zn logbook database. The essential data in the Zn logbooks consists of catch by species, and effort for a fishing event. For each fishing event, the logbook form allows recording of the number of pieces of rockfishes by species, the time fished, and the fishing location (latitude and longitude). Gear type and characteristics can be recorded, as can the date and depth at which fishing occurred. Logbooks for the Strait of Georgia and west coast of Vancouver Island were analyzed by Kronlund and Yamanaka (1997) and Yamanaka and Kronlund (1997c), respectively. The characteristics of the logbook are summarized in the following table:

Fisheries	Category Zn fishery.
Catch	Catch recorded as pieces and/or weight (kg), pieces in recent years.
Gear	Gear type identified as hand line or longline.
Time period	1986 to 1997, 1998 ongoing.
Effort	Effort recorded as soak time (hrs) per set for longline gear, hours fished for hand line gear. Longline sets can be identified from 1986 to 1997, trips can be identified after 1993.
Location	Major statistical area (mandatory), geo-referenced fishing location (optional) recorded to degrees and minutes of latitude and longitude. Variable reporting of latitude and longitude prior to 1993, improved after 1993.
Summary	Spatial scale of data most closely approximates probable scale of biology and mechanism of depletion.

Due to the confidential nature of logbook data, only summary information is available from the International Pacific Halibut Commission. These data have not been analyzed by DFO assessment biologists, but may be useful for examining spatial and temporal trends in rockfish bycatch. Although offloaded weight of rockfishes is required, the degree to which rockfish discards are recorded is unknown.

3.4 Recreational creel surveys

Recreational creel surveys have been conducted by DFO in the Strait of Georgia (statistical areas 13 through 19, 28 and 29), north Vancouver Island (statistical area 12), Barclay Sound (statistical areas 23A, 23B, and 24), and on an *ad hoc* basis in statistical areas 1 through 10. The most recent documentation for the Georgia Strait creel survey is for the 1992 survey year (Collicutt and Shardlow 1992). However, estimates of landings and effort have been reported by the DFO annually from 1980 to date. The north Vancouver Island survey was last documented by Collicutt *et al.* (1994) for the 1993 survey year. No surveys were conducted in area 12 from 1994 to 1997. A creel survey was reinstated in 1998, however, results are not available to date. Yamanaka and Richards (1992, 1995) and Yamanaka and Kronlund (1997c) presented summaries of recreational creel survey data in inshore rockfish assessments. The characteristics of creel surveys are summarized in the following table:

Fisheries	Recreational.
Catch	Rockfish landings generally grouped and reported as piece. Species identification of rockfishes variable among surveys, when attempted. Releases may be recorded by interview.
Time period	Strait of Georgia 1980 to 1998; west coast Vancouver Island 1989 to 1998; north Vancouver Island 1991 to 1993, 1998.
Effort	Effort recorded as boat trips. The number of lines fished may also be recorded. Effort may also be measured as a boat count by time and statistical subarea determined by overflight.
Location	Generally to statistical subarea determined by interview. Location may also be measured by boat count in a statistical subarea observed by overflight.
Summary	Creel surveys have focussed on the estimation of salmon catch; there has been little emphasis on determining the catch of rockfish species. This practice is a major shortcoming of the creel survey data for rockfish assessment, particularly in light of recent changes in fleet behavior in response to restrictions on salmon. Where attempted, the identification of rockfish species has been variable.

3.5 Biological samples (commercial and research)

Biological sampling of inshore rockfishes has been extremely limited. There has been no effective systematic program for the collection of biological samples from the commercial catch, although various attempts have been made through port sampling and cooperative programs with industry. Recreational and bycatch fisheries have been sampled sporadically. Various catch and effort research surveys have collected biological data (*e.g.* Richards and Cass 1987; Richards and Hand 1987; Richards *et al.* 1988; Yamanaka and Richards 1993, unpublished charter cruises in 1997 and 1998).

Biological data derived from commercial sources are very sparsely distributed across species, areas, and time (Table 6). Samples obtained from the commercial sources may be biased, since many were obtained on an opportunistic (non-random sample) basis. Often the specific location and depth from which samples were taken is unknown. There are no time series of data commensurate with the generation time of rockfishes (approx. 25 years) that allow trends in size-at-age, maturity-at-age, or growth to be detected.

For example, length at age data obtained from commercial samples for quillback rockfish in the Strait of Georgia are shown in Figure 1. Each panel of the figure represents a combination of year and statistical area. The fitted values of a von Bertalanffy growth model are shown as a solid line in each panel. The figure demonstrates the sparseness of the biological sampling over time and geographic area (*e.g.* no commercial samples available from areas 14, 19, 28 and 29). The most complete time series corresponds to statistical area 12 (lower row of Figure 1). The plots suggest fewer large fish at age in recent years. It is not possible to determine whether this result is an artefact of sample size (Table 6), grading practices in the commercial fishery, or a relative absence of large fish at age. Hook and line surveys for rockfishes were conducted in statistical area 12 in June of 1986 through 1988, and again in 1992 (Richards and Cass 1987; Richards and Hand 1987; Richards *et al.* 1988; Yamanaka and Richards 1993). Median lengths of quillback rockfish were significantly smaller at depth in 1992 than in the 1986 to 1988 surveys (Yamanaka and Richards 1993). The change measured in 1992 may have been due to a lower abundance of large fish at depth, or to strong recruitment of young, small fish that would dominate the age and size distributions in samples.

4 Landings

Coastwide landings of rockfish species by Zn, dogfish, and lingcod hook and line fisheries are shown for 1995 to 1998 in Figure 2. The landings were based on dockside monitoring data. Total hook and line landings of rockfishes by species and management region are presented in Table 7 for the 1997 fishing year. The regional landings were based on logbooks. The total logbook catch, and total landings based on dockside monitoring, are also shown. Similar data are shown in Table 8 for the January 1, 1998 to March 31, 1998 period and in Table 9 for the April 1, 1998 to October 9, 1998 period. Previous assessment documents (*e.g.* Yamanaka and Kronlund 1997a) provide graphical and tabular summaries of historical landings prior to 1995.

Landings of each species from 1995 to 1998 are shown for each Zn fishing option (A,B,C,I) in Figure 3 through Figure 6. All species with landings greater than 2 tonnes for the calendar year are shown. Note the amount of kelp greenling landed in the live fishery option I is greater than the A2 species (china and tiger rockfishes).

Bycatch of rockfishes in the halibut fishery is shown in Table 10 for 1995 to 1998. The 1998 landings of yelloweye rockfish are likely to be the largest on record given that

the halibut quota was set at 13,000,000 lbs. Landings of A1 and A2 species are relatively small. Rockfish bycatch for 1995 to 1998 is shown in Table 10. Bycatch statistics for 1997 are preliminary, and the 1998 bycatch data is current to November 17, 1998. The percentage rockfish bycatch by weight of halibut landed for 1991 to 1998 was 4.4, 5.8, 10.4, 4.9, 7.7, 7.8, 5.4, and 5.7 (Archipelago Marine Resources).

Trawl catch of selected rockfish species by management region is shown for 1996 to 1998 in Table 11. The catch is based on onboard observer logs, however, fisher logbooks were unavailable for the Strait of Georgia in 1997 and 1998. Relatively small amounts of YE, A1, and A2 species are caught by the trawl sector.

Recreational catch data is available from creel survey in the Strait of Georgia (Table 12) and Barclay Sound (Table 13). Estimates for the north coast statistical areas 1 through 10 are based on lodge logbooks and field observations Table 14. Note that there is no information for statistical areas 3 through 5, and 10 in 1997.

Communal licenses for First Nations include allocations for halibut, sablefish, and "other groundfish" categories. The other groundfish category includes inshore rockfish species, but does not identify aggregate or species specific allocations. Approximately 136 tonnes (300,000 lb) of "other groundfish" are allocated to communal licenses coastwide. Actual removals are undocumented. However, it is believed that nearly all rockfish consumption by First Nations is comprised of inshore and shelf species, accounting for perhaps 75 to 80 percent of groundfish landed excluding halibut and sablefish (F. Crabbe, pers. comm.).

Rockfish landings from the various fisheries are summarized in Table 15 for the 1997 calendar year. The 1997 Zn hook and line fishery was extended into the first three months of 1998, which resulted in an additional 334 tonnes of rockfishes landed (Table 9). Estimates for the recreational sector should be regarded as very conservative since the recreational fishery was not completely surveyed and, where it occurred, survey coverage applied to peak effort months only. For some fisheries, data may not be available or may not be processed.

5 Current assessment work

5.1 Strait of Georgia

The commercial Zn fishery and the recreational fishery dominate landings of rockfishes in the Strait of Georgia. Unprecedented closures in salmon fishery, coupled with increasing awareness and utilization of groundfish species by sport fishers, may increase recreational catch of rockfishes coastwide. Examination of the Strait of Georgia creel survey (SGCS) may produce analyses to help assess the effectiveness of changes to management tactics such as daily bag limits, and to predict the spatial distribution of fishing effort in response to area closures (*e.g.* marine protected areas).

Estimates of recreational landings of rockfishes derived from the SGCS have ranged from a high of 183,500 pieces (approx. 128 tonnes) in 1983 to 85,700 pieces (approx. 60 tonnes) in 1997 ***for the months of April through September only*** (Table 12, Figure 7, upper panel). Survey coverage has declined to the peak effort months of April through September; these months are common to all years of the survey. Estimated rockfish landings have declined since the late 1980s, in conjunction with an overall decline in sport fishing effort following restrictions to salmon fishing (Figure 7, lower panel). The restrictions applied to salmon have increased the proportion of rockfishes landed as a fraction of the total landings of rockfishes, coho (*Oncorhychus kisutch*) and chinook (*O. tshawytscha*), and of rockfishes and total salmon regardless of species.

Estimated rockfish landings over time for each statistical area are shown in Figure 8. Statistical areas 13, 16, 17 and 19B dominate the landings; all show a declining trend coincident with the general decline in sport effort as measured by the creel survey. Figure 9 indicates the relative magnitude of estimated rockfish landings from 1980 to 1997 for each month. May through September account for the majority of landings, with a declining trend over time. Note the absence of survey coverage from October to March in recent years

The landings for the Strait of Georgia management region indicated in Figure 7 may be conservative for several reasons. First, the landings from statistical areas 12 and 20 are not included. The 1992 and 1993 north Vancouver Island creel surveys measured an estimated 14,740 pieces (approx. 10 tonnes) and 13,097 pieces (approx. 9 tonnes) of rockfish landings, respectively (Collicutt et al. 1994a, 1994b). Sport landings of rockfishes from statistical area 12 are unknown from 1994 to 1997. Second, except for a few years, the surveys have been conducted for only a portion of the year. Finally, the surveys were developed to measure salmon fishing and may not capture fishing for groundfish species effectively, particularly for guided fishing trips. Fisheries and Oceans has no license jurisdiction over guided operations or fishing lodges, thus, catch information may be difficult to obtain. Voluntary logbook programs are being developed (T. Gjernes, pers. comm.), but the data are not available to date. These sources of recreational fishing may be relatively poorly covered, with the exception of guided fishing trips intercepted by the creel survey. Nevertheless, the reported landings support the contention that the recreational fishery in the Strait of Georgia is capable of removing about the same tonnage of rockfishes as the Zn fishery, and has done so in some years (Yamanaka and Richards 1992, Yamanaka and Kronlund 1997).

Commercial Zn logbook data for the Strait of Georgia management region was examined by Kronlund and Yamanaka (1997), who presented catch, effort, and catch per unit effort (CPUE) trends for quillback and copper rockfish (A1) and yelloweye rockfish caught by hand line gear. The selection of data and calculation of CPUE is described in the Appendix. The logbook data were divided into three fishing localities (Queen Charlotte Strait, Campbell River, Gulf Islands) based on the spatial concentration of effort. Updated plots including 1997 logbook data are shown in Figure 10 for A1 species and Figure 11 for yelloweye rockfish. The time series show an increase in catch and

effort in the years immediately preceding 1992, followed by a significant drop in both variables in 1992 when limited entry and a reduced quota for A1 species were implemented. These trends likely reflect an anticipatory response by fishers: qualification for limited entry was based in part on landings, so fishers attempted to improve their likelihood of qualification by increasing their catch. However, CPUE did not generally increase in response to increased fishing effort during the 1989 to 1991 period. Over the 1986 to 1996 period, there is a general decline in CPUE for all three localities. The trends in CPUE for Campbell River and the Gulf Islands show two periods of decline separated limited entry in 1992. The "step-up" in CPUE in 1992 likely reflects the reduced number of vessels active in the fishery. These CPUE trends suggest that the logbook data series is effectively broken into two portions by limited entry. The CPUE trend for Queen Charlotte Strait does not show the step in 1992, but does exhibit a general decline over time.

The trends for yelloweye rockfish (Figure 11) are not as stable as those for quillback rockfish due to the relatively low targeting of yelloweye by hand line gear in the Strait of Georgia. Data for the Queen Charlotte Strait locality reflect the general reduction in catch and effort following limited entry in 1992, after a period of increased catch and effort from 1989 to 1991. Catch per unit effort has declined since 1992 in both Queen Charlotte Strait and the Campbell River area. Over the time series, the magnitude of CPUE decreases from Queen Charlotte Strait southward to the Gulf Islands. Kronlund (1997) and Kronlund and Yamanaka (1997) discussed reasons why CPUE may not be a timely indicator of stock abundance for rockfishes.

The recommended yield, quota, and landings for the Strait of Georgia management region from 1986 to 1998 are shown in Table 16 for yelloweye rockfish and in Table 17 for A1 and A2. Note that the "other rockfish" recommended yields are for rockfishes excluding yelloweye rockfish; the quota was set for A1 and A2 species only.

5.2 Inshore rockfish data archiving.

Several database projects have been initiated to archive and ease access to inshore rockfish data. These projects involve the population of two Regional database (1) the groundfish biological sampling database, GFBio, and (2) the Pacific harvest database, PacHarv. GFBio is operational and accessible to users, however, the harvest database is under development. Furthermore, groundfish hook and line fisheries are likely to be implemented in PacHarv following incorporation of salmon and groundfish trawl catch data. Faced with no firm timetable for the incorporation of hook and line data, we have initiated projects to construct databases that conform to regional conventions and to backfill GFBio with historical data. The objective of the data archiving is to identify and collate all available data pertaining to inshore rockfishes into formats that conform to regional database conventions. Specific projects include the following:

1. **Collation and entry of inshore rockfish biological sampling data into GFBio.** Biological data from commercial sampling and research surveys are stored as ASCII files in standard Groundfish Card 04 format. Entry to GFBio is underway.
2. **Upsizing of Zn logbook data to SQL Server.** The volume of data available from logbooks has exceeded the capability of the existing database software (Access) to perform efficient aggregate analysis of times series. Thus, the database must be queried one year at a time. Migration to SQL Server is planned to accommodate the (accumulating) data, and to allow logbooks to be reconciled with dockside monitoring data to increase the spatial resolution of landings. The logbook database (Haigh and Richards 1997) will be modified to conform to regional PacHarv database conventions.
3. **Standardization of hook and line dockside monitoring databases to PacHarv conventions.** Except for halibut data, all available (1995 to 1998) hook and line dockside monitoring data have been standardized to conform to regional catch database (PacHarv) conventions. These data currently reside in Access and will be migrated to SQL Server for comparison with logbook data. Halibut dockside monitoring data standardization is planned.
4. **Design and construction of a relational database for the Strait of Georgia creel survey.** The data structures for the Strait of Georgia creel survey data do not permit analyses for rockfishes beyond the production of catch in pieces for the rockfish aggregate. Conversion of the database from ASCII and dBase files into an Access relational database is complete from 1992 to 1997. The addition of the 1980 to 1991 data will overwhelm the capabilities of Access, thus upsizing to SQL Server is planned.
5. **Miscellaneous data.** International Pacific Halibut Commission survey data should be archived in GFBio since rockfishes are a component of survey catch. The halibut dockside monitoring data should be standardized to PacHarv conventions.

5.3 Evaluation of logbook data

Logbooks for the Strait of Georgia and West Coast Vancouver Island management regions were analyzed by Kronlund and Yamanaka (1997) and Yamanaka and Kronlund (1997c), respectively. These analyses need to be updated following the recommendations of Kronlund and Yamanaka (1997). Analyses of the logbook data for the North Coast, Central Coast, and Queen Charlotte Islands management regions are planned.

5.4 Effects of contrasting exploitation histories on fishing success and population characteristics

Two distinct spatial areas with contrasting exploitation histories were selected on each of the west coasts of Vancouver Island and the Queen Charlotte Islands. Vessels from the Zn fleet were chartered to conduct longline fishing operations in September 1997 and May 1998. Catch rates and species composition were recorded, and biological sampling was conducted for length, sex, maturity, and age of yelloweye and redbanded

rockfishes. Ageing of samples from 1997 is complete; completion of the 1998 ageing is pending. All catch rate data have been input to GFBio.

Preliminary results are available for the September 1997 sampling on the west coast of Vancouver Island for yelloweye rockfish. Figure 12 shows fork length as a function of age, sex, and study area. The heavily exploited area is designated as TOPK (Top Knot) while the lightly exploited area is TRIA (Triangle Island). Each panel shows the result of a von Bertalanffy growth curve fit to the data and reports the sample size. The relative proportion of yelloweye rockfish older than age class 20 is smaller for the heavily exploited area. Adjustment for sample size is not likely to obviate the difference, however, sampling in May 1998 at the same locations was designed to investigate depth and seasonal effects (results pending completion of age determination). The mean age of females (males) was 36(31) and 23(24) years at the Triangle Island and Top Knot study sites, respectively.

The purpose of the experiment was to determine whether catch rates reflect the exploitation history of each fishing location and to determine seasonal effects on catch rate. Additionally, the biological sampling may reveal characteristics that are consistent with exploitation history, and may serve as diagnostics of population status. Sites were selected deliberately to provide maximum contrast: if differences are not measurable statistically between lightly and heavily fished sites, then they are unlikely to be detected elsewhere. Exploitation history will be quantified using logbook records. The data may also be applicable to simulation modeling of the size, number and location of marine protected areas.

5.5 Development of habitat classification and abundance estimates

Collaborative research with the Washington Department of Fish and Wildlife (WDFW) in the southern Gulf Islands was conducted in July 1998. This joint project was proposed by DFO to assess the potential of habitat-based stock assessment methods for inshore rockfishes. For this project, each of seven study sites were subjected to three surveys:

1. acoustic assessment of the seabed to classify and map seabed habitat types;
2. video assessment of reef fishes to estimate density and size composition by seabed habitat type;
3. commercial fishing to determine overall species compositions, catch rates and age/size composition of the catch.

The work attempts to identify, in a non-subjective manner (acoustics), physical habitat types and their associated inshore rockfish densities (video). By interpolating the seabed classification data and constructing seabed maps, inshore rockfish abundance and biomass within each study site can be estimated by seabed class using associated fish density and size information. The relationship between catch rate and species composition from the fishing survey and the habitat-based stock size estimates will also

be determined. The methodology has application to stock assessment and the evaluation of marine protected areas by directly comparing areas that are "no-take" with fished areas.

6 Resource Concerns

Biologists and managers of inshore rockfishes are faced with several fundamental problems, many of which occur regardless of population status. These problems were described in detail by Kronlund (1997) and have been emphasized in previous assessments (*e.g.* Yamanaka and Kronlund 1997a). They are reviewed below for convenience. In the long term, analysis of logbook data and recreational creel surveys may provide some information on stock trends for managers. However, most data currently available are focussed on harvest-driven processes. There is a paucity of data on production-driven processes (*e.g.* empirical measurement of recruitment, rebuilding rates for fished areas, geographic sources of larval production and exchange, stock structure) to assist in evaluating the effects of tactics such as reduced fishery removals or area closures.

6.1 Unknown removals

At present it is difficult to assess the aggregate effect of multiple fisheries on the status of inshore rockfishes. As discussed, landings of rockfishes in the directed Zn fishery, and dogfish, lingcod, halibut, and trawl fisheries are well known. In general, landings of rockfishes by recreational fishers are poorly known, and First Nations landings are unknown. Due to their physiology, rockfishes are unlikely to survive following catch and release so that discarded fish should be considered to be removals. However, there are no data on discarding rates in the Zn, halibut, dogfish, and lingcod hook and line fisheries. Discarding by the groundfish trawl sector is now estimable via the onboard observer data. Releases by recreational fishers were recorded by interview in the Strait of Georgia creel survey, but discarding rates have not been estimated for recreational fishers. Total fishery removals, and hence fishing mortality, are unknown for inshore rockfishes.

6.2 Inability to limit fishery removals

Given the multitude of fisheries that catch inshore rockfishes, control tactics applied to any one fishery are insufficient to limit total fishery removals of rockfishes. For example, restrictions applied to the Zn fleet would not cap the removals of rockfishes where recreational fishing effort is high (*e.g.* Strait of Georgia) since recreational catch is restricted only by a daily bag limit. First Nations utilization is unknown.

Annual halibut landings under the L category license have been about 4300 tonnes recently. Thus, up to about 340 tonnes of rockfishes could be landed by the halibut fleet,

of which about 70 percent (238 tonnes) is likely to be yelloweye rockfish. In 1998, the halibut fleet was allocated 174 tonnes of yelloweye rockfish as bycatch, and had landed 246.8 tonnes as of November 17, 1998. Thus, the conservation gain achieved through a 5 percent (22 t) reduction in the outside Zn yelloweye quota from 425 tonnes in 1997 to 403 tonnes in 1998 has been eliminated by an overage of at least 72 tonnes. Conservation gains are offset by increases in the halibut quota, as occurred in 1998. For example, a 454 tonne (1M lbs., approx. 10 percent) increase in halibut quota translates to an increase of about 36 tonnes of rockfishes permitted as bycatch. The estimated increase in yelloweye landings would be about 25 tonnes.

A similar situation may arise in the Strait of Georgia, where increased targeting on rockfishes by recreational fishers could eliminate conservation reductions in Zn quota for quillback and copper rockfishes. The Zn quota of aggregates 1 and 2 was reduced 10 percent in 1998 to 130 tonnes. The 13 tonne conservation reduction could be offset by an approximately 10 percent increase in recreational landings.

6.3 Extremely long rebuilding time from depressed levels of abundance

Fishes in the genus *Sebastes* are extremely long-lived and therefore experience low rates of natural mortality, probably about M=0.05 (Leaman 1991, Archibald *et al.* 1981, Richards and Schnute 1995). The generation time for rockfishes is lengthy, likely on the order of 25 years (Leaman 1991). Maximum ages for some inshore species in British Columbia, as determined by technicians at the Pacific Biological Station, are 115 years for yelloweye rockfish, 76 years for quillback rockfish, and 45 years for copper rockfish. Therefore, animals that existed at the start of the approximately 50 year exploitation history of rockfishes are potentially still in the population. Walters and Pearse (1996) noted that there is growing empirical evidence that optimal fishing mortality is less than two-thirds of the natural mortality rate of harvestable fish, which for rockfishes would imply an M of about 0.02 to 0.06, depending on the species.

A major risk to the resource, and the viability of commercial and recreational fisheries, is the time required to rebuild depleted populations. Where over-harvest has occurred, decades may be required to rebuild (Francis 1986). Furthermore, the relative longevity and low productivity of rockfishes implies a window of 10 to 20 years for the detection, action, and response to the effects of management tactics (Leaman 1991).

The west coast experience is that fisheries on *Sebastes* can flourish and fail in less than one generation of the animal (Francis 1986, see references in Kronlund 1997). Once depleted, comparatively little fishing pressure is required to maintain low levels of abundance. For example, Pacific ocean perch (*S. alutus*) were fished to low levels by the late 1970s and required 28 years to return to average levels of stock abundance as predicted by Archibald *et al.* (1983) and corroborated in the 1996 assessment (Richards and Olsen 1996). Atlantic redfish (a complex of *S. marinus*, *S. mentalla*, and *S. fasciatus*) in the Gulf of St. Lawrence were closed to commercial fishing in 1995 due to low stock abundance and the absence of significant recruitment since the early 1980s

(DFO Stock Status Report A1-01). The strength of the 1996 year-class may be stronger than recently observed classes, but is not thought to be large and will not recruit to the fishery until 2005.

6.4 Data and management are mismatched to the scale of depletion

Rockfishes are extremely clustered in distribution and, in the case of benthic species, there may be a high degree of fidelity to home ranges or specific habitat features (Matthews 1990, Matthews and Reavis 1990, O'Connell and Carlile 1993). Fishers can reliably target concentrations of rockfishes, so that catch per unit effort could remain stable, despite a decline in overall abundance, by moving to grounds with the greatest concentration of fish. The "hyperstability" of catch rate statistics (Hilborn and Walters 1992) from large areas, such as management regions or statistical areas, effectively masks population depletion. The potentially local nature of the depletion suggests that assessment and management must occur on a much smaller geographic scale than is currently the case, or alternatively, that management strategy should be based on limiting the exposure of rockfish populations to harvest through large scale closed areas. For example, Washington State fishery biologists have proposed placing one third of all Puget Sound reef habitat into no-take reserve status to assure stable rockfish populations (Wayne Palsson, pers. comm.).

6.5 Lack of coherent data times series due to the accumulation and variety of management tactics.

In order for fishery-dependent time series of catch and effort data to be useful for assessment, the conditions under which the data are collected should remain stable. A variety of management tactics have accumulated for the Zn fishery since 1986 that disrupt the continuity of the time-series, as described by Kronlund (1997) and Kronlund and Yamanaka (1997).

6.6 No precise, cost-effective means of estimating abundance.

Estimates of biomass for rockfishes using classic survey methods have large variance components attributable to spatial distribution, localized seasonal migration, fortnightly behavior, and diel changes in vertical distribution. Kronlund (1997) described research to estimate rockfishes *in situ* using video-acoustic techniques and direct observation via submersible. However, these methods are under development and are not yet feasible on a large-scale basis.

6.7 Recommendations

There are no new data or analyses sufficient to identify sustainable harvest targets for inshore rockfishes. Because harvest targets have not been identified or estimated, there is no basis for quantifying risk or for providing yield options. The ability to assess stock status for inshore rockfishes on a coastwide basis is poor, and is likely to remain so pending cost-effective solutions to the problem of abundance estimation. In spite of the inability to estimate sustainable harvest targets, our opinion is that inshore rockfishes are at best fully utilized, and are likely over-utilized in the Strait of Georgia and locally coastwide. This conclusion is based on the implications of rockfish life history on harvest potential, the catch per unit effort trends derived from logbooks (Kronlund and Yamanaka 1997, Yamanaka and Kronlund 1997), and the example provided by rockfish fisheries on the west coast of North America. Although subjective, this conclusion is also based on the opinions expressed to us by recreational and commercial fishers, and DFO fishery officers. Specific recommendations are listed below by category.

Fishery Removals

Past assessments have attempted to account for all sources of landings for inshore rockfishes and yield recommendations were provided. We depart from this practice for the 1999/2000 fishing year because of the aforementioned inability to estimate sustainable harvest levels. Nevertheless, we recommend that the coastwide total removals of inshore rockfishes be reduced. Given the concerns outlined in the previous section, we believe a reduction to be warranted despite the lack of scientific certainty and target harvest levels. We note that the precautionary approach to fisheries (FAO 1995, item 73c, Principal 15 of the Rio Declaration) advises that the "*lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*".

The difficulty in quantifying removals is particularly worrisome in areas where significant recreational fisheries exist. In the Strait of Georgia region, the potential recreational fishing effort is sufficient to offset conservation gains made by reductions in Zn fishery removals. Furthermore, the combined commercial and recreational harvest could maintain depressed rockfish stocks at low levels of abundance.

In 1997, the Groundfish Subcommittee recommended that a process be initiated to reform the assessment and management approach for inshore rockfishes (Stocker and Welch 1997). This recommendation, supported by the Groundfish Management Unit, was to involve the Recreational Fisheries Division and fishery stakeholders. In order to being this process, fishery managers may wish to consider the following actions to make progress towards reducing total removals of inshore rockfishes:

1. Quantify landings from all fisheries, particularly the recreational fishery. Reductions in fishery removals are not measurable without knowledge of current removals.
2. Obtain estimates of discarding or releases through onboard sampling of halibut and Zn vessels. If seasonal or spatial trends in discarding can be identified then directed management actions may be effective at reducing the wastage. For example, Zn fishers report discarding of female rockfishes releasing larvae for reasons of

marketing esthetics. The majority of these discarded fish can be assumed to die. Management tactics such as seasonal closures could reduce this source of mortality.
3. Apply management tactics to cap the total removals, regardless of fisheries sector. It is difficult to argue for conservation concessions in the directed fishery when the benefits of reductions can be eliminated by, for example, a larger halibut quota or increased recreational fishing effort on groundfish species.

Assessment and Management Planning

1. Initiate a strategic planning process for assessment and management of inshore rockfishes. The Groundfish Management Unit, Stock Assessment Division, and Recreational Fish Division should establish a shared vision of inshore rockfish fisheries and a plan to resolve problems identified in assessments. In particular, a long-term plan for the disposition of the Zn research allocation is required.
2. Consider protecting a portion of the population from harvest using area closures. The lack of an abundance estimate or even a practical biomass index is a compelling reason to evaluate management tactics that are independent of abundance. Kronlund (1997) suggested that the adoption of smaller management regions could allow earlier detection of spatial depletion and facilitate the use of area closures when required. This action could begin via consultation with industry and the recreational community to identify geographic areas with conservation concerns and to evaluate management options (*e.g.* area closures, reduced daily bag limits, a cap on total allowable recreational catch of rockfishes, seasonal closures). Managers may also wish to consider the removal of daily bag limits on sport catch of yelloweye rockfish because of discarding mortality when the daily limit is attained prior to reaching the aggregate rockfish limit, *i.e.*, use only a daily aggregate bag limit for rockfishes.
3. Estimate fishery removals by, for example, comparing species composition of the catch via an onboard sample survey to the species composition of landings from the DMP. For the recreational sector, release rates of rockfishes may be estimable from interview data.

Data Issues

1. Complete data archiving projects, with emphasis on rationalizing Zn logbook data with dockside monitoring data;
2. Provide explicit instructions to halibut fishers that logbooks must include recording of all species caught along with associated capture information.
3. Change the spatial resolution of dockside monitored landings (Zn, lingcod, dogfish) so that landings of all species are recorded to the finest possible resolution, i.e. statistical area.

Research

1. Review the Strait of Georgia creel survey data for their potential to provide assessment data for inshore rockfishes. For example, with suitable modifications creel survey data could be used to allow estimates of rockfish landings by species, to estimate rockfish releases, to evaluate changes to bag limits or alternative tactics, and (possibly) to provide a stock index.

2. Develop methods for the analysis of Zn logbook data coastwide as outlined by Kronlund and Yamanaka (1997).
3. Continue development of habitat classification and methods for the estimation of rockfish abundance. This research has application both for assessment and for the purposes of evaluating the effectiveness of area closures and marine protected areas.
4. Complete analysis of research charter data collected from areas with contrasting exploitation histories to evaluate whether research should be extended to other regions.

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Appendix – Calculation of catch per unit effort for Zn logbooks

The mean of ratio estimator was used to compute annual catch per unit effort (CPUE). It is defined as the average of individual catch rates for each fishing event:

$$R = \frac{1}{n}\sum_{i=1}^{n}\frac{C_i}{E_i} \quad ,$$

where C_i is the catch and E_i is effort over the $i=1,...,n$ fishing events. The robustness of this estimator to outliers can be increased by trimming observations from each tail of the distribution of catch rates, C_i/E_i. For example, median CPUE can be estimated by trimming 50 percent of the observations from each tail of the ranked observations. For both longline and hand line CPUE, catch can be expressed in terms of weight (kg) or pieces, while effort can be specified in terms of hours or hooks times hours.

The following algorithm was applied to the Zn logbook data to determine fishing activity directed on rockfishes:

1. Determine the species with the highest catch weight for each fishing event (set, fishing day);

2. Where no target species was specified by the fisher, assign the species with the highest catch weight to be the target species;

3. Exclude fishing events where the target species was not a *Sebastes*.

The small proportion of troll gear records (approximately 2 percent) in the logbook data were lumped with hand line gear records. Following the application of the directed fishing algorithm, analyses of hand line gear excluded logbook records where:

1. The number of hooks was greater than 20. In these cases the gear code is likely coded incorrectly or a data entry error exists;

2. The reported time fished exceeded 24 hours. These records likely represent pooling of two or more days fishing;

3. The CPUE (kg/hr) exceeded 30 for a single species.

For example, a total of 953 hand line fishing events for quillback rockfish were excluded out of a total of 42129 events over the 11 years of data. Additionally, two events with catches greater than 1000 kg were excluded for hand line quillback data.

Table 1 List of *Sebastes* caught by hook and line gear in British Columbia

Species	Common name	Hart
Scorpaenidae	Scorpionfishes	388
S. aleutianus	Rougheye rockfish	394
S. alutus	Pacific ocean perch	396
S. auriculatus	Brown rockfish	398
S. aurora	Aurora rockfish	400
S. babcocki	Redbanded rockfish	401
S. borealis	Shortraker rockfish	403
S. brevispinus	Silvergray rockfish	405
S. caurinus	Copper rockfish	407
S. ciliatus	Dusky rockfish	409
S. crameri	Darkblotched rockfish	410
S. diploproa	Splitnose rockfish	412
S. elongatus	Greenstriped rockfish	414
S. emphaeus	Puget Sound rockfish	415
S. entomelas	Widow rockfish	417
S. flavidus	Yellowtail rockfish	418
S. goodei	Chilipepper rockfish	420
S. helvomaculatus	Rosethorn rockfish	421
S. jordani	Shortbelly rockfish	423
S. maliger	Quillback rockfish	424
S. melanops	Black rockfish	426
S. miniatus	Vermillion rockfish	428
S. mystinus	Blue rockfish	429
S. nebulosus	China rockfish	431
S. nigrocinctus	Tiger rockfish	433
S. paucispinus	Bocaccio	435
S. pinniger	Canary rockfish	437
S. proriger	Redstripe rockfish	439
S. reedi	Yellowmouth rockfish	440
S. ruberrimus	Yelloweye rockfish	442
S. saxicola	Stripetail rockfish	444
S. variegatus	Harlequin rockfish	446
S. zacentrus	Sharpchin rockfish	450

Table 2 Management regions for the directed (Zn) hook and line rockfish fishery.

Management Region	Code	Statistical Areas
Strait of Georgia:	SG	12-20, 28 and 29
West Coast Vancouver Island	WCVI	11, 21-27, 111, 121-127
Queen Charlotte Islands	QCI	1-2, 101-102, 142, 130
North Coast	NC	3-5, 103-105
Central Coast	CG	6-10, 106-110

Table 3 Rockfish aggregates for the Zn hook and line fishery.

Year	**Aggregate**	**Species**
<1995	YE	Yelloweye
	OR	quillback, copper, china, tiger
1995	YE	Yelloweye
	A1	quillback, copper
	A2	china, tiger
	A3	canary, silvergray, yellowtail, widow
	A4	rougheye, shortraker, shortspine and longspine thornyheads
	A5	Pacific ocean perch, yellowmouth, redstripe
	A6	all other species (*Sebastes*) except YE and A1-A5
> 1995	YE	Yelloweye
	A1	quillback, copper
	A2	china, tiger
	A3	canary, silvergray
	A4	rougheye, shortraker, shortspine and longspine thornyhead
	A5	Pacific ocean perch, yellowmouth, redstripe
	A6	yellowtail, black, widow
	A7	all other species (*Sebastes*) except YE and A1-A6

Table 4 1998/1999 Zn quotas by management region.

Management Region	Aggregate	1998/1999 Zn Quota (tonnes)
Strait of Georgia	YE	23
	A1 and A2	130
Queen Charlotte Islands	YE	117
	A1 and A2	38
Prince Rupert	YE	32
	A1 and A2	51
Central Coast	YE	99
	A1 and A2	100
West Coast Vancouver Island	YE	133
	A1 and A2	133

Table 5 Example of fishing period limits: option I in the Strait of Georgia.

Limit	1995	1996	1997	1998
A1	3500 lb.	1800 lb.	1500 lb.	1500 lb.
A2-A6	< 20% of A1,YE/landing	Na	Na	Na
A2-A7	na	600 lb.	600 lb.	600 lb.
A3-A7	< landed weight A1/period			
YE < Cap	6000 lb.	2500 lb.	2500 lb.	2,500 lb.
YE > Cap	Added to A2-A6 after 32t	<20% of A1/landing after 26t	<20% A1/landing after 24t	< 20% A1/landing after 23t
Overage	Max. 20% A1 deducted from next period	Max. of 10% of A1-A7,YE deducted from next period	Max. of 10% of A1-A7,YE deducted from next period	Max. of 10% of A1-A7,YE deducted from next period

Table 6 Number of samples, fish, and fish aged by species, location and year.

Species Name	Region	Stat Area	Year	Samples	Fish Measured	Fish Aged
Redbanded	CC	7	1995	1	50	50
Redbanded	QC	42	1995	1	50	50
Redbanded	QC	42	1996	1	51	51
Redbanded	QCI	2	1995	1	30	30
Redbanded	WCVI	26	1996	1	50	50
Shortraker	SG	12	1995	1	0	31
Copper	NC	5	1991	1	59	59
Copper	NC	5	1992	2	106	55
Copper	NC	5	1993	1	50	50
Copper	NC	5	1994	1	50	50
Copper	NC	5	1995	2	100	50
Copper	SG	12	1991	2	5	1
Copper	SG	13	1984	3	153	107
Copper	SG	13	1986	2	19	14
Copper	SG	13	1988	12	184	51
Copper	SG	13	1992	1	50	50
Copper	SG	17	1986	2	78	21
Copper	SG	17	1993	1	53	54
Copper	SG	18	1992	1	50	50
Copper	WCVI	23	1994	1	45	1
Quillback	CC	6	1991	1	60	60
Quillback	CC	7	1988	1	232	233
Quillback	CC	7	1989	1	180	50
Quillback	CC	7	1993	4	201	50
Quillback	CC	8	1993	1	50	50
Quillback	CC	10	1995	2	102	52
Quillback	NC	4	1992	4	162	66
Quillback	NC	5	1994	2	101	51
Quillback	NC	5	1995	1	48	48
Quillback	QC	42	1994	1	10	10
Quillback	QCI	1	1979	1	100	99
Quillback	QCI	2	1992	1	129	50
Quillback	QCI	2	1993	1	95	95
Quillback	QCI	2	1995	1	38	38
Quillback	SG	12	1984	1	223	53
Quillback	SG	12	1985	1	262	79
Quillback	SG	12	1986	2	479	200
Quillback	SG	12	1987	3	762	75
Quillback	SG	12	1988	2	435	203
Quillback	SG	12	1989	1	223	75
Quillback	SG	12	1990	2	297	162
Quillback	SG	12	1991	2	168	101

Quillback	SG	12	1992	8	131	131
Quillback	SG	12	1993	1	54	54
Quillback	SG	12	1994	1	52	52
Quillback	SG	12	1996	1	100	100
Quillback	SG	13	1984	3	582	146
Quillback	SG	13	1985	2	807	75
Quillback	SG	13	1986	2	607	385
Quillback	SG	13	1987	2	521	101
Quillback	SG	13	1988	27	393	52
Quillback	SG	13	1992	1	50	50
Quillback	SG	13	1993	1	72	72
Quillback	SG	13	1994	1	67	70
Quillback	SG	17	1986	2	323	320
Quillback	SG	17	1991	1	52	52
Quillback	SG	17	1992	1	50	50
Quillback	SG	17	1993	2	100	51
Quillback	SG	17	1994	1	50	50
Quillback	SG	18	1988	2	289	146
Quillback	SG	18	1991	1	50	50
Quillback	SG	18	1992	2	97	98
Quillback	WCVI	11	1993	1	49	49
Quillback	WCVI	11	1994	1	50	50
Quillback	WCVI	23	1994	1	76	61
Quillback	WCVI	27	1991	1	39	39
Quillback	WCVI	27	1992	2	59	22
Yelloweye	CC	6	1989	1	226	50
Yelloweye	CC	6	1995	2	100	50
Yelloweye	CC	7	1990	1	94	50
Yelloweye	NC	4	1996	3	232	52
Yelloweye	QC	30	1991	2	59	49
Yelloweye	QC	30	1994	2	100	100
Yelloweye	QC	42	1986	1	260	260
Yelloweye	QC	42	1989	1	106	70
Yelloweye	QC	42	1990	1	92	78
Yelloweye	QC	42	1994	8	328	270
Yelloweye	QCI	1	1979	1	84	84
Yelloweye	QCI	1	1994	3	136	87
Yelloweye	QCI	2	1991	1	50	50
Yelloweye	QCI	2	1992	1	52	52
Yelloweye	QCI	2	1993	1	66	66
Yelloweye	QCI	2	1995	3	161	101
Yelloweye	SG	12	1994	1	50	50
Yelloweye	SG	12	1995	1	36	34
Yelloweye	SG	17	1988	2	225	225
Yelloweye	WCVI	11	1989	1	100	100
Yelloweye	WCVI	11	1991	1	52	52

Yelloweye	WCVI	11	1992	2	84	50
Yelloweye	WCVI	24	1989	1	57	57
Yelloweye	WCVI	24	1992	2	100	50
Yelloweye	WCVI	24	1993	1	53	53
Yelloweye	WCVI	25	1988	1	100	100
Yelloweye	WCVI	25	1989	1	132	50
Yelloweye	WCVI	26	1992	1	80	80
Yelloweye	WCVI	27	1991	1	72	50
Yelloweye	WCVI	27	1992	2	88	51
Yelloweye	WCVI	27	1993	2	235	50
Yelloweye	WCVI	27	1994	10	854	360

Table 7 Hook and line rockfishes (tonnes) by species for each management region from Jan. 1, 1997 to Dec. 31, 1997. Total catch by species from logbooks (Logbook Total) and landings from dockside monitoring (DMP Total) are also listed. License category Zn (options A,B,C,I), dogfish and lingcod are included. Hart is the DFO species code.

Hart	Species	CC	NC	QCI	SG	WCVI	Logbook Total	DMP Total
442	Yelloweye	119.5	28.7	101.5	29.1	170.4	449.2	442.3
424	Quillback	67.2	50.0	31.2	113.4	57.3	319.2	342.8
394	Rougheye		0.0	148.3	0.1	39.4	187.8	129.0
401	Redbanded	0.5	0.0	38.5	0.6	34.1	73.7	88.1
431	China	8.1	5.9	6.4	4.0	30.0	54.4	71.7
407	Copper	10.1	8.4	9.8	23.9	27.0	79.2	67.1
403	Shortraker	0.0	0.0	14.4	0.0	39.5	54.0	53.0
405	Silvergray	2.4	1.2	31.0	0.5	9.8	44.8	45.6
437	Canary	4.9	1.0	12.2	0.6	17.3	36.0	43.0
426	Black	1.2	0.9	3.2	3.8	20.7	29.8	17.6
433	Tiger	3.6	2.5	0.7	2.0	5.1	13.9	16.9
428	Vermillion	2.7	0.0	0.6	0.2	6.0	9.6	13.1
435	Bocaccio	2.1	0.1	2.4	0.2	5.9	10.7	11.2
418	Yellowtail	1.0	1.3	0.8	4.7	1.0	8.8	11.1
451	Shortspine thornyhead	0.0		1.7		3.2	4.8	8.2
440	Yellowmouth	0.0		1.1		3.4	4.4	6.3
421	Rosethorn	0.8	0.0	1.0	0.0	1.2	3.1	5.8
439	Redstripe	0.1	0.2	0.1	0.1		0.5	1.7
414	Greenstriped	0.0	0.0	0.0	0.1	0.1	0.3	0.7
396	Pacific ocean perch			0.8		0.2	1.0	0.5
417	Widow	0.6	0.2	0.8	0.6	1.6	3.8	0.3
409	Dusky	0.0	0.2	0.1	0.0	0.0	0.4	0.3
410	Darkblotched		0.0	0.0		0.0	0.0	0.10
	All Rockfishes	224.9	100.7	406.6	183.9	473.2	1389.2	1376.1

Table 8 Hook and line rockfishes (tonnes) by species for each management region from Jan. 1, 1998 to Mar. 31, 1998. Total catch by species from logbooks (Logbook Total) and landings from dockside monitoring (DMP Total) are also listed. License category Zn (options A,B,C,I), dogfish and lingcod are included. Hart is the DFO species code.

Hart	Species	CC	NC	QCI	SG	WCVI	Logbook Total	DMP Total
442	Yelloweye	42.8	22.6	47.2	0.1		112.7	100.7
424	Quillback	45.9	14.7	2.6	0.2		63.4	79.1
394	Rougheye	0.0	0.0	82.7			82.7	77.5
431	China	7.6	2.2	0.4			10.2	13.6
437	Canary	3.2	1.1	7.0			11.3	13.2
405	Silvergray	0.9	0.7	22.0			23.6	12.9
407	Copper	8.8	2.1	0.1	0.0		11.1	11.9
403	Shortraker	0.0	0.0	15.0	0.1		15.1	5.6
401	Redbanded	0.0	0.0	4.1			4.2	4.5
426	Black	1.1	0.1	0.1			1.3	3.9
433	Tiger	1.4	0.7	0.1	0.0		2.3	3.2
428	Vermillion	1.8	0.0	0.0			1.9	1.8
418	Yellowtail	0.5	0.1	0.1			0.8	1.8
435	Bocaccio	0.3	0.1	2.0			2.3	1.2
451	Shortspine thornyhead		0.0	0.7	0.0		0.7	1.0
421	Rosethorn	0.2	0.0	0.4			0.6	1.0
414	Greenstriped	0.1	0.0	0.0			0.2	0.2
439	Redstripe	0.0	0.0	0.1			0.1	0.2
396	Pacific ocean perch		0.0	0.2			0.2	0.2
440	Yellowmouth			0.1			0.1	0.1
417	Widow	0.7	0.2	0.3			1.2	0.0
409	Dusky	0.0	0.1	0.1			0.2	0.0
410	Darkblotched	0.0	0.0				0.0	0.0
	All Rockfishes	115.5	44.9	185.1	0.4		345.9	333.5

Table 9 Hook and line landings of rockfishes (tonnes) by species from dockside monitoring Apr. 1, 1998 to Oct. 19, 1998. License category Zn (options A,B,C,I), dogfish and lingcod are included. Hart is the DFO species code.

Hart	Species	DMP Total
442	Yelloweye	286.0
394	Rougheye	224.3
424	Quillback	180.2
401	Redbanded	65.3
437	Canary	57.0
407	Copper	45.4
431	China	37.7
405	Silvergray	37.0
403	Shortraker	34.8
426	Black	15.8
451	Shortspine thornyhead	11.1
433	Tiger	10.4
428	Vermillion	9.6
418	Yellowtail	9.2
435	Bocaccio	8.1
440	Yellowmouth	6.9
421	Rosethorn	3.2
396	Pacific ocean perch	1.4
417	Widow	0.3
414	Greenstriped	0.2
409	Dusky	0.2
439	Redstripe	0.1
410	Darkblotched	0.1
412	Splitnose	0.0
400	Aurora	0.0
450	Sharpchin	0.0
398	Brown	0.0
429	Blue	0.0
	All Rockfishes	1044.3

Table 10 Bycatch of rockfishes in the halibut fishery from 1995 to 1997 based on dockside monitoring data. Landings for 1997 are preliminary. Note that landings for 1998 landings are current to November 17, 1998 (D. Trager, pers. comm.).

	1995 Landings		1996 Landings		1997 Landings		1998 Landings	
	t	lbs	t	lbs	t	lbs	t	lbs
Yelloweye	246.5	543,448	241.9	533,242	203.4	448,521	246.8	544,124
Redbanded	28.2	62,146	28.7	63,303	26.8	59,106	21.7	47,806
Rougheye	15.1	33,213	16.2	35,766	17.3	38,035	15.6	34,415
Quillback	15.4	33,883	18.3	40,335	8.0	17,637	7.9	17,404
Shortspine...	7.1	15,672	8.1	17,851	13.4	29,537	11.3	24,849
Yellowmouth	2.6	5,653	4.1	9,071	1.4	3,169	2.1	4,638
Shortraker	6.0	13,277	4.9	10,776	6.4	14,015	5.3	11,713
Silvergray	5.1	11,261	4.9	10,883	2.7	5,886	3.7	8,213
Canary	2.2	4,777	3.2	6,976	1.8	3,946	3.1	6,896
Boccacio	1.5	3,227	1.5	3,232	0.8	1,728	0.5	1,170
Vermillion	0.2	408	0.6	1,289	NA	NA	NA	NA
Copper	0.4	796	0.6	1,351	0.3	652	0.2	389
China	0.3	621	0.5	1,183	0.3	581	0.2	390
Tiger	0.5	1,094	0.5	1,190	0.3	678	0.3	742
OTHERS	3.5	7,777	0.7	1,574	0.8	1,699	0.8	1,816
Total Rockfish	333.3	734,856	334.8	738,022	283.6	625,190	319.6	704,565
Bycatch percent	7.7		7.8		5.1		5.5	
Total Halibut	4,314.2	9,511,031	4,311.8	9,505,694	5589.4	12,322,337	5840.8	12,876,668

Table 11 Trawl catch (tonnes) of selected rockfish species based on onboard observer data. Logbooks were not available for the Strait of Georgia (SG) catch in 1997 and 1998. Data for 1998 is based on the months of January to July only.

Year	Species	SG	WCVI	QCI	NC	CC	Unknown	Coastwide
1996	Black	0.1	0.7	1.2	0.3	5.5	0.0	7.8
	Canary	0.0	379.0	39.9	9.0	103.5	1.0	532.5
	China	0.0	0.1	0.1	0.3	0.1	0.0	0.6
	Copper	0.0	0.4	3.4	8.3	4.5	0.0	16.6
	Quillback	0.3	4.1	3.3	3.9	1.3	0.0	12.9
	Redbanded	0.0	56.2	53.0	11.0	219.2	0.3	339.6
	Rougheye	0.1	212.1	785.9	0.0	70.4	0.7	1,069.3
	Silvergray	0.0	515.7	428.6	5.7	213.5	0.2	1,163.7
	Yelloweye	0.0	38.4	7.3	0.5	11.9	0.0	58.2
1997	Black	0.0	0.1	0.0	3.8	0.7	0.0	4.7
	Canary	0.0	465.9	24.0	4.6	160.2	0.3	655.0
	China	0.0	0.1	0.1	0.1	0.1	0.0	0.3
	Copper	0.0	2.3	0.6	4.4	0.7	0.0	8.0
	Quillback	0.0	3.2	0.6	3.1	1.6	0.0	8.5
	Redbanded	0.0	62.1	32.5	19.5	164.2	0.0	278.3
	Rougheye	0.0	118.5	241.7	0.2	27.9	0.1	388.4
	Silvergray	0.0	471.0	361.7	12.9	270.5	0.0	1,116.1
	Yelloweye	0.0	9.0	1.0	0.5	11.7	0.0	22.1
1998	Black	0.0	0.1	0.1	0.5	5.3	0.0	6.0
	Canary	0.0	411.8	27.5	0.4	48.3	2.2	490.2
	China	0.0	0.0	0.0	0.1	0.0	0.0	0.1
	Copper	0.0	0.6	0.5	1.4	0.1	0.0	2.7
	Quillback	0.0	2.8	0.1	0.7	0.5	0.0	4.1
	Redbanded	0.0	27.6	23.6	0.8	40.2	0.1	92.3
	Rougheye	0.0	126.6	254.5	0.0	5.4	0.1	386.7
	Silvergray	0.0	281.1	325.1	0.6	69.5	0.3	676.6
	Yelloweye	0.0	4.9	0.8	0.1	2.3	0.0	8.0

Table 12 Estimates of recreational effort and landings of rockfishes for the Strait of Georgia creel survey for the months of April through September in statistical areas 13 through 19, 28 and 29.

Year	Effort (boat trips)	Landings (pieces)
1980	448,100	NA
1981	443,804	77,889
1982	520,335	165,034
1983	495,756	183,493
1984	595,998	144,174
1985	576,885	121,681
1986	523,272	152,391
1987	525,047	121,297
1988	590,389	174,709
1989	532,968	181,537
1990	497,550	142,797
1991	409,376	150,524
1992	422,088	124,339
1993	480,747	98,134
1994	423,622	149,668
1995	306,849	107,379
1996	289,423	102,818
1997	258,280	85,701
1998	158,559	81,591

Table 13 Recreational catch of rockfishes by statistical area for the west coast of Vancouver Island. Catch as tonnes estimated by multiplying pieces by an average weight of 0.7 kg, effort as boat trips, and C/E is catch per ten boat trips. The survey was conducted from July to September in 1989 to 1995, June 15 to September 30 in 1997 (W. Luedke, pers. comm.).

	Area 23A			Area 23B (+ area 123)			Area 24 (+south portion area 124)		
Year	Catch	Effort	C/E	Catch	Effort	C/E	Catch	Effort	C/E
1989	0.3	27,050	0.13	15.9	42,190	3.76			
1990	0.1	26,510	0.03	17.5	49,290	3.55			
1991	0.0	43,120	0.00	10.0	44,660	2.23			
1992	0.4	53,000	0.08	13.9	58,230	2.39	2.9	3,830	7.52
1993	0.2	36,910	0.06	11.3	43,120	2.62	1.8	4,560	3.86
1994	0.1	33,930	0.03	12.9	52,870	2.43			
1995	0.0	8,210	0.01	7.5	36,390	2.06	1.7	7,080	2.35
1996	0.1	10,080	0.08	8.0	62,780	1.27	2.3	7,900	0.29
1997	0.0	26,860	0.02	7.0	27,493	2.56	3.0	4,850	6.16

Table 14 Recreational rockfish catch by year in pieces and estimated tonnes for statistical areas 1 to 10 inclusive (S. Cox-Rogers, T. Gjernes and E. Fast pers. comm.). Weight was estimated from pieces by multiplying by an average weight of 0.7 kg.

Year	**Pieces**	**Weight (t)**
1990	2961	2.1
1991	3064	2.1
1992	3084	2.2
1993	4552	3.2
1994	8319	5.8
1995	14,703	10.3
1996	17,240	12.1
1997	15,973	11.1

Table 15 Summary of landings (tonnes) of rockfishes by fishery for 1997. Cells marked NA indicate where data are not available or have not been processed. Landings are rounded to the nearest tonne.

Fishery	YE	A1+A2	Total Rockfishes	Source/Comment
Commercial				
Hook and line (non-halibut)	442	500	1,376	Dockside monitored
Halibut bycatch	188	8	250	Dockside monitored
Hook and line except Zn, lingcod, dogfish, halibut	3	NA	29	Preliminary
Trawl	22	17		Onboard observer
Salmon troll	NA	NA	NA	
Shrimp beam trawl	NA	NA	NA	Unknown
Mid-water hake and pollock	NA	NA	NA	Negligible for YE, A1, A2
Option B flatfish	NA	NA	NA	
Recreational				Conservative estimates, partial spatial/temporal coverage
Strait of Georgia	NA	NA	75	Creel estimates Apr-Sep, 15 t assumed for area 12
Barclay Sound	NA	NA	10	Creel estimate June to Sept
North Coast	NA	NA	11	Lodge logbooks, DFO observation
First Nations	NA	NA	100	Guess

Table 16 Yelloweye recommended yield, TAC, landings and the difference between landings and TAC for the Strait of Georgia management region. No regional yield recommendation was provided beginning in 1996. The 1997 fishing year includes January 1 to March 31, 1998. The 1998/99 landings include April 1 to October 19, 1998.

Year	Rec. Yield (t)	TAC (t)	Landings (t)	Difference (t)
1986	na	Na	94	Na
1987	na	Na	101	Na
1988	na	Na	131	Na
1989	50-100	Na	126	Na
1990	25-75	Na	135	Na
1991	50	50	115	65
1992	59-86	59	30	-29
1993	81-121	70	42	-28
1994	31-48	70	86	16
1995	25-38	62	40	-22
1996	NA	38	32	-6
1997	NA	24	25	1
1998/99	NA	23	23	0

Table 17 Other rockfish recommended yield, TAC, landings and the difference between landings and TAC for the Strait of Georgia management region. No regional yield recommendation was provided beginning in 1996. The 1997 fishing year includes January 1 to March 31, 1998. The 1998/99 landings include April 1 to October 19, 1998.

Year	Rec. Yield (t)	Quota (t)	Landings (t)	Difference (t)
1986	NA	Na	432	Na
1987	150-300	Na	322	Na
1988	275-375	Na	366	Na
1989	275-500	na	335	Na
1990	225-475	na	335	Na
1991	400	300	366	66
1992	185-277	130	148	18
1993	236-358	140	157	17
1994	181-270	150	188	38
1995	176-269	150	153	3
1996	NA	150	155	-
1997	NA	143	141	-2
1998/99	NA	130	97	-33

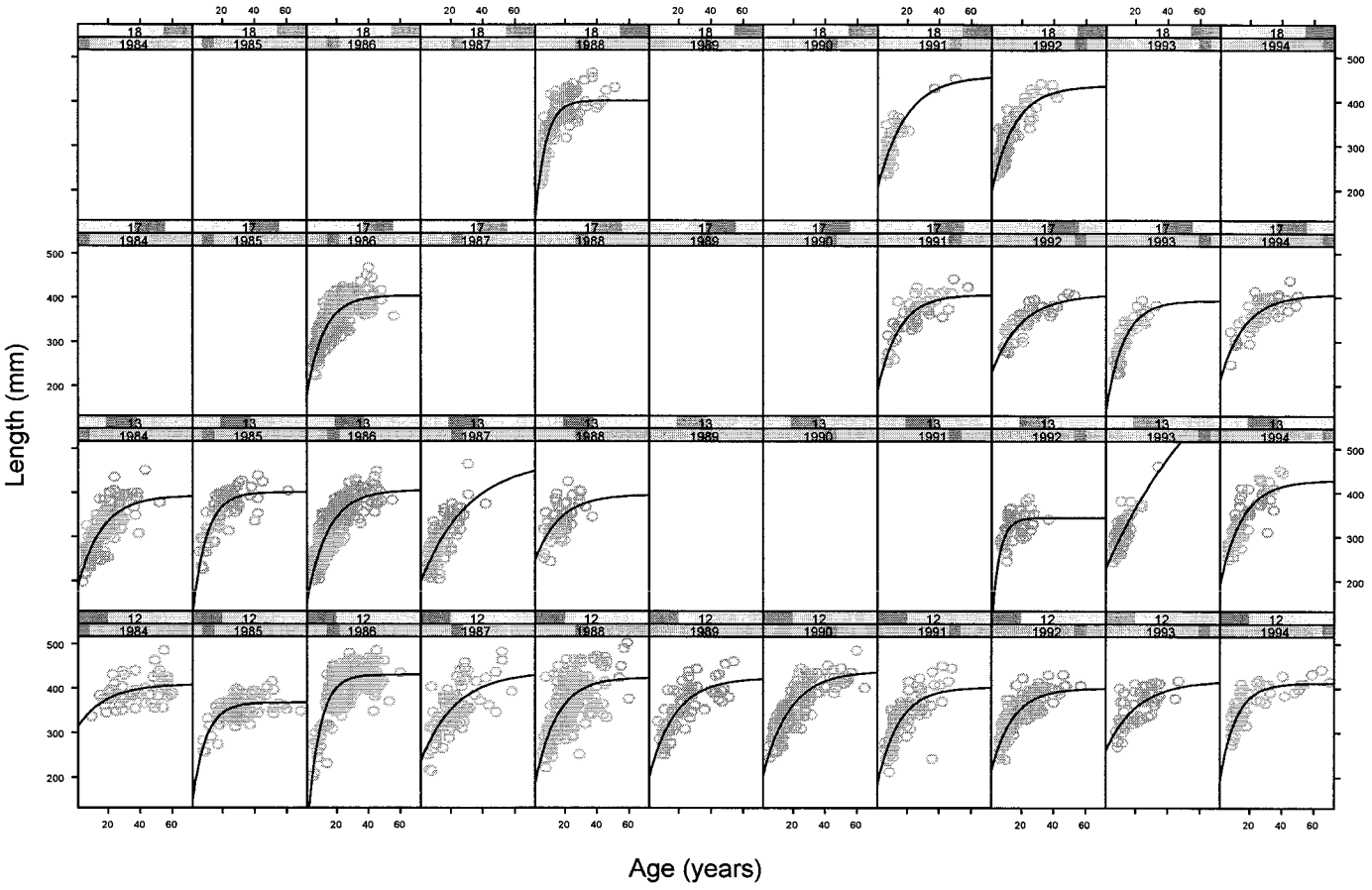

Figure 1 Length as a function of age by year and statistical area for quillback rockfish in the Strait of Georgia. Samples were obtained from the commercial fishery. Fitted von Bertalanffy growth curves are shown as a solid line within each panel.

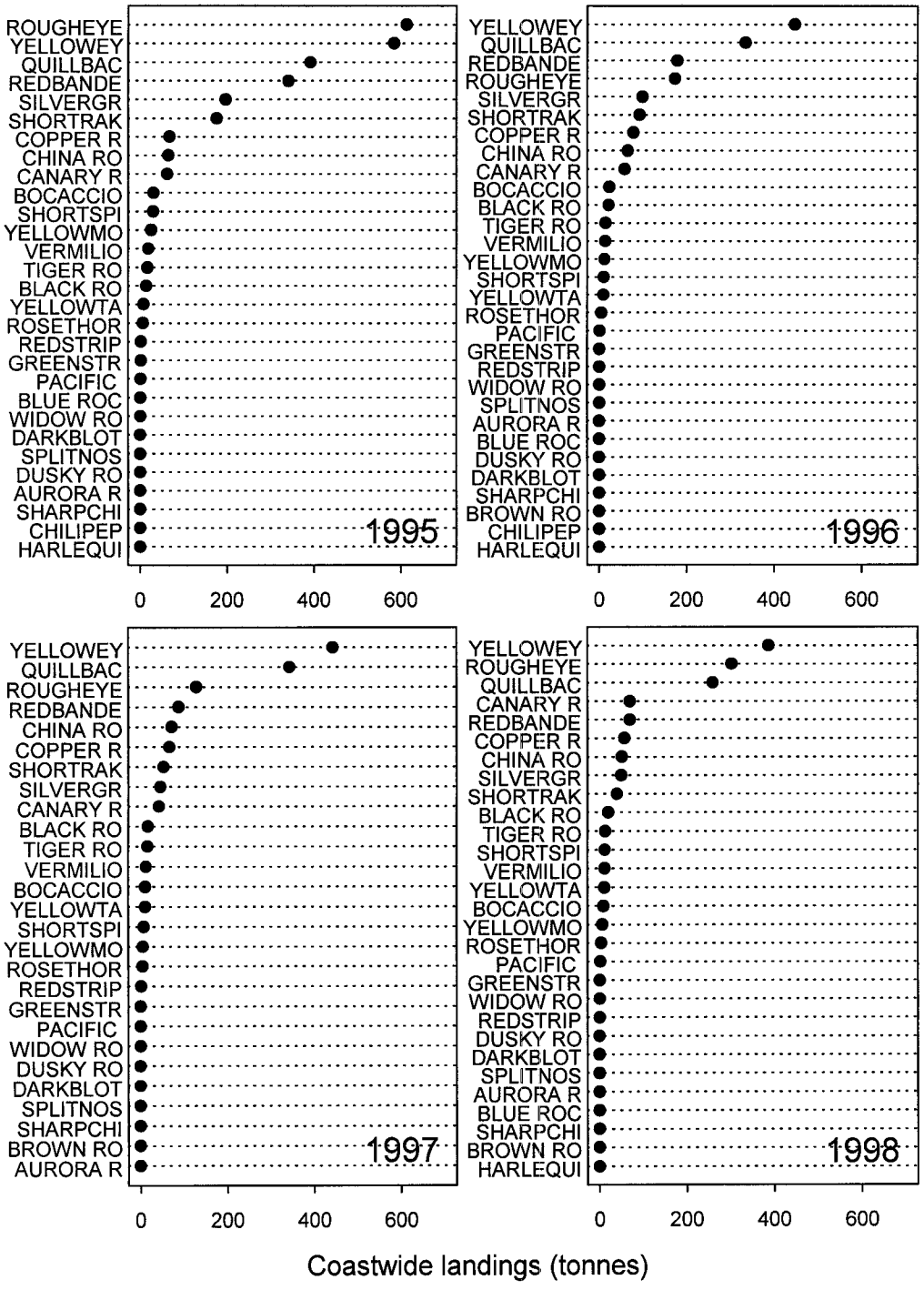

Figure 2 Coastwide landings (tonnes) of rockfishes from hook and line dockside monitoring (Zn, lingcod, dogfish), excluding halibut bycatch.

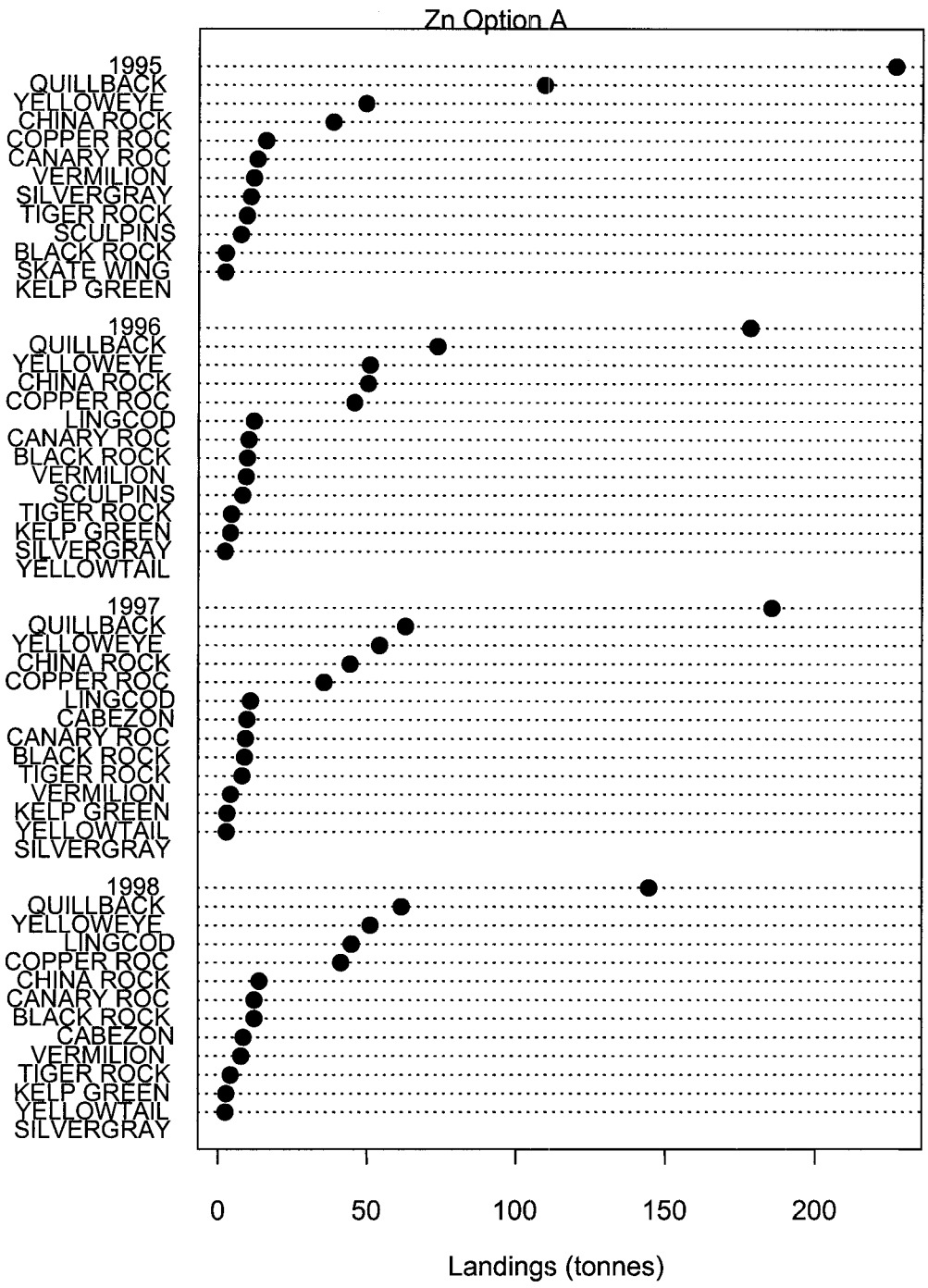

Figure 3 Landings (tonnes) by year and species for Zn option A. Landings of species greater than 2 t are shown.

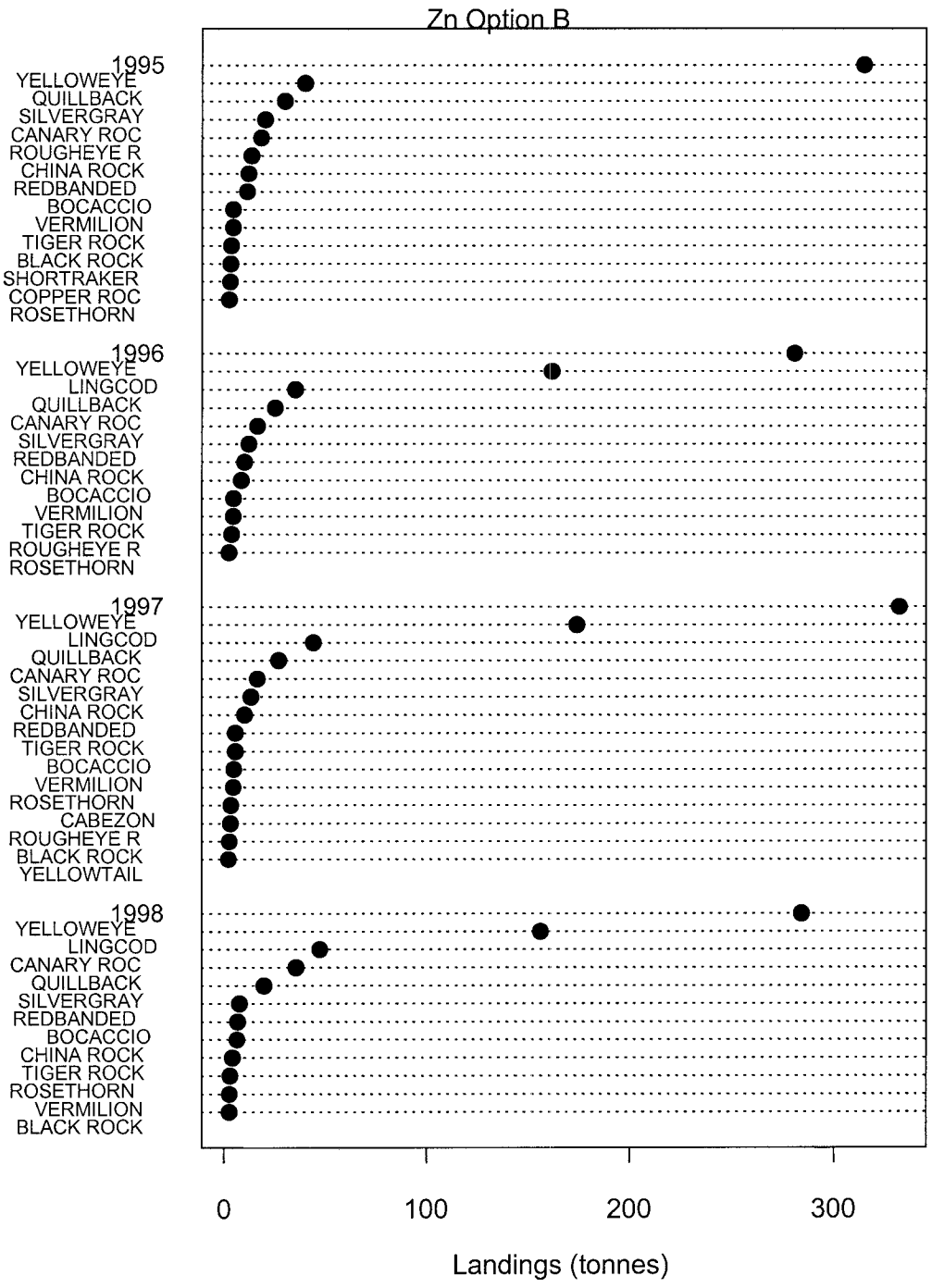

Figure 4 Landings (tonnes) by year and species for Zn option B. Landings of species greater than 2 t are shown.

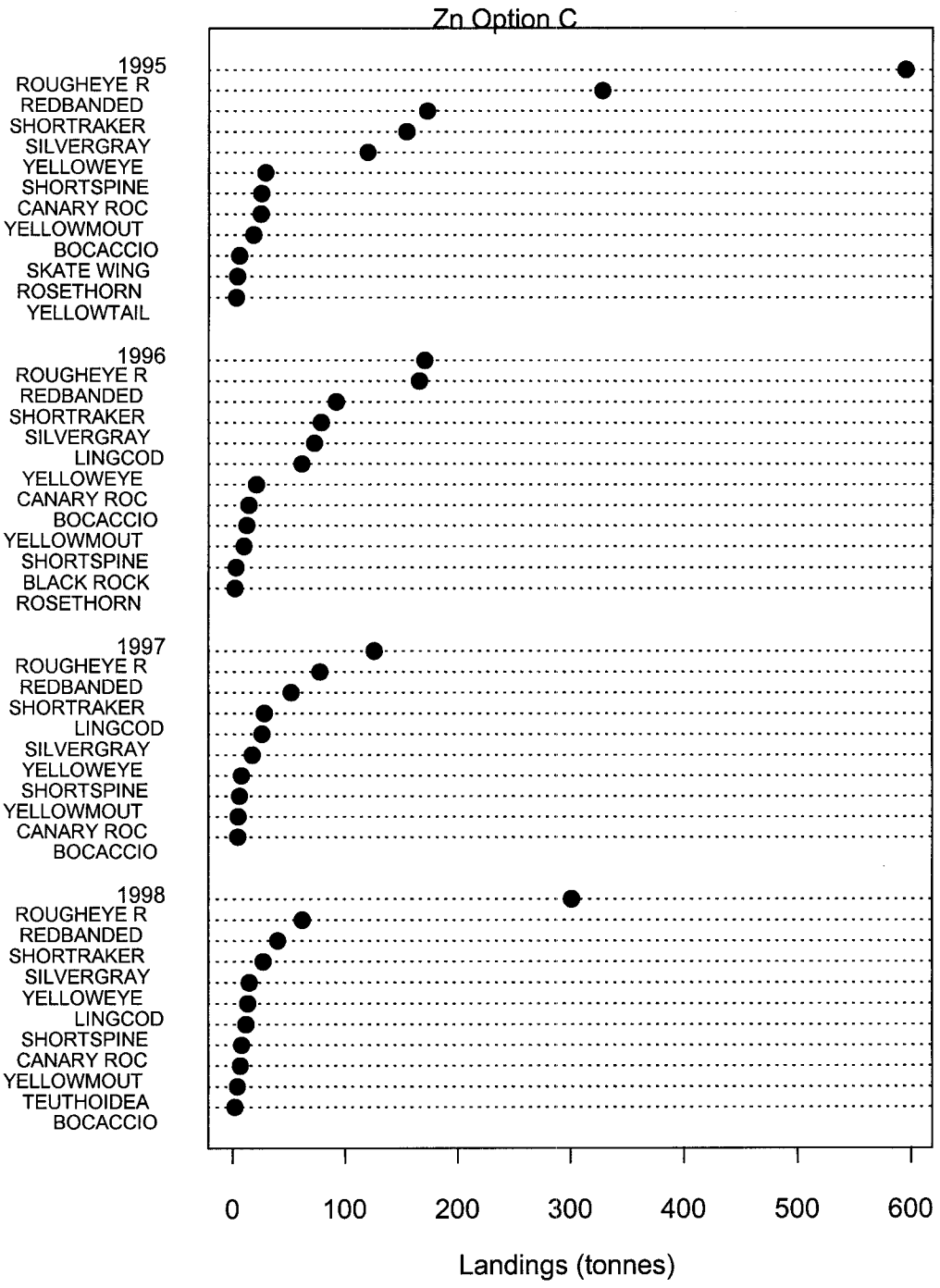

Figure 5 Landings (tonnes) by year and species for Zn option C. Landings of species greater than 2 t are shown.

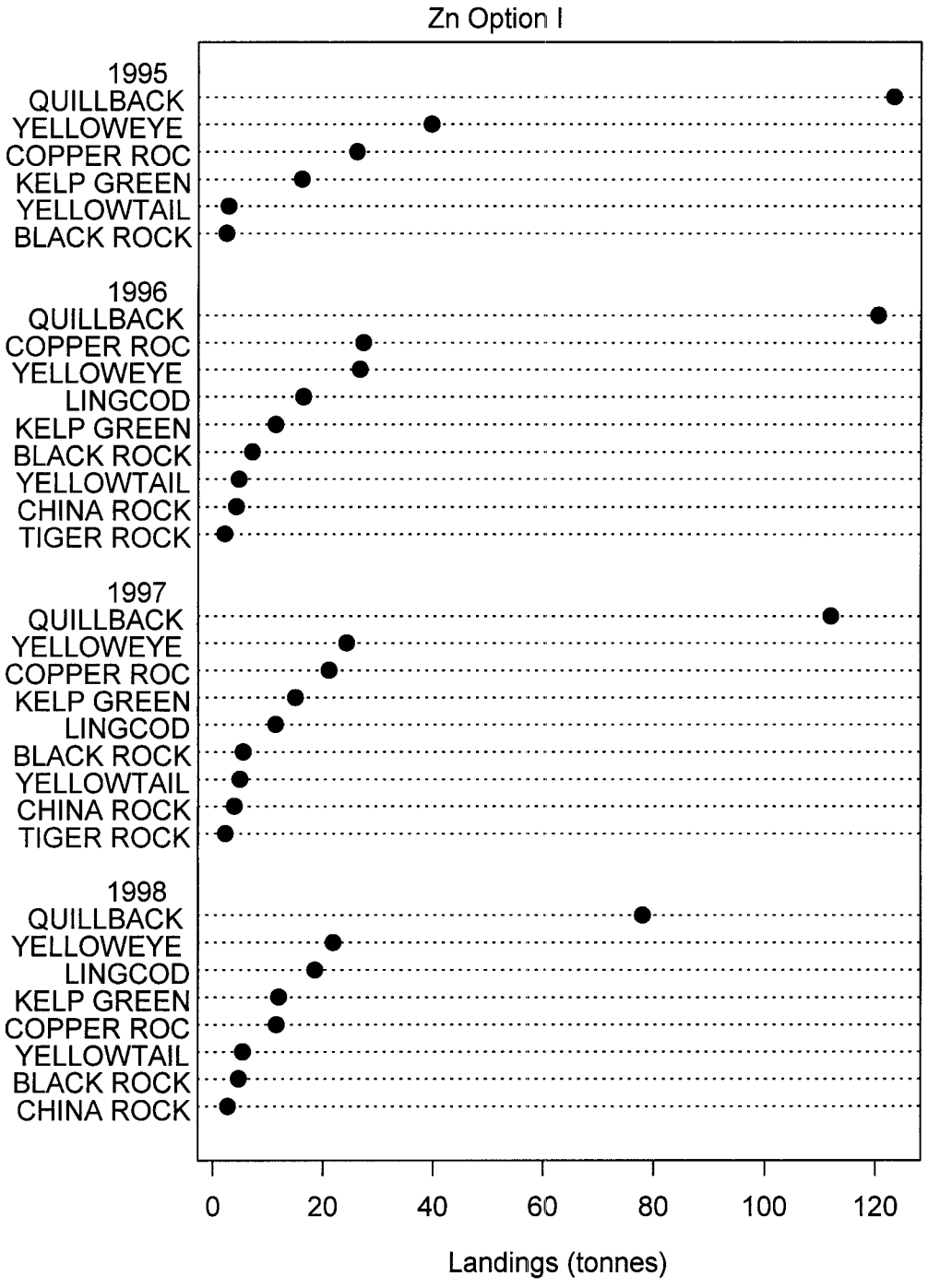

Figure 6 Landings (tonnes) by year and species for Zn option I. Landings of species greater than 2 t are shown.

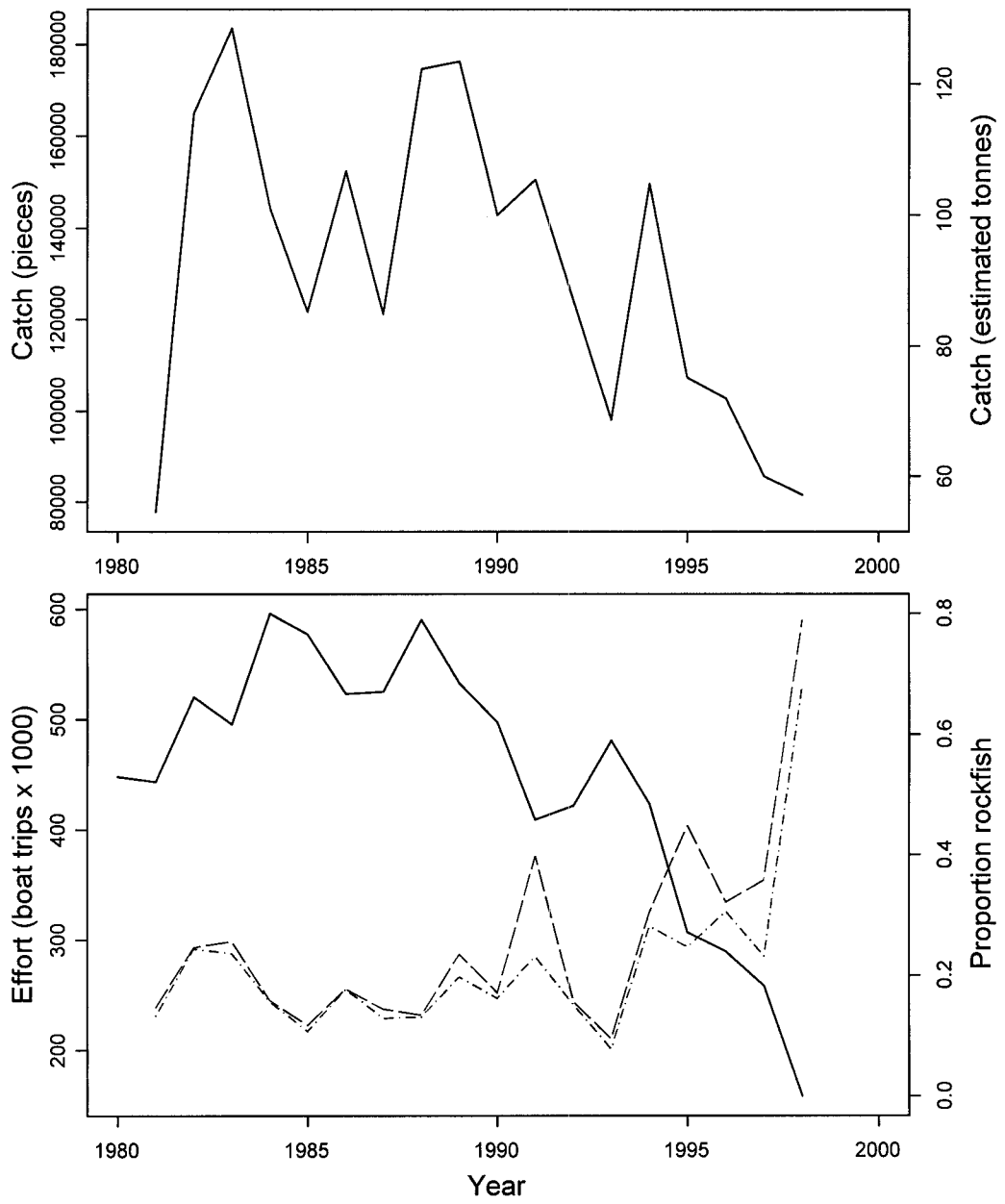

Figure 7 Strait of Georgia recreational catch of rockfishes (pieces and tonnes, upper panel) and effort in thousands of boat trips (lower panel, solid line) based on the creel survey. The dashed line in the lower panel shows rockfish pieces as a proportion of rockfish, coho, and chinook pieces. The dot-dash line shows rockfish pieces as a proportion of rockfish and salmon pieces.

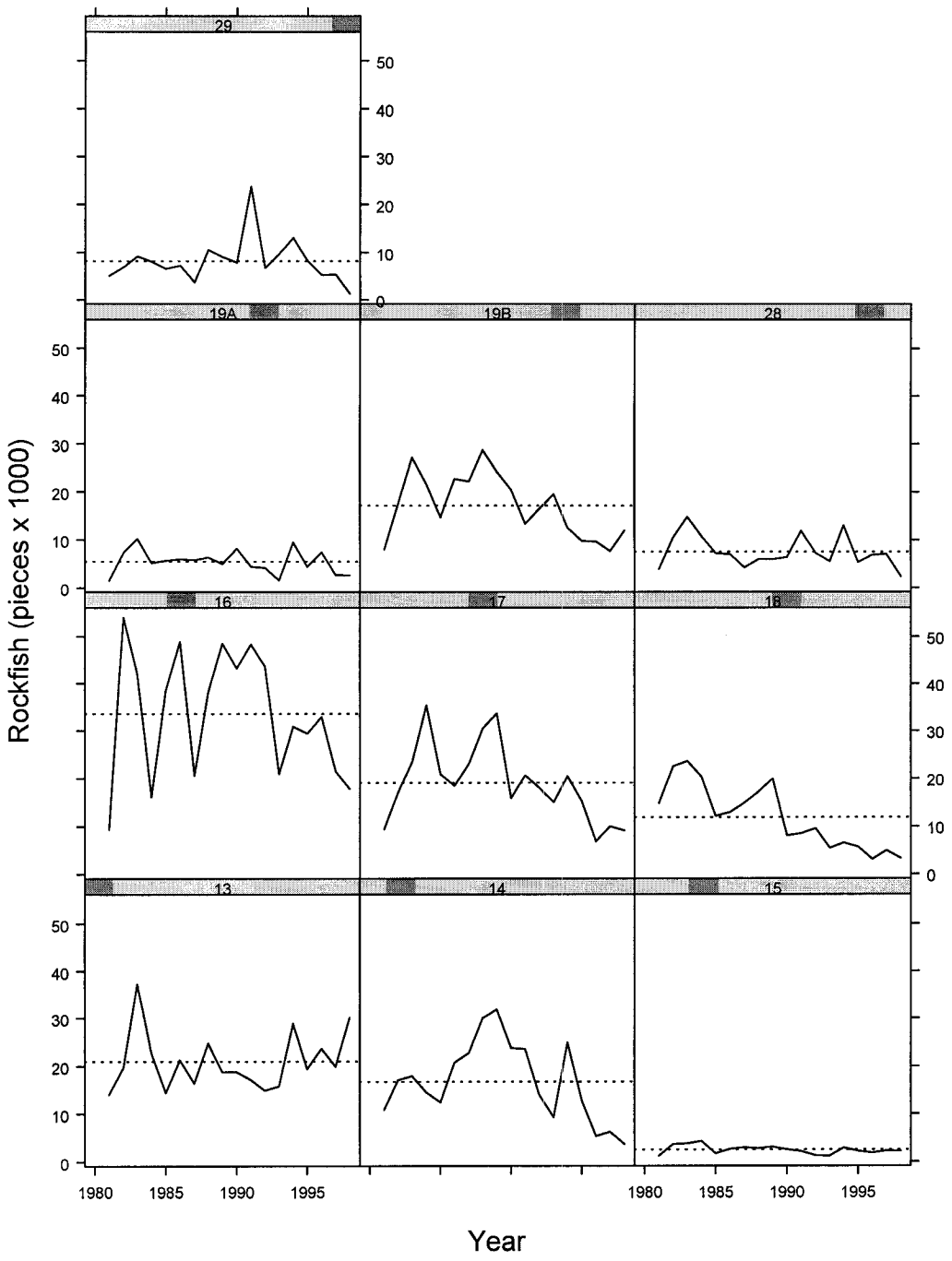

Figure 8 Recreational catch of rockfishes (thousands of pieces) as a function of year and statistical area. The horizontal dashed line in each panel is the mean catch over time.

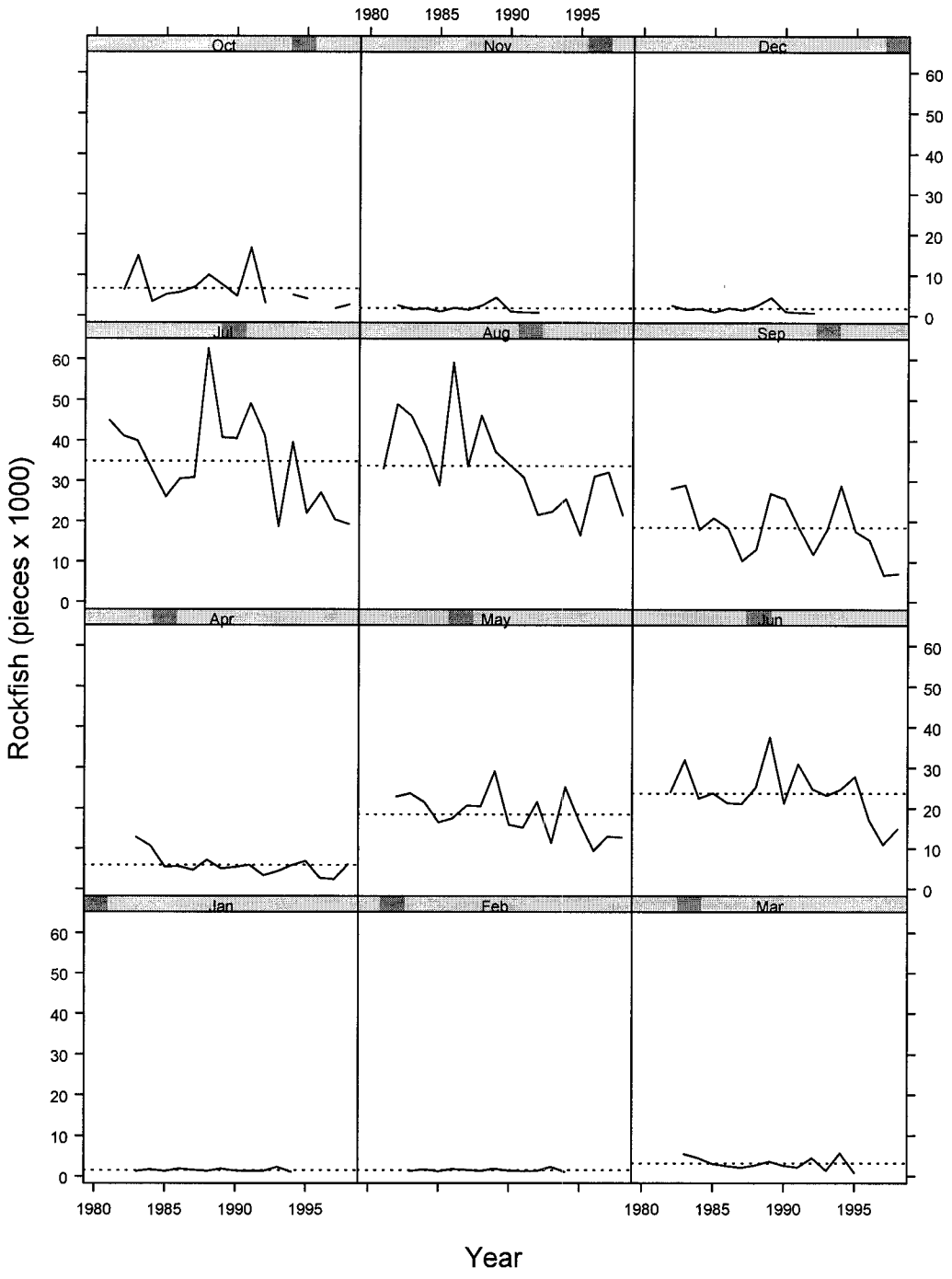

Figure 9 Recreational catch of rockfishes (thousands of pieces) as a function of year and month. The horizontal dashed line in each panel is the mean catch.

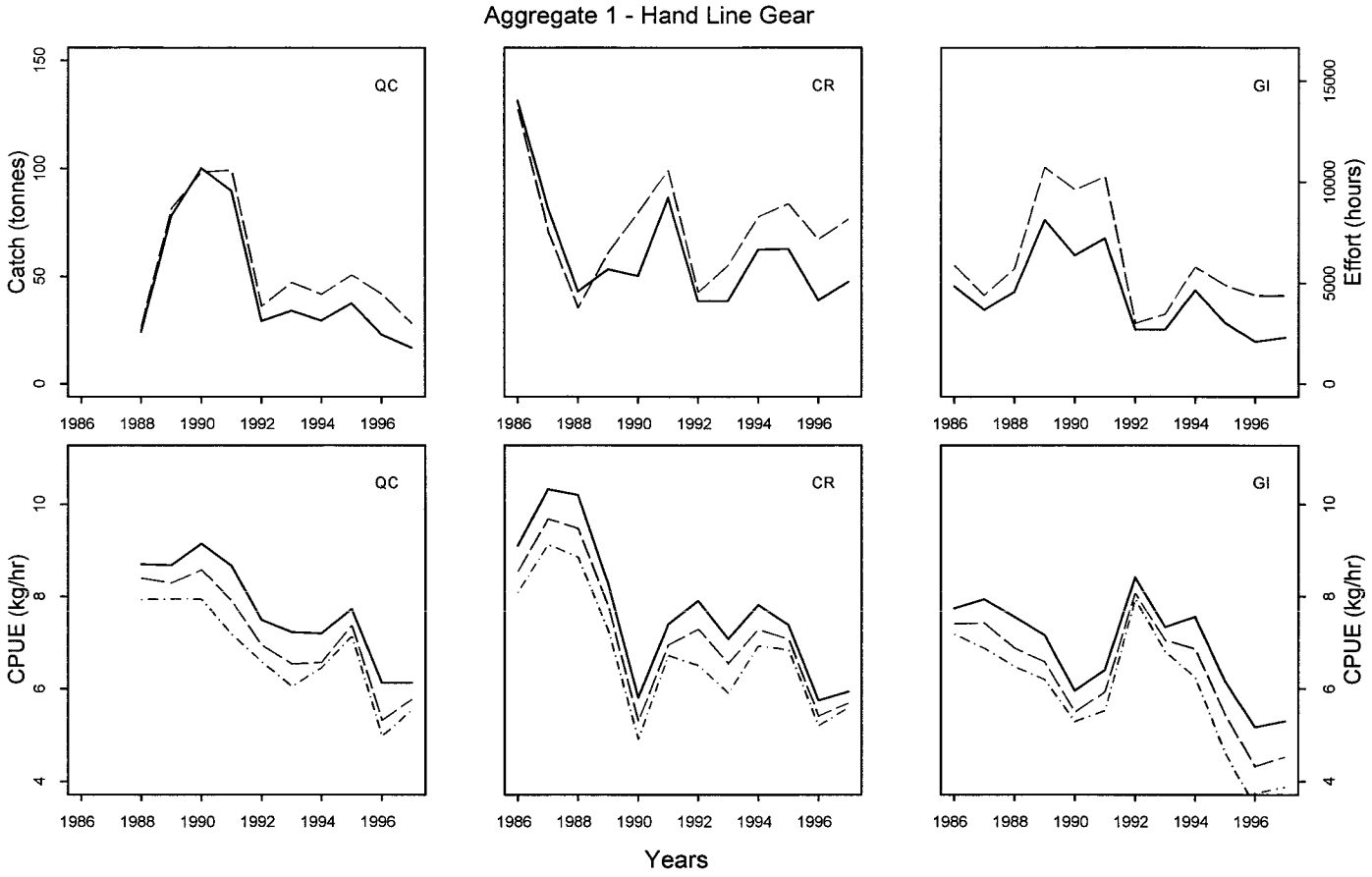

Figure 10 Catch, effort, and catch per unit effort for quillback and copper rockfishes caught by hand line gear in three localities. The upper three panels represent annual time series of catch (tonnes, solid line) and effort (hours fished, dashed line) in the Queen Charlotte Strait (QC), Campbell River (CR) and Gulf Islands (GI) localities. The lower three panels show mean CPUE (kg/hr, solid line), a 10% trimmed mean CPUE (dashed line) and median CPUE (dot-dash line) for each locality by year.

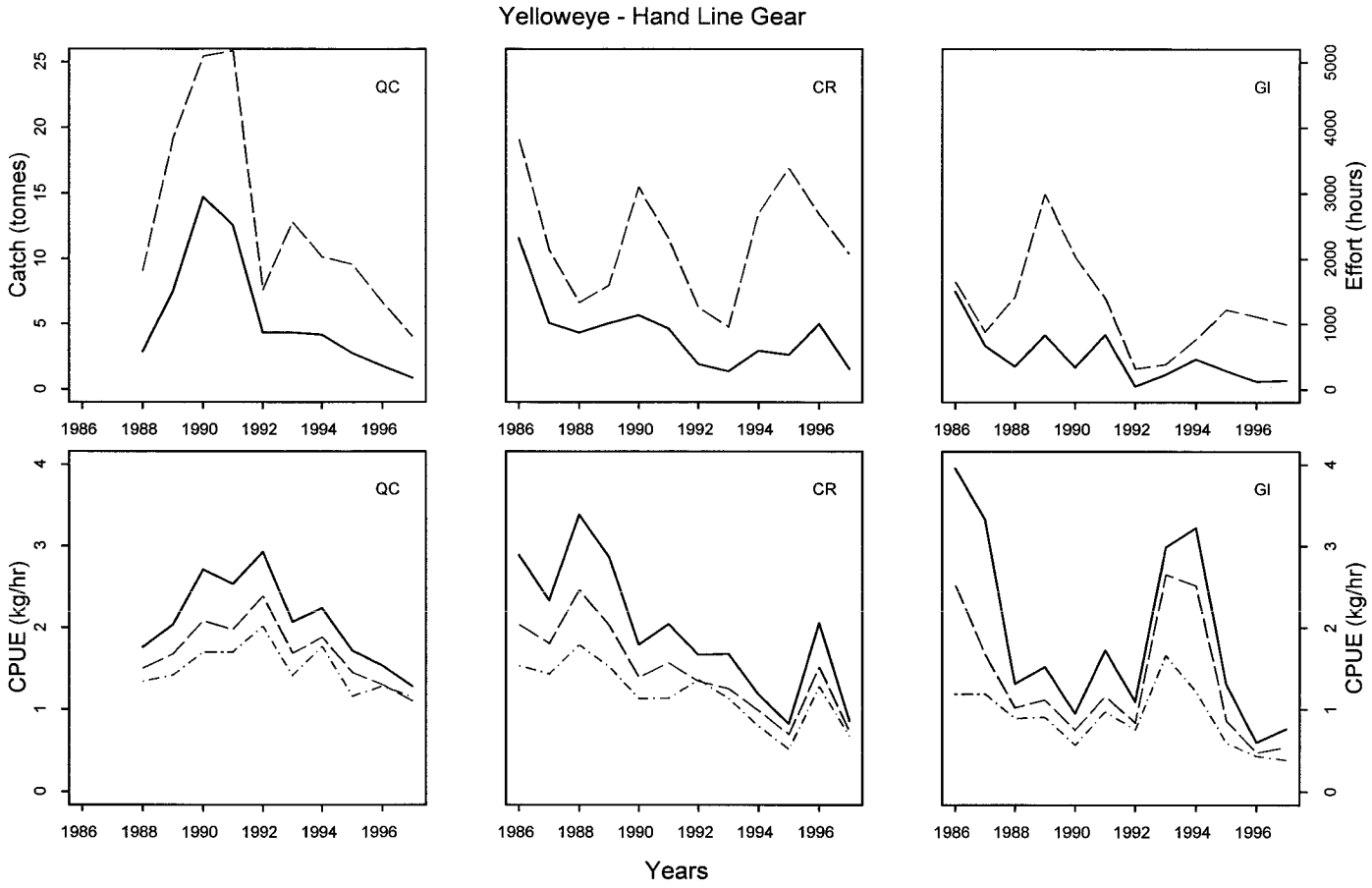

Figure 11 Catch, effort, and catch per unit effort for yelloweye rockfish caught by hand line gear in three localities. The upper three panels represent annual time series of catch (tonnes, solid line) and effort (hours fished, dashed line) in the Queen Charlotte Strait (QC), Campbell River (CR) and Gulf Islands (GI) localities. The lower three panels show mean CPUE (kg/hr, solid line), a 10% trimmed mean CPUE (dashed line) and median CPUE (dot-dash line) for each locality by year.

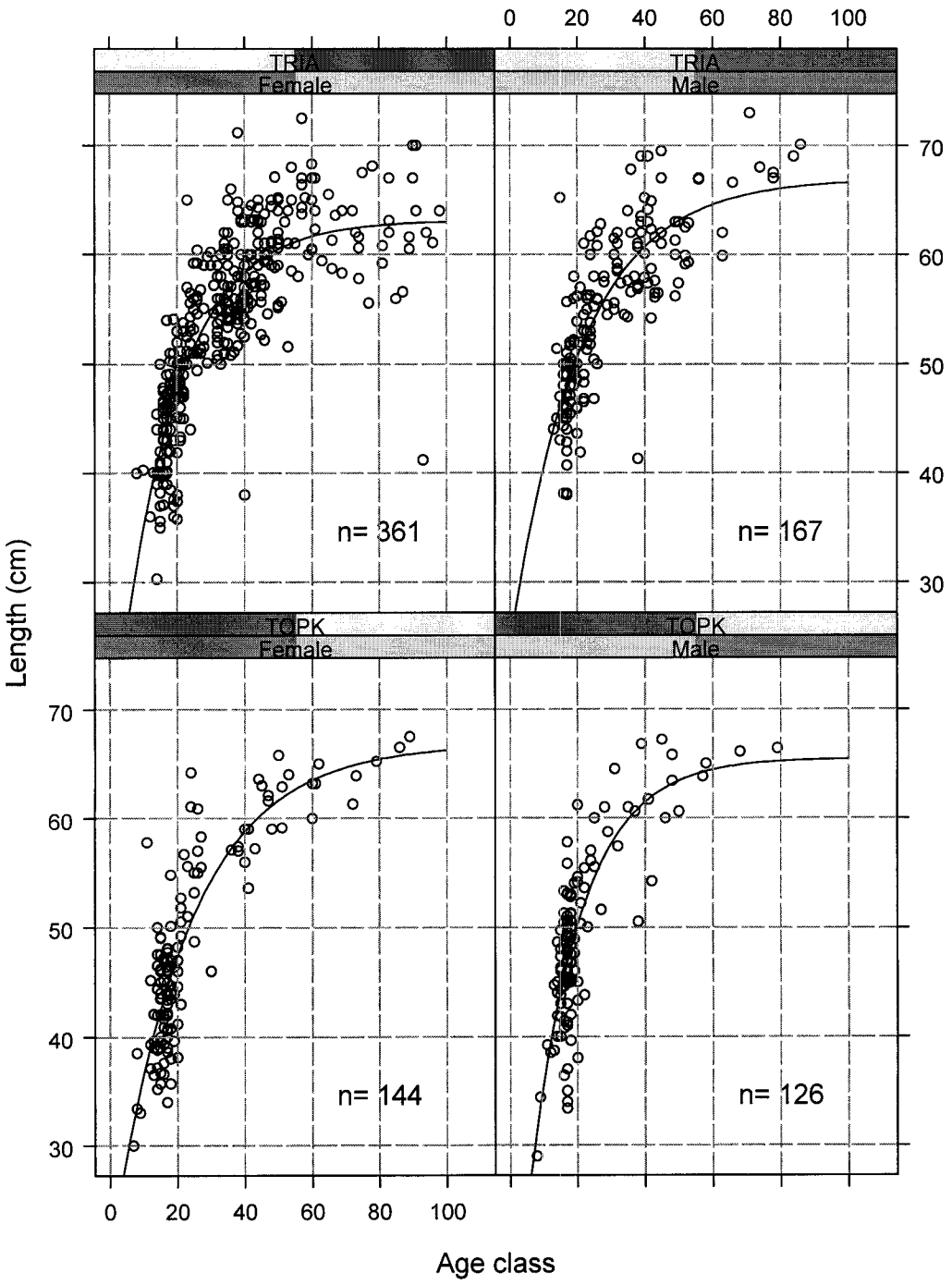

Figure 12 Length as a function of age by study site and sex for yelloweye rockfish. The solid line in each panel represents the result of a von Bertalanffy growth curve. The sample size is indicated in each panel.