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Slope rockfish assessment  
for the west coast of Canada in 1998

J. T. Schnute, N. Olsen, and R. Haigh

Fisheries and Oceans Canada  
Science Branch, Pacific Region  
Pacific Biological Station  
Nanaimo, BC V9R 5K6

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## ABSTRACT

For assessment purposes, slope rockfish include seven species: Pacific ocean perch, yellowmouth rockfish, redstripe rockfish, roughey rockfish, shortspine/longspine thornyheads, and shortraker rockfish. These are managed within six major areas (3C, 3D, 5AB, 5CD, 5ES, 5EN), giving a total of 42 species-area combinations. Historically, these 42 assessment units have been managed with reference to a benchmark stock of Pacific ocean perch in Area 5AB. A catch-at-age analysis of this stock played a central role in the assessment. This assessment differs from past reports in three principle respects. First, we use a new trawl observer database to examine abundance ratios among species and areas. Second, we use information gathered from experienced members of the industry, and we record some of their concerns. Third, we do not include a new catch-at-age analysis of the benchmark stock. No new survey data are available to alter substantially the 1997 analysis.

We draw several conclusions from our analysis of the trawl observer database. First, as stated by industry members, CPUE varies substantially with depth. Second, commercial slope rockfish tows that occur in similar times and places as research survey tows sometimes exhibit lower CPUE profiles in relation to depth, confirming observations by fishermen that a system of IVQs may induce avoidance fishing. Third, analysis of heavily fished blocks shows little evidence of stock depletion, except possibly for longspine thornyheads. Finally, industry abundance estimates conform more closely to recent yield and quota recommendations than to various computed indices based on effort qualification and spatial stratification.

Recognizing the need for further analysis and lacking evidence for substantial change at this time, we recommend that the 1998 yield options be extended to 1999.

## RÉSUMÉ

Aux fins de l'évaluation, les sébastes du talus ou de la pente, englobent sept espèces : le sébaste à longue mâchoire, le sébaste à bouche jaune, le sébaste à raie rouge, le sébaste à œil épineux, le sébastolobe à courtes épines, le sébastolobe à longues épines et le sébaste boréal. Leur gestion est faite selon six grandes zones (3C, 3D, 5AB, 5CD, 5ES et 5EN), ce qui donne un total de 42 combinaisons espèce-zone. Ces 42 unités d'évaluation ont toujours été gérées en utilisant comme repère le stock de sébaste à longue mâchoire de la zone 5AB. L'analyse des captures selon l'âge de ce stock servait de fondement à l'évaluation. La présente évaluation diffère en trois grands points de celles faites antérieurement. Tout d'abord, nous avons utilisé une nouvelle base de données des observations des captures au chalut pour examiner les rapports d'abondance entre les espèces et les zones. Deuxièmement, nous utilisons les renseignements recueillis par des pêcheurs d'expérience et nous faisons état de certaines de leurs préoccupations. Troisièmement, nous n'utilisons pas une nouvelle analyse des captures selon l'âge du stock repère et nous ne disposons d'aucune nouvelle donnée de relevé influant de façon appréciable sur l'analyse de 1997.

Nous tirons plusieurs conclusions de notre analyse de la base de données de l'observation de la pêche au chalut. Tout d'abord, tel que souligné par les pêcheurs, les PUE varient de façon appréciable en fonction de la profondeur. Ensuite, les chalutages visant les sébastes du talus qui sont effectués à des moments et à des lieux similaires à ceux des relevés de recherche présentent parfois des profils de PUE inférieurs en fonction de la profondeur, ce qui confirme les observations des pêcheurs selon lesquelles l'utilisation des QIB pouvait donner lieu à de l'évitement. Troisièmement, l'analyse des stocks fortement exploités montre peu d'indices d'appauvrissement, sauf peut-être pour le sébastolobe à longues épines. Enfin, les estimations d'abondance de l'industrie correspondent plus fidèlement aux récentes recommandations de rendement et de quotas qu'aux divers indices calculés à partir d'une qualification de l'effort et de la stratification spatiale.

Étant donné la nécessité de poursuivre l'analyse et ne disposant pas de données à l'appui d'une modification appréciable du régime de pêche, nous recommandons que les options de rendement de 1998 soient maintenues pour 1999.

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**SLOPE ROCKFISH**  
**(Pacific ocean perch, yellowmouth rockfish, redstripe rockfish,**  
**rougheye rockfish, shortspine/longspine thornyheads, and shortraker rockfish)**

**1. Introduction**

For assessment purposes, slope rockfish include Pacific ocean perch, yellowmouth rockfish, redstripe rockfish, rougheye rockfish, shortspine/longspine thornyheads (collectively termed “thornyheads”), and shortraker rockfish. A major review of the stock status of slope rockfish in British Columbia (BC) was completed in 1996 (Richards and Olsen 1996). The 1997 update (Richards et al. 1998) took account of new data from surveys in 1996–97, as well as the developing database compiled from observers aboard trawl vessels since 1996. This current assessment differs from past reports in three principal respects:

1. We use the new observer database to examine abundance ratios among species and areas.
2. We incorporate information gathered from experienced members of the industry, and we record some of their concerns.
3. We do not include a new analysis of the benchmark stock of Pacific ocean perch (POP) in Area 5AB.

Historically, slope rockfish have been managed with reference to the POP benchmark stock, and a catch-at-age analysis of this stock occupied a central role in the assessment. For example, the 1997 report (Richards et al. 1998) presented a detailed risk analysis leading to quota recommendations. No new data are currently available to alter the 1997 risk analysis significantly. Consequently, we shift the focus in this report from the benchmark stock to many others that require assessment. For each of the seven species listed above, we consider six major areas (3C, 3D, 5AB, 5CD, 5ES, 5EN). Thus, we examine a total of 42 species-area combinations, which we refer to in this report as *assessment units*. Table 1.1 lists historical yield options and quotas for these units. In some cases, yields or quotas have been applied to combined units; these appear as extra lines in the Table. For example, assessment reports in 1997 and 1996 specified POP yield options in all six major areas. Corresponding POP quotas were set somewhat differently, with a quota in each of four areas and a fifth quota for two areas (5ES, 5EN) combined. Yields or quotas may also have been set on a coastwide basis, with additional restrictions in only some of the six areas or combinations of areas.

Table 1.1 has been designed to portray the actual history of yield options and quotas, but we have added a ‘Total’ summary line for each species. This repeats coastwide numbers, where appropriate, but otherwise gives totals calculated from the relevant areas or combinations of areas. In particular, yield ranges on the ‘Total’ line are obtained by summing low and high ends of the appropriate ranges. Historically, yield recommendations have sometimes been flexible about transferring yield among regions to achieve the appropriate combined yield. The ‘Total’ line serves to indicate overall productivity of each species on the BC coast.

As mentioned earlier, this report contains a detailed analysis of the observer database and information gathered from experienced fishermen, with particular emphasis on setting appropriate quotas for the 1999 fishing year. We demonstrate that the database offers much information about the trawl fishery in each of the 42 assessment units. For example, we can confirm key features of advice from industry, such as a strong relationship between fishing depth and species captured in the assessment units. In some cases, particularly for longspine thornyheads, we find evidence of stock depletion. However, we also find many limitations in our analysis, some of which could potentially be rectified in the future. When we examine several sets of output, we find that recent yield options come closest to matching industry abundance estimates. Recognizing the need for further analysis and lacking evidence for substantial change at this time, we recommend that the 1998 yield options be extended to 1999.

To conduct the analyses presented here, we have developed an extensive technology for archiving and accessing the observer database. This work has required months of effort and continues to be a focal point of our research. We have designed these tools partly to promote dialogue among stakeholders, so that yield recommendations can be discussed in a more open atmosphere.

### 1.1. History of the fishery

A trawl fishery for slope rockfish has existed in BC since the 1940s. However, historical Canadian trawl catches were relatively minor. Between 1965-76, rockfish along the BC coast were targeted primarily by Soviet and Japanese vessels. Exact removals by foreign fisheries are unknown due to a lack of species composition and locality information, especially for Soviet vessels. Ketchen (1980) estimated the Soviet rockfish catch in BC to be between 29,000-63,000 tonnes in 1966, the year of the largest fishery.

No quotas were in effect for slope rockfish prior to 1977. For most subsequent years, rockfish management has involved a combination of species/area quotas, area/time closures, and trip limits on the major species (Table 1.1.1). Quotas were first introduced in 1979 for Pacific ocean perch (Table 1.1.2) and yellowmouth rockfish (Table 1.1.3), in 1982 for roughey rockfish (Table 1.1.4), in 1993 for redstripe rockfish (Table 1.1.5), and in 1996 for shortraker rockfish and shortspine thornyheads.

In 1983, an open-fishing experiment was initiated in the Langara Spit area (north of 54°). Open fishing continued until 1991, when a trawl closure was established in the main region of the Pacific ocean perch fishery. The experimental design involved an open fishery, followed by a fishery closure, where open and closed periods were planned to extend for equivalent time periods, initially five years each (Leaman and Stanley 1993). This experiment is now complete and the area re-opened to fishing in 1997.

All slope rockfish assessments suffer from the lack of reliable time series on fishery catch. The port monitoring program initiated in 1994 and the at-sea observer program initiated in 1996 have led to major improvements in data quality. However, we



have no information on historical levels of dumping, discarding, or misreporting. Without a mechanism for reconstructing the actual historical catch, we have assumed that the reported landed catch represents the actual catch at-sea, except where explicitly stated, and we treat the term “catch” as synonymous with the term “landings”.

The trawl fishery underwent a major change in 1997 through the introduction of individual vessel quotas (IVQs). In addition, the schedule of management was changed from a calendar year basis to a fishing year that begins in April and ends the following March. For example, recent periods of fishery regulation include

- 1995 fishing year (January 1, 1995, to December 31, 1995)
- 1996 fishing year (January 1, 1996, to December 31, 1996)
- 1997 first quarter (January 1, 1997, to March 31, 1997)
- 1997 fishing year (April 1, 1997 to March 31, 1998)
- 1998 fishing year (April 1, 1998 to March 31, 1999)

In this report, we refer to these regulatory periods as 1995, 1996, 1997a, 1997, and 1998, respectively. Each period had a distinct quota, with a lag of one quarter (1997a) before the introduction of IVQs in 1997.

## **2. Data sources**

### **2.1. GFCATCH database: 1954-1995**

The Department of Fisheries and Oceans (DFO) maintains detailed statistics of groundfish landings by trawl gear (1954-1995), longline gear (1979-1986), and trap gear (1979-1995). The database, called GFCATCH (Leaman and Hamer 1985), is currently housed on a networked computer at the Pacific Biological Station (PBS), Nanaimo, BC. Groundfish Division staff can access the data through a FORTRAN program called GFSEL.

There are three sources for historical groundfish catch data (details in Rutherford 1998): (i) trip reports/fisher logs, (ii) landing records (sales slips or validation records), and (iii) anecdotal evidence. Logbooks, kept by vessel captains, contain confidential fishing information – location, depth, effort, and estimates of weight by species or species groups. Until 1989, port liaison officers transcribed logbooks to trip reports. Processing plants and fishermen submitted sales slips, which record the actual catch weight by species and price paid. The two systems are complementary. Logbooks provide good information on areas and effort, but only estimates of catch. By contrast, sales slips provide an accurate estimate of weight, but give very little information on fishing area or effort. Actual weights from sales slips were substituted monthly into trip reports and, where possible, prorated to replace estimates given by fishermen. Anecdotal information – viewing an offload or interviewing the vessel’s crew – was used to supplement and, occasionally, override the data from the other two sources.

A data retrieval program called GFSEL (groundfish selection) was developed to gain access to the data files (Leaman and Hamer 1985). Based on user specifications, the program returns records of the corresponding catch and effort data. The user can also

download these records to a text file. Catch and fishing event information in GFCATCH are available from 1954 to 1995, representing 66,327 landing records. Since 1996, an onboard observer program (Section 2.2) has taken the place of fisher logs. Sales slips were supplanted by 'validation records' from a mandatory dockside monitoring program, implemented in 1994 for trawl landings. Validation records provide greater species detail than sales slips; otherwise, both these data sources have identical structure.

## 2.2. Trawl observer database

In 1996, a mandatory observer program for all Option A vessels and some Option B vessels became an important new data source for the groundfish fishery. Archipelago Marine Research (AMR) was contracted to provide trained observers, who record fishing event and catch information. AMR also converts observer logs to electronic format and performs quality control on the data. Captains of vessels not covered by the observer log program (Options B and C) submit their own logbook records. Currently, fisher logs are computerized by AMR as a courtesy. All trawl data from the observer program will eventually reside in an ORACLE database housed on a networked DFO computer in Vancouver. The new system will perform error checks, convert geo-referenced data to management areas, and compare official dockside-monitored weights with observer species composition per tow to prorate the validated weights accordingly.

At present the ORACLE database is not fully operational. As an interim measure, we have constructed a database, managed by Microsoft SQL Server on a networked computer at the Pacific Biological Station, that mirrors the planned design of the ORACLE database. All groundfish analysts can connect to this database using Microsoft Access 97. The connection uses linked tables, whose names have prefixes *A*, *B*, and *C* to indicate documentation, primary data, and codes, respectively. In particular, the six primary data tables are named: *B1\_Hails*, *B2\_Trips*, *B3\_Fishing\_Events*, *B4\_Catches*, *B5\_Validation\_Headers*, and *B6\_Validation\_Species*. Table 2.2.1 lists the number of records in each of these tables at the time of writing this report. Note that the largest table currently includes over 590,000 records. Analysis in this report depends principally on the tables *B2\_Trips*, *B3\_Fishing\_Events*, and *B4\_Catches*. Figure 2.2.1 illustrates the links among these tables.

When a trawler leaves port for a fishing trip, the captain hails out to the nearest port authority and is subsequently assigned a hail-out number. Upon returning from a fishing trip, the vessel is assigned a hail-in number, which serves as a trip identifier in this database. *B1\_Hails* contains information collected by the port authorities and is the most current record of fishing activity available. *B2\_Trips* similarly contains information unique to each trip, identified by the hail-in number. However, this table includes records only for trips where either observer logs or fisher logs have been submitted to AMR and converted to electronic format.

Table *B3\_Fishing\_Events* contains information unique to each tow within a trip. A tow is identified by combinations of hail number and set number. The fishing event table has been constructed from annual observer log tables (1996-98) and one fisher log

table (1996). By giving preference to observer logs over fisher logs, duplicate records have been eliminated when both were computerized for any given tow. In our version of the database, we have also converted latitude and longitude fields to decimals from degrees/minutes, converted depths from fathoms to metres, and added fields to describe fishing year, slope rockfish (SRF) assessment areas, mean latitude/longitude, and mean bottom depth. Most records in the database correspond to bottom trawls, although currently about 8% of the records describe midwater trawls.

Table *B4\_Catches* documents the catch of each species (in kg) within a tow. Unique catches are identified by combinations of hail number, set number, species code and utilization code, where the latter documents the fate of the catch (e.g., retained or discarded). In the current database, over 50% of the records document discarded catch, accounting for about 18% of the total captured biomass. There are catch records available from only 51,214 tows described in *B3\_Fishing\_Events*. The number of species per tow ranges from 1 to 47, with a mean of 9.25 (Table 2.2.2). Since 1996, 336 species, including invertebrates, have been captured by the trawl fishery; 214 of these were fish species, 57 of which were sold commercially.

Table *B5\_Validation\_Headers* describes trawl landings recorded by the dockside monitoring program. The catch composition and weight of these landings are detailed in *B6\_Validation\_Species*. The number of validated species per offload ranges from 1 to 39 with a mean of 13.0 (SD = 9.55). Note that validated landings do not provide estimates of discarded catch.

### 2.3. Hook and line rockfish logbook database

Data from the commercial hook and line rockfish fishery are entered in a Microsoft Access 97 database called RFLOGS.MDB (Haigh and Richards 1997). At present, annual database tables describe fishing event and species catch information for each trip and for each set. On a spatial scale, the inshore rockfish fishery is divided into management areas that are approximate subareas of the Pacific Marine Fisheries Commission (PMFC) areas. Thus, both temporal and spatial categories for the hook and line data require translation into a slope rockfish context. First, calendar fishing years must be divided into the regulatory periods identified here (1996, 1997a, 1997, 1998). This is a straightforward calculation, given the dates of fishing events. Second, inshore rockfish areas must be combined to give catch estimates within the six SRF areas. This calculation depends on rather extensive definitions of DFO management areas and subareas that correspond to the SRF areas (Table 2.3.1).

### 2.4. Survey data

DFO has conducted independent and joint surveys to investigate the distribution, abundance, and biology of rockfish in the northeast Pacific Ocean since 1963. The main objective of these swept-area trawl surveys is to provide a fishery-independent index of abundance and to collect synoptic biological samples of rockfish caught in the survey area. Biological sampling provides representative size, age, and maturity data for

commercially important rockfish species. Sampling also provides information from areas that have experienced different exploitation histories.

Information collected during surveys is similar to that collected by observers of the commercial fishery. Survey tow data include date, latitude, longitude, duration, depth, distance trawled, and the catch of each species. It is therefore possible to compare survey and commercial tows in areas of overlap, and we conduct such an analysis later in Section 4.2. For this purpose, we have extended tables in the SQL Server database (Section 2.2) to include records from two research surveys:

- in 1996, off the west coast of Vancouver Island (Area 3C), and
- in 1997, off the west coast of the Queen Charlotte Islands (Areas 5ES, 5EN).

## 2.5. GFBIO database

GFBIO is a relational database system for storing, maintaining, and gaining access to groundfish biological data. The database was developed in 1993-1994 by DFO staff in the Biological Sciences Branch and the Informatics Systems Division, and is currently housed in an ORACLE system on a VAX computer at Regional Headquarters, Vancouver. GFBIO primarily archives data collected from individual fish samples. These data have been collected since the 1940s from waterfront, observer, charter, and research trip sampling activities. Records include information on species, length, sex, and age in conjunction with background information such as location and collection methodology.

Previous slope rockfish assessments (Richards and Olsen 1996; Richards et al. 1998) used age structure data from this database in the benchmark analysis of POP in area 5AB. This current report, which does not revise last year's benchmark, makes no explicit use of biological data. In the future, we anticipate closer examination of this database, not only for catch-age analyses, but also for leading indicators of stock change, such as shifts in size at age.

## 2.6. Catch, effort, and CPUE summaries

Catch data by species, area, and fishing year can be obtained from the three databases discussed in Section 2.1–2.3: GFCATCH, the trawl observer database, and the hook and line database. For this report, we have devised a system to render the hook and line data compatible with trawl data. Table 2.6.1 gives a compilation of available hook and line data, based on the area translations defined in Table 2.3.1. Of the seven slope rockfish species, rougheye and shortraker are most affected by the hook and line fishery.

Tables 2.6.2 to 2.6.8 present catch (excluding discards) and median CPUE from the slope rockfish (SRF) trawl fishery. Six tables correspond to the six SRF areas (Tables 2.6.2–2.6.7) and a final table gives statistics for the entire coast (Table 2.6.8). Catches of shortspine and longspine thornyheads have been combined. Each table includes information on Canadian trawl catch, species proportions, CPUE, and effort. Catch prior to 1996 is the Canadian trawl landed catch from the GFCATCH database. From 1996 on, catch is obtained from the trawl observer database, in which data by tow (from *B2\_Trips*,

*B3\_Fishing\_Events*, and *B4\_Catches*) have not been rectified with landed weights (from *B5\_Validation\_Headers* and *B6\_Validation\_Species*). Eventually, validated landed weights will be prorated and replace these catch weights, where possible.

For consistency with past reports, we calculate the median CPUE by a 20% qualification rule within suitably defined trips. First, for a given area or the entire coast, we screen the data for all records with a slope rockfish catch. Next, catch and effort are summed across the selected records for a given trip. From 1996 on, a trip is defined as the portion of a “hail-in” trip where tows occurred in one SRF assessment area. Thus, each record in the analysis represents one trip (or a portion of a “hail-in” trip) with a slope rockfish catch in a given area. Trip records are considered “qualified” if the total slope rockfish catch accounts for at least 20% of the total fish catch (all fish species) for that trip. Although a qualification method based on individual tows rather than trips might be preferable, tow-by-tow data are not available in the GFCATCH database prior to 1991.

Species proportions in Tables 2.6.2–2.6.8 are computed from qualified records only. Thus, the reported proportion  $p_s$  of species  $s$  is the ratio

$$p_s = \frac{\text{total catch of species } s}{\text{total fish catch}},$$

where totals apply to qualified records in the given area. Following Richards and Schnute (1992), CPUE is calculated as the median CPUE value (ratio of catch to effort) across qualified records. Estimated effort on slope rockfish is then the ratio of total SRF catch (qualified or not) to qualified CPUE. For comparison, we define nominal effort as the total effort from all SRF trips (qualified or not). The number of qualified trips gives the sample size used to calculate CPUE.

The observer database includes information on both kept and discarded catch. Table 2.6.9 summarizes this information by species, area, and fishing year. In particular, beginning in 1996, total catch can be distinguished from the landed catch reported in Tables 2.6.2–2.6.8. For consistency with historical data, we do not include discards in those tables.

Tables 2.6.2–2.6.8 focus on catch by species and CPUE for the entire complex of slope rockfish. Figures 2.6.1 to 2.6.7 portray catch and CPUE graphically, where the CPUE is now computed individually for each species. The 20% qualification rule still applies, but in this case the catch of a given species must be at least 20% of the total fish catch. The catch portrayed in these figures represents the total trawl catch including discards in 1996–97 (Table 2.6.9), as well as the hook and line catch in 1993–97 (Table 2.6.1). In Figs. 2.6.6–2.6.7, we treat all thornyheads as shortspine prior to the development of the observer database in 1996. Although we recognize that observers may have difficulty distinguishing between the two thornyhead species, we simply portray the data in the current database. To maintain a consistent series of annual catches in these figures, we do *not* include data for the fishing period 1997a (Section 1.1).

Figures 2.6.1 to 2.6.7 also indicate quotas for each assessment unit, in cases where such quotas have been imposed historically. Thus, the figures can be used to assess whether or not shifts in catch have resulted from changing (or newly imposed) quotas. In cases where quotas have been assigned to combined assessment units, we compute a quota retrospectively for each assessment unit by allocating the combined quota in proportion to the historical catch.

Slope rockfish effort has been expanding since the mid-1980s. In 1996, both estimated and nominal effort increased to the highest values ever recorded, followed by an apparent reduction in 1997 (Table 2.6.8). The historical CPUE data are considered to have little value in interpreting recent stock abundance trends, because of restrictive trip limits, unknown levels of dumping, discarding and misreporting, and frequent changes to the management plan. The new observer database resolves at least some of these issues by providing more precise records of effort and catch, including discards.

### **3. Industry concerns**

Representatives from the trawl fishing industry (Groundfish Society), DFO stock assessment staff, and DFO groundfish managers met on September 9, 1998, at the Pacific Biological Station (PBS). Stock assessment staff presented data from the observer trawl database, and industry provided feedback on a variety of issues. Both assessment staff and the industry representatives recognized opportunities for improved evaluation of slope rockfish species, based on the new observer database. In the past, yield options have been based on very poor knowledge of most of the 42 assessment units. Fishermen at the meeting participated in an exercise to estimate relative abundance of each SRF species in the various management areas. The concerns and opinions expressed by the trawl industry are outlined in the Appendix.

Subsequent to the PBS meeting, representatives of the trawl fishing industry attended a meeting of the Canadian Groundfish Research and Conservation Society (CGRCS) on October 7, 1998, in Langley BC. This second meeting served to explore how the observer data might be used to validate the fishermen's qualitative abundance estimates of the PBS meeting. The Appendix provides further details of this discussion.

With the recent introduction of individual vessel quotas and the direct cost of observer coverage borne by the industry, assessment staff thought it timely to take advantage of the knowledge of groundfish resources that fishermen have gained from years of fishing along the BC coast. Each participant in the trawl industry now has a strong incentive to preserve and enhance the resource. Assessment staff made the analogy of managing an investment portfolio, where an investor must consider long term capital value and the consequences of any withdrawal strategy. Furthermore, the multispecies character of the trawl fishery also raises issues related to asset allocation and investment diversity.

The slope rockfish assessment has traditionally focused on Goose Island Gully where POP has been extensively surveyed over the past few decades. Assessment staff

have used somewhat ad hoc rules of proportionality, based on limited available data, to set yield options for other species and areas. Fishermen sometimes perceived a problem with the relative allocations. For example, they might find it difficult to achieve the required mix of species, given their perception of relative abundances. It might, for example, be necessary to actively avoid one species in order to take the quota of another. In some instances, they felt that quotas were too high and in others too low. They also criticized the random design of research surveys, upon which these proportionalities are partly based, stating that catchability of a species depends on many factors, such as the tide and time of day.

During the course of the PBS meeting, the fishermen pointed out that the historical analysis of POP might have been based on numbers of misidentified species. Prior to the 1980s, the term “redfish” was often used to describe both POP and yellowmouth rockfish. Consequently, yellowmouth rockfish may have been wrongly identified as perch, inflating historical POP catches. The most recent assessment model indicates that the historical biomass of POP in Goose Island Gully was lowest in 1977 (Richards et al. 1998). Some fishermen recalled, however, that the stock was even smaller from 1968 to the mid 1970s, when there appeared to be almost “no life” in Goose Island Gully.

Assessment staff asked industry representatives to estimate the relative abundance of slope rockfish in each SRF area. Initially, the fishermen were unsure of whether they were estimating total biomass or fish density. There was also some apprehension in divulging knowledge that might be used to lower quotas or help competitors. However, the group felt most comfortable basing comparisons on how quota should be allocated (Table 3.1). In this report, we interpret these comparisons as fishermen’s perception of relative abundance. We acknowledge the difficulty of bringing informal knowledge of the industry into a scientific context, and our analysis in the next section seeks to make our interpretation more precise.

When no other data are available, assessment staff sometimes treat catch per unit effort (CPUE) as an index of abundance. Fishermen suggested that CPUE might serve as an improved index if the target species were identified for each tow. To meet quota allocations, fishermen often conduct avoidance fishing, in which one species is avoided while trying to catch another. For instance, a fisherman targeting POP may want to minimize yellowmouth rockfish catch because he is nearing his quota for the latter. This might be accomplished by choosing a ground where, although POP density is low, the relative proportion of yellowmouth is also low. Thus, CPUE could appear to decline for both species. During the second meeting, fishermen suggested using tow depth to determine the target species, and they suggested explicit depth intervals for various species and areas (Appendix).

In this report, we examine the industry concerns in light of the observer data, and seek to obtain improved relative abundance estimates and yield recommendations.

## 4. Trawl fishery data analysis

### 4.1. Effort and catch summaries

The observer database provides highly detailed information on the characteristics of the trawl fishery. We begin with figures that portray the effort and corresponding catch of slope rockfish species. Figure 4.1.1 shows 1996-1998 tow locations by depth strata on a map of the BC coast, where each point has been plotted at the midpoint of a tow. Boundary lines for major statistical areas (3C, 3D, 5AB, 5CD, 5ES, 5EN) are also shown. The shallowest depth interval (0–100 m) has been chosen to include most catch of flatfish species, which are not part of this assessment. Thereafter, the depth intervals increase by 50, 100, 200, 400, and 800 m. Typically, shelf rockfish are found down to 150 m, and slope rockfish are harvested in the four depth intervals below 150 m.

Figure 4.1.2 extends the spatial analysis of Fig. 4.1.1 by including a temporal component of the fishery. Here tows by depth are grouped by month and latitude intervals of  $\frac{1}{2}^\circ$ ; for example, the label “48” denotes the latitude interval from  $48^\circ$  to  $48^\circ 30'$ . Circles in this figure represent the number of tows in each latitude-month-depth stratum, where circular area is proportional to the total hours towed. Most effort was expended in the 150–450 m depth range, with shallow fisheries (0–150 m) primarily in the north, and deep water fisheries (below 450 m) primarily in the south, off the west coast of Vancouver Island. The figure also shows some seasonal patterns in the effort, where vertical dotted lines indicate boundaries between fishing years 1996, 1997a, and 1998. We examined another figure similar to Fig. 4.1.2, depicting the number of tows, rather than the number of hours towed. Patterns of effort by tow are very similar to those of effort by hours, except that the very deep tows (below 850 m) represent disproportionately larger amounts of time. Thus, fishermen tend to extend tow duration for nets dropped to depths near 1 km.

The effort patterns in Figs. 4.1.1–4.1.2 produced a catch of 336 species over the period Jan 1996 to Jul 1998 (Table 2.2.2), as mentioned earlier. Figure 4.1.3 presents the catch, including discards, of Pacific Ocean perch, yellowmouth rockfish, redstripe rockfish, rougheye rockfish, longspine thornyhead, and shortspine thornyhead. The seventh SRF species, shortraker rockfish, has been excluded for lack of space. In panels of this figure, circles indicate the catch biomass within a stratum defined by species, month, and latitude, where circular area is proportional to biomass. Circle shading portrays catch depth, using the shadings introduced in Fig. 4.1.2. Because a species-month-latitude stratum can include catches at various depths, the shading indicates mean fishing depth  $d$  weighted by catch:

$$d = \frac{\sum_i c_i d_i}{\sum_i c_i}$$

where  $c_i$  and  $d_i$  denote the catch and depth of the  $i$ th tow in the stratum. The six species in Fig. 4.1.3 occur almost entirely in the four deepest strata of Figs. 4.1.1–4.1.2. Ideally,



all circles in Fig. 4.1.3 should be comparable to each other; however, this would leave nothing but circles reduced to invisible dots for the minor species. To avoid this problem, maximum circle sizes correspond to the biomass scale of 64, 128, 256, or 512 t, where factors of 2 allow easy comparison among panels. For each species, the maximum circle size has been chosen to best reveal the catch distribution among strata. As in Fig. 4.2, fishing years are delimited by vertical dotted lines.

From Fig. 4.1.3, Pacific ocean perch catch was greatest between latitudes  $51\frac{1}{2}^{\circ}$  and  $52^{\circ}$  N (Area 5AB) at depths of 250-400 m. Just to the south ( $51^{\circ}$ - $51\frac{1}{2}^{\circ}$  N), fishing occurred at shallower depths (150-250 m). In 1996, there appeared to be a lull in catch during Jul-Aug that corresponded to a switch of effort by Option A vessels to the offshore joint-venture hake fishery. However, starting under the new management regime of 1997, monthly catches became more regular, with a tendency to spread the quota more evenly through the fishing year. Noticeable overlap by season and depth occurred between the yellowmouth rockfish and Pacific Ocean perch fisheries, although yellowmouth rockfish tended to be caught earlier in the year and further south.

Redstripe rockfish were consistently caught at 150-250 m, predominantly at  $51$ - $51\frac{1}{2}^{\circ}$  N. Roughey rockfish catch occurred at depths of 250-450 m along the northwest coast of the Queen Charlotte Islands, predominantly in the spring and fall of 1996 and towards the end of the 1997 fishing year. Shortspine thornyheads were harvested along the west coast of Vancouver Island at depths greater than 450 m, where they appear to co-occur with longspine thornyheads. Further north, shortspine thornyheads were caught at 250-450 m in Moresby Gully and off the northwest coast of the Queen Charlotte Islands in spring and autumn. Longspine thornyhead catch exhibited separation by depth from most other slope rockfish, except shortspine thornyheads. They were typically caught at depths greater than 850 m along the west coast of Vancouver Island.

#### 4.2. Species depth ranges

The observer database contains information on effort and catch from every tow. Such data potentially can give swept area estimates of biomass, similar to those obtained from research surveys. We know, however, that commercial tows are often deliberately crafted to target some species and avoid others, depending on available quota. At the industry meeting on October 7, 1998, fishermen suggested that depth range could be used as an indicator of target species (Appendix). Figures 4.2.1 to 4.2.7 give substantial support to this claim. For each of the 42 assessment units, we show a scatterplot of CPUE (kg/hr) in relation to mean tow depth for individual tows in 1997. A log scale on the vertical axis gives a reasonably symmetric scatter around a trend curve constructed with the S-PLUS function `loess.smooth` (Venables and Ripley 1994; pp. 250, 386). Fitting is based on a locally linear regression (`degree=1`) with  $\frac{2}{3}$  of the data weighted inversely by horizontal distance to the current point (`span=2/3`).

Most panels in Fig. 4.2.1-4.2.7 show a clear relationship between CPUE and depth, where a peak CPUE is associated with a particular depth. The scatter plots often reveal a characteristic inverted V-shaped pattern, such as that for POP in Areas 3C and

5CD (Fig. 4.2.1). The loess curves usually achieve a single maximum. Points on a loess curve are defined at evenly spaced depth intervals, so that a cumulative sum of vertical coordinates produces a (typically sigmoid) cumulative CPUE distribution. Figure 4.2.8 illustrates these distributions for POP in the six SRF areas. Vertical lines indicate the 25%, 50%, and 75% quantiles for each curve. A similar analysis for all other assessment units leads to the quantiles listed in Table 4.2.1 and portrayed in Fig. 4.2.9.

Similar patterns can also be found among research tows, such as the two recent surveys cited in Section 2.4. Spatial and temporal ranges for these surveys are:

Survey	Longitudes	Latitudes	Dates	Tows
1	125° 45' – 127° 15' W	48° 15' – 49° 28' N	Sep 11–26, 1996	98
2	131° 17' – 133° 50' W	52° 00' – 54° 28' N	Sep 07–21, 1997	105

where the number of tows on each survey is also listed. Figure 4.2.10 shows data from these surveys, as well as data from commercial tows within the same spatial ranges and similar time periods. As in earlier Figs. 4.2.1–4.2.7, this figure uses a logarithmic scale to depict the broad range of possible CPUE values. Here we also indicate tows with no catch (CPUE 0) of the given species; these appear as linear scatter plots along the bottom of each panel.

Both research and commercial tows reveal dependencies on depth. Actual levels of research and commercial CPUE appear similar in the logarithmic scale of Fig. 4.2.10; however, close examination reveals notable differences. For POP, yellowmouth rockfish, and redstripe rockfish, the highest levels of CPUE were obtained in the research surveys. Because research tows theoretically take random samples with no particular target, this fact suggests that commercial tows actually avoid these species to some extent. Thus, the data appear to confirm observations by fishermen (Appendix) that a system of IVQs sometimes induces avoidance fishing, in which the aim is to fulfill a finite quota, rather than to optimize fishing efficiency.

This difference indicates that commercial tows cannot be used as surrogates for research tows in a scientific analysis. For example, swept area biomass estimates from commercial tows may be inappropriate. Nevertheless, we have data from only hundreds of research tows, sparsely distributed in space and time. By contrast, data from tens of thousands of commercial tows cover the entire range of the fishery. Perhaps these extensive data could be used in a modeling framework that takes account of fishermen's responses to available quota. Thus, commercial tows may still contain some information about underlying population abundances, even though that information cannot be extracted correctly from swept area biomass estimates.

### 4.3. Spatial analysis

Sections 4.1 and 4.2 suggest that observer data from the trawl fishery might best be analyzed by taking account of all three spatial dimensions: longitude, latitude, and

depth. To implement such an analysis, we consider a spherical rectangle (perhaps more precisely, a spherical trapezoid) on the earth's surface defined by:

- the longitude range  $123^\circ$ – $135^\circ$  W,
- the latitude range  $47^\circ$ – $55^\circ$  N.

This rectangle of size  $12^\circ\text{W} \times 8^\circ\text{N}$  covers the entire coastal region relevant to the database. For our spatial analysis, we subdivide the rectangle into blocks of dimension  $2'\text{W} \times 1'\text{N}$ . The resulting grid includes 360 blocks horizontally (along a latitude line) and 480 blocks vertically (along a longitude line), for a total of:

$$360 \times 480 = 172800 \text{ blocks.}$$

Each panel in Fig. 4.1.1 shows a Mercator projection of a slightly smaller coastal rectangle than the one considered here. An arbitrary point on such a map has coordinates  $(x, y)$ , where  $x$  and  $y$  correspond to longitude and latitude, respectively. Notice, however, that the  $x$  coordinate increases to the left, rather than to the right as in a standard Cartesian system. We define block  $B_{ij}$  to be the block in the grid defined above with integer coordinates  $(i, j)$ , where  $1 \leq i \leq 360$  and  $1 \leq j \leq 480$ . Thus, the lower right corner of block  $B_{ij}$  has coordinates  $(x_i, y_j)$ , where

$$(4.3.1) \quad x_i = 123 + \frac{i-1}{30}, \quad y_j = 47 + \frac{j-1}{60},$$

where each coordinate is measured in degrees. A tow centered at location  $(x, y)$  lies in the block  $B_{ij}$  specified by the integer coordinates

$$(4.3.2) \quad i = 1 + \text{int}[30(x - 123)], \quad j = 1 + \text{int}[60(y - 47)],$$

where the function ‘int’ extracts the integer part of a real number. For example,  $\text{int}(5.83) = 5$ .

To a high degree of approximation, the area of block  $B_{ij}$  is

$$(4.3.3) \quad A_{ij} = 2 \cos y_j \text{ nm}^2.$$

By definition, a nautical mile corresponds to a movement of  $1'$  at the equator, where a  $2' \times 1'$  block has area  $2 \text{ nm}^2$ . The factor  $\cos y_j$  adjusts for shorter distances along latitude lines as the latitude  $y_j$  increases. For convenient bookkeeping, we also assign each block  $B_{ij}$  a linear index

$$(4.3.4) \quad k = i + 360(j - 1)$$

where  $1 \leq k \leq 172,800$ . Given the index  $k$ , the coordinates  $(i, j)$  can be computed from the formulas

$$(4.3.5) \quad j = 1 + \text{int}\left(\frac{k}{360}\right), \quad i = k - 360(j - 1).$$

Tows recorded in the database occur in remarkably few of the 172,800 blocks. For example, the table below lists the number of blocks in which each species has been caught. Block counts are derived from all tows in the current database with slope rockfish catch logged by trawl observers.

Species	Blocks
Pacific ocean perch	2,737
yellowmouth rockfish	1,564
redstripe rockfish	1,834
rougeye rockfish	1,389
shortspine thornyhead	2,663
longspine thornyhead	992
shortraker rockfish	1,066
all slope rockfish	4,018

Fishing effort varies considerably among blocks. Table 4.3.1 shows data from the ten blocks with highest catch for each species, based again on all observer logs in the current database. Many of these ‘hot’ blocks have experienced very high levels of effort, sometime measured in hundreds of hours per year. Fishermen have estimated net widths in the range 16.8-18.3 m (wingtip to wingtip) and towing speeds in the range 2.5-2.6 nm/h. These estimates suggest that a net towed for 100 hr would sweep an area in the range:

$$(4.3.6a) \quad 16.8 \text{ m} \times 2.5 \text{ nm/hr} \times 100 \text{ hr} = 2.27 \text{ nm}^2,$$

$$(4.3.6b) \quad 18.3 \text{ m} \times 2.6 \text{ nm/hr} \times 100 \text{ hr} = 2.57 \text{ nm}^2.$$

In research surveys, similar estimates of swept area can be as high as  $10 \text{ nm}^2$  per 100 hr, based on door spread, rather than wing spread. Blocks in our analysis have areas in the range  $1.2\text{--}1.3 \text{ nm}^2$ ; thus, by any estimate a block should be more than completely swept during 100 hr fishing. If only parts of a block constitute trawlable grounds, then effort becomes more concentrated on the trawlable portion.

If fish were confined to blocks and consistently available to the gear, such high effort levels would reduce abundance rapidly. Figures 4.3.1 to 4.3.7 investigate possible depletion evidenced by the CPUE history in the top six hot blocks (with at least 5 tows) during the time period available in the database. Plots in these figures also show a linear trend regression line. Similarly, Table 4.3.1 lists the regression slope for each of the top 10 blocks, along with a confidence level for the hypothesis of no trend (slope 0). Of the

70 blocks in Table 4.3.1, 10 appear to show depletion, that is, a significant negative trend. Another 3 blocks suggest a positive trend. The following table summarizes these results by species:

Species	Trend	Blocks			
Pacific ocean perch	-	105,345			
Yellowmouth rockfish	+	73,243			
"	-	103,191			
Redstripe rockfish	+	92,335			
Rougheye rockfish	+	148,996	135,660		
Shortspine thornyhead	-	56,660			
Longspine thornyhead	-	41,515	41,875	31,058	35,020
Shortraker rockfish	-	101,392	50,165		

Among the slope rockfish species, this analysis shows the greatest evidence of depletion for longspine thornyheads (four significant negative trends in the top 10 hot blocks).

In spite of large catch removals, 60 of the 70 'hot' blocks show no statistical evidence of depletion during the time period available in the database typically. (Three of these show a positive trend, as mentioned above.) We conjecture that fishing in the 'hot' blocks is typically directed at migrant fish from surrounding regions when schooling behaviour makes them available to the gear. Thus, swept area biomass estimates provide at best an abundance index of surrounding populations. Possible explanations for the absence of a negative trend include the following:

- The surrounding population is large enough not to show serious depletion from the removals.
- The time frame of less than two years is too short to show changes in abundance, given highly variable CPUE.
- CPUE cannot be used to detect abundance changes. In a worst case scenario, fish would persist in the areas of greatest vulnerability, even while donor populations of migrant fish declined. This could create an illusion of security when populations are actually at risk.

#### 4.4. Depth Qualification

Attempts to use CPUE as an abundance index are usually accompanied by methods of qualifying fishing activities in relation to the species of interest. For example, in Section 2.6 we have described a method of qualifying fishing trips if the target species represents at least 20% of the catch. We have also confirmed in Section 4.2 the observation by fishermen that fishing depth can also be used as a potential qualifier. We can make depth qualification mathematically precise by taking account of the spatial analysis in Section 4.3. We illustrate such an analysis here for the fishing year 1997.

Given a species and SRF area, we first determine a corresponding depth range from Table 4.2.1 (or Fig. 4.2.9). To identify spatial regions of interest, we stratify the analysis by blocks. Thus, for all tows in the SRF area that catch the given species, we use

tow midpoints (latitude  $x$  and longitude  $y$ ) to identify relevant blocks  $B_k$  in which these tows occur, based on equations (4.3.2) and (4.3.4). We then compute the depth of each block as the mean depth of tows within the block. A block qualifies for the analysis if its depth lies within the specified depth range.

For qualified blocks  $B_k$ , we compute the total effort  $E_k$  and catch  $C_k$  from all tows. We also compute the CPUE  $U_k$  as the median catch per unit effort from all tows within the block. We choose the median, rather than the mean or the ratio  $C_k / E_k$ , as more resistant to outliers and other anomalous effects (Richards and Schnute 1992). Finally, we also compute the block area  $A_k$  from equation (4.3.3). Final estimates of qualified effort  $E$ , catch  $C$ , area  $A$ , and CPUE  $U$ , are then given respectively by:

$$(4.4.1) \quad E = \sum_{k \in Q} E_k, \quad C = \sum_{k \in Q} C_k, \quad A = \sum_{k \in Q} A_k$$

$$(4.4.2) \quad U = \frac{\sum_{k \in Q} A_k E_k U_k}{\sum_{k \in Q} A_k E_k},$$

where  $Q$  is the set of indices  $k$  that meet the qualification criteria. In particular, (4.4.2) defines a weighted median CPUE, where higher weights  $A_k E_k$  are assigned to blocks with larger areas  $A_k$  and fishing efforts  $E_k$ .

Swept area biomass estimates typically involve a factor  $f$  that converts fishing effort (hours towed) to area ( $\text{nm}^2$ ), such as

$$(4.4.3) \quad f = \frac{2.27 \text{ nm}^2}{100 \text{ hr}} = 0.0227 \frac{\text{nm}^2}{\text{hr}}$$

computed from (4.3.6a). The effort  $E_k$  in block  $B_k$  then sweeps a fraction  $f E_k / A_k$  of the total area. Expanding the catch  $C_k$  upward by the inverse of this fraction gives the estimate

$$(4.4.4) \quad S_k = \frac{A_k C_k}{f E_k}$$

of stock biomass  $S_k$  in the block. However, as discussed in Section 4.3, tows in a heavily fished block can sweep the area many times, so that  $f E_k > A_k$ . In such cases, (4.4.4) gives a biomass estimate that is actually *less* than the catch. We take the somewhat different view here that the CPUE provides a relative index of abundance, so that (4.4.4) is replaced by

$$(4.4.5) \quad S_k = \frac{1}{f} A_k U_k$$

where we use the block median CPUE  $U_k$  in (4.4.5), rather than the ratio  $C_k / E_k$  in (4.4.4). Thus, we obtain the depth qualified biomass estimate

$$(4.4.6) \quad S = \frac{1}{f} \sum_{k \in Q} A_k U_k .$$

Table 4.4.1 gives a complete list of estimates of qualified effort and CPUE, based on the two criteria discussed here: 20% and depth. In some cases, no estimates are available because no data meet the qualification criteria. The table also shows depth qualified biomass estimates, as potential indicators of relative abundance. We have based our biomass calculations on the fishermen's minimal estimate (4.4.3) of  $f$ , thus giving the highest possible abundance estimates. This choice plays no essential role in our analysis, however, because we treat biomass estimates at best as relative indices. Furthermore, we emphasize that these estimates pertain only to blocks fished, which may represent only a fraction of the habitat available in the appropriate depth range for the given species and SRF area. Unfortunately, we currently lack a geographic information system capable of dealing seriously with habitat analysis, and we leave this as an issue to be addressed in future assessment documents.

The estimates of effort and CPUE in Table 4.4.1 contain an interesting pattern. Let  $(E_{20\%}, U_{20\%})$  and  $(E_d, U_d)$  denote estimates qualified by 20% and depth, respectively, and define

$$\Delta E = E_{20\%} - E_d, \quad \Delta U = U_{20\%} - U_d .$$

Figure 4.4.1 contains a scatter plot of all points  $(\Delta E, \Delta U)$  where these data are defined in Table 4.4.1. The figure shows that most points lie inside or near the second and fourth quadrants, where  $\Delta E$  and  $\Delta U$  have opposite sign. To understand this fact biologically, consider tows in a depth range appropriate to a given species. Thus, all these tows qualify by the depth criterion. If fishermen cannot particularly target on this species among others available in the depth range, then most tows probably will not meet the 20% criterion. By chance, however, some tows may achieve a high catch of the species and thus indicate a small effort with high CPUE that qualifies at 20%. This case would be characterized by the conditions

$$(4.4.7) \quad E_{20\%} < E_d, \quad U_{20\%} > U_d ,$$

as in the fishery on yellowmouth rockfish in Area 5CD (Table 4.4.1). Conversely, a fishery may be highly concentrated on a particular species, so that most tows meet the 20% qualification. Of these, however, only some tows may occur in the depth range

optimal for the species, where the CPUE is particularly high. This case would be characterized by conditions opposite to (4.4.7):

$$(4.4.8) \quad E_{20\%} > E_d, U_{20\%} < U_d,$$

as in the Pacific ocean perch fishery in Area 5CD (Table 4.4.1). Figure 4.4.1 shows that the two scenarios (4.4.7)–(4.4.8) account for most slope rockfish fisheries in 1997. Thus, the combination of two qualification methods may reveal more about a fishery than either method alone. Perhaps the geometric mean  $\sqrt{U_{20\%}U_d}$  could serve as a compromise density index, taking account of both points of view.

#### 4.5. Comparisons with industry opinion

We have organized the analysis in this report to allow formal comparison with the industry opinions compiled in Table 3.1. In particular, we have extended Table 4.4.1 to include lists of yields and quotas from 1997–98 derived from Table 1.1, as well as the kept catch and total catch (including discards) from the 1997 fishery. To achieve the format necessary in Table 4.4.1, we have divided combined yields and quotas (Table 1.1) among various SRF areas by using the corresponding proportions in the 1997 kept catch. Thus, output from the analysis so far consists of the following 12 quantities in all 42 assessment units:

- 20% qualified effort and CPUE
- depth qualified effort, CPUE, area, and biomass
- yield, quota, kept catch, and total catch from 1997
- yield and quota from 1998

In a few instances, data are not available in some assessment units because no qualified data are available.

Each column in Table 4.4.1 can be compared with the fishermen's opinions in Table 3.1. Conceptually, the comparison involves data reduction from 42 values in a column of the first table to 22 values in a column of the second. Thus, we require an appropriate algorithm to reduce 42 numbers to 22, where 6 of the latter numbers are preset at 10. The correct algorithm depends somewhat on the quantity of interest. For effort, area, biomass, yield, quota, or catch, quantities must be *summed* to achieve the clustering discussed by fishermen. By contrast, CPUE must be *averaged* to obtain meaningful combinations. In the analysis here, we use weighted averages similar to (4.4.2). Thus, if  $U_a$  denotes the CPUE in assessment unit  $a$ , then the average CPUE for a combined group of assessment units has the form

$$(4.5.1) \quad U = \frac{\sum_a w_a U_a}{\sum_a w_a},$$



for suitably defined weights  $w_a$ . In the case of 20% qualified CPUE, we use  $w_a = E_a$ , where  $E_a$  is the 20% qualified effort in unit  $a$ . For depth qualified CPUE, we use  $w_a = A_a E_a$ , where  $A_a$  and  $E_a$  are the depth qualified area and effort in unit  $a$ . Thus, (4.5.1) corresponds precisely to (4.4.2) for depth qualified CPUE.

By applying the algorithms discussed above, we convert the 12 data columns in Table 4.4.1 to the 12 columns in Table 4.5.1, each of which can be compared directly with the column of opinions. For each opinion  $i$  documented in Table 4.5.1, i.e. each row of the table, let  $F_i$  and  $\sigma_i$  denote the mean value and standard deviation of fishermen's opinions. Similarly, let  $X_i$  be the corresponding value of opinion  $i$  derived from a column in Table 4.4.1. To compare our values  $X_i$  with fishermen's opinions  $F_i$ , we use a score function of the form

$$(4.5.2) \quad S_x = \sum_{i=1}^{22} \left| \frac{X_i - F_i}{1 + \sigma_i} \right|^n,$$

where  $n$  is 1 or 2. In effect, we compute a residual from the difference  $X_i - F_i$  weighted inversely by the fishermen's uncertainty  $1 + \sigma_i$ , where the extra term 1 avoids excessive weighting of small residuals. We then compute an absolute sum of residuals ( $n = 1$ ) or a sum of squares ( $n = 2$ ). The sum in (4.5.2) could also be written as if the index  $i$  ranged from 1 to 16; because in six instances both  $X_i$  and  $F_i$  have default values 10.

A low score characterizes good agreement with the fishermen. By this criterion, Table 4.5.2 ranks the 12 quantities evaluated in this analysis, where both choices of  $n$  lead to the same rank order. Perhaps not too surprisingly, the kept catch in 1997 best fits the ratios specified by fishermen, followed by the 1997 total catch. After the catch, various yield recommendations and quotas rank most highly. Thus, catches, yields, and quotas define a cluster of attributes more closely tied to industry opinion than any quantities computed from the database by various qualification methods. Of these latter quantities, 20% qualified effort ranks most highly, followed by depth qualified biomass and area. The two CPUE characteristics rank most poorly.

If CPUE serves as an index of fish density, then it can also serve as an abundance index only if an estimate of habitat area is also available. We have addressed this problem partially in Section 4.4 through our analysis of blocks in which fishing occurs. Our biomass indices (4.4.6) result from products of CPUE times block area. As discussed earlier, however, the blocks in this calculation reflect only the available fishing grounds, not the full habitat available to the species. In spite of this limitation, CPUE estimates adjusted for available area produce biomass indices closer to the complex of historical opinions reflected by yields, quotas, and industry estimates. In fact, depth qualified area without any measure of CPUE ranks ahead of CPUE estimates without area corrections.

## 5. Summary and recommendations

This report demonstrates that the new trawl observer database provides a valuable scientific resource for an in-depth analysis of the groundfish trawl fishery. Major conclusions from this analysis include:

1. CPUE varies substantially with depth, and spatial stratification can be used to qualify tows by depth.
2. Different methods of qualifying fishing activities can give alternative perspectives on the conduct of the fishery.
3. Commercial slope rockfish tows that occur in similar times and places as research survey tows show similar dependencies of CPUE on depth. For some species, however, commercial tows show evidence of avoidance fishing, in which the aim is to fulfill a finite quota, rather than to optimize fishing efficiency.
4. Analysis of heavily fished blocks shows little evidence of stock depletion, except for longspine thornyheads.
5. Industry opinions conform more closely to recent yield and quota recommendations than to various indices computed here, based on effort qualification and spatial stratification.

Our analysis also contains limitations inherent in the decision to focus our resources on the new database. In particular:

1. We have not considered biological data, such as the data currently under development in the GFBIO database. Consequently, we lack external indicators of stock status, such as shifts in size at age.
2. Our analysis deals primarily with attempts to index abundance from the trawl data. We have not attempted to estimate stock productivity and adjust quotas accordingly. Such an analysis would require at least the biological data cited in item 1.
3. We currently lack an adequate system for evaluating the habitat available to each species. This stems from limitations in both data and technology.

Given highly variable data and diverse potential assumptions about stocks in this fishery, we have detected a relatively stable body of opinion among assessment scientists, managers, and even fishermen in recent years. This body of opinion reflects itself in the yield recommendations, quotas, and catches. As illustrated here, the trawl observer database offers opportunities for extending the analysis in new directions. After a few years, it may become possible to shift the conceptual framework, based on deeper understanding of the fish stocks. In this report, however, it would be premature to suggest such a paradigm shift.

If nothing else, our analysis indicates great uncertainty about stock status in the 42 assessment units. Uncertainty necessitates a precautionary approach. However, lacking evidence that suggests a clear shift in direction, we recommend extending the 1998 yield options into the 1999 fishing year with the caveats noted below. The following table summarizes coastwide mean yields, quotas, kept catch, and total catch (tonnes) by species for the 1997 fishing year, extracted from Tables 1.1 and 4.4.1:

1997 Coastwide Fishery					
Species	Yield	Quota	Kept	Total	Trends
Pacific ocean perch	5635	6481	5632	5795	-
Yellowmouth rockfish	2140	2430	2200	2215	- +
Redstripe rockfish	1410	1623	890	1186	+
Rougheye rockfish	700	380	484	485	++
Shortspine thornyheads	680	748	487	521	-
Longspine thornyheads	345	860	510	583	----
Shortraker rockfish	140	77	56	56	--

We have also indicated the number of significant trends, negative or positive, for each species in the top 10 blocks (Section 4.3). We note that quotas were not achieved in several cases. This might have happened for several reasons, including low abundance and deliberate decisions to carry quota into the next fishing year. We particularly note the frequency of negative trends for longspine thornyheads. Our analysis of heavily fished blocks illustrates the potential for detecting abundance shifts in a large database, even if absolute biomass estimates cannot reliably be derived.

Some decline in longspine thornyhead abundance can be expected as the newly harvested resource is fished down. Nevertheless, the longevity of this species suggests that some catch reduction may be appropriate now in the interests of preserving the stock for the long run. If current catch levels are possible only because the stock is newly harvested, then managers and fishermen should be aware that such levels cannot be sustained into the future. We are concerned that the initial period of high harvest may be drawing to a close.

The slope rockfish fishery has a long history, and thus far seems reasonably successful. The recent IVQ system for the trawl fishery gives the industry a long-term stake in the assets. In a worst case scenario, discussed in Section 4.3, fish could persist in the areas of high vulnerability, while donor populations of migrant fish decline to dangerously low levels. We caution both managers and fishermen not to be lulled by an illusion of security. We hope that our concerns for sustainability and our explorations of the database encourage thoughtful conduct of this fishery in the future.

## Acknowledgements

We thank members of the groundfish industry for communicating their concerns and giving us the benefit of their expert knowledge. Laura Richards helped us place the current work into the perspective of past reports and offered insightful interpretations of the data. Bruce Turris played an instrumental role by organizing the meetings with industry and contributing his notes from those meetings. Ray Hilborn made numerous valuable suggestions for the analysis presented here and greatly facilitated our conversations with the industry. We have been much influenced by his practical concerns for the essential issues. Comments and encouragement from Doug March contributed substantially to the team effort required for this report.

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## Appendix. Summary of industry concerns

### Main Concerns

#### Historical analysis

- Species misidentification in historical catch records: yellowmouth probably identified as perch; "redfish" describes POP and yellowmouth; proper identification started in 1980s.
- 1968 to mid 1970s: "no life" in Goose Island Gully; apparent disagreement with assessment model, in which 1977 has lowest biomass.

#### Research survey data

- Research surveys do not show real declines and recoveries; fishermen “feel” extremes more than surveys indicate.
- Fundamental flaw in survey method: tows performed irrespective of time of day (temporally random).

#### Immigration

- After depletion experiment in Langara area (5EN), fish returned very quickly; movement of fish follow Haida Current.

#### By-catch issues

- Yellowmouth quotas not allocated sensibly: in some areas quota used up early, leads to avoidance fishing; 5CD quota far too large.
- Catchability depends on time of day; remove gear from water before daybreak to avoid catching POP.
- Need to identify target species to improve analysis.

#### Swept-area biomass estimates

- Percentage of trawlable ground in each slope rockfish area needs to be estimated.
- Swept area parameters: wingtip to wingtip 55-60 ft (16.8-18.3 m); average towing speed ~2.5-2.6 knots.

#### Exercise in estimating abundance

##### Pacific Ocean Perch

- Abundance in northern areas increasing; fish extremely dense in 5EN, “polluted with perch”; huge biomass from SE Alaska swings south into BC.
- 5C biomass > 5D biomass.
- Resistance to stating relative abundance in 5EN.

##### Yellowmouth Rockfish

- Dominant in areas 3D and 5AB; harder to catch yellowmouth in 3C.
- Occur more frequently in midwater during September; disperse during winter and silvergrays can be targetted.

##### Redstripe Rockfish

- Relative abundance similar to that of yellowmouth; estimate redstripe biomass ~70% of POP biomass coastwide; another estimate closer to 20%.
- Quotas for redstripe should be on marketable fish; note: this species experiences highest discard rate (Table 2.6.9).

##### Rougheye Rockfish

- Not particularly valuable; value greater than that of shortspines if freezer boats used.

##### Shortspine Thornyhead

- Ubiquitous along BC coast.

#### POP comparison with other slope rockfish

- Great resistance to comparing POP to yellowmouth; concerns over yellowmouth quota reductions.

- Reluctance to relate shortraker and thornyheads to POP.

#### Thornyhead comparison

- Reluctance to relate shortraker to thornyheads because shortraker catches very low.

#### How to use data (Oct 7, 1998)

- Focus: How to use observer data as an independent means of validating fishermen's qualitative estimates of relative abundance by species and area.
- Find best way to measure CPUE.
- Avoidance fishing at certain times in various locations; reflected in commercial CPUE lower than research survey CPUE.
- Fisherman suggested stratifying by tow depth.
- West coast Queen Charlotte Islands, tows at 120-200 fathoms (219-366 m) target slope rockfish.
- Any tow coastwide at 140-160 fathoms (256-293 m) probably targets POP.
- West coast Vancouver Island to Queen Charlotte Sound, tows at 300-350 fathoms (549-640 m) target shortspine thornyhead and Dover Sole.
- West coast Vancouver Island, tows > 400 fathoms (732 m) target longspine thornyhead.
- Future: Commercial vessels collecting survey-type information; setting TAC aside for research; 500-1000 tows annually.

**Table 1.1.** Recent history of yield options and quotas (tonnes) for slope rockfish species.

Species	Area	1997 Yield Option	1997 Mean Yield	1997 Quota	1998/1999 Yield Option	1998 Mean Yield	1998 Quota
POP	3C	250 - 500	375	431	80 - 110	95	300
	3D	100 - 300	200	230	100 - 300	200	230
	5AB	1760 - 2340	2050	2358	1200 - 2400	1800	2070
	5CD	1500 - 3400	2450	2818	1500 - 3400	2450	2817
	5EN	150 - 170	160		280 - 520	400	
	5ES	300 - 500	400		170 - 300	235	
	5ES/5EN			644			730
	<b>total</b>	<b>4060 - 7210</b>	<b>5635</b>	<b>6481</b>	<b>3330 - 7030</b>	<b>5180</b>	<b>6147</b>
YelMth	3C			100	130 - 260	195	221
	3D				190 - 390	290	
	5AB				460 - 980	720	
	5CD			360	390 - 830	610	691
	5EN				110 - 200	155	
	5ES				100 - 210	155	
	3D/5AB	710 - 1000	855	1866			1145
	5ES/5EN			104			328
	Coastwide	1540 - 2740	2140	2430			2385
	<b>total</b>	<b>1540 - 2740</b>	<b>2140</b>	<b>2430</b>	<b>1380 - 2870</b>	<b>2125</b>	<b>2385</b>
RedStr	3C			150	120 - 190	155	178
	3D				70 - 150	110	
	5AB				370 - 790	580	
	5CD			49	190 - 400	295	339
	5EN				20 - 80	50	
	5ES				140 - 200	170	
	3D/5AB	470 - 660	565	1198			794
	5ES/5EN			226			253
	Coastwide	1020 - 1800	1410	1623			1564
	<b>total</b>	<b>1020 - 1800</b>	<b>1410</b>	<b>1623</b>	<b>910 - 1810</b>	<b>1360</b>	<b>1564</b>
RghEye	3C				70 - 130	100	
	3D				40 - 70	55	
	5AB				60 - 110	85	
	5CD				90 - 160	125	
	5EN				50 - 100	75	
	5ES				210 - 380	295	
	Coastwide	500 - 900	700	380			549
	<b>total</b>	<b>500 - 900</b>	<b>700</b>	<b>380</b>	<b>520 - 950</b>	<b>735</b>	<b>549</b>
Sthorn	3C				310 - 540	425	
	3D				80 - 140	110	
	5AB				20 - 30	25	
	5CD				50 - 90	70	
	5EN				20 - 30	25	
	5ES				10 - 20	15	
	Coastwide	490 - 870	680	748			749
	<b>total</b>	<b>490 - 870</b>	<b>680</b>	<b>748</b>	<b>490 - 850</b>	<b>670</b>	<b>749</b>
Lthorn	3C						
	3D						
	5AB						
	5CD						
	5EN						
	5ES						
	Coastwide	250 - 440	345	860	245 - 425	335	861
	<b>total</b>	<b>250 - 440</b>	<b>345</b>	<b>860</b>	<b>245 - 425</b>	<b>335</b>	<b>861</b>
SrtRak	3C				20 - 40	30	
	3D				20 - 40	30	
	5AB				10 - 20	15	
	5CD				30 - 50	40	
	5EN				10 - 20	15	
	5ES				20 - 30	25	
	Coastwide	100 - 180	140	77			117
	<b>total</b>	<b>100 - 180</b>	<b>140</b>	<b>77</b>	<b>110 - 200</b>	<b>155</b>	<b>117</b>

**Table 1.1.1.** Outline of historic fishery management practices and participating countries in the slope rockfish fishery off the BC coast between 1965-98.

<b>Year</b>	<b>Management Practice</b>	<b>Participants</b>
1965-76	None.	Soviet, Japanese, US, Canadian
1977-85	Species/area quotas, area/time closures, trip limits.	US until 1980, Canadian
1986	Coastwide quotas and trip limits.	Canadian
1987-88	Species/area quotas, area/time closures, trip limits.	Canadian
1989-93	Coastwide quotas and trip limits.	Canadian
1994-95	Aggregate rockfish management.	Canadian
1995-96	Aggregate rockfish management.	Canadian
1996-97	Species/area quotas, area/time closures, trip limits.	Canadian
1997-98	Species/area quotas, IVQs, area/time closures.	Canadian



**Table 1.1.2.** History of recommended yield options (low to high risk), assigned quotas, and commercial trawl catch for Pacific ocean perch stocks. Area 5ES was managed on the basis of the slope rockfish aggregate (Pacific ocean perch, yellowmouth rockfish, and roughey rockfish) between 1983-1988. An open fishing experiment was conducted in Area 5EN between 1983-90; the area was closed from 1991-97 and yields were given for reference only. In 1986, coastwide aggregate quotas were assigned to the slope aggregate. In 1989-93 species quotas were assigned on a coastwide basis and area-specific quotas reflect the contribution in the coastwide quota. Coastwide aggregate quotas were again assigned in 1994-96. Quotas listed for years in which aggregates were assigned include other species in addition to Pacific ocean perch.

Year	Yield	Area 3C		Yield	Area 3D		Yield	Area 5AB		Yield	Area 5CD		Yield	Area 5ES		Yield	Area 5EN		Yield	Area 3C-5E	
		Quota	Catch		Quota	Catch		Quota	Catch		Quota	Catch		Quota	Catch		Quota	Catch		Quota	Catch
1979	50	50	125	10		-	2000	2000	1257			370	600	600	839			227	2670		2818
1980	600	600	430			-	2000	2200	1387			2545	600	600	877		200	85	3200		5324
1981	500	500	547			-	1500	1500	1621	1600	1800	2217	600	600	599	200	200	109	4400		5094
1982	500	500	508		250	-	1000	1000	913	1600	2000	3626	600	600	614	200	200	342	3900		6003
1983	500	500	752	250	250	86	1100-2000	1000	1485	2000-2800	2000	2220	agg	agg	835	open	open	292			5670
1984	150-500	500	551	250	250	193	1100-2000	800	937	1900-2800	2000	2055	agg	agg	841	open	open	2186			6763
1985	0-500	300	243	250-500	350	313	850-1300	850	823	1700-2500	2000	1967	400-1000	agg	829	0-200	open	1921			6096
1986	0-350	100	242	175-350	350	1046	595-910	500	644	1190-1750	2000	629	280-700	agg	642	0-140	open	2725	2550-3800	5000	5928
1987	0-200	100	542	250-500	350	450	400-650	500	1646	1700-2500	2000	1911	400-1000	agg	661	open	open	1130			6340
1988	100-200	100	307	200-600	350	492	700-1000	700	1198	1900-3000	3000	3105	400-700	agg	766	150-170	open	1089			6957
1989	100-200	150	278	200-600	400	994	700-1000	850	1179	1900-3000	3000	1498	300-500	400	571	150-170	open	1525		4650	6045
1990	100-200	150	278	200-600	400	919	700-1000	850	1391	1900-3000	2450	1410	300-500	400	605	150-170	open	1154		4100	5757
1991	100-200	0	22	200-600	400	807	700-1000	850	865	1900-3000	2150	2019	300-500	400	635	150-170	0	-		3800	4349
1992	100-200	0	390	200-600	400	681	700-1000	850	949	1900-3000	2400	1699	300-500	400	374	150-170	0	-		4050	4093
1993	100-200	150	970	200-600	400	667	700-1000	850	895	1900-3000	2400	1556	300-500	400	477	150-170	0	19		4200	4584
1994	*		1365	*		233	350-1800		2428	1500-3400		1270	*		287	*	0	28	3400-5700	4917	5613
1995	*		789	*		102	350-1800		2600	1500-3400		1539	*		802	*	0	48	3400-5700	4234	5880
1996	*		402	*		141	350-1800		1224	1500-3400		3738	*		613	*	0	21	3400-5700	6884	6139
1997	250-500	431	455	100-300	230	79	1760-2340	2358	2095	1500-3400	2818	2400	300-500	644 (5E)	400	150-170	0	203	4060-7210	6481	5632
1998	80-110	300		100-300	230		1200-2400	2070		1500-3400	2817		170-300	730 (5E)		280-520			3330-7030	6147	

**Table 1.1.3.** History of recommended yield options (low to high risk), assigned quotas, and commercial trawl catch for yellowmouth rockfish stocks. Area 5ES was managed on the basis of the slope rockfish aggregate (Pacific ocean perch, yellowmouth rockfish, and roughey rockfish) between 1983-1988. An open fishing experiment was conducted in Area 5EN between 1983-90; the area was closed from 1991-97 and yields were given for reference only. In 1986, coastwide aggregate quotas were assigned to the slope aggregate. In 1989-93 species quotas were assigned on a coastwide basis and area-specific quotas reflect the contribution in the coastwide quota. Coastwide aggregate quotas were again assigned in 1994-96. Quotas listed for years in which aggregates were assigned include other species in addition to yellowmouth rockfish. The quota for 1996 is included in the Pacific ocean perch quota (Table 1.1.2).

	Area 3C			Area 3D			Area 3D/5AB			Area 5CD			Area 5ES			Area 5EN			Area 3C-5E		
Year	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch
1979	*		2	*		-	100	50	-	50		20	750	750	389			17	950		438
1980	*		-	*		-	100	250	-	50		20	800	800	500			-	1200		548
1981	*		-	*		-	250		-	50		110	600	800	922	200		2	1200		1039
1982	*		7	*		-	250	250	-			442	600	100	414	100	600	68	950		1159
1983	*		52	*		20	200-500	250	628			204	agg	agg	588	open	open	52			1524
1984	*		12	*		114	200-500	250	458	300	300	338	agg	agg	441	open	open	73			1322
1985	*		4	*		412	200-500	350	716	200-300	250	232	400-1000	agg	496		open	180			1628
1986	*		3	*		980	140-350		1208	140-210	250	100	280-700	agg	564		open	615	400-800		2491
1987	*		11	*		699	200-500	350	1170	200-300	250	116	400-1000	agg	451		open	109			1857
1988	*		14	*		161	250-750	375	574	160-500	250	323	400-700	agg	289	350-500	open	107			1307
1989	*		56	*		299	250-750	500	983	160-500	350	176	400-700	600	228	350-500	open	158		1450	1602
1990	*		67	*		253	250-750	500	974	160-500	330	141	400-700	550	299	350-500	open	178		1380	1659
1991	*		52	*		201	250-750	500	862	160-500	330	169	400-700	550	121	350-500	0	-		1380	1204
1992	*		87	*		245	250-750	500	937	160-500	330	316	400-700	550	123	350-500	0	1		1380	1464
1993	*		73	*		276	250-750	500	741	160-500	330	156	400-700	550	144	350-500	0	4		1380	1119
1994	*		124	*		330	*		989	*		62	*		44	*	0	-	1100-1850	1593	1219
1995	*		92	*		231	*		1027	*		119	*		72	*		-	1100-1850	1465	1310
1996	*		158	*		234	*		854	*		496	*		127	*		-	1100-1850		1635
1997	*	100	62	*		377	710-1000	1866	1878	*		360	216	*	104 (5E)	38	*	5	1540-2740	2430	2200
1998	130-260	221		190-390			460-980 (5A/B)	1145		390-830		691		100-210	730 (5E)		110-200		1380-2870	2385	

**Table 1.1.4.** History of recommended yield options (low to high risk), assigned quotas, and commercial trawl catch for roughey rockfish stocks. Area 5ES was managed on the basis of the slope rockfish aggregate (Pacific ocean perch, yellowmouth rockfish, and roughey rockfish) between 1983-1988. An open fishing experiment was conducted in Area 5EN between 1983-90; the area was closed from 1991-97 and yields were given for reference only. In 1986, coastwide aggregate quotas were assigned to the slope aggregate. In 1989-93 species quotas were assigned on a coastwide basis and area-specific quotas reflect the contribution in the coastwide quota. Coastwide aggregate quotas were again assigned in 1994-96.

Year	Area 3C			Area 3D			Area 5A/B			Area 5C/D			Area 5ES			Area 5EN			Area 3C-5E		
	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch	Yield	Quota	Catch
1979	*		3	*		-	*		5	*		4	150		192			14	150		218
1980	*		27	*		-	*		-	*		1	150		51			3	150		82
1981	*		7	*		-	*		1	*		-	250		10	200		98	450		116
1982	*		5	*		-	*		-	*		38	250	250	274	250		69	500		386
1983	*		2	*		-	*		5	*		6	agg	agg	74	open	open	127			214
1984	*		-	*		-	*		11	*		7	agg	agg	101	open	open	227			346
1985	*		1	*		-	*		-	*		3	100-500	agg	158	0-250	open	454			616
1986	*		1	*		12	*		14	*		3	70-350	agg	269	0-175	open	461	100-500		758
1987	*		3	*		2	*		3	*		6	100-500	agg	296	open	open	180	100-400		490
1988	*		49	*		22	*		106	*		95	200-300	200	353	50-100	open	467			1092
1989	*		140	*		17	*		57	*		28	200-300	250	251	50-100	open	511			1003
1990	*		106	*		19	*		89	*		17	200-300		470	50-100	open	494			1195
1991	*		171	*		52	*		103	*		31	200-300		607	50-100	0	1			964
1992	*		302	*		99	*		144	*		29	200-300		1061	50-100	0	7			1641
1993	*		403	*		98	*		167	*		27	200-300		1126	50-100	0	54			1874
1994	*		156	*		13	*		118	*		20	*		946	*	0	80	500-900	796	1333
1995	*		241	*		17	*		159	*		77	*		567	*		41	500-900	735	1101
1996	*		172	*		36	*		108	*		209	*		467	*		47	500-900	**1311	1039
1997	*		98	*		3	*		46	*		45	*		263	*		29	500-900	380	484
1998	70-130			40-70			60-110			90-160			210-380			50-100			520-950	549	

\*\* includes roughey rockfish and shortraker rockfish quotas.

**Table 1.1.5.** History of recommended yield options (low to high risk), assigned quotas, and commercial trawl catch for redstripe rockfish stocks. No quotas were assigned prior to the coastwide quota in 1993.

Year	Yield	Area 3C Quota	Catch	Yield	Catch	Yield	Area 3D/5AB Quota	Catch	Yield	Area 5CD Quota	Catch	Yield	Area 5ES Quota	Catch
1988	200-1000		393	*	285	350-900		678	350-570		199	100-200		517
1989	200-1000		288	*	311	350-900		599	350-570		234	50-100		154
1990	200-1000		343	*	218	350-900		561	350-570		321	50-100		199
1991	200-1000		251	*	238	350-900		489	350-570		120	50-100		245
1992	200-1000		271	*	237	350-900		508	350-570		266	50-100		388
1993	200-1000		349	*	198	350-900		547	350-570		95	50-100		330
1994	*		435	*	96	*		531	*		153	*		226
1995	*		193	*	300	*		493	*		93	*		99
1996	*		99	*	76	*		494	*		207	*		114
1997	*	100	128	*	84	470-660	1198	529		49	139		226 (5E)	89
1998	120-190	178		70-150		370-790 (5A/B)	794		190-400	339		140-200	253 (5E)	

Table 2.2.1. Current number of fields and records in the six primary tables of the observer database

Table	Fields	Records
B1_Hails	24	5,439
B2_Trips	19	3,381
B3_Fishing_Events	46	53,664
B4_Catches	11	592,904
B5_Validation_Headers	27	5,575
B6_Validation_Species	8	72,413

Table 2.2.2. Number of tows and species captured by fishing year ('Year', as defined in Section 1). 'Species' refers to all species, 'Fish' to fish species, and 'Comm' to commercial fish species. Mean and standard deviation (SD) refer to the number of species per tow.

Year	Tows	Species	Fish	Comm	Mean	SD
1996	24,814	279	182	57	8.0	4.9
1997a	4,935	197	128	53	9.5	4.6
1997	16,500	247	168	56	10.7	4.8
1998	5,172	177	123	54	10.3	4.8
Total	51,421	336	214	57	9.3	5.0

Table 2.3.1. Approximation of slope rockfish assessment areas based on combinations of DFO management areas and subareas. The conversions are used to estimate hook and line catch of the SRF

SRF Area	DFO areas-subareas
3C	21, 23, 23-1:23-11, 24, 24-1:24-10, 25, 25-1:25-16
3D	26, 26-1:26-11, 27, 27-2:27-7
5AB	7, 7-1:7-30, 8, 8-1:8-16, 9, 9-1:9-12, 10, 10-1:10-12, 11, 11-1:11-2, 12-12, 27-1, 107, 107-1:107-3, 108, 108-1:108-16, 109, 109-1:109-12, 110, 110-1:110-13, 111, 111-1:111-5, 130, 130-1:130-2
5CD	1, 1-2:1-7, 2-1:2-19, 3, 3-1:3-4, 4, 4-1:4-15, 5, 5-1:5-24, 6, 6-1:6-25, 101, 101-4:101-10, 102, 102-1:102-3, 103, 103-1:103-7, 104, 104-1:104-13, 105, 105-1:105-2, 106, 106-1:106-26, 130-3:130-4
5ES	2, 2-31:2-100, 101-1, 142, 142-1:142-2
5EN	1-1, 101-2:101-3

**Table 2.6.1.** Hook and line catch (kg) of Pacific ocean perch, yellowmouth rockfish, redstripe rockfish, rougheye rockfish, shortspine thornyhead, and shortraker rockfish from 1993 to 1998.

Year	Species	Area						Total	Fishery Types
		3C	3D	5AB	5CD	5ES	5EN		
1993	POP	9	10	14	200	277		509	longline
	Yellowmouth	1,520	431	386	64	39	544	2,982	longline, handline
	Redstripe	31	56	150	288	227	142	894	longline
	Rougheye	636	2,952	417	1,472	5,077	5,453	16,008	longline, handline
	Shortspine	181			9	5		195	longline
	Shortraker			23		10,126	18	10,167	longline
1994	POP	569	265					835	longline
	Yellowmouth			11,686		13		11,699	longline
	Redstripe	15	940	559	72	239	4	1,829	longline, handline
	Rougheye	795	270	14,888	710	101,946	435	119,045	longline
	Shortspine	23	42	614	74	947		1,699	longline
	Shortraker			3,794	1,017	34,011		38,822	longline
1995	POP	57	17	238	2	617		930	longline
	Yellowmouth	10	13	11,571	151	4,650		16,396	longline
	Redstripe	6	1	58	55	190		310	longline, handline
	Rougheye	1,490	8,650	40,685	5,521	413,727	849	470,922	longline, handline
	Shortspine	294	1,066	2,762	319	11,708	37	16,186	longline, handline
	Shortraker	590	9,018	14,457	819	62,796	138	87,817	longline
1996	POP		110	499		362		971	longline
	Yellowmouth		675	7,045		1,848		9,567	longline
	Redstripe		38	49	58	65	29	240	longline, handline
	Rougheye	1,568	47,986	29,102	461	52,064	541	131,721	longline, handline
	Shortspine	167	3,090	1,674	1	953		5,885	longline, handline
	Shortraker	1,084	30,386	17,973		10,632		60,075	longline, handline
1997a	POP					5		5	longline
	Yellowmouth							0	
	Redstripe			107	70			177	longline, handline
	Rougheye					15,554		15,554	longline
	Shortspine			1		613		614	longline, handline
	Shortraker					2,404		2,404	longline
1997	POP		31	654	2	296	58	1,041	longline
	Yellowmouth		220	2,669		292		3,181	longline
	Redstripe			48	181	71		299	longline, handline
	Rougheye	1	20,666	18,242	6	152,587		191,502	longline, handline
	Shortspine	90	1,884	1,158	7	1,384		4,524	longline
	Shortraker	10	19,025	20,245	25	26,051		65,356	longline, handline
1998*	POP		6	10		656		672	longline
	Yellowmouth		136	1,025		506		1,668	longline
	Redstripe		7	0	3			11	longline, handline
	Rougheye		684	755	118	12,039		13,596	longline
	Shortspine		34	198	6	734		971	longline
	Shortraker		380	579		1,596		2,554	longline

\* Apr-May only

**Table 2.6.2.** Area 3C (including statistical areas 25 and 125) Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the 20% qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E. Eff (h)	N. Eff (h)	No. trips
	POP	Reds	YelM	Reye	Skaker	Thorny	POP	Reds	YelM	Reye	Skaker	Thorny				
1967	7	-	-	-	-	-	0.85	-	-	-	-	-	0.255	27	17	3
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
1969	2	-	-	-	-	-	0.26	-	-	-	-	-	0.101	20	41	1
1970	304	-	-	-	-	-	0.66	-	-	-	-	-	0.739	411	580	12
1971	218	-	-	9	-	-	0.52	-	-	0.02	-	-	0.245	928	717	16
1972	117	-	-	-	-	-	0.87	-	-	-	-	-	0.502	233	21	2
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	5	-	-	-	-	-	0.52	-	0.17	-	-	-	0.274	18	167	2
1976	1	-	-	-	-	-	1.00	-	-	-	-	-	0.869	1	5	1
1977	16	-	-	-	-	-	0.32	-	-	-	-	-	0.188	85	467	3
1978	53	1	-	-	-	-	0.49	-	-	-	-	-	0.499	108	78	3
1979	125	2	2	3	5	1	0.41	0.02	0.01	0.01	0.02	0.02	1.241	111	213	4
1980	430	-	-	27	16	-	0.61	-	-	0.03	0.01	-	0.681	694	765	13
1981	547	13	-	7	3	-	0.58	0.01	-	0.01	-	0.01	0.634	899	1095	22
1982	508	3	7	5	3	-	0.63	-	0.01	0.01	-	-	0.565	931	916	17
1983	752	30	52	2	-	2	0.50	0.03	0.05	-	-	-	0.874	959	916	21
1984	551	35	12	-	-	-	0.75	0.01	0.01	-	-	-	0.555	1078	1043	21
1985	243	61	4	1	1	2	0.37	0.08	0.01	-	-	-	0.340	918	1409	28
1986	242	515	3	1	-	1	0.16	0.31	-	-	-	-	0.711	1071	1895	44
1987	542	377	11	3	1	3	0.32	0.21	0.01	-	-	-	0.727	1289	1921	66
1988	307	393	14	49	7	14	0.14	0.25	0.01	0.02	-	0.01	0.381	2057	3022	74
1989	278	288	56	140	19	27	0.13	0.15	0.03	0.05	0.01	0.01	0.304	2661	4622	100
1990	278	343	67	106	23	73	0.14	0.20	0.04	0.04	-	0.01	0.294	3029	4359	115
1991	22	251	52	171	18	75	0.02	0.20	0.04	0.11	0.01	0.01	0.257	2296	2670	113
1992	390	271	87	302	92	114	0.17	0.11	0.04	0.12	0.04	0.01	0.399	3148	3943	235
1993	970	349	73	403	27	215	0.24	0.09	0.02	0.10	-	0.01	0.347	5865	7138	402
1994	1365	435	124	156	70	177	0.37	0.11	0.03	0.04	0.01	0.01	0.337	6903	7580	357
1995	789	193	92	241	78	446	0.28	0.07	0.03	0.08	0.02	0.03	0.280	6576	6763	339
1996	402	99	158	172	41	971	0.12	0.02	0.05	0.05	0.01	0.32	0.135	13638	14534	267
1997a	57	29	9	57	11	312	0.06	0.02	0.01	0.05	0.01	0.39	0.111	4268	4730	73
1997	455	128	62	98	25	678	0.15	0.02	0.02	0.02	0.01	0.26	0.126	11476	12457	159
1998*	129	18	23	64	6	356	0.11	0.02	0.02	0.03	0.00	0.41	0.110	5429	5077	55

\* Data available to July, 1998 only.

**Table 2.6.3.** Area 3D Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E Eff (h)	N Eff (h)	No. trips
	POP	Reds	YelM	Reye	Skaker	Thorny	POP	Reds	YelM	Reye	Skaker	Thorny				
1974	3	-	-	-	-	-	-	-	-	-	-	-	-	-	59	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	3	6	-	-	-	-	-	0.23	-	-	-	-	0.193	47	36	1
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	-
1983	86	4	20	-	-	-	0.34	-	0.04	-	-	-	1.127	98	115	2
1984	193	9	114	-	-	-	0.50	0.02	0.39	-	-	-	1.671	189	122	5
1985	313	43	412	-	-	4	0.36	0.04	0.42	-	-	0.01	0.943	818	529	19
1986	1046	678	980	12	-	10	0.25	0.22	0.29	-	-	-	1.287	2117	1388	93
1987	450	696	699	2	2	3	0.17	0.26	0.26	-	-	-	1.649	1123	904	73
1988	492	285	161	22	1	4	0.37	0.21	0.12	0.02	-	-	1.061	910	1094	82
1989	994	311	299	17	3	8	0.42	0.13	0.13	0.01	-	-	1.129	1445	1467	114
1990	919	218	253	19	5	13	0.42	0.11	0.13	0.01	-	-	1.002	1424	1665	129
1991	807	238	201	52	-	10	0.47	0.15	0.12	0.03	-	-	0.946	1383	1326	155
1992	681	237	245	99	54	11	0.37	0.13	0.14	0.06	0.02	0.01	0.788	1684	1567	217
1993	667	198	276	98	16	17	0.33	0.11	0.15	0.05	0.01	-	0.626	2030	1972	313
1994	233	96	330	13	12	18	0.23	0.08	0.33	0.01	0.01	0.01	0.577	1217	1263	145
1995	102	300	231	17	11	56	0.10	0.30	0.23	0.02	-	0.01	0.499	1437	1363	169
1996	141	76	234	36	7	251	0.13	0.07	0.22	0.03	0.00	0.24	0.263	2832	2990	138
1997a	26	37	147	10	3	66	0.07	0.08	0.40	0.03	0.01	0.18	0.287	1016	1056	56
1997	79	84	377	3	1	126	0.08	0.07	0.40	0.00	0.00	0.13	0.378	1774	2350	103
1998*	7	40	24	1	1	44	0.04	0.24	0.15	0.01	0.01	0.27	0.400	293	494	24

\* Data available to July, 1998 only.



**Table 2.6.4.** Area 5AB (Goose Island and Mitchell's Gullies) Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E. Eff (h)	N. Eff (h)	No. trips
	POP	Reds	YelM	Reye	Sraker	Thorny	POP	Reds	YelM	Reye	Sraker	Thorny				
1967	399	-	-	-	-	-	0.79	-	-	-	-	-	0.758	526	449	33
1968	881	-	-	-	-	-	0.87	-	-	-	-	-	0.655	1345	1048	42
1969	1539	-	-	-	-	-	0.80	-	-	-	-	-	0.639	2408	2319	59
1970	1767	-	-	-	-	-	0.83	-	-	-	-	-	0.604	2925	2814	53
1971	1116	-	5	-	-	-	0.77	-	-	-	-	-	0.450	2488	2317	35
1972	2196	-	-	8	-	-	0.73	-	-	-	-	-	0.739	2982	2944	44
1973	1360	-	177	-	-	-	0.74	-	0.10	-	-	-	1.195	1286	1446	33
1974	1513	-	79	-	-	-	0.79	-	0.04	-	-	-	0.866	1838	1688	43
1975	1911	13	1	-	-	-	0.83	0.01	-	-	-	-	0.775	2483	2520	63
1976	1518	12	12	14	-	-	0.69	0.01	0.01	0.01	-	-	0.696	2236	2428	63
1977	1074	34	336	-	-	-	0.58	0.02	0.15	-	-	-	0.597	2420	2339	57
1978	1203	18	17	1	-	-	0.53	0.01	0.01	-	-	-	0.704	1760	2525	59
1979	1257	8	10	5	-	-	0.77	-	0.01	-	-	-	0.707	1811	2069	57
1980	1387	-	28	-	-	-	0.74	-	0.02	-	-	-	0.876	1616	1556	64
1981	1621	-	5	1	2	-	0.85	-	-	-	-	-	0.903	1804	1256	35
1982	913	3	228	-	5	-	0.62	-	0.17	-	-	-	0.663	1734	1572	30
1983	1485	37	608	5	-	2	0.53	0.01	0.29	-	-	-	2.033	1051	626	26
1984	937	40	344	11	-	-	0.64	0.02	0.16	-	-	-	0.806	1652	795	30
1985	823	117	304	-	-	4	0.34	0.11	0.07	-	-	0.01	0.733	1703	1491	42
1986	644	395	228	14	5	2	0.27	0.25	0.11	0.01	-	-	0.889	1450	1692	73
1987	1646	649	471	3	1	3	0.35	0.16	0.13	-	-	-	0.719	3855	3798	180
1988	1198	316	413	106	4	4	0.33	0.09	0.13	0.03	-	-	0.616	3313	4457	197
1989	1179	477	684	57	1	1	0.26	0.12	0.17	0.01	-	-	0.737	3257	4218	193
1990	1391	821	721	89	1	5	0.25	0.13	0.12	0.01	-	-	0.735	4117	5998	232
1991	865	742	661	103	3	2	0.22	0.20	0.19	0.03	-	-	0.724	3282	4018	275
1992	949	1889	692	144	7	16	0.15	0.26	0.12	0.02	-	-	0.760	4864	4679	395
1993	895	928	465	167	14	50	0.19	0.20	0.11	0.04	-	0.01	0.741	3399	3812	430
1994	2428	485	659	118	63	282	0.41	0.07	0.11	0.02	0.01	0.04	0.752	5365	5469	397
1995	2600	591	796	159	21	169	0.40	0.09	0.12	0.02	-	0.02	0.814	5329	6150	587
1996	1224	418	620	108	4	59	0.32	0.10	0.15	0.03	0.00	0.01	0.363	6694	5685	329
1997a	333	168	365	18	2	6	0.22	0.11	0.24	0.01	0.00	0.00	0.601	1485	1445	113
1997	2095	445	1501	46	2	41	0.32	0.06	0.23	0.01	0.00	0.01	0.693	5958	6213	328
1998*	1016	108	459	24	0	10	0.43	0.05	0.19	0.01	0.00	0.00	0.717	2254	2163	107

\* Data available to July, 1998 only.

**Table 2.6.5.** Area 5CD (Moresby Gully) Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E. Eff (h)	N. Eff (h)	No. trips
	POP	Reds	YelM	Reye	Sraker	Thorny	POP	Reds	YelM	Reye	Sraker	Thorny				
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44	-
1969	1	-	-	-	-	-	-	-	-	-	-	-	-	-	24	-
1970	27	-	-	-	-	-	-	-	-	-	-	-	-	-	594	-
1971	10	-	-	-	-	-	0.90	-	-	-	-	-	0.055	181	346	3
1972	13	-	-	-	-	-	-	-	-	-	-	-	-	-	567	-
1973	38	-	-	-	-	-	0.79	-	-	-	-	-	0.763	50	673	2
1974	36	-	-	-	-	-	0.67	-	-	-	-	-	1.051	34	596	4
1975	117	-	-	-	-	-	0.79	-	-	-	-	-	0.804	146	1024	8
1976	86	-	-	-	-	-	0.68	-	-	-	-	-	0.233	368	2185	8
1977	74	1	4	-	-	-	0.31	0.01	0.10	-	0.01	-	0.198	399	1793	8
1978	174	4	92	-	-	-	0.46	0.01	0.26	-	-	-	1.272	212	979	11
1979	370	1	20	4	-	-	0.44	-	0.03	-	-	0.01	0.426	926	2086	36
1980	2545	19	20	1	2	-	0.76	0.01	0.01	-	-	-	1.019	2539	2282	78
1981	2217	5	110	-	2	4	0.73	-	0.02	-	-	-	1.062	2202	1807	45
1982	3626	23	442	38	29	9	0.79	-	0.10	0.01	0.01	-	1.797	2318	1860	62
1983	2220	20	204	6	11	5	0.83	0.01	0.04	-	0.01	-	1.865	1322	866	38
1984	2055	71	338	7	2	6	0.72	0.02	0.07	-	-	-	1.472	1684	1636	39
1985	1967	181	232	3	9	17	0.65	0.07	0.09	-	-	-	1.615	1491	1667	49
1986	629	110	100	3	2	8	0.46	0.08	0.08	-	-	-	0.805	1058	1369	50
1987	1911	307	116	6	2	7	0.66	0.11	0.03	-	-	-	1.342	1750	1845	104
1988	3105	199	323	95	29	19	0.66	0.04	0.07	0.02	0.01	-	1.429	2637	2954	199
1989	1498	234	176	28	4	7	0.49	0.07	0.06	0.01	-	-	1.124	1733	2209	123
1990	1410	321	141	17	3	13	0.51	0.12	0.05	0.01	-	-	0.967	1970	2247	110
1991	2019	120	169	31	12	13	0.68	0.04	0.06	0.01	-	-	1.264	1870	1890	158
1992	1699	266	316	29	7	21	0.57	0.10	0.12	0.01	-	-	0.954	2451	1908	166
1993	1556	95	156	27	6	61	0.60	0.04	0.07	0.01	-	0.01	0.729	2607	2368	217
1994	1270	153	62	20	18	85	0.51	0.06	0.03	0.01	0.01	0.02	0.530	3032	2856	152
1995	1539	93	119	77	60	262	0.52	0.03	0.04	0.03	0.02	0.05	0.463	4641	3792	221
1996	3738	207	496	209	55	162	0.60	0.03	0.08	0.03	0.01	0.02	0.741	6570	7162	327
1997a	279	26	31	6	4	19	0.48	0.04	0.05	0.01	0.01	0.03	0.509	715	608	42
1997	2400	139	216	45	15	89	0.67	0.04	0.06	0.01	0.00	0.02	0.879	3302	3347	190
1998*	1177	12	171	9	4	30	0.70	0.01	0.10	0.01	0.00	0.02	1.338	1048	1241	68

\* Data available to July, 1998 only.

**Table 2.6.6.** Area 5ES Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E Eff (h)	N Eff (h)	No. trips
	POP	Reds	YelM	Reye	Sraker	Thorny	POP	Reds	YelM	Reye	Sraker	Thorny				
1976	79	-	-	-	-	-	0.99	-	-	-	-	-	1.339	59	59	2
1977	1549	156	1257	76	10	-	0.46	0.05	0.39	0.02	-	-	2.411	1264	1061	66
1978	2414	231	1105	139	25	1	0.56	0.05	0.26	0.03	0.01	-	3.201	1223	1140	64
1979	839	73	389	192	11	1	0.50	0.04	0.23	0.11	0.01	-	1.936	778	644	38
1980	877	111	500	51	1	-	0.37	0.09	0.38	0.04	-	-	1.465	1051	595	42
1981	599	133	922	10	4	4	0.45	0.08	0.39	0.01	-	-	2.019	828	295	23
1982	614	34	414	274	3	1	0.42	0.02	0.25	0.20	-	-	2.212	606	481	33
1983	835	143	588	74	17	10	0.42	0.07	0.30	0.03	0.01	0.01	2.186	762	717	37
1984	841	148	441	101	11	4	0.46	0.09	0.21	0.07	-	-	2.351	658	389	24
1985	829	919	496	158	1	4	0.29	0.37	0.17	0.06	-	-	1.828	1316	913	50
1986	642	728	564	269	4	14	0.19	0.26	0.22	0.07	-	-	2.107	1054	840	43
1987	661	629	451	296	8	25	0.25	0.28	0.18	0.12	-	0.01	1.990	1040	1044	41
1988	766	517	289	353	5	11	0.30	0.20	0.12	0.15	-	-	1.967	987	1257	54
1989	571	154	228	251	6	6	0.36	0.10	0.15	0.17	-	-	1.294	940	799	35
1990	605	199	299	470	21	25	0.29	0.09	0.15	0.23	0.01	0.01	1.354	1196	1120	44
1991	635	245	121	607	15	17	0.31	0.12	0.06	0.29	0.01	0.01	1.523	1077	1119	74
1992	374	388	123	1061	61	48	0.14	0.14	0.05	0.41	0.02	0.01	0.920	2234	2410	181
1993	477	330	144	1126	218	93	0.14	0.11	0.05	0.36	0.04	0.02	0.859	2781	2541	225
1994	287	226	44	946	292	99	0.13	0.09	0.02	0.40	0.09	0.03	0.864	2193	1972	129
1995	802	99	72	567	72	61	0.39	0.05	0.03	0.27	0.03	0.02	1.012	1653	1708	114
1996	613	114	127	467	30	35	0.36	0.07	0.08	0.28	0.02	0.02	0.942	1470	1368	110
1997a	353	100	20	39	5	3	0.58	0.16	0.03	0.06	0.01	0.01	1.607	323	304	33
1997	400	89	38	263	6	8	0.39	0.09	0.04	0.25	0.00	0.01	1.368	588	595	50
1998*	81	11	84	41	0	1	0.31	0.04	0.32	0.16	0.00	0.00	1.183	184	130	11

\* Data available to July, 1998 only.

**Table 2.6.7.** Area 5EN Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E Eff (h)	N Eff (h)	No. trips
	POP	Reds	YelM	Reye	Sraker	Thorny	POP	Reds	YelM	Reye	Sraker	Thorny				
1977	1	-	-	-	-	-	1.00	-	-	-	-	-	0.328	3	20	1
1978	22	-	-	-	1	-	0.65	-	-	-	0.13	-	0.337	68	151	5
1979	227	5	17	14	2	-	0.63	0.01	0.05	0.04	0.01	0.01	0.576	460	204	9
1980	85	-	-	3	-	-	0.71	-	-	0.02	-	0.01	0.314	280	130	7
1981	109	-	2	98	-	-	0.30	-	0.01	0.47	-	-	3.134	67	44	4
1982	342	13	68	69	1	3	0.49	0.01	0.13	0.16	-	0.01	2.467	201	145	14
1983	292	18	52	127	3	36	0.37	0.01	0.03	0.13	-	0.03	1.162	454	402	15
1984	2186	111	73	227	8	41	0.63	0.04	0.02	0.07	-	0.01	1.639	1615	1227	42
1985	1921	259	180	454	12	30	0.52	0.07	0.05	0.13	-	0.01	1.224	2334	1917	56
1986	2725	717	615	461	6	51	0.52	0.12	0.12	0.08	-	0.01	1.387	3299	3036	65
1987	1130	224	109	180	3	25	0.55	0.11	0.06	0.09	-	0.01	1.120	1492	1325	28
1988	1089	114	107	467	13	73	0.44	0.05	0.04	0.20	0.01	0.03	1.077	1730	1802	34
1989	1525	151	158	511	10	66	0.47	0.04	0.05	0.16	-	0.02	1.188	2038	2238	43
1990	1154	69	178	494	52	81	0.46	0.03	0.07	0.20	0.02	0.03	0.706	2872	2551	30
1991	-	4	-	1	30	39	0.01	0.36	-	0.03	0.03	0.31	0.247	300	67	6
1992	-	1	1	7	21	9	0.01	0.06	0.06	0.24	0.07	0.10	0.211	184	29	9
1993	19	12	4	54	63	77	0.09	0.07	0.02	0.27	0.04	0.05	0.361	634	376	29
1994	28	1	-	80	94	151	0.06	-	-	0.20	0.09	0.17	0.346	1023	818	50
1995	48	6	-	41	93	176	0.12	0.01	-	0.09	0.07	0.15	0.176	2070	899	40
1996	21	1	0	47	6	57	0.07	0.00	0.00	0.14	0.02	0.17	0.131	1007	1019	47
1997a	10	0	0	10	1	12	0.18	0.00	0.00	0.12	0.01	0.13	0.197	165	167	11
1997	203	5	5	29	7	55	0.44	0.01	0.01	0.05	0.01	0.11	0.302	1005	846	41
1998*	39	0	0	6	1	11	0.52	0.00	0.00	0.07	0.01	0.15	0.590	97	167	7

\* Data available to July, 1998 only.

**Table 2.6.8.** Coastwide Canadian trawl catch (tonnes) of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads, the proportions of Pacific ocean perch, redstripe, yellowmouth, rougheye, and shortraker rockfish, and longspine and shortspine thornyheads constituting the qualified catch, 20% qualified median CPUE, estimated effort, nominal effort, and the number of vessel trips used to calculate CPUE.

Year	Catch (tonnes)						Proportion of qualified catch						CPUE (tonnes/h)	E. Eff (h)	N. Eff (h)	No. trips
	POP	Reds	YelM	Reye	Skaker	Thorny	POP	Reds	YelM	Reye	Skaker	Thorny				
1967	406	-	-	-	-	-	0.79	-	-	-	-	-	0.757	536	465	36
1968	882	-	-	-	-	-	0.87	-	-	-	-	-	0.655	1346	1185	42
1969	1542	-	-	-	-	-	0.80	-	-	-	-	-	0.638	2416	2384	60
1970	2098	-	-	-	-	-	0.80	-	-	-	-	-	0.606	3464	4004	64
1971	1344	-	5	9	-	-	0.72	-	-	-	-	-	0.440	3085	3380	51
1972	2327	-	-	8	-	-	0.73	-	-	-	-	-	0.739	3159	3532	46
1973	1398	-	177	-	-	-	0.74	-	0.10	-	-	-	1.085	1451	2119	34
1974	1552	-	79	-	-	-	0.79	-	0.04	-	-	-	0.879	1855	2343	44
1975	2033	13	2	-	-	-	0.81	0.01	0.00	-	-	-	0.775	2642	3710	71
1976	1684	12	12	14	-	-	0.69	0.01	0.01	0.01	-	-	0.695	2479	4677	67
1977	2715	191	1596	77	10	-	0.50	0.04	0.30	0.02	-	-	0.959	4784	5679	127
1978	3869	261	1213	140	27	1	0.53	0.04	0.17	0.02	-	-	1.166	4727	4909	131
1979	2818	89	438	218	18	2	0.58	0.02	0.09	0.05	-	-	0.758	4725	5216	130
1980	5324	131	548	82	19	1	0.66	0.02	0.08	0.01	-	-	1.063	5744	5332	176
1981	5094	151	1039	116	11	9	0.67	0.02	0.08	0.02	-	-	0.979	6555	4514	113
1982	6003	75	1159	386	41	14	0.65	0.01	0.13	0.05	0.01	-	1.268	6057	5002	120
1983	5670	252	1524	214	30	55	0.55	0.03	0.17	0.02	-	0.01	1.614	4798	3641	110
1984	6763	414	1322	346	22	52	0.63	0.04	0.09	0.04	-	0.01	1.240	7194	5211	124
1985	6096	1579	1628	616	22	61	0.46	0.14	0.11	0.06	-	0.01	1.083	9235	7926	170
1986	5928	3142	2491	758	17	85	0.35	0.19	0.15	0.04	-	-	1.215	10220	10220	308
1987	6340	2882	1857	490	16	66	0.38	0.18	0.12	0.03	-	-	1.074	10852	10836	387
1988	6957	1824	1307	1092	58	125	0.41	0.11	0.08	0.07	-	0.01	0.900	12624	14586	459
1989	6045	1616	1602	1003	44	115	0.35	0.09	0.10	0.06	-	0.01	0.762	13687	15553	433
1990	5757	1970	1659	1195	105	209	0.31	0.10	0.09	0.07	0.01	0.01	0.634	17175	17939	489
1991	4349	1600	1204	964	78	156	0.35	0.13	0.10	0.08	-	-	0.776	10758	11089	557
1992	4093	3051	1464	1641	242	219	0.24	0.17	0.09	0.11	0.01	0.01	0.719	14896	14537	921
1993	4584	1912	1119	1874	345	512	0.25	0.11	0.07	0.11	0.01	0.01	0.571	18115	18206	1217
1994	5613	1397	1219	1333	549	812	0.34	0.08	0.08	0.08	0.02	0.03	0.536	20395	19957	949
1995	5880	1282	1310	1101	334	1171	0.35	0.08	0.08	0.07	0.01	0.03	0.527	21017	20715	1093
1996	6139	916	1635	1039	143	1536	0.38	0.05	0.10	0.06	0.01	0.09	0.338	33790	32758	1218
1997a	1059	360	572	140	24	419	0.27	0.09	0.15	0.03	0.01	0.10	0.395	6509	8311	328
1997	5632	890	2200	484	56	996	0.37	0.05	0.15	0.03	0.00	0.06	0.554	18510	25807	871
1998*	2449	188	762	145	12	452	0.45	0.03	0.14	0.02	0.00	0.08	0.616	6510	9272	272

\* Data available to July, 1998 only.

**Table 2.6.9.** Observer reported catches and discards (tonnes) and the percent discarded of Pacific ocean perch, yellowmouth rockfish, redstripe rockfish, roughey rockfish, shortspine thornyhead, longspine thornyhead, and shortraker rockfish.

Year	Area	POP			Yellowmouth			Redstripe			Roughey			Shortspine		
		Total	Disc	%Disc	Total	Disc	%Disc	Total	Disc	%Disc	Total	Disc	%Disc	Total	Disc	%Disc
1996	3C	419.5	17.4	4.2	160.4	2.4	1.5	136.9	37.5	27.3	171.9	0.3	0.2	331.7	13.1	4.0
	3D	144.0	3.3	2.3	239.9	5.5	2.3	97.9	21.6	22.0	36.4	0.1	0.2	106.2	7.0	6.6
	5AB	1,278.9	55.0	4.3	636.2	16.1	2.5	504.2	86.3	17.1	108.2	0.6	0.5	59.3	1.6	2.6
	5CD	3,877.4	139.5	3.6	501.5	5.4	1.1	227.5	20.3	8.9	210.1	0.8	0.4	165.4	6.3	3.8
	5ES	616.7	3.8	0.6	126.9	0.3	0.2	121.3	7.2	6.0	469.3	2.8	0.6	37.6	3.2	8.5
	5EN	21.6	0.5	2.3	0.2	0.0	1.6	1.0	0.2	22.7	47.6	0.3	0.6	57.7	1.5	2.6
	Coast	6,358.1	219.6	3.5	1,665.1	29.6	1.8	1,088.9	173.1	15.9	1,043.6	4.8	0.5	757.9	32.6	4.3
1997a	3C	61.4	3.9	6.4	8.9	0.1	1.6	46.8	17.4	37.2	57.4	0.7	1.1	102.1	2.4	2.3
	3D	28.5	2.0	7.2	148.9	1.4	1.0	54.6	17.5	32.1	10.6	0.2	2.1	19.8	0.9	4.6
	5AB	342.5	9.4	2.7	369.8	4.7	1.3	246.7	79.1	32.1	17.9	0.1	0.5	6.9	1.0	14.5
	5CD	304.4	25.8	8.5	32.1	1.2	3.7	38.1	12.6	32.9	6.3	0.1	1.7	18.7	0.4	2.1
	5ES	355.8	2.5	0.7	20.0	0.0	0.1	103.7	3.8	3.6	38.6	0.0	0.0	3.0	0.4	14.6
	5EN	10.9	1.1	10.3	0.2	0.0	0.0	0.3	0.0	0.0	10.1	0.0	0.4	11.4	0.8	7.0
	Coast	1,103.3	44.7	4.1	579.8	7.4	1.3	490.2	130.4	26.6	140.9	1.1	0.8	161.9	5.9	3.6
1997	3C	474.0	19.0	4.0	62.3	0.6	0.9	199.4	71.1	35.7	98.8	0.3	0.3	265.6	16.6	6.2
	3D	81.3	2.5	3.1	378.5	1.1	0.3	123.9	39.9	32.2	3.0	0.0	0.0	54.3	3.8	7.0
	5AB	2,166.1	71.5	3.3	1,511.5	10.6	0.7	600.0	155.3	25.9	45.9	0.1	0.3	44.1	5.9	13.3
	5CD	2,466.0	66.1	2.7	219.2	2.8	1.3	165.2	26.0	15.8	45.0	0.4	0.8	92.5	4.7	5.1
	5ES	402.6	2.2	0.5	38.7	0.2	0.5	92.6	3.2	3.5	263.6	0.3	0.1	9.4	1.8	18.7
	5EN	205.5	2.2	1.1	4.7	0.0	0.1	4.7	0.1	2.1	29.1	0.2	0.8	55.2	1.7	3.1
	Coast	5,795.4	163.5	2.8	2,214.9	15.2	0.7	1,185.8	295.6	24.9	485.2	1.3	0.3	521.1	34.5	6.6
1998*	3C	134.9	5.9	4.4	23.3	0.0	0.0	46.8	29.2	62.5	64.5	0.2	0.3	109.0	6.7	6.2
	3D	7.1	0.5	6.4	24.2	0.0	0.1	45.8	6.0	13.1	1.3	0.0	0.0	19.1	1.8	9.6
	5AB	1,040.0	23.7	2.3	460.3	1.4	0.3	132.7	24.4	18.4	23.9	0.0	0.0	10.2	2.0	19.9
	5CD	1,195.5	18.3	1.5	174.4	3.0	1.7	18.2	6.5	35.7	8.6	0.1	0.7	30.7	1.9	6.1
	5ES	81.0	0.3	0.4	84.3	0.0	0.0	11.0	0.3	2.3	41.1	0.1	0.1	1.7	0.5	31.2
	5EN	39.6	0.1	0.3	0.0	0.0	NA	0.0	0.0	0.0	5.9	0.1	1.9	10.9	0.3	2.4
	Coast	2,498.0	48.8	2.0	766.5	4.5	0.6	254.5	66.4	26.1	145.2	0.4	0.3	181.6	13.2	7.3

\* Data available to July, 1998 only.

**Table 3.1.** Relative quota allocation as an index of abundance. Quota allocation specified by the fishermen (A-F) are relative to an area or species which is assumed, for the purposes of the exercise, to have a quota of 10.

Pacific Ocean perch quota when area 5AB quota is assigned the value 10.

Area	A	B	C	D	E	F	Mean	STD
3C	3	3	1	3	2	1	2.17	0.98
3D	6	3	2	4	4	2	3.50	1.52
5AB	10	10	10	10	10	10	10.00	0.00
5CD	6.5	12	9	9	8	9	8.92	1.80
5ES	9	5	---	8	10	8	8.00	1.87
5EN	3	4	---	9	4	10	6.00	3.24

Yellowmouth rockfish quota when area 3D/5AB quota is assigned the value 10.

Area	A	B	C	D	E	F	Mean	STD
3C	1	1	1	1	1	0.5	0.92	0.20
3D/5AB	10	10	10	10	10	10	10.00	0.00
5CD	3.5	4	1.5	3	3	2.5	2.92	0.86
5E	---	4	1.5	4	5	3.5	3.60	1.29

Redstripe rockfish quota when area 3D/5AB quota is assigned the value 10.

Area	A	B	C	D	E	F	Mean	STD
3C	1	2	2	2	3	2	2.00	0.63
3D/5AB	10	10	10	10	10	10	10.00	0.00
5CD	3.5	4	1.5	3	2	2.5	2.75	0.94
5ES/5EN	2	4	2.5	4	4	3.5	3.33	0.88

Rougheye rockfish quota when area 5ES/5EN quota is assigned the value 10.

Area	A	B	C	D	E	F	Mean	STD
5ES/5EN	10	10	10	10	10	10	10.00	0.00
Rest of coast	7	8	---	10	3	7	7.00	2.55

Chief slope rockfish species quotas when POP quota is assigned the value 10.

Species	A	B	C	D	E	F	Mean	STD
POP	10	10	10	10	10	10	10.00	0.00
Yellowmouth	7	8	7	8	5	7	7.00	1.10
Redstripe	5	5	5	6	6	2	4.83	1.47
Rougheye	3	3	4	4	4	5	3.83	0.75

Thornyhead species quotas when longspine thornyhead quota is assigned the value 10.

Species	A	B	C	D	E	F	Mean	STD
Longspine	10	10	10	10	10	10	10.00	0.00
Shortspine	10	10	---	15	10	15	12.00	2.74

**Table 4.2.1.** Depth ranges (m) by species and area, expressed as quantiles of cumulative, LOESS-smoothed CPUE.

<b>Quantile</b>	<b>POP</b>	<b>YelMth</b>	<b>RedStr</b>	<b>RghEye</b>	<b>SThorn</b>	<b>LThorn</b>	<b>SrtRak</b>
<b><u>3C</u></b>							
0.25	254	220	198	287	567	831	215
0.5	287	282	256	372	752	993	345
0.75	330	366	328	437	933	1105	462
<b><u>3D</u></b>							
0.25	259	232	189	386	519	728	388
0.5	312	272	231	410	682	867	472
0.75	382	357	329	440	851	990	533
<b><u>5AB</u></b>							
0.25	245	236	157	519	414	350	378
0.5	300	284	195	542	526	520	485
0.75	363	336	241	556	634	640	535
<b><u>5CD</u></b>							
0.25	270	233	155	315	572	283	287
0.5	302	302	190	371	693	348	385
0.75	337	378	253	465	837	415	489
<b><u>5ES</u></b>							
0.25	278	255	188	353	426	353	335
0.5	315	283	205	387	548	393	420
0.75	347	328	225	427	679	477	495
<b><u>5EN</u></b>							
0.25	234	272	280	349	389	481	330
0.5	244	292	295	498	437	505	453
0.75	261	313	310	550	488	527	521



**Table 4.3.1.** Data from the ten highest blocks determined by catch of Pacific ocean perch, yellowmouth rockfish, redstripe rockfish, and rougheye rockfish. Block number is defined by coordinates [i, j] with a mean longitude & latitude in area SRF. Effort is defined by the number of tows and hours towed. D is the mean fishing depth. Catches (t) associated with tows in hot blocks are given for POP, yellowmouth (YE), redstripe (RS), rougheye (RE), and shortraker (SR) rockfish and shortspine (ST) and longspine (LT) thornyheads. Regression line through CPUE vs time data yields change in CPUE per year (m) and its significance (p).

Block	i	j	Lon	Lat	SRF	Tows	Hrs	D	POP	YelMth	RedStr	RghEye	Sthorn	Lthorn	SrtRak	Other	m	p
<b>Pacific ocean perch</b>																		
104,268	228	290	130.57	51.82	5CD	145	165	317	342	27		3	4		1	166	-0.01	0.82
148,996	316	414	133.50	53.88	5ES	90	96	325	277	4	5	86	2		1	30	0.13	0.17
102,472	232	285	130.70	51.73	5CD	87	120	283	242	57		1	2		1	56	0.00	0.99
105,345	225	293	130.47	51.87	5CD	85	153	309	213	26		1	2			38	-0.20	0.03
104,985	225	292	130.47	51.85	5CD	107	174	295	193	21		1	1			36	-0.06	0.52
148,997	317	414	133.53	53.88	5ES	66	85	345	184	2		59	1			24	-0.17	0.19
101,753	233	283	130.73	51.70	5CD	45	52	302	183	11		1	1		1	47	-0.03	0.83
101,392	232	282	130.70	51.68	5CD	70	85	320	182	2		6	4		5	155	0.21	0.14
104,625	225	291	130.47	51.83	5CD	72	128	286	157	20			2			22	-0.22	0.08
103,191	231	287	130.67	51.77	5CD	53	59	292	150	12		1	1		1	13	0.12	0.39
<b>Yellowmouth rockfish</b>																		
77,209	169	215	128.60	50.57	5AB	129	189	238	18	235	18		1			116	-0.07	0.35
73,964	164	206	128.43	50.42	3D	97	262	240	44	137	19		1			95	0.12	0.13
74,325	165	207	128.47	50.43	3D	46	117	242	28	88	7		1			38	-0.20	0.12
103,192	232	287	130.70	51.77	5CD	51	60	269	91	85			1			33	-0.22	0.26
90,542	182	252	129.03	51.18	5AB	45	111	180	48	80	5					58	-0.05	0.84
76,849	169	214	128.60	50.55	5AB	47	59	238	8	78	2		1			20	0.01	0.94
89,108	188	248	129.23	51.12	5AB	27	45	213	10	73	30					9	0.12	0.51
73,243	163	204	128.40	50.38	3D	56	126	236	14	70	12		1			40	0.28	0.01
103,191	231	287	130.67	51.77	5CD	42	42	288	115	68		1	1		1	10	-0.41	0.02
76,127	167	212	128.53	50.52	5AB	47	69	228	3	66	5					15	-0.26	0.20
<b>Redstripe rockfish</b>																		
92,334	174	257	128.77	51.27	5AB	65	90	193	6	10	73					174	0.12	0.50
104,247	207	290	129.87	51.82	5CD	17	21	163		1	65					32	-0.30	0.09
92,335	175	257	128.80	51.27	5AB	63	108	194	1	7	58					216	0.37	0.00
94,511	191	263	129.33	51.37	5AB	41	54	148		29	53					52	-0.39	0.71
130,607	287	363	132.53	53.03	5ES	43	96	251	34	3	43	3			1	68	0.30	0.17
91,974	174	256	128.77	51.25	5AB	41	66	195	3	6	43					121	0.06	0.71
83,354	194	232	129.43	50.85	5AB	6	14	152			41						0.20	0.79
130,247	287	362	132.53	53.02	5ES	38	62	251	18	2	37					24	-0.03	0.92
104,258	218	290	130.23	51.82	5CD	5	13	144			36					20	-0.13	0.68
76,485	165	213	128.47	50.53	5AB	16	25	177		1	34					16	-0.60	0.15
<b>Rougheye rockfish</b>																		
91,289	209	254	129.93	51.22	5AB	66	113	415	7			107	2			14	0.10	0.26
148,996	316	414	133.50	53.88	5ES	80	89	327	254	3	2	87	2		1	29	0.47	0.00
148,997	317	414	133.53	53.88	5ES	62	83	362	165	2	1	62	1			29	0.14	0.34
135,299	299	376	132.93	53.25	5ES	16	30	353	11	3		46	1			2	-0.01	0.96
134,939	299	375	132.93	53.23	5ES	15	25	405	1			39	1			2	0.12	0.58
135,660	300	377	132.97	53.27	5ES	27	58	365	23			38	1		1	3	0.30	0.05
148,636	316	413	133.50	53.87	5ES	32	43	400	55	1		36	1			14	0.45	0.06
150,077	317	417	133.53	53.93	5ES	17	26	429	3			36	1			8	0.07	0.72
149,718	318	416	133.57	53.92	5ES	18	29	452	4			36	1		1	36	-0.10	0.70
50,526	126	141	127.17	49.33	3C	86	203	381	5			35	2		2	308	-0.04	0.65

**Table 4.3.1. continued.** Data from the ten highest blocks determined by catch of shortspine thornyhead, longspine thornyhead, shortraker rockfish, and other commercial fish species. Block number is defined by coordinates [i, j] with a mean longitude & latitude in area SRF. Effort is defined by the number of tows and hours towed. D is the mean fishing depth. Catches (t) associated with tows in hot blocks are given for POP, yellowmouth (YE), redstripe (RS), roughey (RE), and shortraker (SR) rockfish and shortspine (ST) and longspine (LT) thornyheads. Regression line through CPUE vs time data yields change in CPUE per year (m) and its significance (p).

Block	i	j	Lon	Lat	SRF	Tows	Hrs	D	POP	YeIMth	RedStr	RghEye	Sthorn	Lthorn	SrtRak	Other	m	p
<b>Shortspine thornyhead</b>																		
55,940	140	156	127.63	49.58	3D	129	790	921					36	81		15	-0.04	0.40
55,580	140	155	127.63	49.57	3D	137	832	933					28	90		19	-0.03	0.54
56,660	140	158	127.63	49.62	3D	80	352	841					21	26		25	-0.28	0.00
41,515	115	116	126.80	48.92	3C	95	545	904					19	42		10	0.04	0.54
41,875	115	117	126.80	48.93	3C	97	564	852					18	38		12	0.05	0.22
50,166	126	140	127.17	49.32	3C	81	338	620				3	17	8	2	93	0.07	0.37
50,527	127	141	127.20	49.33	3C	102	506	821					17	32	1	55	-0.04	0.52
50,526	126	141	127.17	49.33	3C	130	446	506	7			25	15	14	4	297	-0.10	0.10
31,418	98	88	126.23	48.45	3C	91	431	892					15	41		11	-0.01	0.89
35,021	101	98	126.33	48.62	3C	130	563	920					14	65		14	-0.08	0.11
<b>Longspine thornyhead</b>																		
55,580	140	155	127.63	49.57	3D	137	836	934					27	92		19	-0.07	0.12
55,940	140	156	127.63	49.58	3D	124	773	925					33	81		14	-0.07	0.19
35,021	101	98	126.33	48.62	3C	130	563	920					14	65		14	-0.04	0.36
41,515	115	116	126.80	48.92	3C	94	544	909					19	42		10	-0.18	0.00
31,418	98	88	126.23	48.45	3C	91	431	892					15	41		11	-0.07	0.16
41,875	115	117	126.80	48.93	3C	99	573	852					18	39		12	-0.18	0.00
45,842	122	128	127.03	49.12	3C	77	437	947					13	37		9	-0.08	0.18
31,058	98	87	126.23	48.43	3C	77	371	913					12	35		7	-0.10	0.05
35,020	100	98	126.30	48.62	3C	69	339	900					8	34		11	-0.16	0.00
41,876	116	117	126.83	48.93	3C	70	395	929					10	33		9	-0.05	0.46
<b>Shortraker rockfish</b>																		
101,392	232	282	130.70	51.68	5CD	48	64	340	112	1		7	3		6	154	-0.39	0.00
141,064	304	392	133.10	53.52	5ES	6	15	529				5	1		4	3	-0.33	0.29
50,526	126	141	127.17	49.33	3C	47	121	406	3			15	2		4	110	-0.05	0.62
147,193	313	409	133.40	53.80	5ES	2	4	405				3			3		NA	NA
116,138	218	323	130.23	52.37	5CD	39	113	345	31			3	7		3	24	-0.14	0.11
101,032	232	281	130.70	51.67	5CD	13	18	463				3	1		3	29	-0.04	0.89
72,522	162	202	128.37	50.35	3D	28	65	482	3		1	5	1		3	39	0.25	0.11
27,806	86	78	125.83	48.28	3C	28	72	393	5	1		2	2		3	80	0.01	0.90
148,273	313	412	133.40	53.85	5ES	1	1	498				1			3		NA	NA
50,165	125	140	127.13	49.32	3C	20	59	399				8	1		3	62	-0.42	0.00

**Table 4.4.1.** Statistics by assessment units: 20% qualified effort (hr), depth qualified effort (hr), 20% qualified CPUE (kg/hr), depth qualified CPUE (kg/hr), depth qualified area (nm2), depth qualified biomass (tonnes), quota (tonnes), kept catch (tonnes), and total catch (tonnes).

Species	Area	20% Qualified Effort	Depth Qualified Effort	20% Qualified CPUE	Depth Qualified CPUE	Depth Qualified Area	Depth Qualified Biomass	1997 Yield	1997 Quota	1998 Yield	1998 Quota	1997 Kept Catch	1997 Total Catch
POP	3C	650	414	291	558	105	2031	375	431	95	300	455	474
	3D	82	141	397	242	18	149	200	230	200	230	79	81
	5AB	3553	484	519	639	144	3179	2050	2358	1800	2070	2095	2166
	5CD	2400	890	895	1393	178	8558	2450	2818	2450	2817	2400	2466
	5EN	282	6	854	859	6	174	400	214	400	246	203	205
	5ES	456	173	892	1316	48	2175	160	430	235	484	400	403
YeIMth	3C	48	183	202	106	65	237	60	100	195	221	62	62
	3D	489	293	573	535	29	543	367	312	290	230	377	378
	5AB	2178	343	499	371	118	1510	1460	1554	720	915	1501	1512
	5CD	79	907	1088	96	191	636	211	360	610	691	216	219
	5EN		9		191	5	31	5	3	155	36	5	5
	5ES	27	102	235	106	30	110	37	101	155	292	38	39
RedStr	3C	80	638	172	70	125	303	203	150	155	178	128	199
	3D	123	361	406	149	63	324	133	190	110	126	84	124
	5AB	545	1857	565	168	370	2150	704	1008	580	668	445	600
	5CD	186	354	995	432	123	1841	221	49	295	339	139	165
	5EN		4		158	2	13	7	12	50	12	5	5
	5ES	95	29	628	648	10	215	141	214	170	241	89	93
RghEye	3C	10	1040	43	56	133	257	142	77	100	112	98	99
	3D							4	2	55	3	3	3
	5AB	30		451				66	36	85	52	46	46
	5CD	11	381	1118	76	89	234	65	35	125	51	45	45
	5EN	33	528	152	42	95	136	42	23	75	33	29	29
	5ES	270	85	771	1493	32	1654	381	207	295	299	263	264
Sthorn	3C	2456	5013	32	30	361	374	348	383	425	383	249	266
	3D	630	417	43	49	61	104	71	78	110	78	50	54
	5AB		34		59	10	21	53	59	25	59	38	44
	5CD	126	1	185	36	1	2	123	135	70	135	88	93
	5EN	178	537	124	82	88	247	75	82	15	82	53	55
	5ES		82		30	21	22	11	12	25	12	8	9
Lthorn	3C	5579	4718	69	77	286	762	290	723	282	724	429	493
	3D	1102	1168	65	64	60	131	51	126	49	127	75	83
	5AB		19		22	6	5	2	5	2	5	3	4
	5CD		31		18	18	11	1	2	1	2	1	1
	5EN		2		35	2	3	1	2	1	2	1	1
	5ES							0	1	0	1	0	0
SrtRak	3C		622		15	119	60	62	34	30	52	25	25
	3D		5		34	4	5	3	2	30	3	1	1
	5AB		19		16	4	2	6	3	15	5	2	2
	5CD		512		19	126	82	37	20	40	31	15	15
	5EN		280		21	61	43	18	10	25	15	7	7
	5ES		52		42	24	35	14	8	15	12	6	6

**Table 4.5.1.** Statistics from Table 4.4.1. scaled with respect to fisherman's opinion.

Species	Area	Fisherman's Mean	Fisherman's StdDev	20% Qualified Effort	Depth Qualified Effort	20% Qualified CPUE	Depth Qualified CPUE	Depth Qualified Area	Depth Qualified Biomass	1997 Yield	1997 Quota	1998 Yield	1998 Quota	1997 Kept Catch	1997 Total Catch
POP	3C	2.17	0.98	1.83	8.54	5.61	8.73	7.32	6.39	1.83	1.83	0.53	1.45	2.17	2.19
	3D	3.50	1.52	0.23	2.91	7.65	3.79	1.24	0.47	0.98	0.98	1.11	1.11	0.38	0.38
	5AB	10.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
	5CD	8.92	1.80	6.75	18.37	17.26	21.81	12.34	26.92	11.95	11.95	13.61	13.61	11.46	11.38
	5EN	8.00	1.87	0.79	0.13	16.46	13.44	0.41	0.55	1.95	0.91	2.22	1.19	0.97	0.95
	5ES	6.00	3.24	1.28	3.56	17.19	20.61	3.32	6.84	0.78	1.82	1.31	2.34	1.91	1.86
YelMth	3C	0.92	0.20	0.18	2.88	3.94	2.66	4.38	1.15	0.33	0.54	1.93	1.93	0.33	0.33
	3D/5AB	10.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
	5CD	2.92	0.86	0.30	14.26	21.23	2.41	12.96	3.10	1.15	1.93	6.04	6.03	1.15	1.16
	5E	3.60	1.29	0.10	1.75	4.58	2.69	2.35	0.68	0.23	0.56	3.07	2.86	0.23	0.23
RedStr	3C	2.00	0.63	1.19	2.87	3.21	4.18	2.89	1.22	2.43	1.25	2.25	2.24	2.43	2.75
	3D/5AB	10.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
	5CD	2.75	0.94	2.78	1.59	18.56	25.77	2.85	7.44	2.63	0.41	4.28	4.27	2.63	2.28
	5E	3.33	0.88	1.43	0.15	11.73	37.79	0.28	0.92	1.78	1.89	3.19	3.19	1.78	1.34
RghEye	5ES/5EN	10.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
	Rest of coast	7.00	2.55	1.68	23.18	7.39	5.12	17.50	2.75	8.23	16.64	11.49	11.56	6.56	6.58
POP	POP	10.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Compare	Yellowmouth	7.00	1.10	3.80	8.71	7.95	2.26	8.77	1.88	3.80	3.75	4.10	3.88	3.91	3.82
	Redstripe	4.83	1.47	1.39	15.39	9.15	1.85	13.89	2.98	2.50	2.50	2.63	2.54	1.58	2.05
	Rougheye	3.83	0.75	0.48	9.65	10.34	1.20	6.99	1.40	1.24	0.59	1.42	0.89	0.86	0.84
Lthorn	Longspine	10.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Compare	Shortspine	12.00	2.74	5.07	10.25	6.59	4.87	14.55	8.44	19.71	8.71	20.00	8.70	9.55	8.93
SSQ Score				29.44	124.50	240.11	543.40	83.73	74.29	22.00	28.57	24.68	22.80	20.58	21.17
SDev Score				19.13	34.93	45.59	54.49	29.00	25.03	16.01	18.27	17.40	16.33	14.89	15.52

**Table 4.5.2.** Ranked scores from Table 4.5.1.

<b>Quantity</b>	<b>SumDev</b>	<b>SumSq</b>	<b>Rank</b>
1997 Kept Catch	14.89	20.58	1
1997 Total Catch	15.52	21.17	2
1997 Yield	16.01	22.00	3
1998 Quota	16.33	22.80	4
1998 Yield	17.40	24.68	5
1997 Quota	18.27	28.57	6
20% Qualified Effort	19.13	29.44	7
Depth Qualified Biomass	25.03	74.29	8
Depth Qualified Area	29.00	83.73	9
Depth Qualified Effort	34.93	124.50	10
20% Qualified CPUE	45.59	240.11	11
Depth Qualified CPUE	54.49	543.40	12

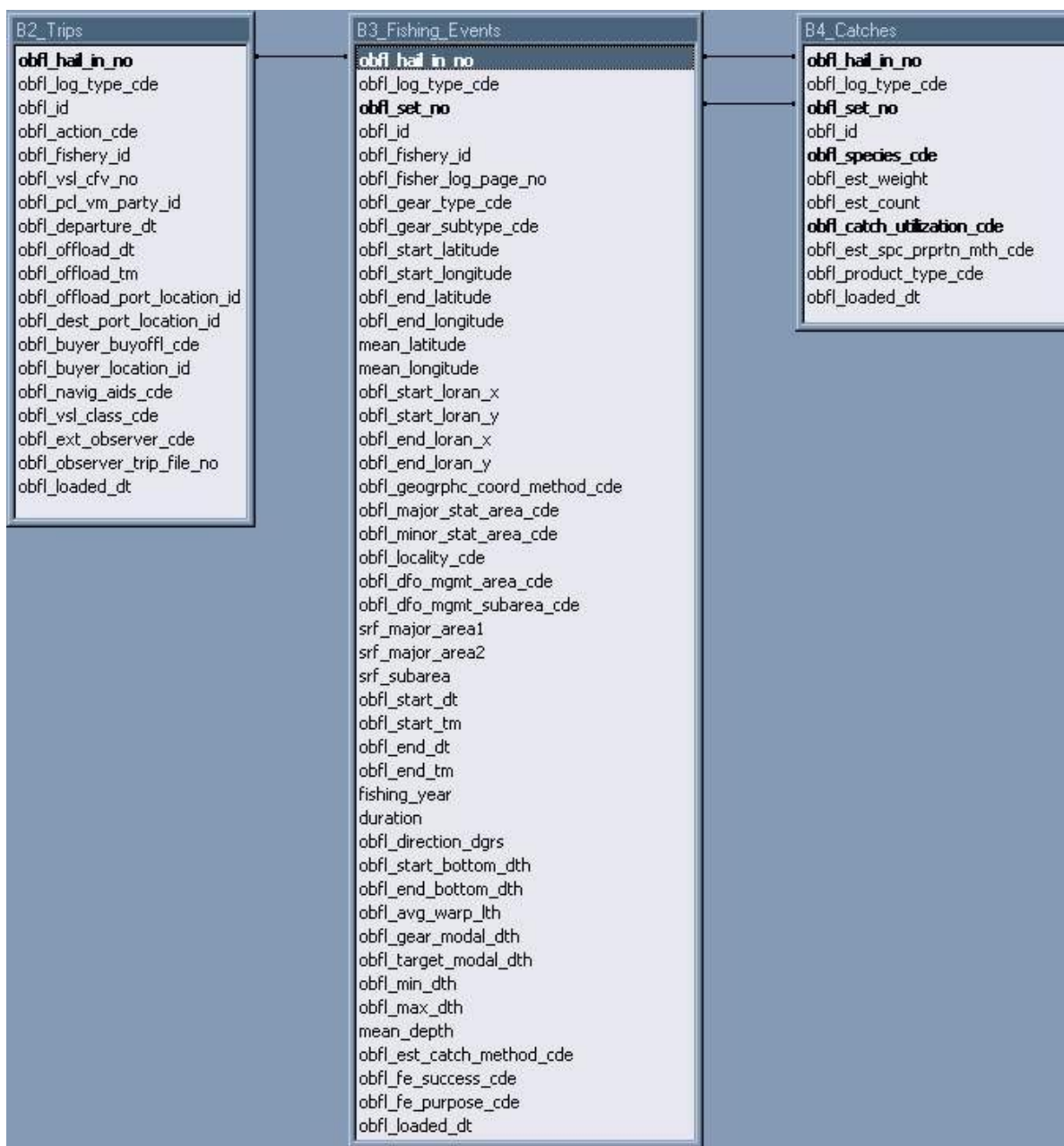


Figure 2.2.1. Links among the primary data tables used in this report.

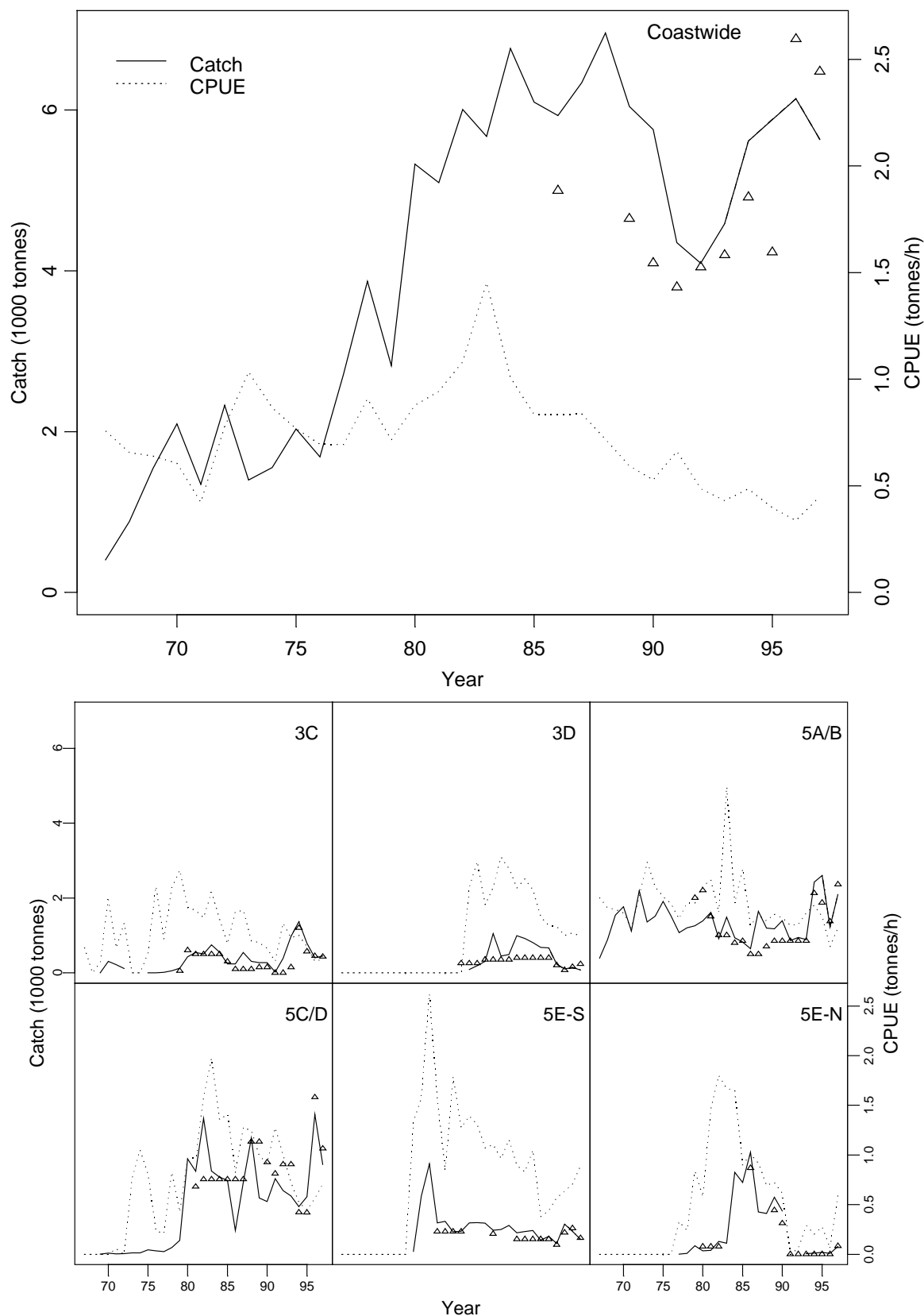


Figure 2.6.1. Pacific ocean perch catch (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.

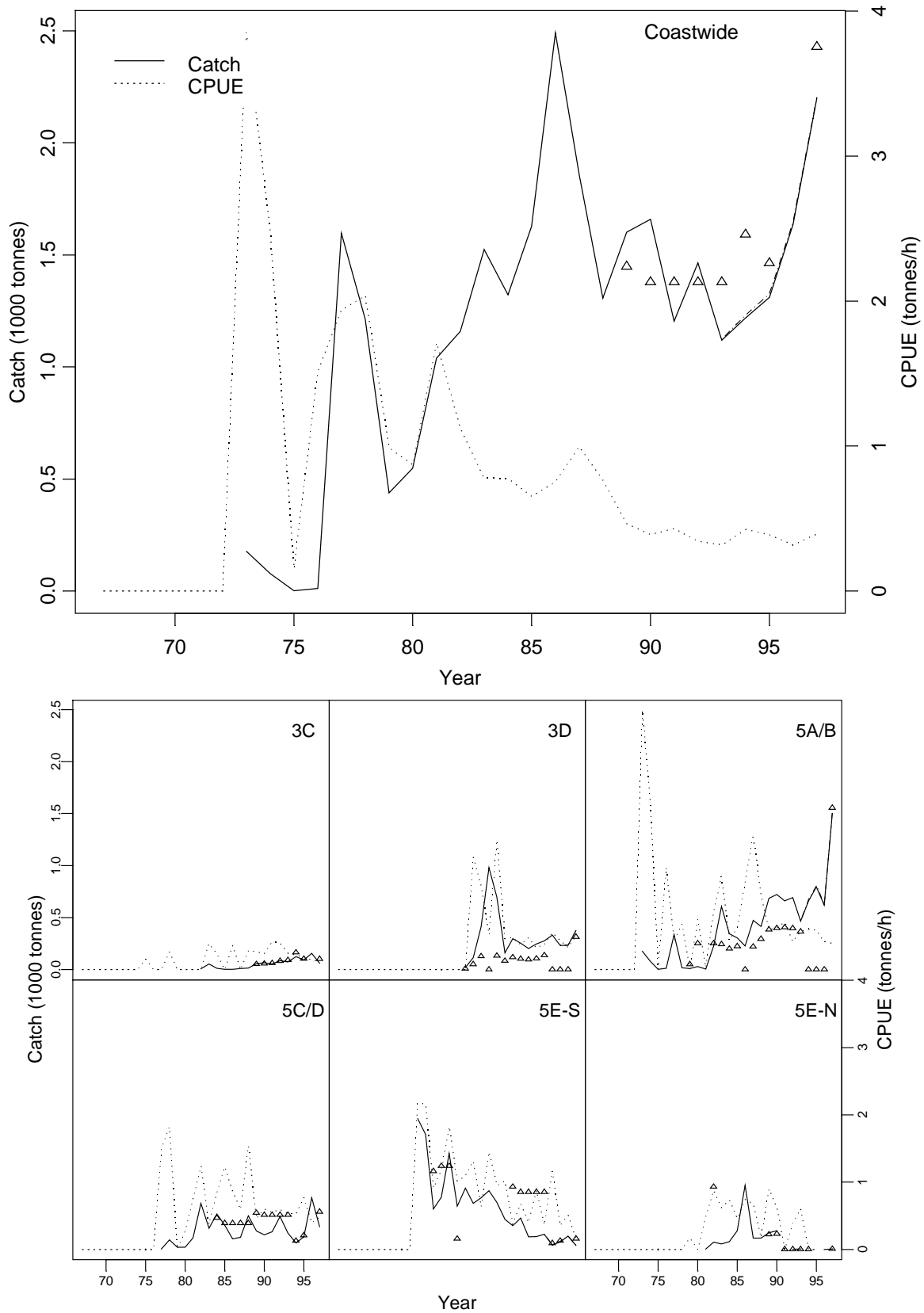


Figure 2.6.2. Yellowmouth rockfish catch (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.



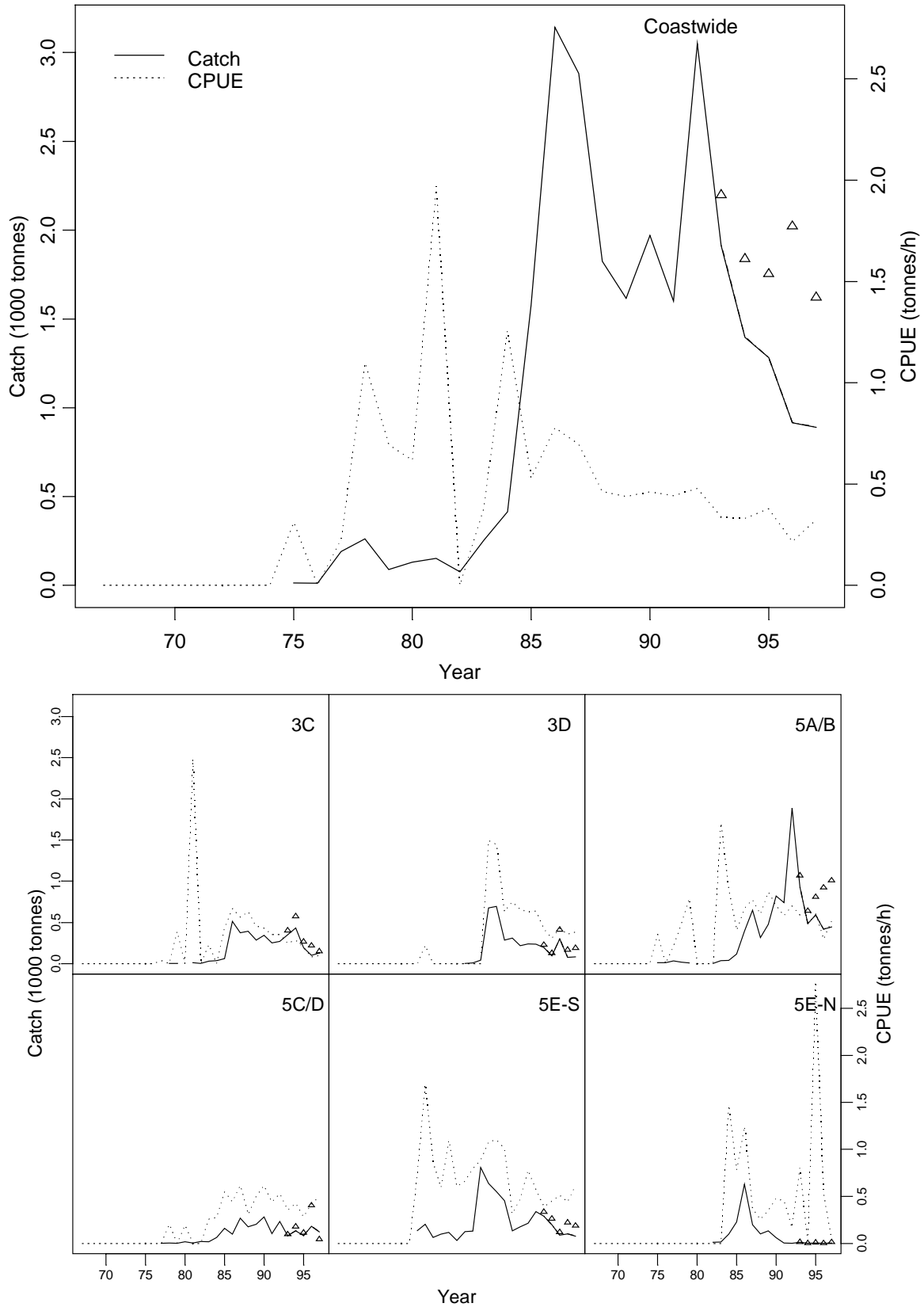


Figure 2.6.3. Redstripe rockfish catch (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.

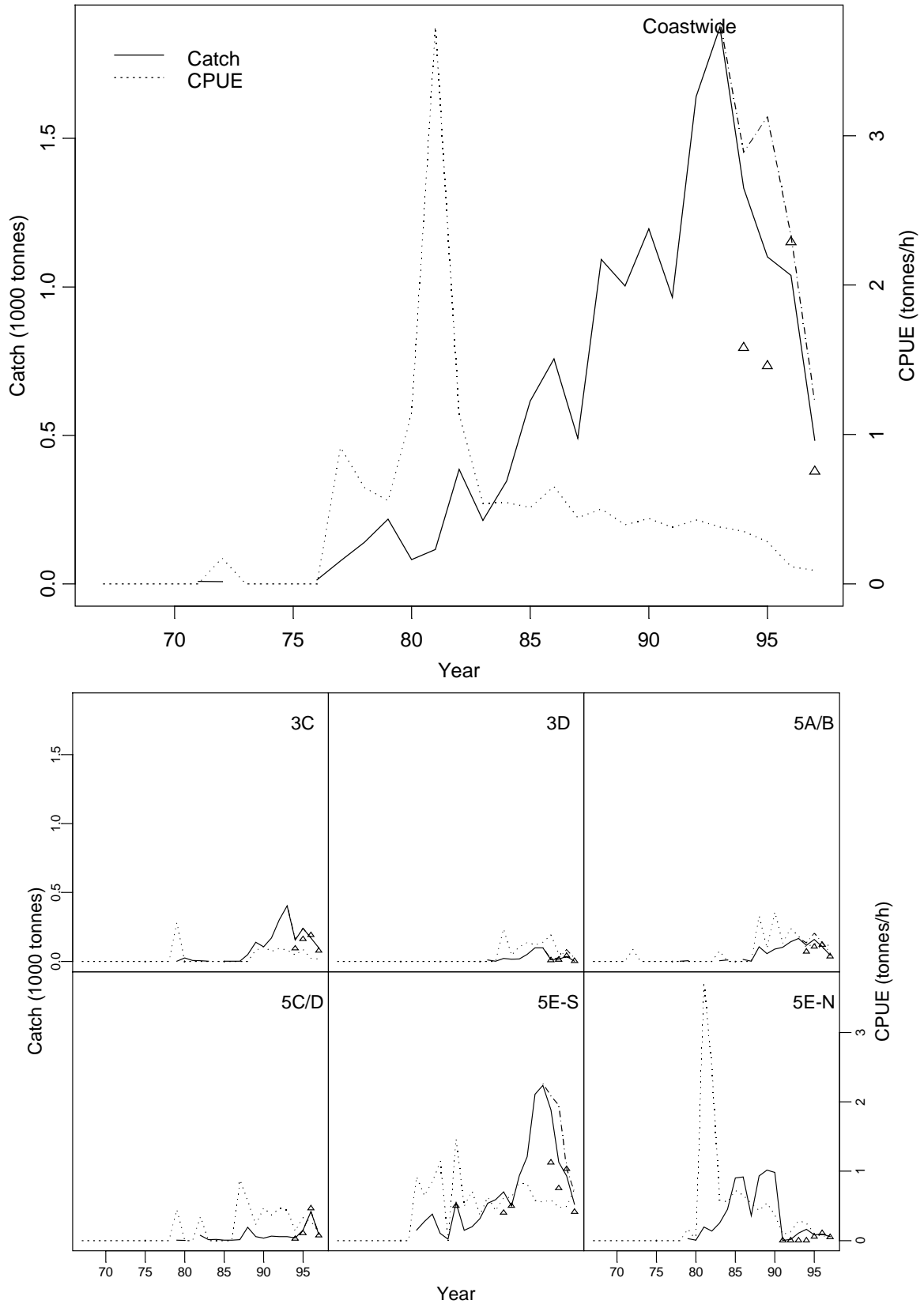


Figure 2.6.4. Roughey rockfish catch (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.

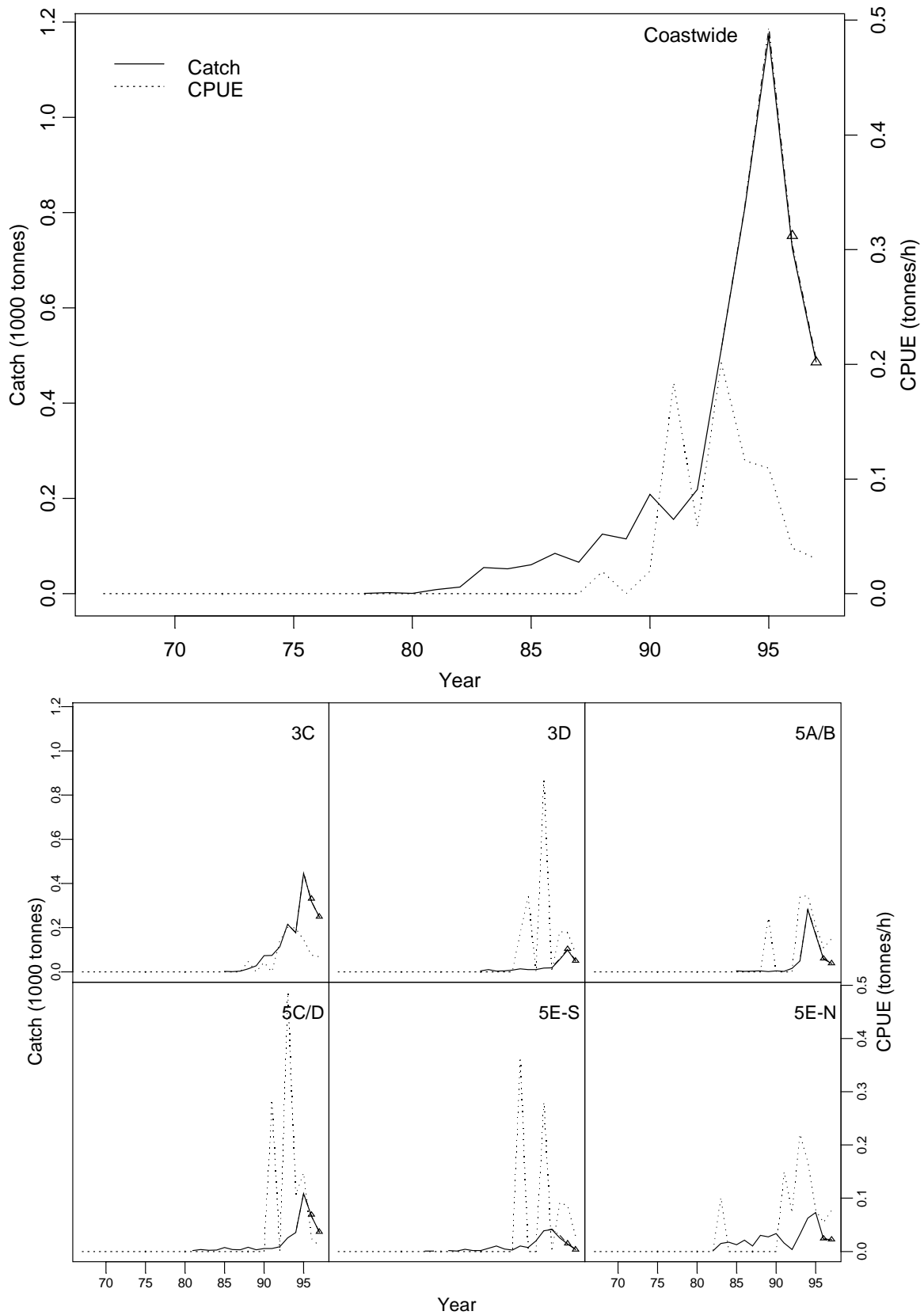


Figure 2.6.5. Shortspine thornyhead (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.

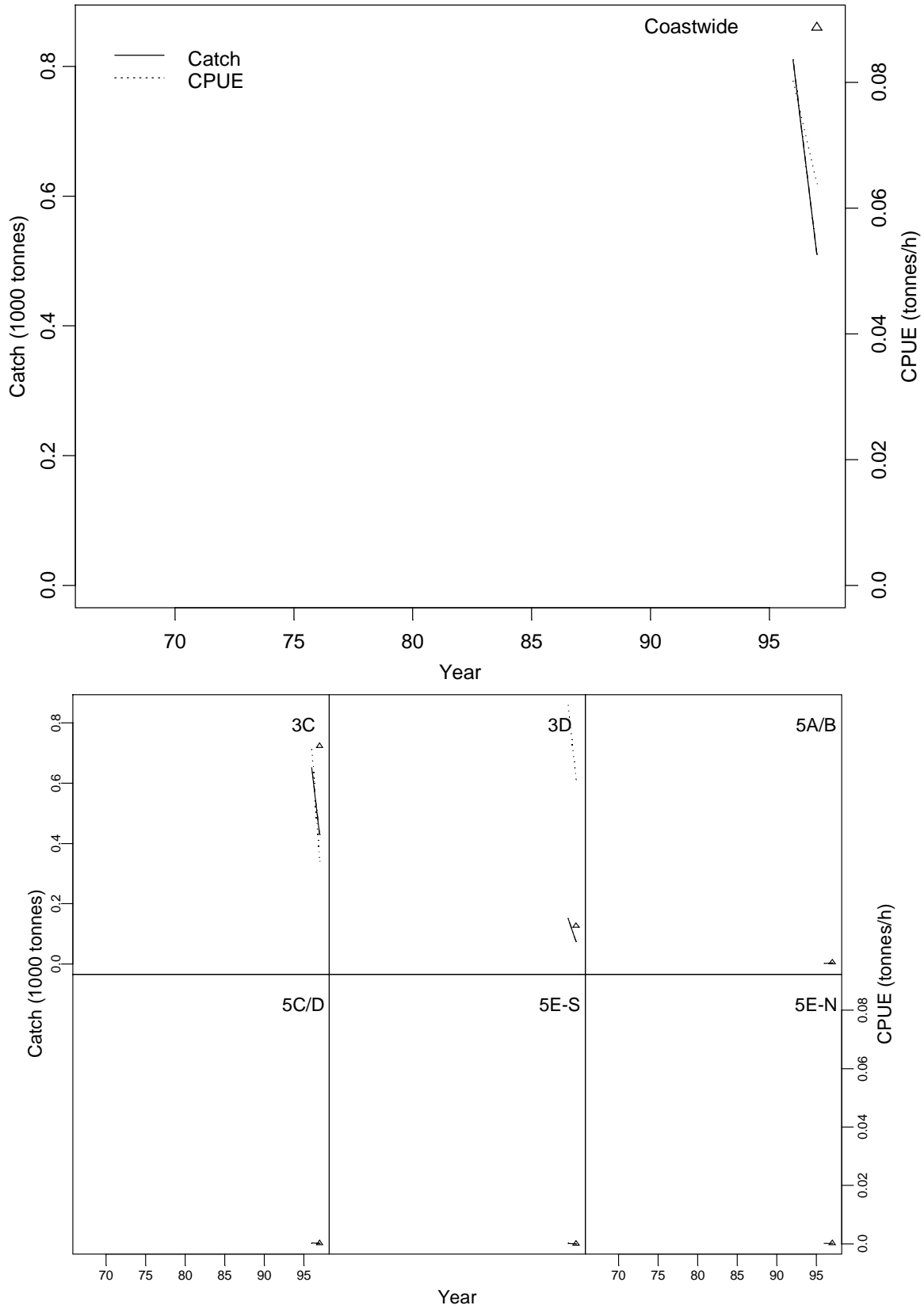


Figure 2.6.6. Longspine thornyhead (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.

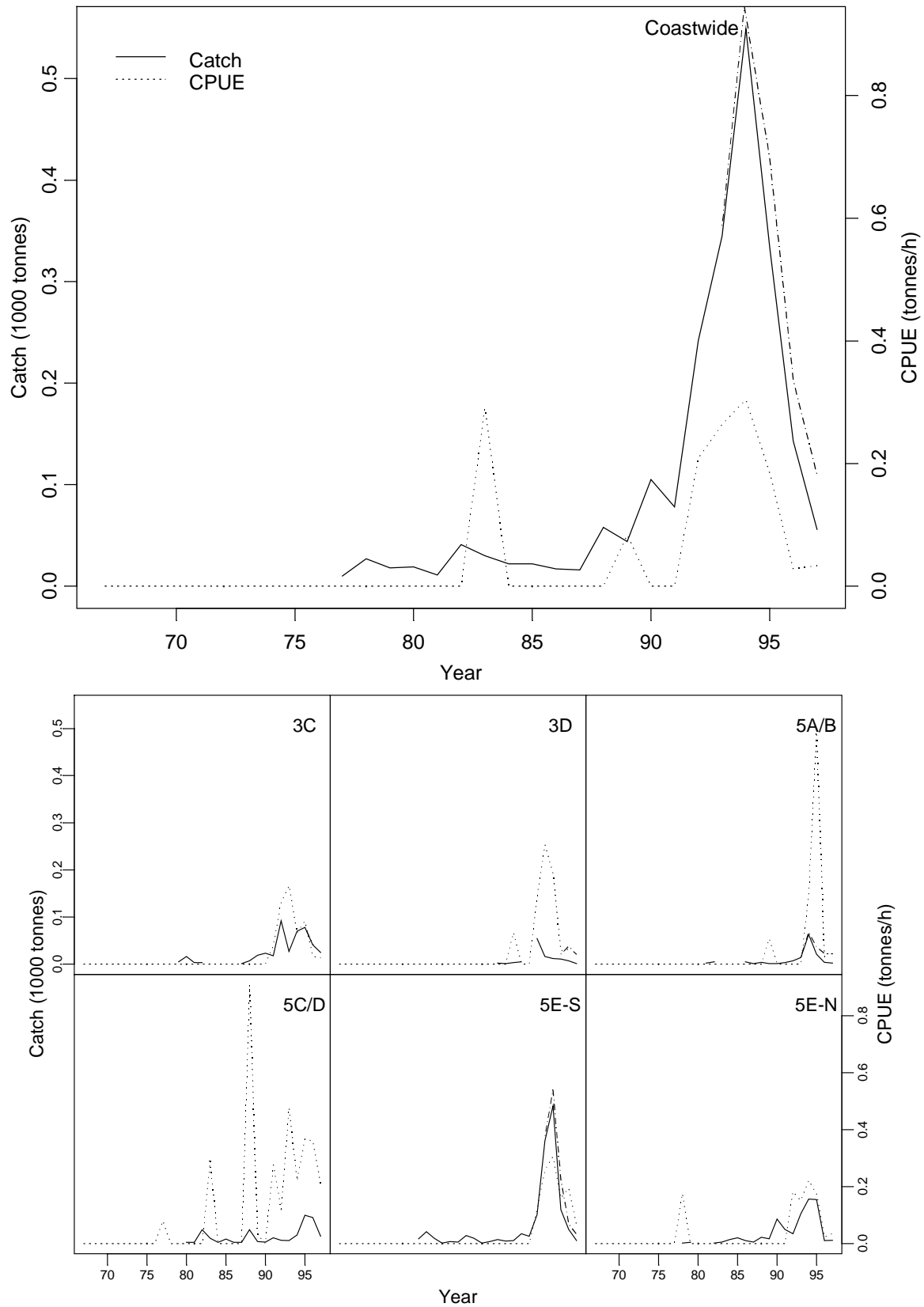


Figure 2.6.7. Shortraker rockfish (trawl = solid line, hook and line = dashed line) and 20% qualified CPUE (dotted line). Annual quotas plotted as triangles.

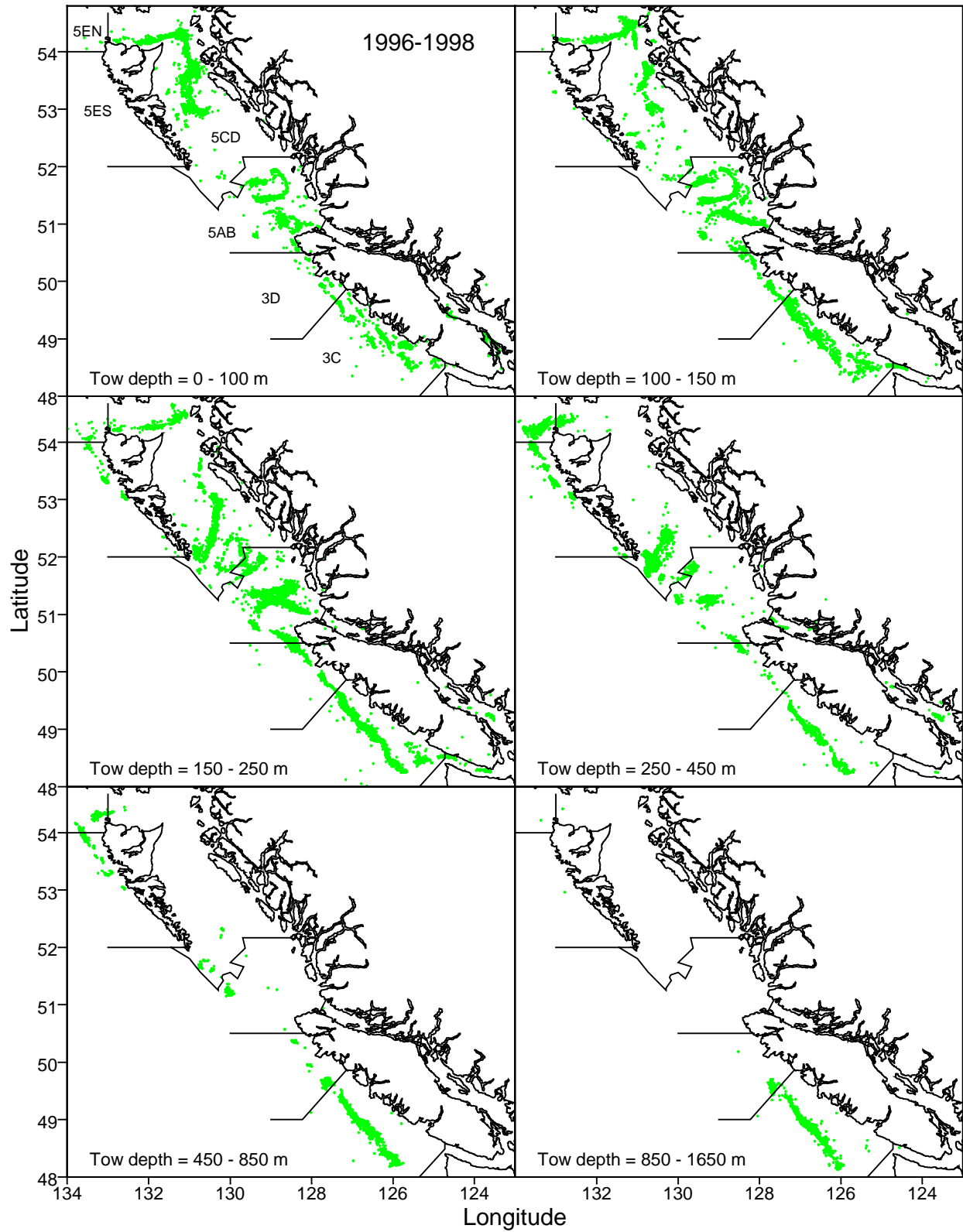


Figure 4.1.1. Trawl tow locations, stratified by fishing depth, and SRF areas along the BC coast, January 1996 to July 1998.

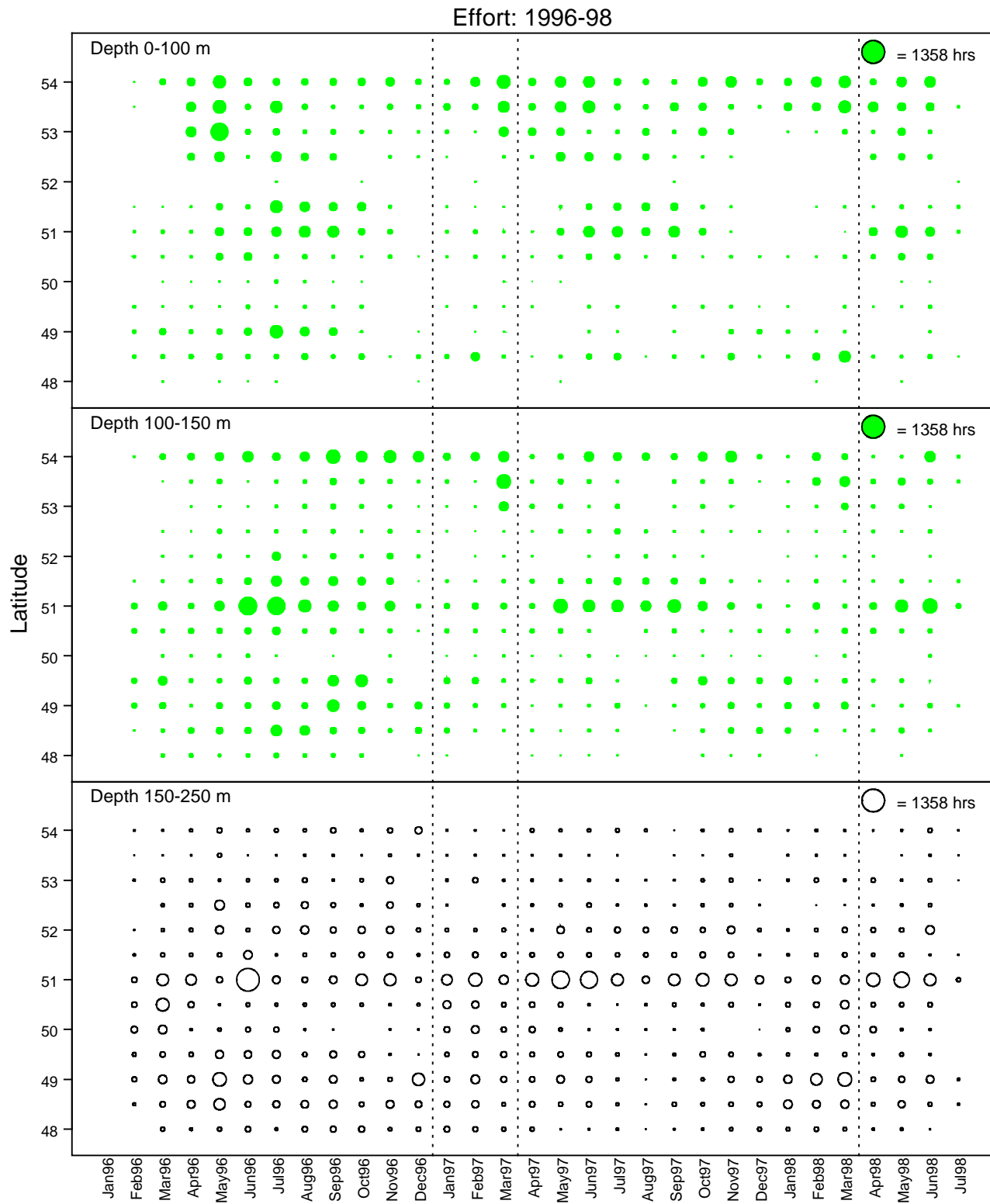


Fig. 4.1.2. Trawl effort by month, latitude, and fishing depth, January 1996 to July 1998.

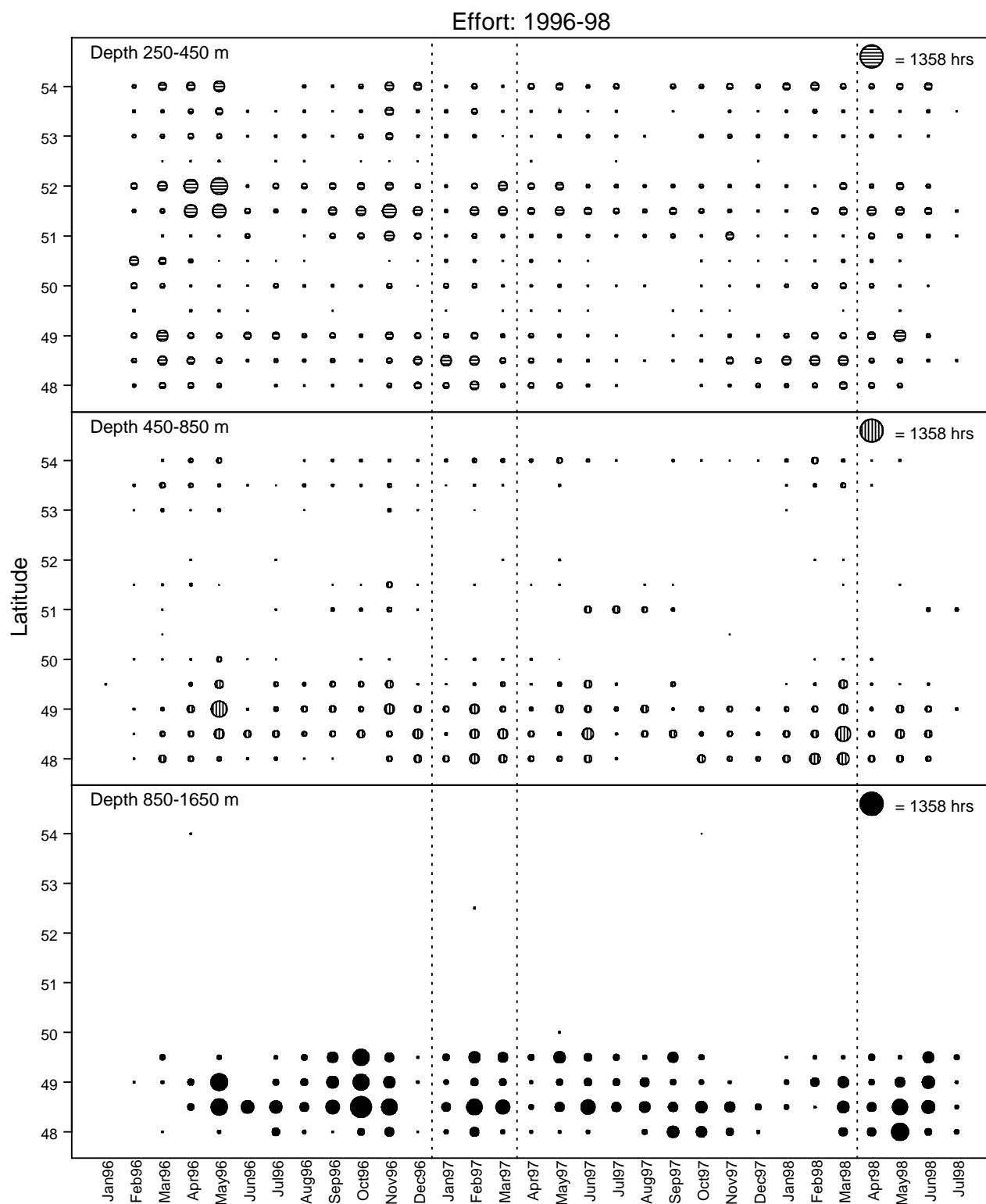


Figure 4.1.2. cont'd. Trawl effort by month, latitude, and fishing depth, January 1996 to July 1998.



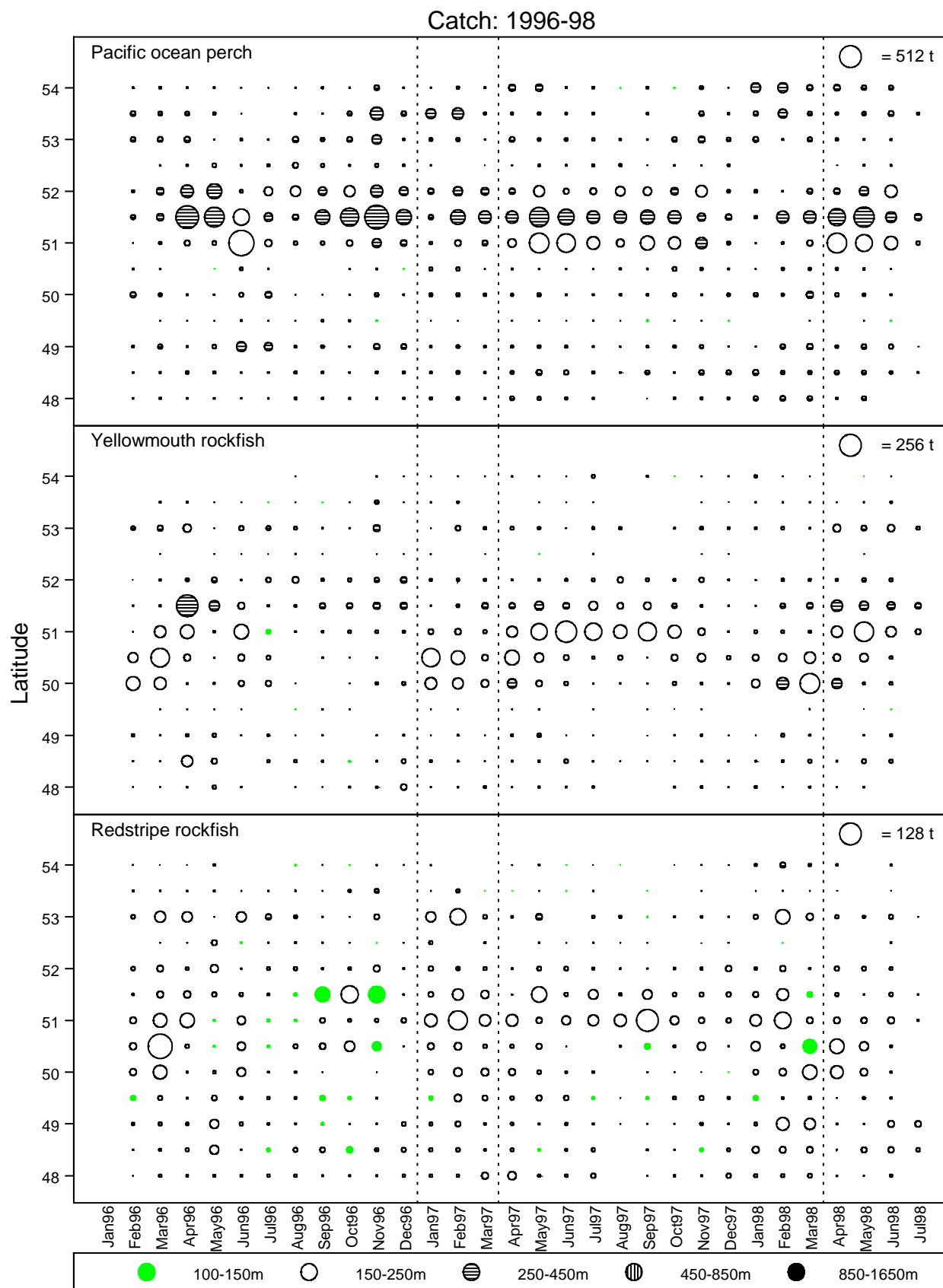


Fig. 4.1.3. Trawl catch by species, month, latitude, and mean fishing depth weighted by catch for Pacific ocean perch, yellowmouth rockfish, and redstripe rockfish.

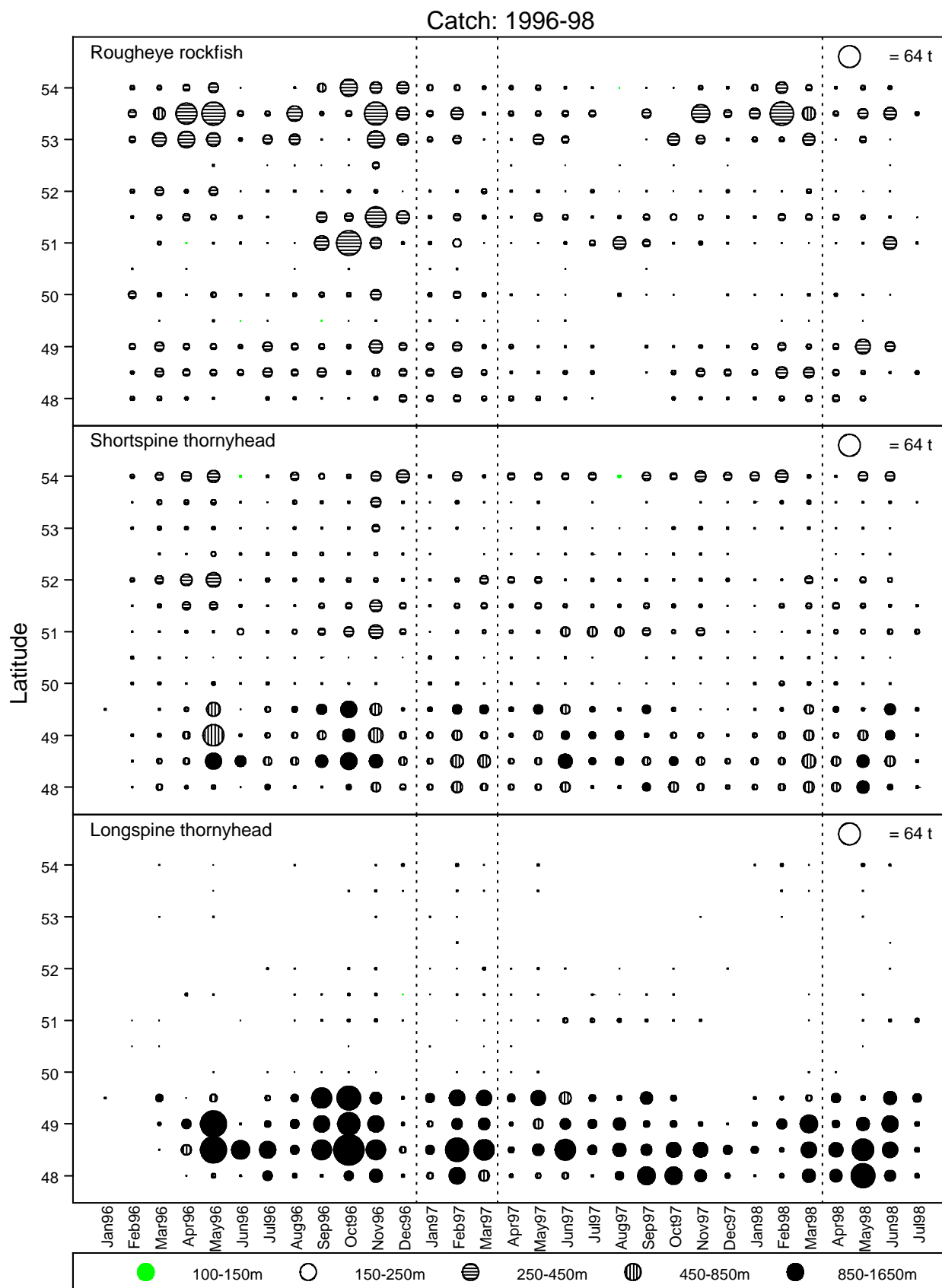


Fig. 4.1.3. cont'd. Trawl catch by species, month, latitude, and mean fishing depth weighted by catch for rougheye rockfish, shortspine thornyhead, and longspine thornyhead.

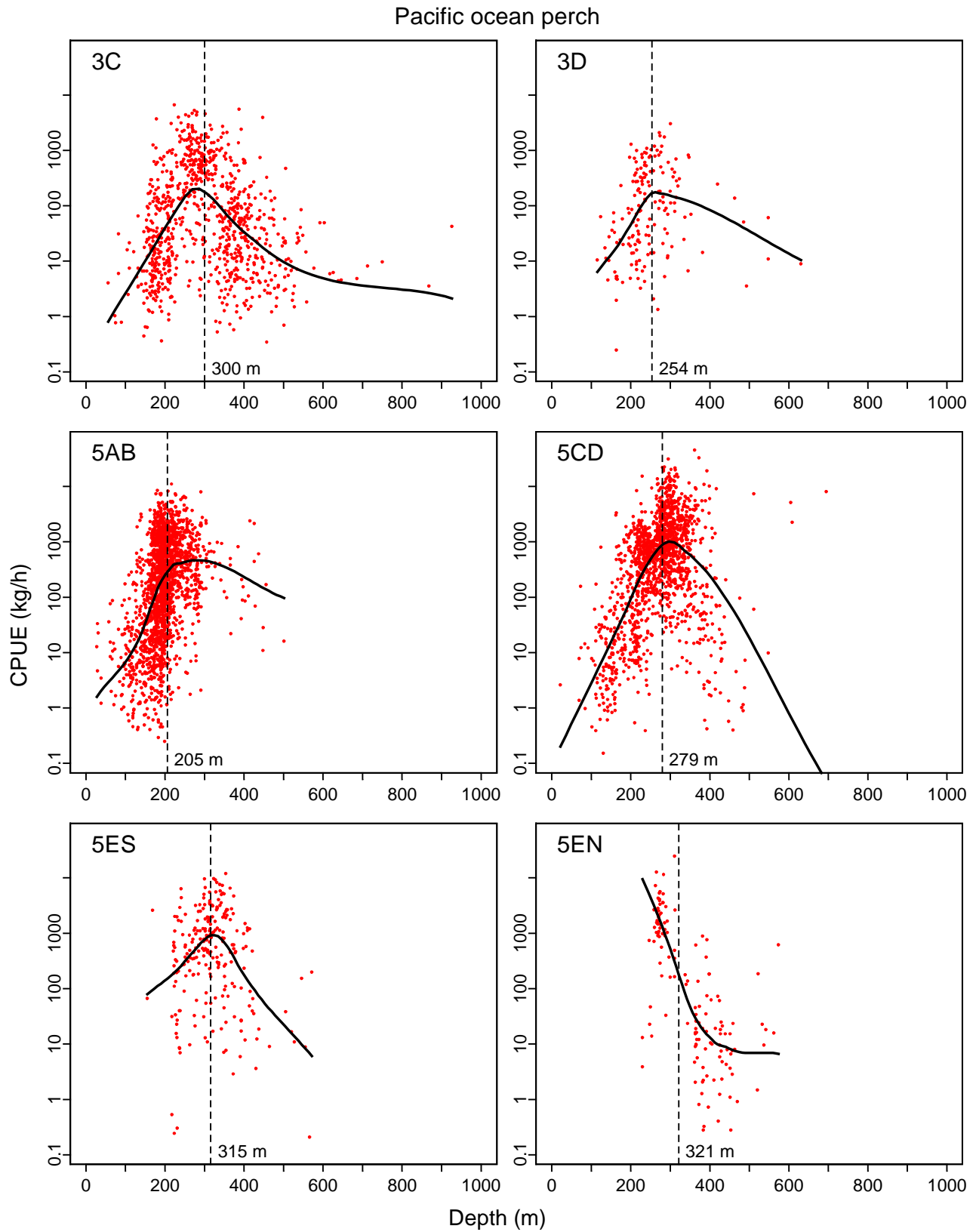


Fig. 4.2.1. Pacific ocean perch CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.

# Yellowmouth rockfish

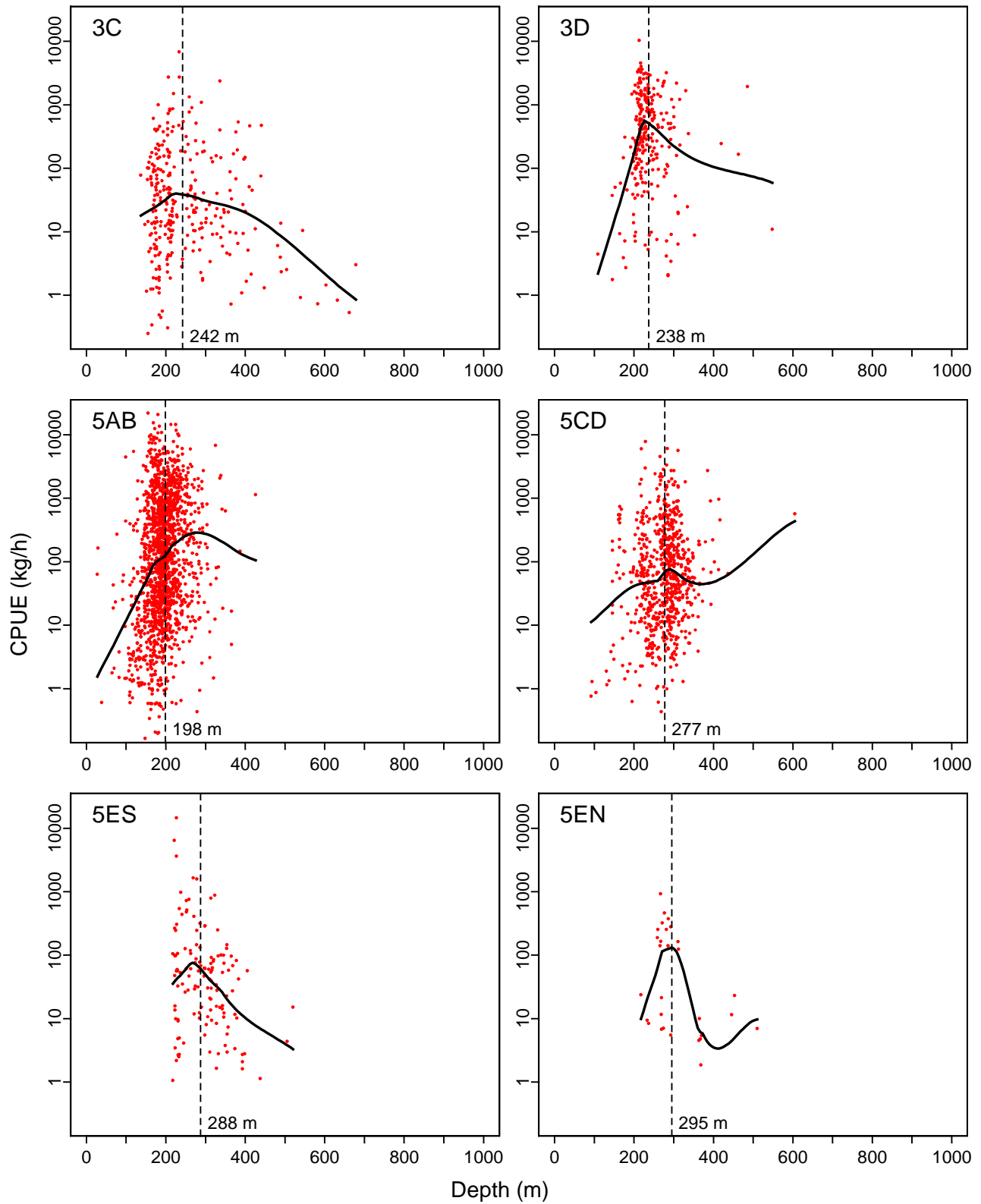


Fig. 4.2.2. Yellowmouth rockfish CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.

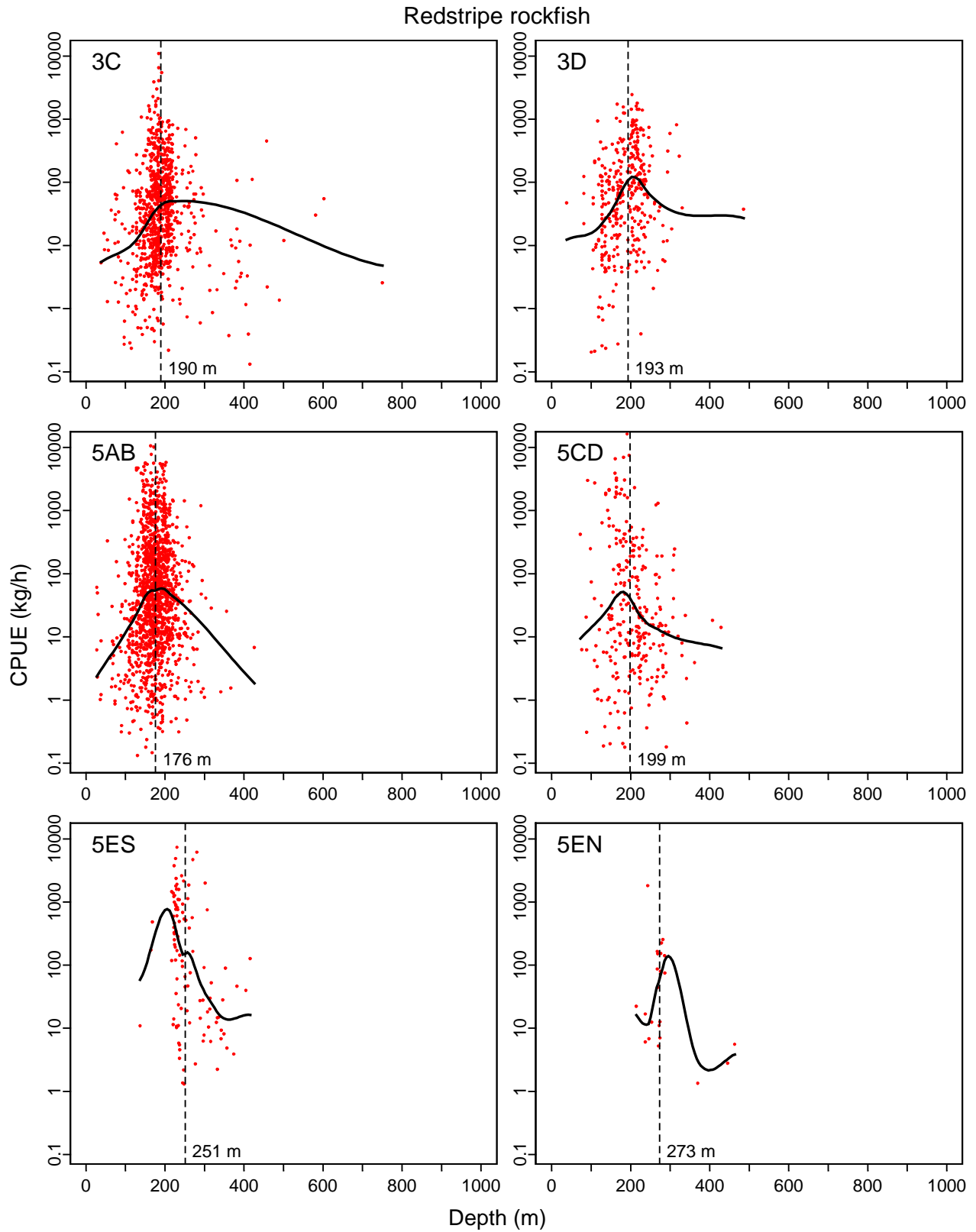


Fig. 4.2.3. Redstripe rockfish CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.

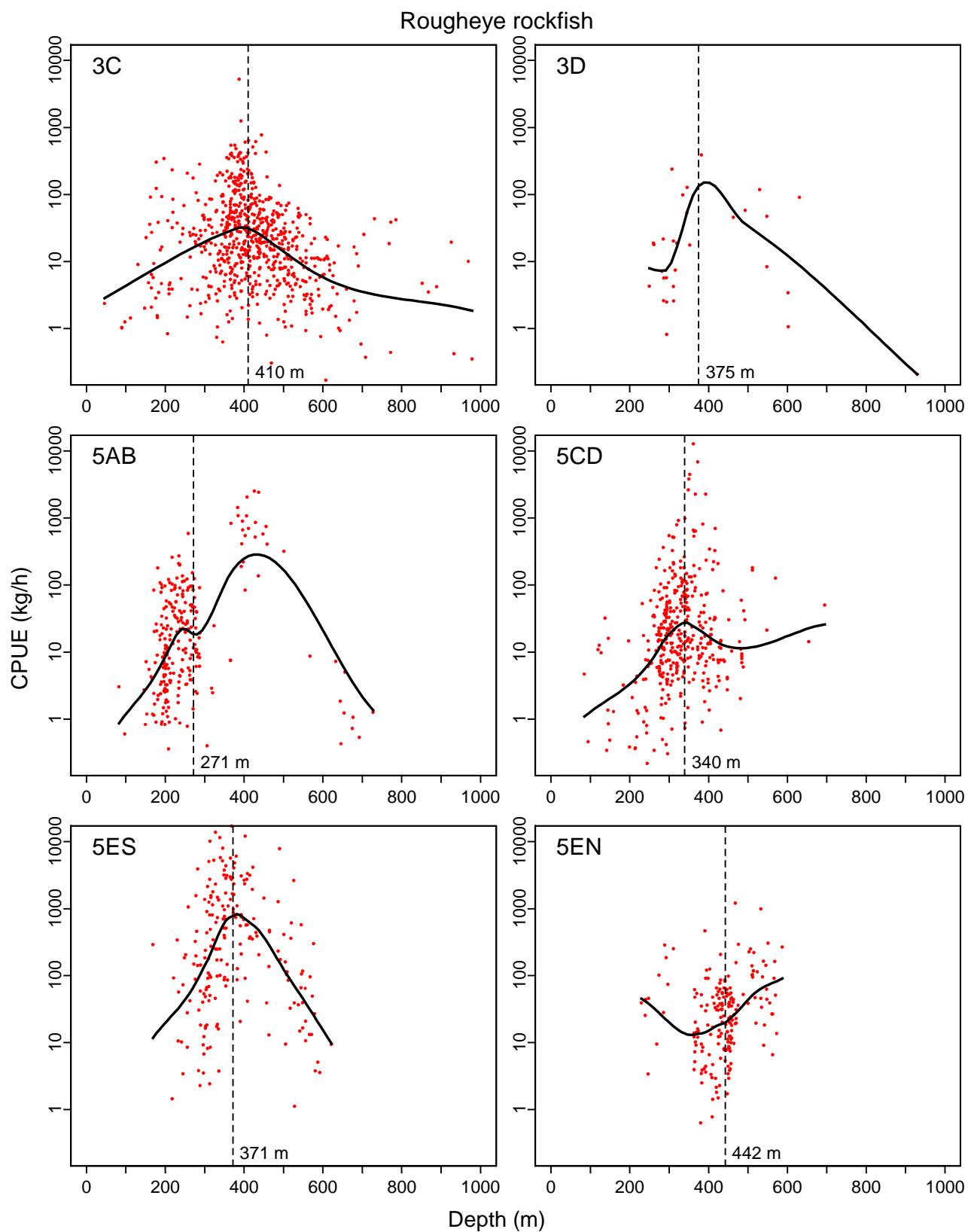


Fig. 4.2.4. Rougheye rockfish CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.

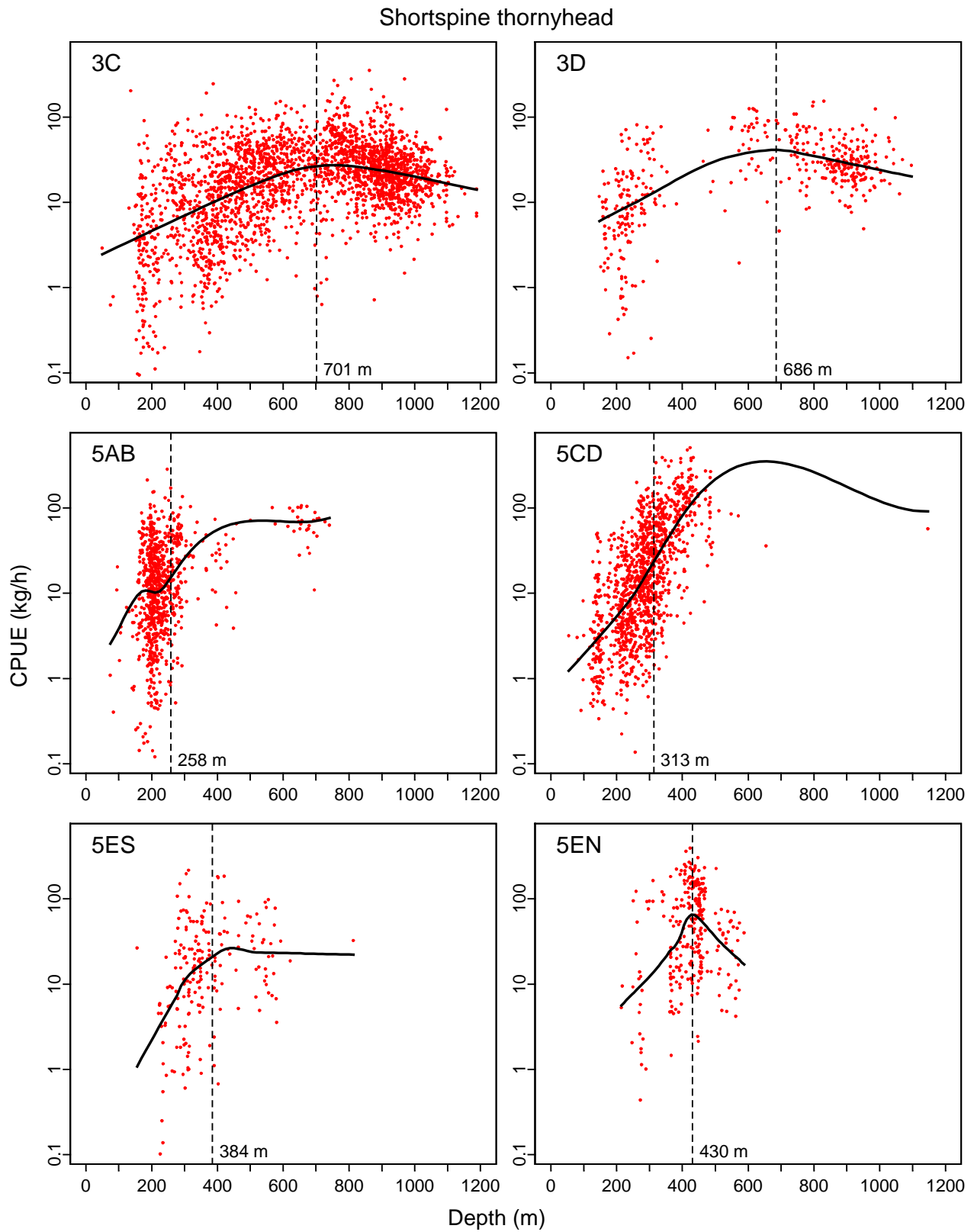


Fig. 4.2.5. Shortspine thornyhead CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.

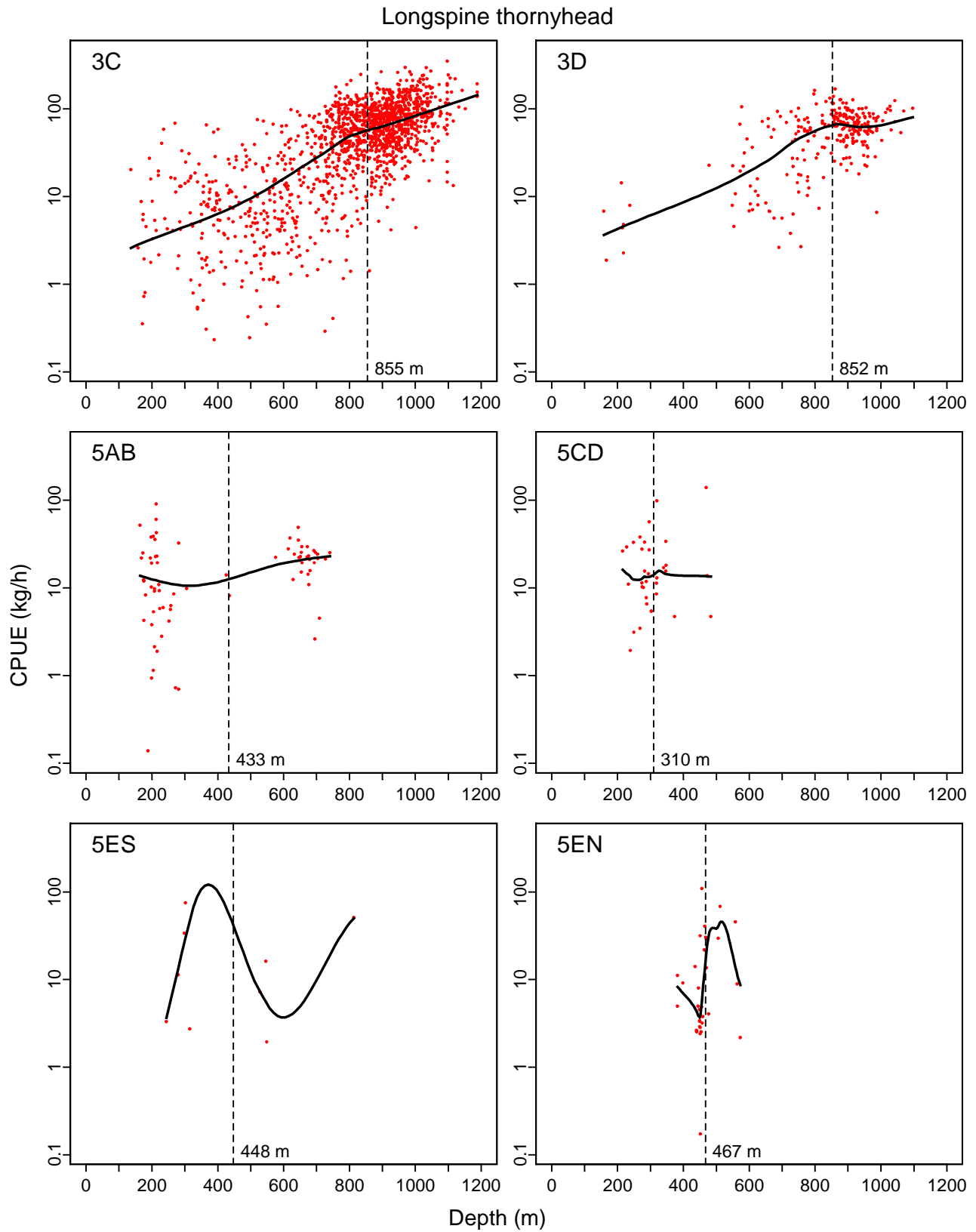


Fig. 4.2.6. Longspine thornyhead CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.



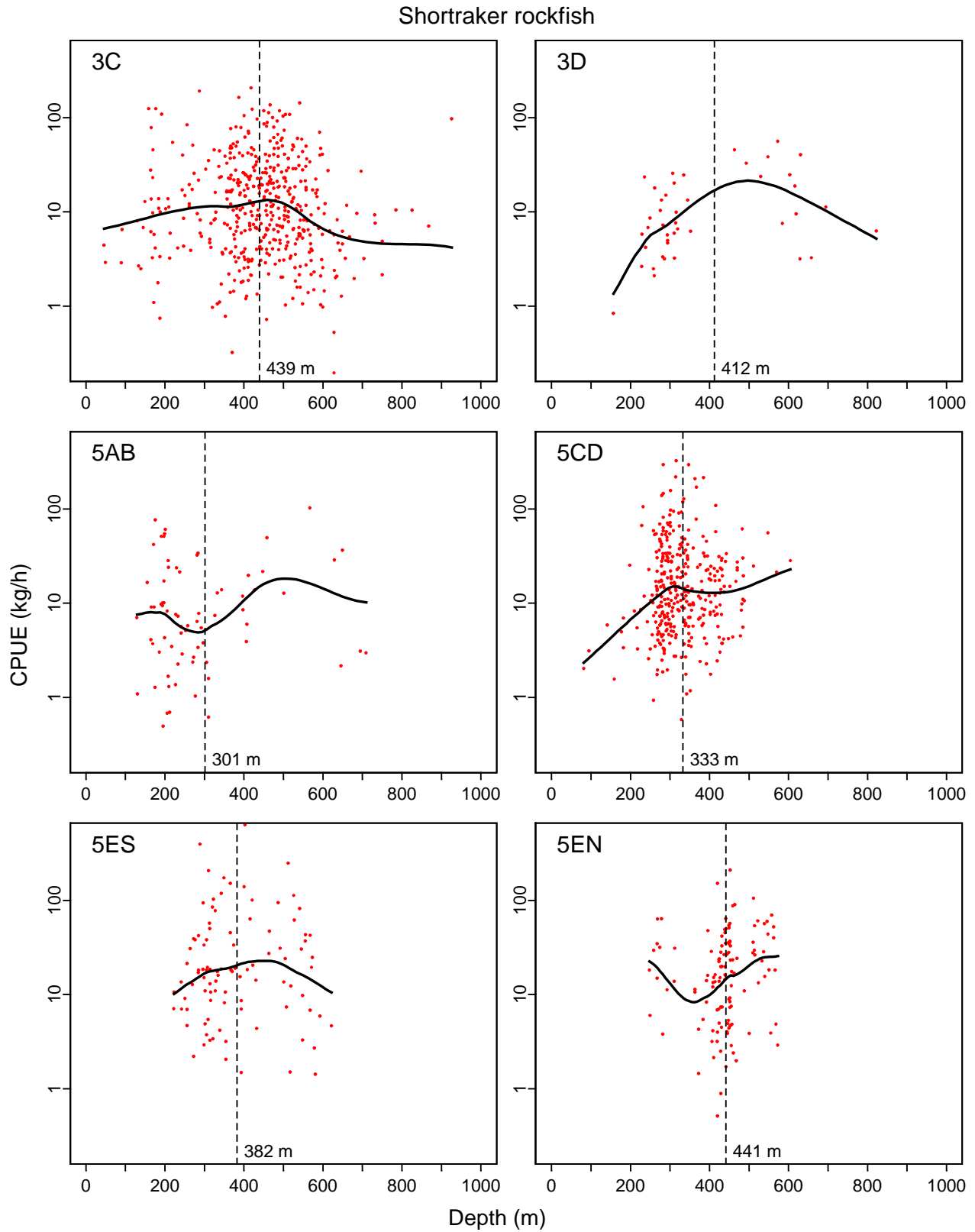


Fig. 4.2.7. Shortraker rockfish CPUE (kg/h) vs fishing depth (m). Smoothed curve is based on a local linear regression with 2/3 of the data weighted inversely by horizontal distance to the current point. Dashed vertical line indicates mean weighted depth.

# Pacific ocean perch

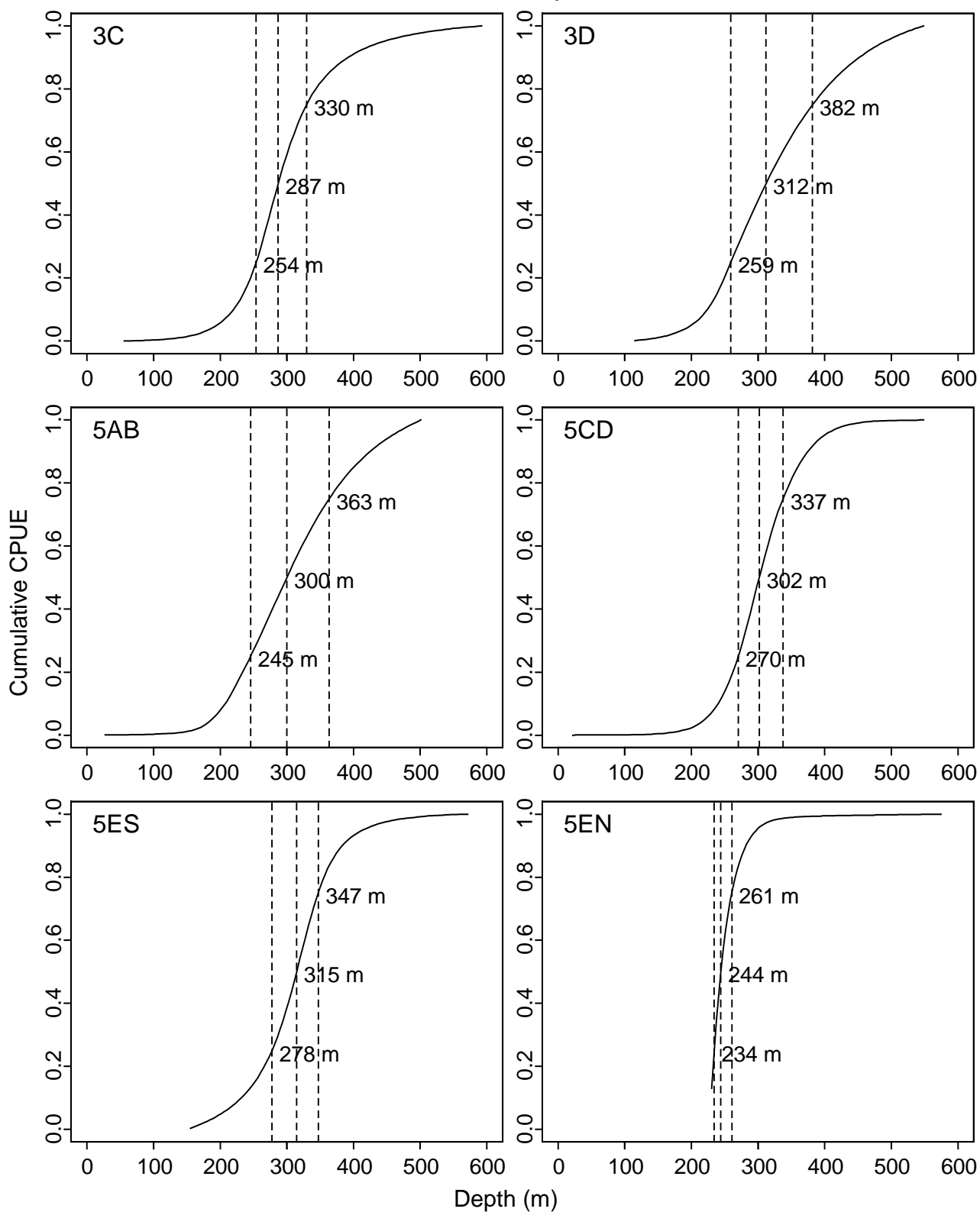


Fig. 4.2.8. Cumulative CPUE curves for Pacific ocean perch derived from loess-smoothed CPUE values. Depths (dashed lines) correspond to 25%, 50% and 75% quantiles.

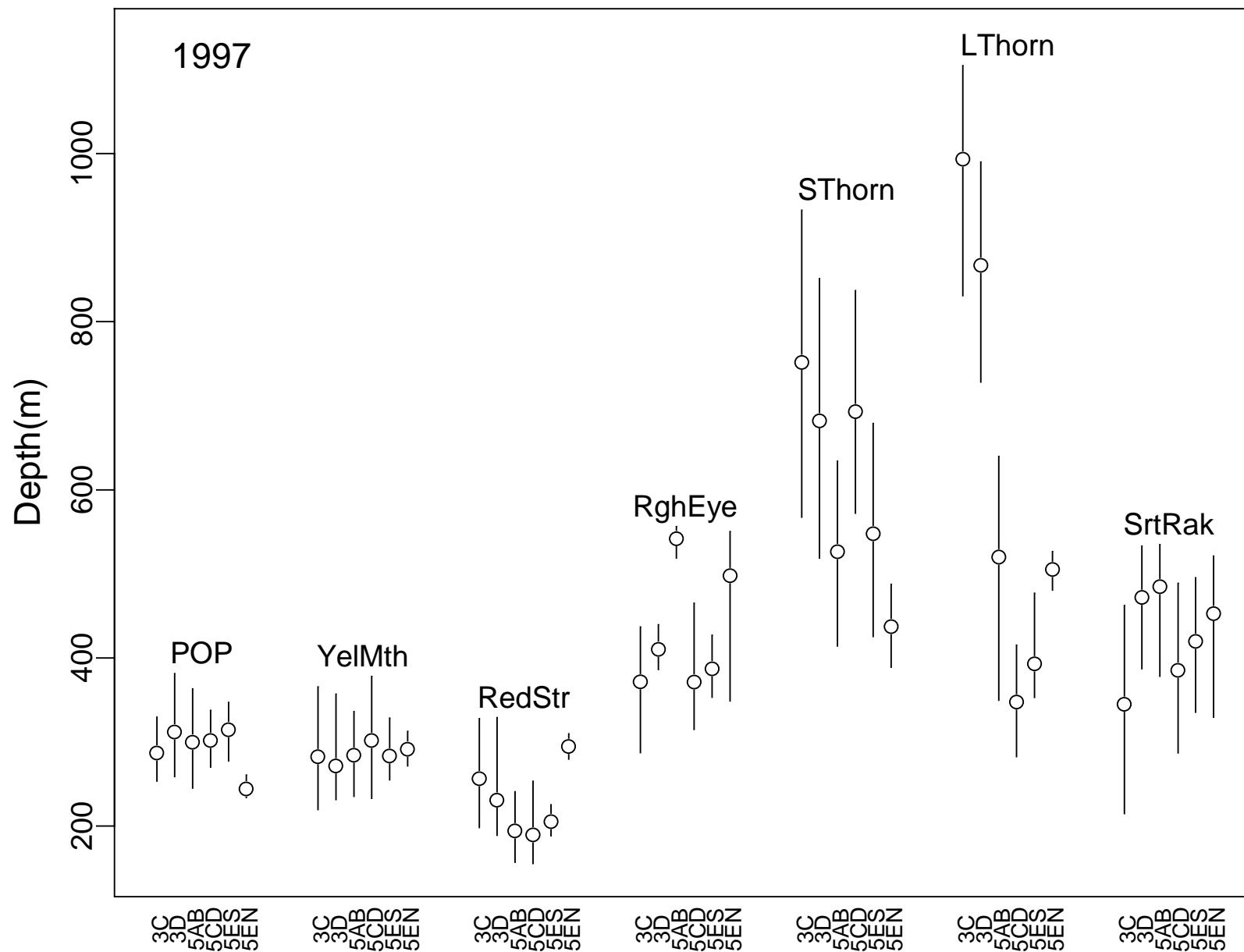


Fig. 4.2.9. Depth ranges (25% to 75% quantiles) with 50% quantile point for each species and area.

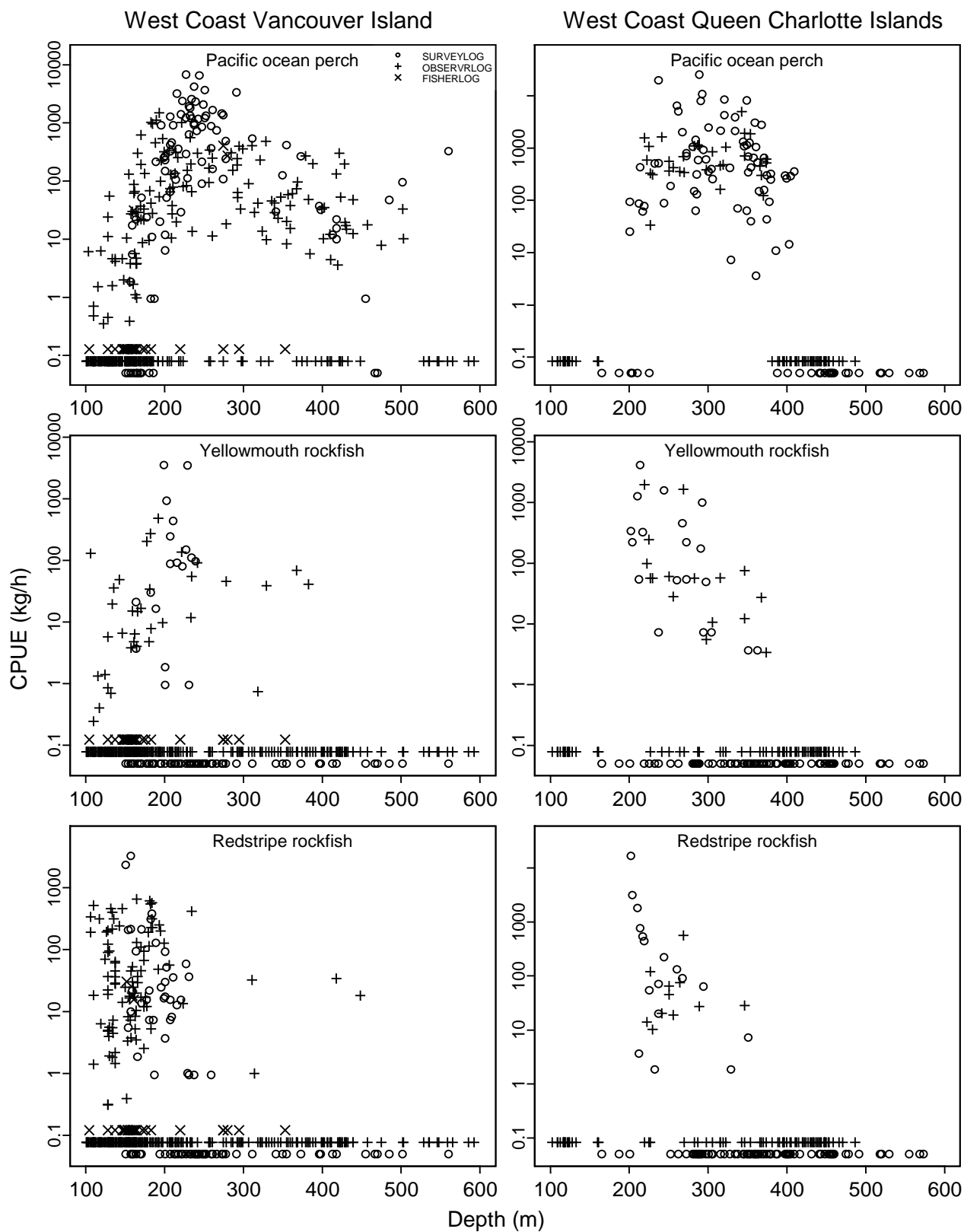


Fig. 4.2.10. Comparison of survey and commercial CPUE with depth for Pacific ocean perch, yellowmouth rockfish, and redstripe rockfish. Commercial tows were chosen to overlap in area and time,  $\pm 30$  days.

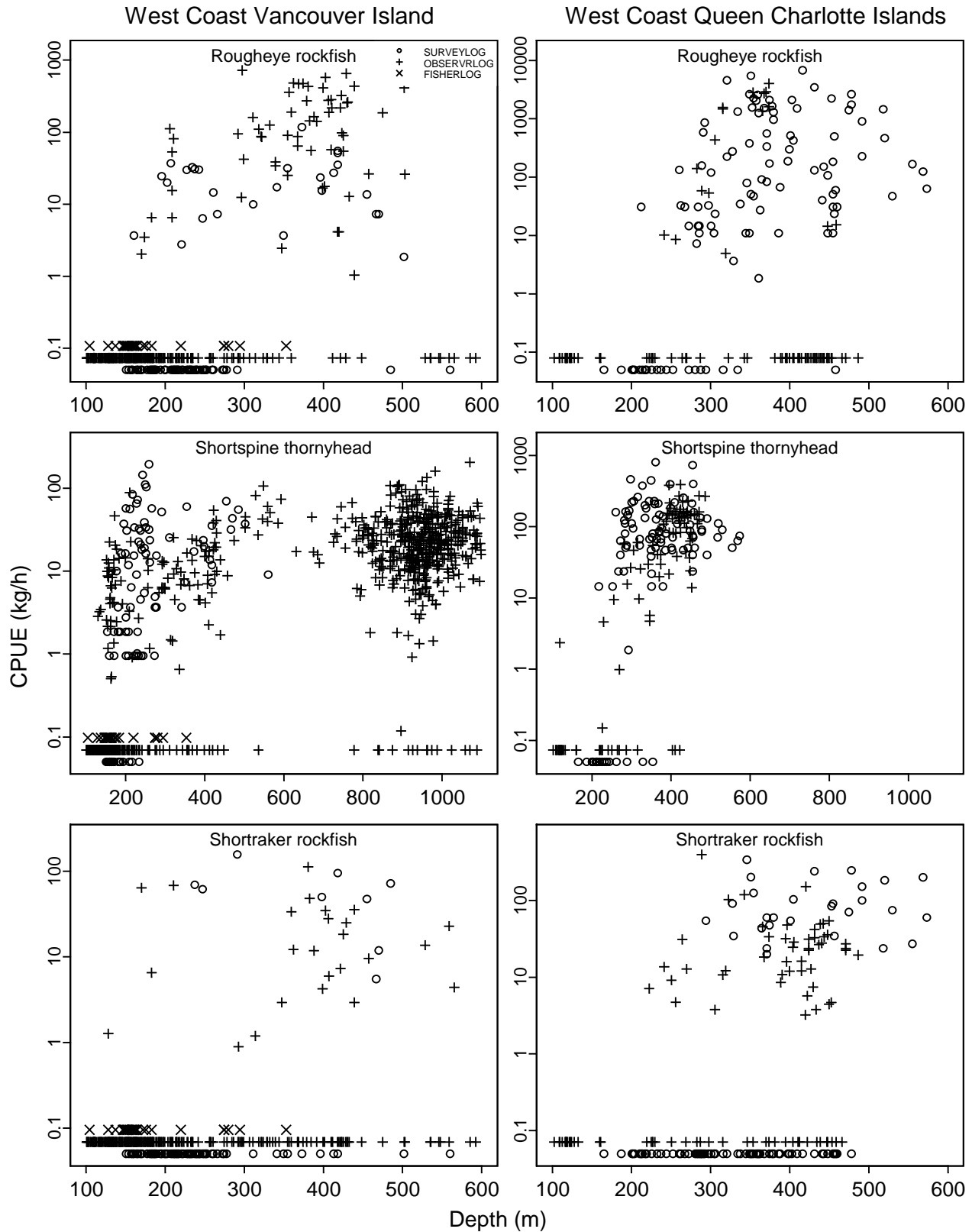


Fig. 4.2.10. Comparison of survey and commercial CPUE with depth for rougheye rockfish, shortspine thornyhead, and shortraker rockfish. Commercial tows were chosen to overlap in area and time,  $\pm 30$  days.

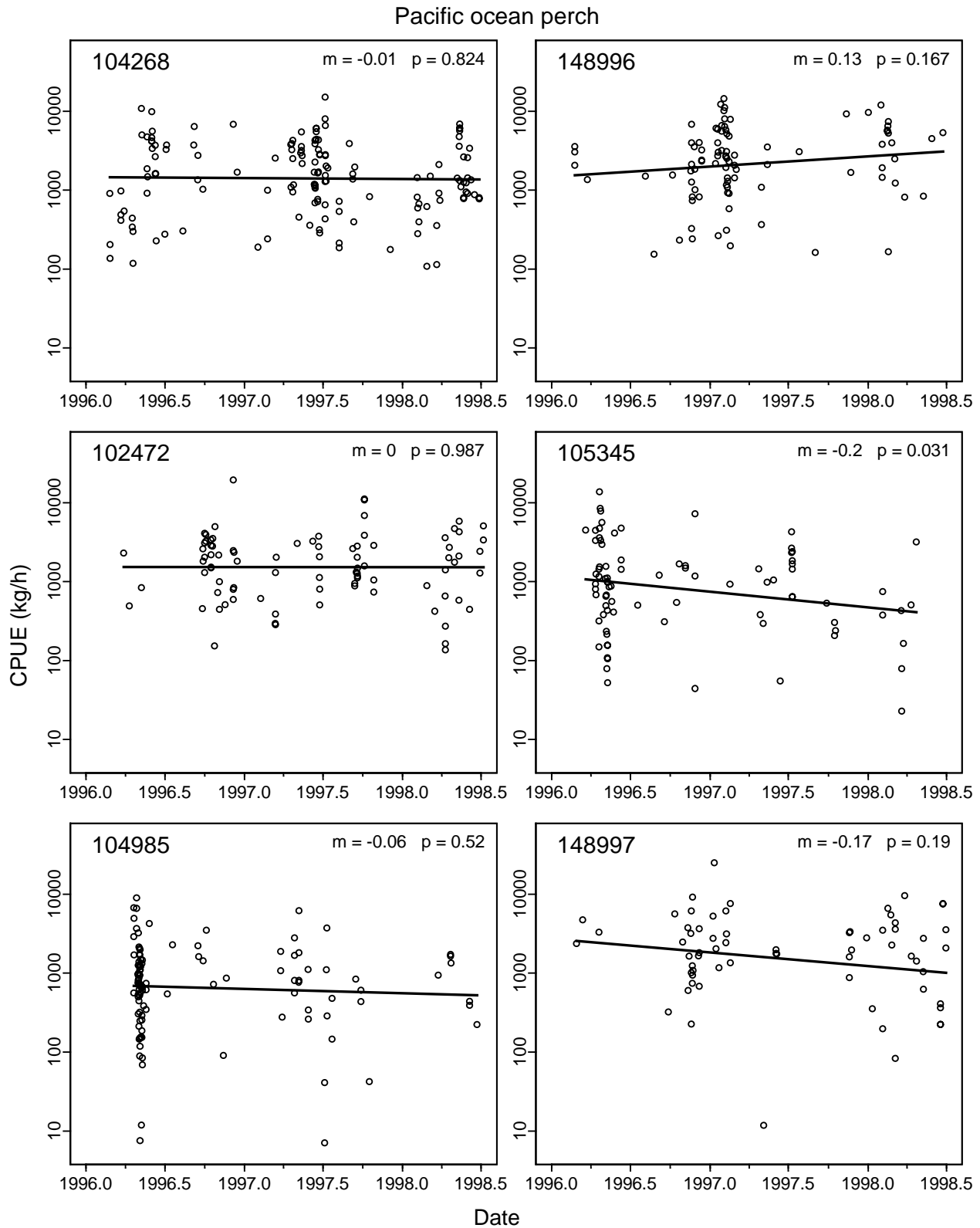


Fig. 4.3.1. Pacific ocean perch CPUE over time for the six blocks in which POP catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.

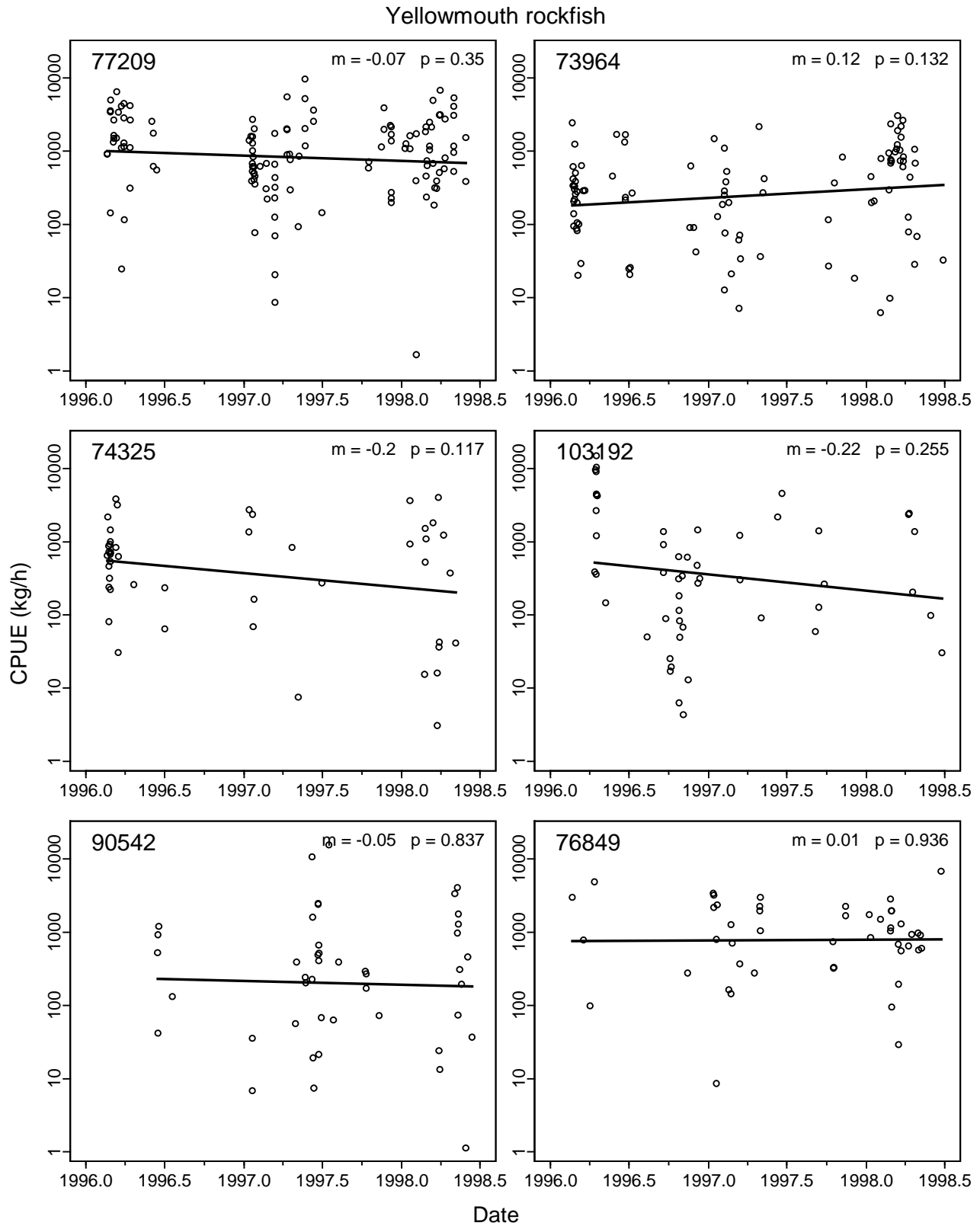


Fig. 4.3.2. Yellowmouth rockfish CPUE over time for the six blocks in which yellowmouth catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.

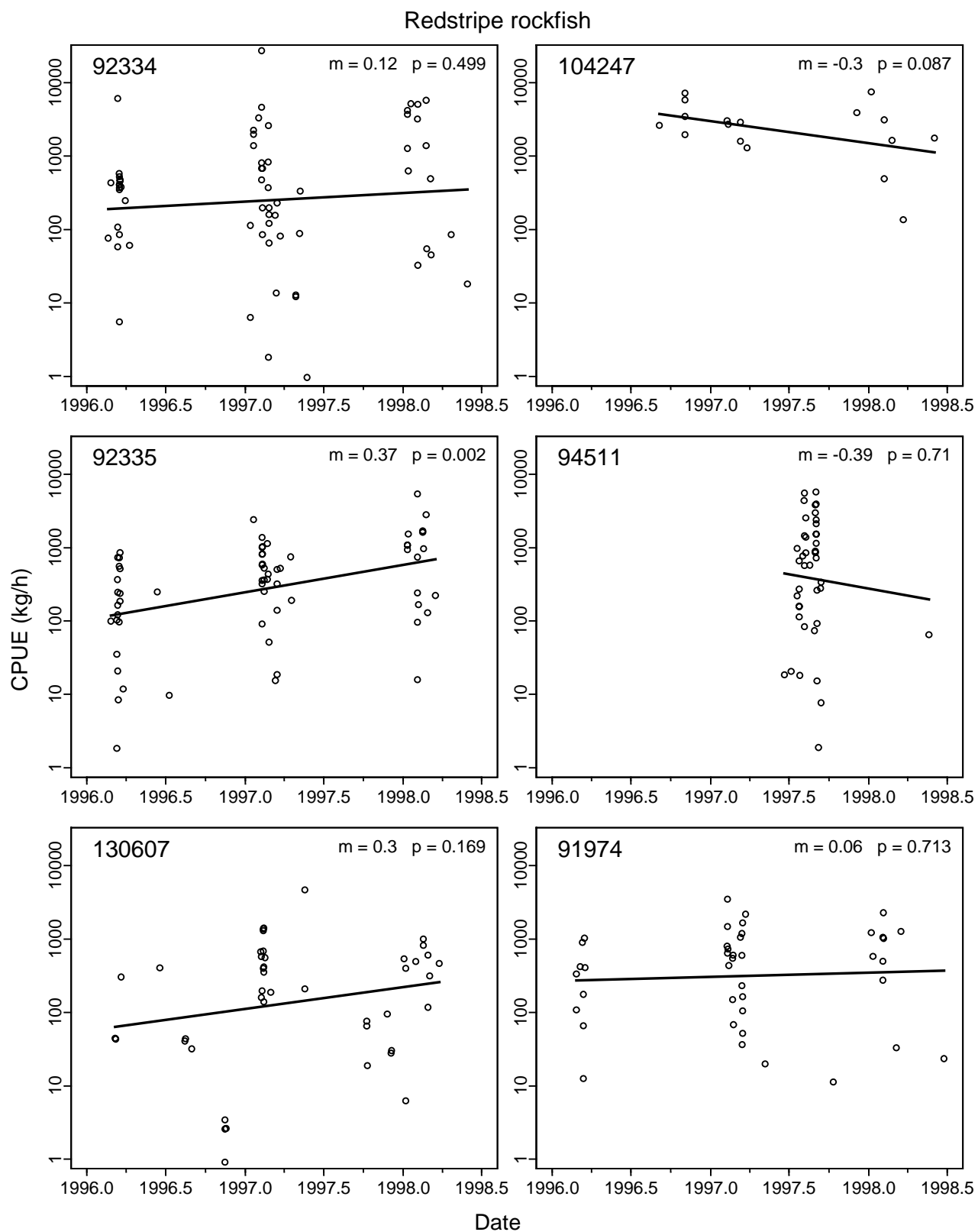


Fig. 4.3.3. Redstripe rockfish CPUE over time for the six blocks in which redstripe catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.



Rougheye rockfish

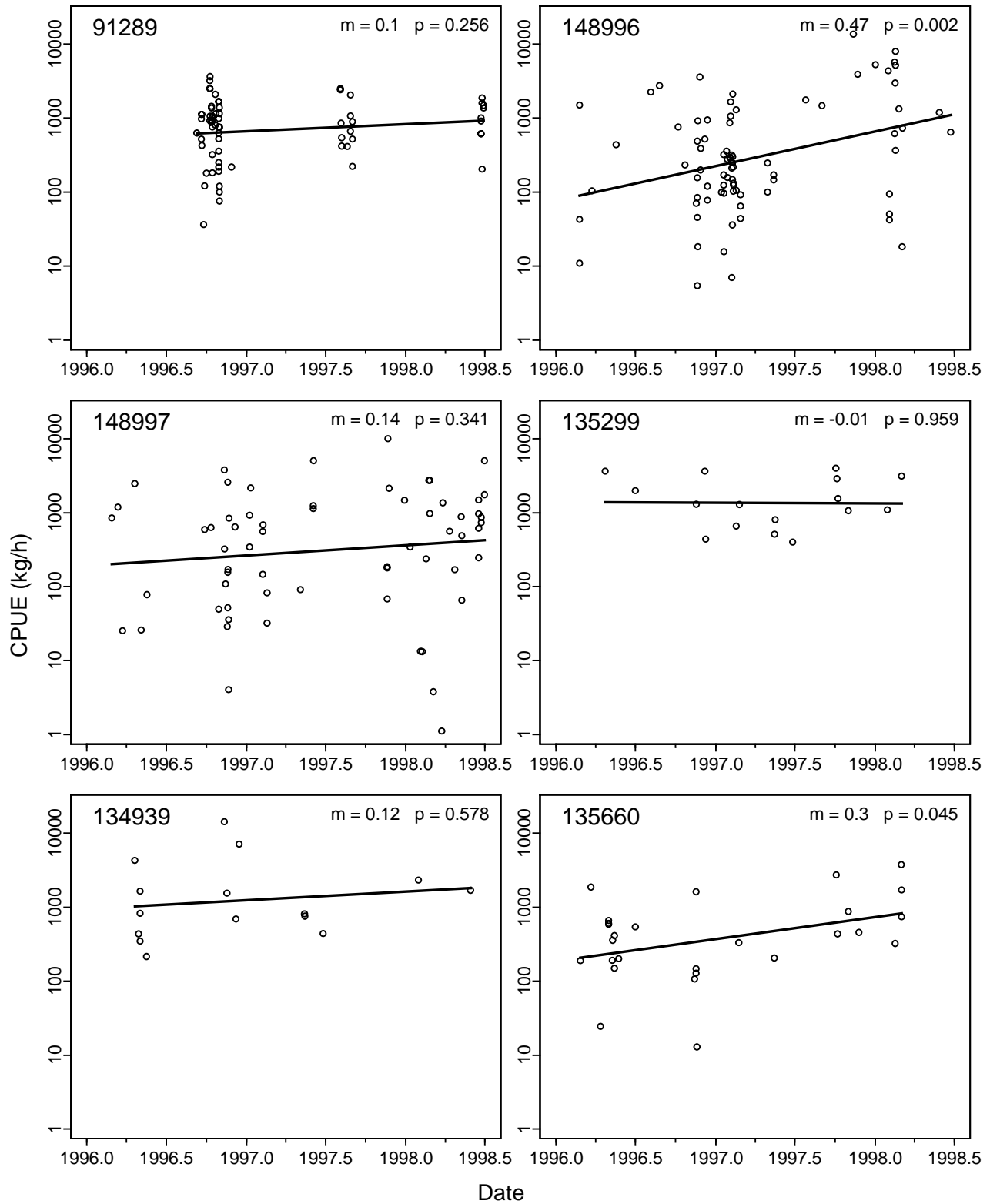


Fig. 4.3.4. Rougheye rockfish CPUE over time for the six blocks in which rougheye catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.

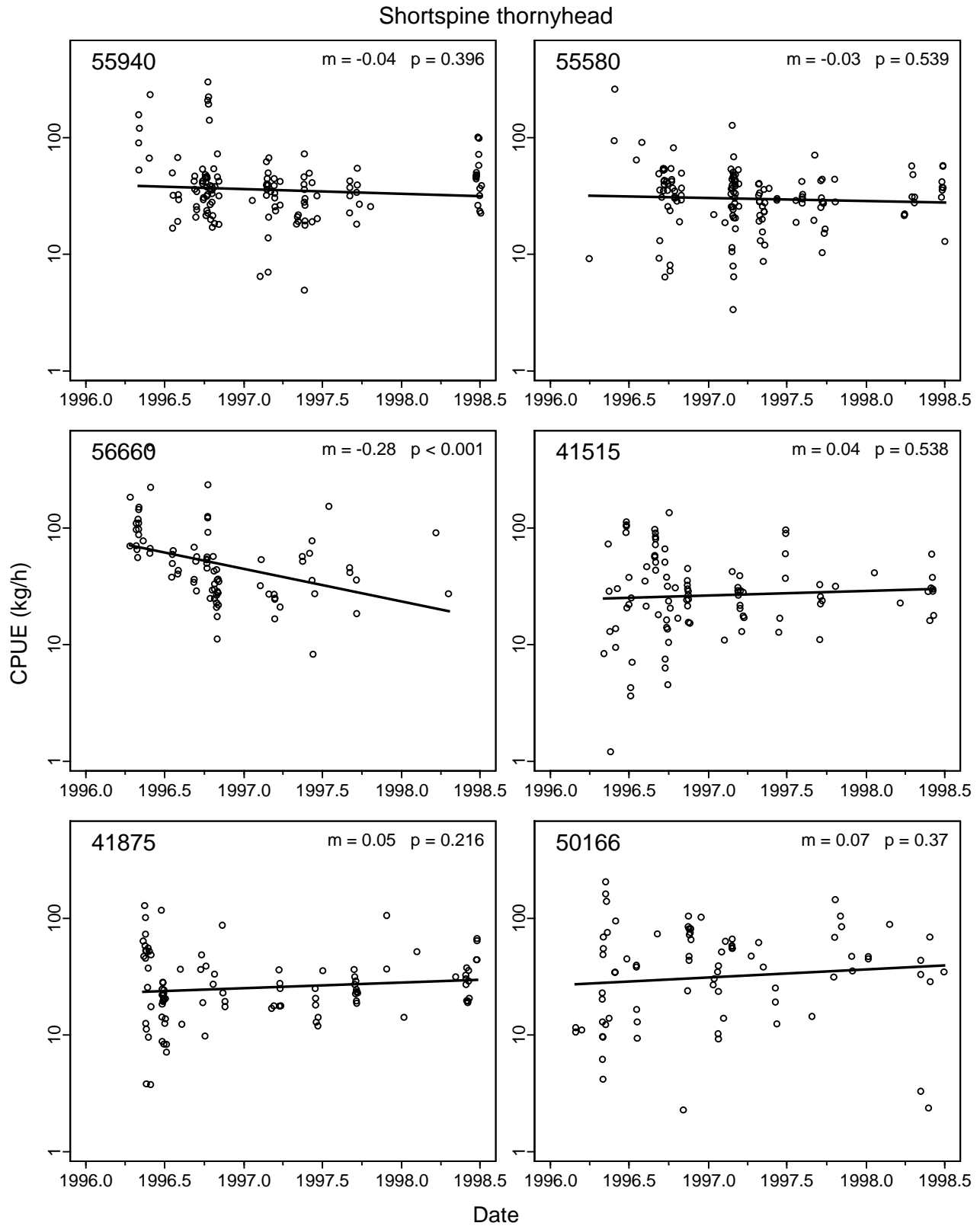


Fig. 4.3.5. Shortspine thornyhead CPUE over time for the six blocks in which shortspine catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.

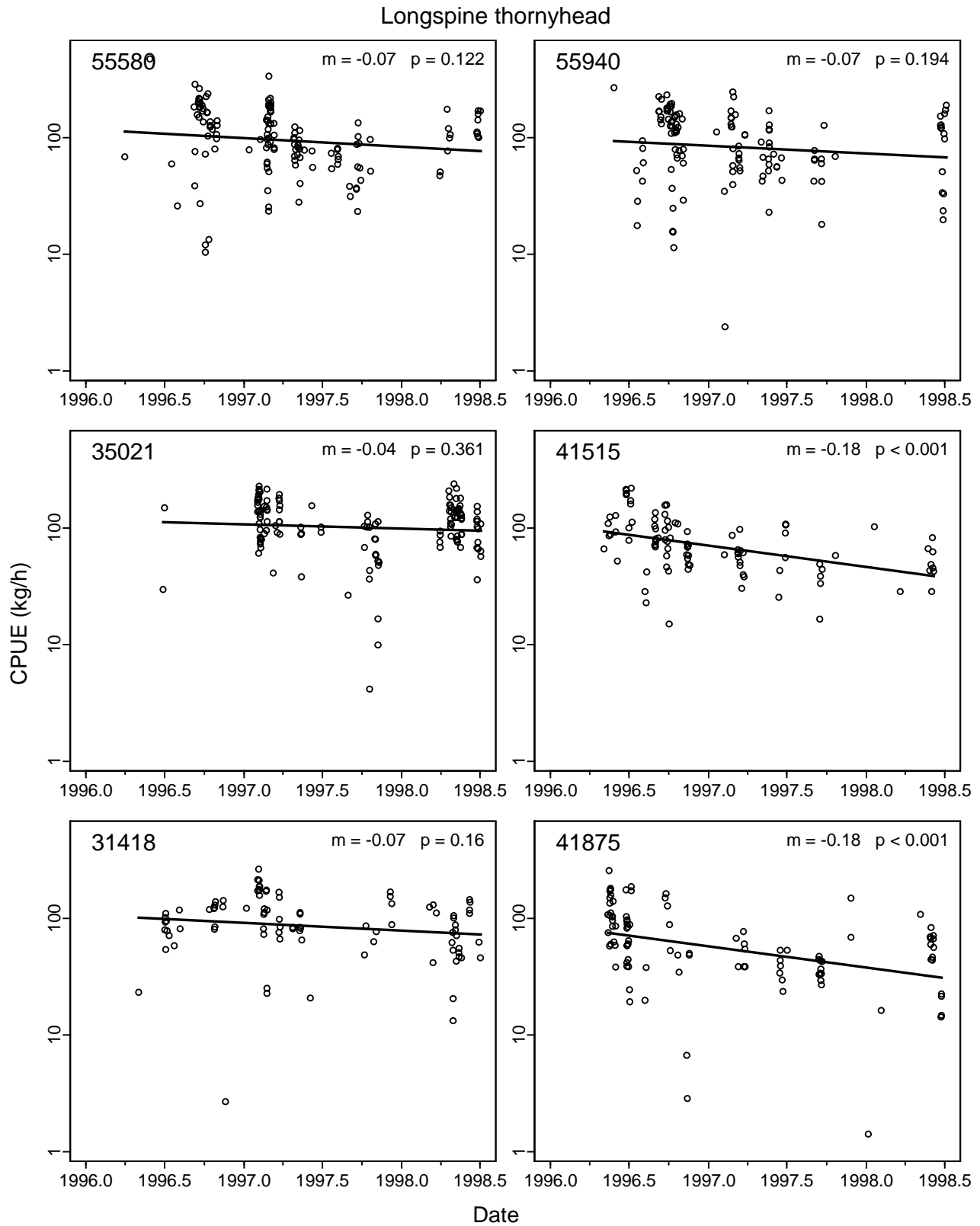


Fig. 4.3.6. Longspine thornyhead CPUE over time for the six blocks in which longspine catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.

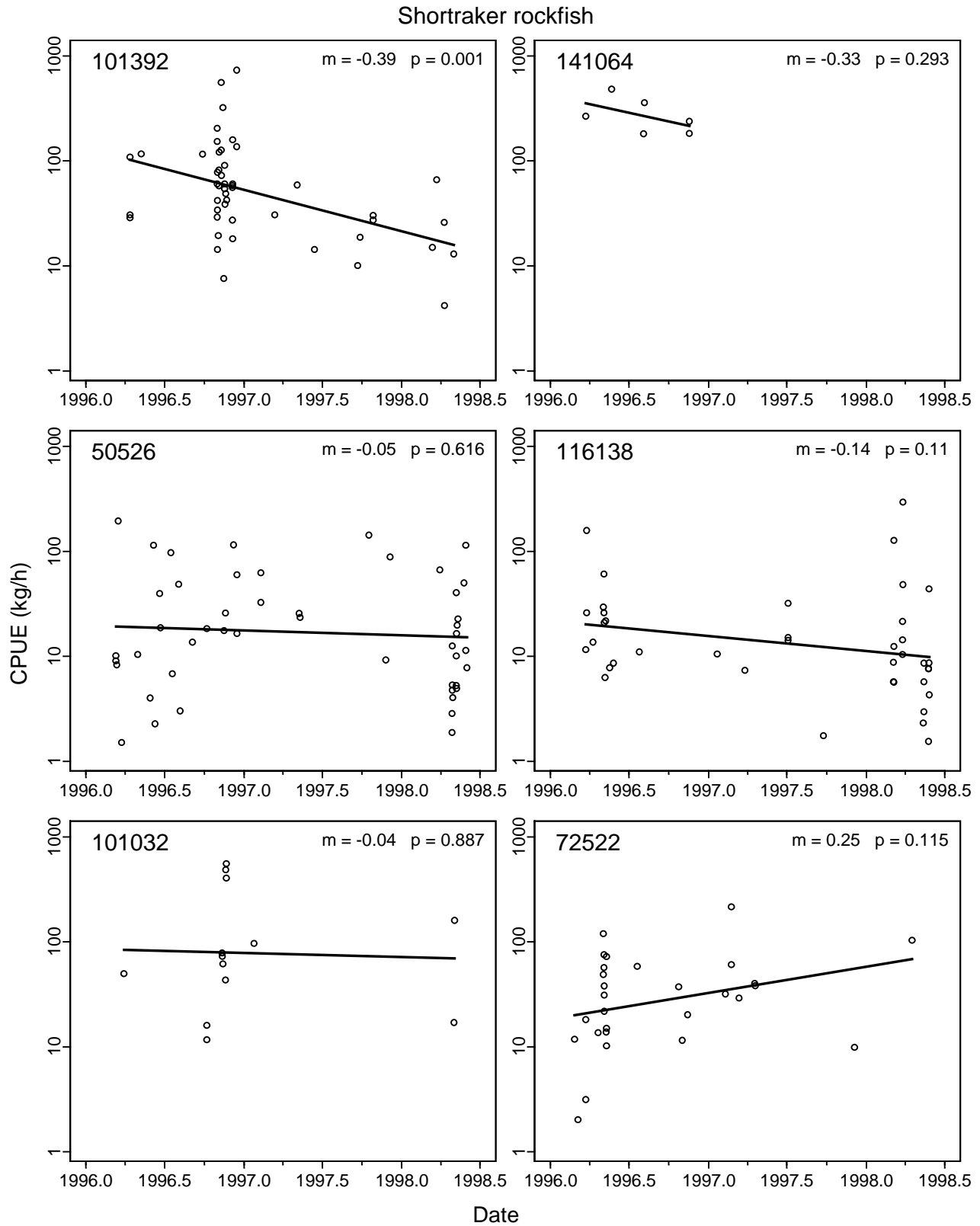


Fig. 4.3.7. Shortraker rockfish CPUE over time for the six blocks in which shortraker catch was greatest. Slope (m) and significance (p) of regression line is indicated in upper right.

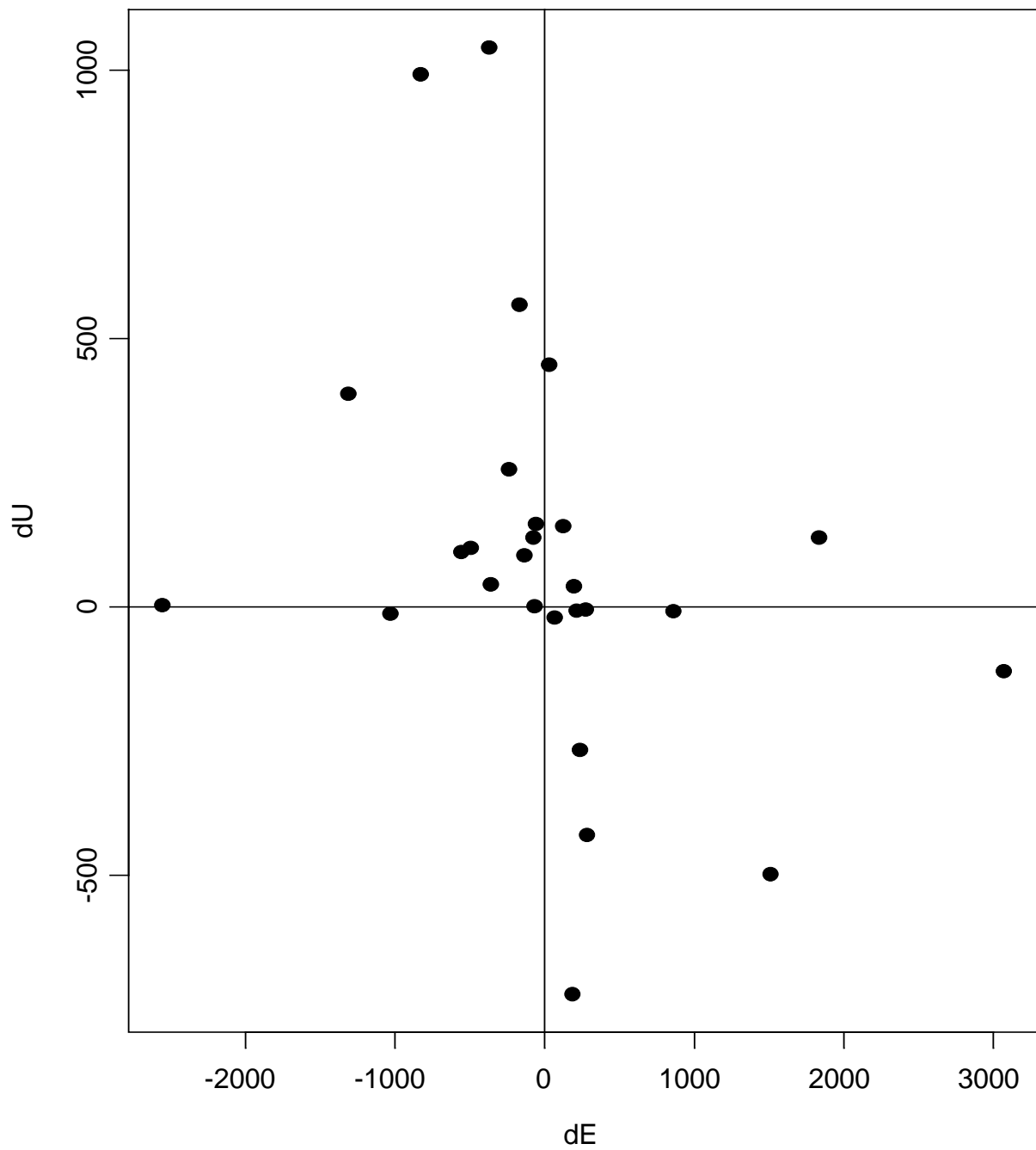


Fig. 4.4.1. Difference in CPUE qualified by 20% total fish catch and depth vs difference in Effort qualified by 20% fish catch and depth.