Summary Report for the Inshore Rockfish (*Sebastes spp.*) Longline Survey Conducted in Statistical Areas 12 and 13, August 24 - September 10, 2004

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SUMMARY REPORT FOR THE INSHORE ROCKFISH (*Sebastes spp.*) LONGLINE SURVEY CONDUCTED IN STATISTICAL AREAS 12 AND 13, AUGUST 24 - SEPTEMBER 10, 2004

by

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ABSTRACT

Lochead, J.K. and Yamanaka, K.L. 2006. Summary report for the inshore rockfish (*Sebastes spp.*) longline survey conducted in Statistical Areas 12 and 13, August 24 – September 10, 2004. Can. Tech. Rep. Fish. Aquat. Sci. 2627: ix + 65 p.

The second consecutive, annual longline survey, was conducted during the late summer, 2004, in Statistical Areas 12 and 13. The purpose of the survey is to collect catch rate and biological data to improve stock monitoring and assessment of inshore rockfishes (*Sebastes caurinus, S. maliger*, *S. nigrocinctus*, and *S. ruberrimus*). The depth-stratified random design targeted rocky habitat in water depths of 41 – 100m. A total of 14 rockfish and 17 other fish species were caught on the survey. Quillback rockfish (*S. maliger*) and yelloweye rockfish (*S. ruberrimus*) were the most frequently encountered rockfish species, with 420 and 146 fish caught, respectively.

Quillback rockfish catch rates did not differ significantly between statistical areas, but catch rates from the deep stratum were significantly higher than those from the shallow stratum. Yelloweye rockfish catch rates did not differ significantly between depth strata, but catch rates from SA 13 were more than double the catch rates from SA 12.

Several observed trends were consistent in both the 2003 and 2004 surveys, including similar species composition and catch rates. Inter-annual variation in mean catch rates was low for most species and no significant differences in catch rates were found between years for the ten most frequently encountered species on the surveys. Other between-year similarities included higher rockfish species diversity in SA 12 than in SA 13, larger quillback rockfish and older yelloweye rockfish in the deep stratum, larger quillback and yelloweye rockfish in SA 12, and higher yelloweye rockfish catch rates in SA 13.

A simulation model was used to assess the suitability of the survey's catch rate data to track trends in rockfish populations. The survey's ability to track relative abundance improved in 2004 despite the smaller sample size. This was due to a lower proportion of sets with zero rockfish catch, and lower coefficients of variation for the non-zero sets, results which may have stemmed from an improved ability to target rockfish habitat in 2004. Simulation results, using combined 2003 and 2004 data, indicate that a minimum of 7 years of survey data are needed to accurately track population trends for quillback and yelloweye rockfishes.

RÉSUMÉ

Lochead, J.K. et Yamanaka, K.L. 2006. Rapport sommaire de la campagne de recensement par ligneurs des stocks côtiers de sébaste (*Sebastes spp.*) dans les zones statistiques 12 et 13 (24 août – 10 septembre 2004). Can. Tech. Rep. Fish. Aquat. Sci. 2627: ix + 65 p.

La deuxième campagne consécutive de recensement par pêche aux lignes a été effectuée à la fin de l'été 2004 dans les zones statistiques 12 et 13, en vue de l'amélioration des programmes de surveillance et d'évaluation des stocks de sébastes du littoral (*Sebastes caurinus, S. maliger*, *S. nigrocinctus* et *S. ruberrimus*). Il s'agissait de sondages aléatoires stratifiés visant des habitats rocheux situés à des profondeurs de 41 à 100 mètres. Au total, 14 espèces de sébastes et 17 autres espèces ont été concernées par les captures effectuées. Le Sébaste à dos épineux (*S. maliger*) et le Sébaste aux yeux jaunes (*S. ruberrimus*) ont été les deux espèces les plus fréquemment rencontrées, avec respectivement 420 et 146 individus capturés.

Dans le cas du Sébaste à dos épineux, le taux de capture était sensiblement le même d'une zone statistique à l'autre, mais le nombre capturé augmentait avec la profondeur. Dans le cas du Sébaste aux yeux jaunes, les captures étaient sensiblement les mêmes d'un niveau de profondeur à l'autre, mais elles étaient plus de deux fois plus nombreuses dans la zone SA 13 que dans la SA 12.

Plusieurs tendances observées en 2003 sont restées inchangées en 2004, notamment la composition des espèces et les taux de capture. On observe une faible variation 2003-2004 des taux de prise moyens concernant le Sébaste à dos épineux et le Sébaste aux yeux jaunes, et aucune différence significative pour les dix espèces les plus fréquemment rencontrées lors de ces sondages. Parmi les différences inter-annuelles observées, citons la plus grande diversité des espèces de sébastes présentes dans la zone SA 12 par rapport à la zone SA 13, la taille relativement importante des sébastes à dos épineux et l'âge supérieur des sébastes à yeux jaunes dans les eaux profondes, la taille relativement importante des sébastes à dos épineux et des sébastes aux yeux jaunes dans la zone SA 12, et le taux de capture plus élevé de sébastes aux yeux jaunes dans la zone SA 13.

Un modèle de simulation qui visait à déterminer si les données de capture de la campagne 2003 permettait d'avoir une bonne idée des tendances démographiques de l'espèce a été répété avec les données de 2004. La capacité de cette campagne de recensement à donner une idée du taux d'abondance relatif de l'espèce s'est améliorée en 2004 malgré le moindre effectif des échantillons recueillis. Ceci s'explique par la plus faible proportion de traits ayant rapporté 0 sébaste et le plus faible coefficient de variation dans les traits ayant rapporté des sébastes, résultats qui pourraient être attribuables à une meilleure capacité de cibler les habitats fréquentés par le sébaste en 2004. Les résultats des simulations indiquent qu'il faut un minimum de 7 années de données de recensement pour suivre avec exactitude les tendances démographiques du Sébaste à dos épineux et du Sébaste aux yeux jaunes.

1.0 INTRODUCTION

The difficulty of managing and assessing inshore rockfishes (*Sebastes caurinus, S. maliger*, *S. nigrocinctus*, and *S. ruberrimus*) led Fisheries and Oceans Canada to develop a Rockfish Conservation Strategy (RCS) (Yamanaka and Lacko, 2001). The RCS was first announced in December 2001 and includes harvest reductions, the establishment of closed areas, increased catch monitoring, and improved stock monitoring and assessment.

To improve stock monitoring and assessment of inshore rockfishes, a new longline survey was designed and conducted in August and September, 2003, to provide fishery independent indices of abundance together with biological samples in the northern portion of the 4B management region (Lochead and Yamanaka, 2004). The depth-stratified random survey design used in Statistical Areas (SA) 12 and 13 in 2003 was replicated in 2004, and the second survey was conducted August 24 – September 10, 2004. Details of the methods used for the survey are described in Lochead and Yamanaka (2004). The current document summarizes the catch rate and biological data, presents simulation results, and compares results to those obtained in 2003.

2.0 METHODS

The 2004 survey methodology was identical to that used in 2003. This section presents a simplified description of the methods; for a more detailed description see Lochead and Yamanaka (2004).

2.1 Survey Design

The survey employed a depth-stratified, random design to select 2 km by 2 km survey blocks to fish as described in Lochead and Yamanaka (2004). All waters in SA 12 and 13 with depths from 41 to 100 metres were stratified into shallow (41 – 70m) and deep (71 – 100m) depth intervals, using Canadian Hydrographic Service (CHS) charts. Eighty blocks were randomly selected out of a total of 1247 blocks within SA 12 and 13 (ESRI ® ArcMap™ 8.3).

As in 2003, one longline set was fished within each survey block and the location of the set within each block was determined by bottom type. Hard bottom areas were targeted and the gear was set along contour lines where possible.

In 2004, twelve survey blocks were rejected when depths obtained from CHS charts did not correspond to depths observed in the field. Survey blocks were rejected and permanently removed from the survey grid when sufficient area within appropriate depths (41 – 100 m) could not be located. In such cases an additional survey block was randomly selected from adjacent blocks using GIS software (ESRI ® ArcMap™ 9.0).

2.2 Survey Vessel

Both surveys (2003 and 2004) were conducted by the fisheries research vessel CCGS *Neocaligus*. In 2004, the vessel was skippered by Captain Alan Young and crewed with a chief mate, engineer, deck hand/cook and 3 scientific staff.

2.3 Fishing Gear and Operations

Snap type longline gear used in 2003 was also used in 2004. As in 2003, each longline set or 'string' consisted of two skates of groundline with 225 circle hooks (13/0) spaced 3.7 m (12 ft) apart, and perlon gangions measuring 0.38 m (1.2 ft) were crimped at both ends and attached to the circle hook with a swivel (Lochead and Yamanaka, 2004). As in 2003, hooks were baited with thawed Argentinean squid, approximately 15 cm long, and cut into fifths.

In both years of the survey, the start and end positions and depths of each set were recorded from the vessel's global positioning system (GPS) and depth sounder respectively, when the first and last anchors were set over the stern (Lochead and Yamanaka, 2004). Minimum, maximum and modal depths were also recorded. Modal set depth was used to assign each set to either the shallow or the deep depth stratum.

In 2003 and 2004, all survey blocks were fished during daylight hours (Lochead and Yamanaka, 2004). The duration, or soak time, of each set was 2 hours and was calculated as the time elapsed between the last anchor over the stern and the first anchor hauled aboard.

2.4 Data Collection

As in 2003, the yield on each hook was recorded as the gear was retrieved (Lochead and Yamanaka, 2004). The catch was identified to species and recorded with individual hook numbers. Partial fish returning on hooks, usually heads whose bodies were predated, and fish drop offs at the side of the vessel were enumerated and included in the total catch weight using average weights. During gear retrieval the catch was sorted by species and set aside until gear retrieval was complete. The catch was then weighed by species and biological sampling began.

2.4.1 Biological sampling

Biological sampling consisted of measuring weight (W) in grams (g), length (L) in millimetres (mm) or centimetres (cm), and visually determining the sex (S) and maturity state (M) of the gonads. Both sagittal otoliths (O) were excised from rockfish and fin rays (F) were removed from lingcod (*Ophiodon elongatus*) for subsequent age determination. L/W/S/M/O samples were collected from all rockfish, L/W/S/M/F samples were collected from lingcod, and L/S or L samples were collected from all other vertebrate species.

Sagittal otoliths from quillback and yelloweye rockfishes were aged in the Pacific Biological Station (PBS) ageing lab, using the burnt section technique for rockfishes (MacLellan, 1997).

2.4.2 Catch Rate Calculations

The catch rate (U), as defined in 2003, is the total weight in kilograms of fish per set (Wt) divided by the number of intact skates returned (N) from the set.

$$U_{is} = Wt_{is} / N_i$$

where *s* denotes the species, and *i* denotes the set.

All statistical analyses were performed using SPlus 2000 or Statistix version 7.0.

2.4.3 Simulations

In 2003, catch rate data for quillback and yelloweye rockfishes were used to estimate the initial parameters for a simulation model (Schnute and Haigh, 2003). This model was then used to investigate the utility of the survey for indexing rockfish abundance (Lochead and Yamanaka, 2004). Results indicated that the survey could effectively monitor population trends for quillback and yelloweye rockfishes if it was continued with the same level of sampling effort over the long-term (Lochead and Yamanaka, 2004). In 2004, sampling effort was reduced due to vessel availability and values of the three key survey parameters differed. The simulation model was re-run using 2004 catch rate data for quillback and yelloweye rockfish to observe how these changes affected simulation results.

The model was based on the compound binomial-gamma distribution, and used three key survey parameters:

P = Proportion of sets with zero catch
μ = Mean density of non-zero sets
ρ = Coefficient of variation of non-zero sets

The simulations allowed a known population biomass to increase by 5% compounded annually and used the survey parameters (P, μ, ρ) to bootstrap biomass estimates expected from similar surveys 20 years into the future. A random process error of 15% was added to the biomass estimate to account for inter-annual variation (Francis et al., 2003). The number of sets (K) was manipulated to observe how sample size affects variability of the biomass estimates. The utility of the survey catch rates as abundance indices was evaluated quantitatively by comparing the $\log_2$-transformed slopes of the estimated biomass trend lines to the known slope or rate of increase. One thousand simulations were performed and the values of the bootstrapped slopes (r) were calculated. The percentage of times that the estimated annual rate of change (r) fell within ± 20% of the known annual rate of change is reported.

3.0 RESULTS AND DISCUSSION

Location, catch and biological data are archived in DFO's GFBio database and can be retrieved by Trip ID 55980.

3.1 Survey set locations, depths and times

Figure 1 presents a map of the study area with the location of the 64 randomly selected blocks sampled in 2004. Forty-seven sets were conducted in SA 12 from August 26 to September 5, 2004, and 17 sets in SA 13 from September 5 to 9, 2004. In 2003, the number of sets fished in SA 12 and SA 13 were 56 and 24, respectively.

Gear deployment took place between 0638 h and 1741 h and soak time varied from 115 – 134 minutes. Fishing took place during daylight hours and gear retrieval was complete no later than 2012 h. Across all sets, the minimum depths ranged from 35 – 86 m, the maximum depths ranged from 49 – 155 m, and the modal depths ranged from 44 – 100 m (Appendix A). Depths fished were similar in 2003 when the modal depths ranged from 35 – 118 m (Lochead and Yamanaka, 2004). Distribution of sets between strata was also comparable between years. In 2003, 55% of sets were conducted in the shallow stratum, compared to 50% in 2004.

3.2 Catch Summary

3.2.1. Hook by Hook

A total of 14,264 hooks were fished during the survey. Thirty-eight percent of all hooks retrieved yielded catch, 35% were empty, and 26% were returned with bait (Table 1). Partial fish returning on hooks, usually heads whose bodies were predated, and fish drop offs at the side of the vessel were uncommon, together making up 1.2% of total hooks retrieved (Table 1). These hook yield percentages are very similar to the previous year's survey. In 2003, 18,778 hooks were fished and 40% returned with catch, 27% were empty and 32% returned with bait (Lochead and Yamanaka, 2004).

A total of 31 species and 7 taxonomic groups were caught during the survey, including14 were rockfishes and 17 other fish species (Table 2). Spiny dogfish (*Squalus acanthias*) were caught in the greatest number of sets, occurring in 61 of 64 sets. Quillback rockfish were the most widespread *Sebastes* species in the catch, and were observed in 51 of 64 sets. Sunflower starfish (*Pycnopodia helianthoides*) were the most prevalent invertebrate species, found in 22 of 64 sets.

A total of 8.8 tonnes (t) of catch were landed during the 2004 survey (Table 2). Spiny dogfish dominated the landings and represented 72.8% (6.3 t) of the total fish weight. Spotted ratfish (*Hydrolagus colliei*) and Pacific halibut (*Hippoglossus stenolepis*) were the second and third most prevalent species by weight, making up 6.5% (0.6 t) and 5.3% (0.5 t) of the total fish weight, respectively. Quillback and yelloweye rockfishes ranked fourth and fifth most common by weight, making up 4.5% (0.4 t) and

4.2% (0.4 t) of the total fish landings. Canary (*S. pinniger*), greenstriped (*S. elongates*), black (*S. melanops*), and yellowtail (*S. flavidus*) rockfish were much less common with landings of 0.2 – 0.3% of the total fish weight (~ 20 kg each). China (*S. nebulosus*), blue (*S. mystinus*), copper (*S. caurinus*), silvergray (*S. brevispinis*), widow (*S. entomelas*), tiger (*S. nigrocinctus*), redstripe (*S. proriger*) and sharpchin (*S. zacentrus*) rockfishes were present in the catch, but were rare with total landings of less than 5 kg each.

Catch composition was consistent between years. In 2003 and 2004 the top ten species in the catch were identical. These same ten species contributed 98.6% of the total fish weight in 2003, and 98.8% in 2004, and the percentage contribution for each individual species did not vary by more than 2% between years (Table 2; Lochead and Yamanaka, 2004).

In 2004, black, China, greenstriped, quillback and yellowtail rockfishes were more prevalent in the deep stratum, canary and copper rockfish were more commonly found in the shallow stratum, and yelloweye rockfish were evenly distributed between the two strata (Table 3). Spiny dogfish numbers exceeded those of all other fish species combined and were found in approximately equal numbers in both strata (Table 4). Red Irish lords (*Hemilepidotus hemilepidotus*) and Pacific halibut were caught in higher numbers in the shallow stratum, whereas lingcod, Pacific cod (*Gadus macrocephalus*) and sablefish (*Anoplopoma fimbria*) were more common in the deep stratum (Table 4). These depth associations were similar between years of the survey with the exception of Pacific halibut which was caught in higher numbers in the deep stratum in 2003 (Lochead and Yamanaka, 2004).

3.2.2 Biological Sampling

A total of 4176 fish were sampled on the 2004 survey, including 2899 spiny dogfish sampled for L/S and 658 rockfish sampled for L/W/S/M/O (Table 2). Figure 2 presents length frequency histograms by sex for all fish species taken on the 2004 survey.

Quillback rockfish fork lengths ranged from 264 – 454 mm, with a mean of 357 mm (Figure 2, Table 5). As in 2003, samples from the deep stratum were significantly larger than those from the shallow stratum, and samples from SA 12 were significantly larger than those caught in SA 13 (Table 6). The 2004 mean quillback rockfish fork length was significantly smaller than the 2003 mean of 363 mm (Table 7). Between-year comparisons of the 2003 and 2004 quillback rockfish fork length data split by sex, SA or depth stratum revealed that the overall smaller size in 2004 was a result of significantly smaller males caught that year, as well as significantly smaller individuals caught in SA 12 and the deep stratum (Table 7).

Yelloweye rockfish fork lengths ranged from 280 – 715 mm (Figure 2, Table 5). Samples from the deep stratum were significantly larger than those from the shallow stratum, and as in 2003, samples from SA 12 were significantly larger than those caught in SA 13 (Table 6). The yelloweye rockfish mean fork length was unchanged between years at 491 mm in 2004 and 492 mm in 2003 (Table 7).

Spiny dogfish mean total lengths ranged from 440 – 1070 mm. The 2004 mean length of 705 mm was significantly smaller than the 2003 mean of 734 mm (Table 7). Between-year comparisons of spiny dogfish data split by SA, depth stratum or sex showed that the mean length was significantly smaller in 2004 for all groupings except the deep stratum, where no difference was found between years (Table 7).

The fork length (mm) to weight (g) relationship for rockfish can be expressed as:

$$\text{Weight} = a\ \text{Length}^{b}$$

Constants were calculated for quillback and yelloweye rockfish using 2004 data:

quillback rockfish	$a = 0.044(10^{-5})$	$b = 3.25$	(Figure 3)
yelloweye rockfish	$a = 0.133(10^{-5})$	$b = 3.07$	(Figure 3)

Most species encountered on the 2004 survey were observed to have approximately equal sex ratios, however there were some species that exhibited skewed sex ratios (Figure 4). Greenstriped rockfish were 90% female (n = 41), lingcod were 95% female (n = 22), Pacific cod were 72% female (n = 46), Pacific halibut were 90% female (n = 31), and spotted ratfish were 92% female (n = 409). These same species also exhibited comparably skewed sex ratios in 2003, with the exception of Pacific halibut which were found to be 44% female in 2003 (Lochead and Yamanaka, 2004).

Over 85% of all rockfish captured on the 2004 survey were sexually mature (Table 8). Only 16% of male rockfish and 9% of female rockfish were 'immature' or 'maturing'. The majority of males (74%) were observed to be 'developing', and the majority of females (82%) were 'mature'. These maturity data are similar to those obtained in the previous year of the survey (Lochead and Yamanaka, 2004).

Age frequency distributions were plotted by sex for quillback and yelloweye rockfishes. Spikes in the age frequency distributions correspond to 9, 12, 18, 19 and 21 year olds for quillback rockfish (Figure 5), and to 18 and 21 year olds for yelloweye rockfish (Figure 6). The strong 1985 year class, age 19 in 2004, was noted in previous quillback rockfish age samples taken from research survey sites in SA 12 (Yamanaka and Richards, 1993; Yamanaka and Lacko, 2001; Lochead and Yamanaka, 2004).

Overall mean age was 21.5 years for quillback rockfish, and 26.0 years for yelloweye rockfish (Table 9). The mean age of yelloweye rockfish caught in SA 12 was 29.9 years, which is significantly older than the SA 13 mean age of 23.6 years (Table 10). Inter-annual comparisons of quillback rockfish mean age, pooled by year as well as split by statistical area, depth stratum or sex, revealed no significant differences (Table 11). For yelloweye rockfish from SA 13, the mean age was significantly older in 2003 than in 2004, at 27.0 and 23.6 years, respectively (Table 11).

Estimates of von Bertalanffy growth parameters L_∞, k and t_0, were derived from the combined 2003 and 2004 quillback and yelloweye biological sampling data (Table

12). The von Bertalanffy (1938) growth equation predicts fish length (mm) as a function of age (years):

$$L_t = L_\infty[1 - e^{-K(t-t_0)}]$$

where: L_t = fork length at age t
L_∞ = maximum (asymptotic) fork length
K = growth constant
t = age
t_0 = theoretical age when length equals zero

Female rockfish grow to a slightly larger size than males, and therefore L_∞ values are generally higher for females than for males (Love *et al*., 2002). Estimates of L_∞ derived from 2003 and 2004 survey data are larger for quillback rockfish females than for males, but the reverse is true for yelloweye rockfish (Table 12). The lower L_∞ value for yelloweye rockfish females is due to the larger maximum size of sampled males. Female yelloweye rockfish maximum size was 684 mm and male yelloweye rockfish maximum size was 715 mm (Table 6).

3.2.3 Catch Rates

Overall mean rockfish catch rates in 2004 ranged from 0.002 kg/skate for sharpchin rockfish up to 3.01 kg/skate for quillback rockfish (Table 13). Yelloweye rockfish had the second highest mean catch rate of 2.84 kg/skate (Table 13). All rockfish had median catch rates equal to zero, except quillback and yelloweye rockfish, whose median catch rates were 2.10 kg/skate and 0.70 kg/skate, respectively. This indicates that all rockfish, except quillback and yelloweye rockfish, were absent from at least half of the skates fished.

Rockfish catch rates exhibited high within-year variability in both 2003 and 2004. Since rockfish distribution patterns are closely linked to bottom type, relief and complexity (Richards, 1986; Richards, 1987; Martin and Yamanaka, 2004) differences in these variables likely contributed to variability in catch rates among sets. Additionally, although hard bottom was targeted, the patchy distribution of rockfish and their habitat also likely increased catch rate variability.

In both years of the survey quillback rockfish catch rates were highly variable with respect to start deployment time, sea state (Appendix B), tide and lunar phase, and no consistent trends were observed (Figures 7 and 8). Some differences in environmental variables existed between years. A broader range of weather conditions, and therefore Beaufort scale (BS) values, were fished in 2004 (BS 0 – 6) than in 2003 (BS 0 – 3) (Figure 7). Also, the full lunar phase cycle was not fished in either year. In 2003, fishing did not take place during the full moon and in 2004, no sets were made during the new or first quarter moons (Figure 8).

Catch rate coefficients of variation (CV) for quillback and yelloweye rockfish were lower in 2004 than in 2003, due to fewer sets fished and a lower range of values obtained in 2004. In 2003, 80 sites were surveyed, compared to 64 sites surveyed in 2004. In 2003, quillback rockfish catch rates ranged from 0 – 33.6 kg/skate and the CV was 1.51 (Lochead and Yamanaka, 2004). In 2004, the range for quillback rockfish catch rates was lower at 0 – 12.1 kg/skate and the CV was 1.06 (Table 13). A reduction in catch rate range between years was also observed for yelloweye rockfish, whose catch rates ranged from 0 – 26.8 kg/skate in 2003, and from 0 – 20.5 kg/skate in 2004 (Lochead and Yamanaka, 2004; Table 13). The yelloweye rockfish catch rate CV was 1.81 in 2003, compared to 1.50 in 2004 (Lochead and Yamanaka, 2004; Table 13).

The spatial distribution of 2004 catch rates (kg/skate) by statistical area is presented for all rockfish species in Figures 9 – 22. Spatial distribution patterns are similar to those observed in 2003. In 2004, quillback rockfish were found throughout SA 12 and SA 13, but nowhere did their catch rate exceed 15 kg/skate (Figure 15). In 2003, two sets had quillback catch rates that exceeded 15 kg/skate. One was located on the north side of Nigei Island where the catch rate was 33.6 kg/skate, and the other was in Blackfish Sound at 15.6 kg/skate (Lochead and Yamanaka, 2004). In 2004, the highest quillback rockfish catch rate of 12.1 kg/skate was observed on the north side of Nigei Island. Yelloweye rockfish were more common in SA 13 in both years. In 2004, yelloweye rockfish catch rates above 15 kg/skate were found in southern Ramsay Arm and in Johnstone Strait (Figure 21). In 2003, yelloweye rockfish catch rates exceeding 15 kg/skate were also observed in Ramsay Arm (Lochead and Yamanaka, 2004).

Catch rates by species were plotted against modal set depths for the six most frequently encountered rockfish species in 2004 (Figure 23). These plots illustrate peaks in abundance within species specific depth ranges. Modal set depths at peak catch rates for black, canary, greenstriped, quillback, yelloweye and yellowtail rockfishes were 80, 55, 78, 80, 95, and 86 metres, respectively.

Statistical comparisons of 2004 catch rates between areas and depth strata were performed for quillback and yelloweye rockfishes (Table 14). Quillback rockfish catch rates did not differ significantly between statistical areas in 2004, but catch rates from the deep stratum were significantly higher than those from the shallow stratum. Yelloweye rockfish catch rates did not differ significantly between depth strata, but catch rates from SA 13 were more than double the catch rates from SA 12. The same results were found for yelloweye rockfish in 2003. This difference in catch rates between areas may be attributable to a greater quality and/or quantity of yelloweye rockfish habitat, such as the steep walls that line the inlets in SA 13, and/or relatively less fishing effort, in that area.

As in 2003, the 2004 rockfish species diversity was higher in SA 12 than SA 13 (Figures 9 to 22). All 14 species of *Sebastes* encountered on the 2004 survey were present in the catches from SA 12, whereas only canary, greenstriped, quillback, yelloweye and yellowtail rockfishes were observed in SA 13. The highest species diversity in 2004 was found at sites on the northern side of Nigei Island where six species of rockfish were observed (china, black, blue, canary, quillback, and widow rockfishes).

In 2003, a total of ten *Sebastes* species were caught overall, of which only copper, greenstriped, quillback, yelloweye and yellowtail rockfishes were caught in SA 13 (Lochead and Yamanaka, 2004).

Mean 2003 and 2004 catch rates with 95% confidence intervals were plotted for the top ten most numerous species in the catch (Figure 24). Catch rates were consistent between 2003 and 2004 (Figure 24). No significant differences in catch rates were found between years for any of the ten most frequently encountered species (Table 15).

Partial correlations, controlled for modal set depth, of quillback rockfish catch rates (kg/skate) with catch rates of the top ten most numerous species were performed with data from the 2003 and 2004 surveys combined. This statistical procedure was used to measure the strength of association between inter-specific catch rates while removing the effects of modal set depth. Partial correlation coefficients were plotted by species (Figure 25). Quillback rockfish catch rates were significantly positively correlated with lingcod and yelloweye rockfish catch rates ($r_{critical} = 0.171$, $p<0.05$). This is expected given that quillback rockfish, yelloweye rockfish and lingcod are known to share near-shore rocky habitats (Yamanaka and Richards, 1993; Richards *et al*., 1988; Richards and Cass, 1987; Richards and Hand, 1987). Quillback rockfish catch rates were significantly negatively correlated with spiny dogfish catch rates ($r_{critical} = 0.171$, $p<0.05$). This negative correlation may reflect differing habitat preferences and/or inter-specific competition for hooks whereby spiny dogfish out-compete rockfish for bait.

3.3 Simulations

Simulation model parameters (P = proportion of sets with zero catch, μ = mean density of non-zero sets, ρ = coefficient of variation of non-zero sets, N = number of sets) for quillback and yelloweye rockfish are presented by area and by year in Table 16. Some similarities and differences were noted between years. The proportion of sets with zero catch in 2004 was less than half the value obtained in 2003 for quillback and yelloweye rockfishes in SA 13. SA 12 'proportion zero' values were unchanged between years. Mean density of non-zero sets were similar between years for all groupings. The coefficient of variation of non-zero sets was lower in 2004 than in 2003 for both species, with the exception of quillback rockfish from SA 13 whose 'ρ' values increased slightly in 2004. These observed differences in CVs are a result of differing ranges of values obtained each year, as discussed above (see Section *3.2.3.*). Sample size was smaller in 2004 by 3 sets in SA 12, and by 7 sets in SA 13.

The 2004 simulation plots show biomass projections 20 years into the future for three survey sample sizes of 64, 80 and 100 sets for quillback (Figure 26) and yelloweye (Figure 27) rockfishes. Overall, the loess lines tracking the biomass estimates derived from the survey parameters follow the abundance trends of the known population over time. Variability around the known population trend line, shown as a vertical dashed lines from each biomass estimate, decreases with increasing sample size, and is greater for yelloweye rockfish whose CVs were greater than those of quillback rockfish.

Given the variability in the catch rate data, the simulation plots indicate that long-term monitoring of these populations is required. For quillback rockfish with a sample size of 64 sets, if a trend line was drawn through the first 5 years of data the estimated population would inaccurately show a biomass that is decreasing in two out of three simulations (Figure 26, 'Sim 2 and 3', top panel). Even with a greater sample size of 100 sets, one of the three simulations (Figure 26, 'Sim 1', lower left panel) illustrates an example when 9 or more years of data is required to accurately track the population trend. For yelloweye rockfish, the 'Sim 1' plot for a survey sample size of 64 sets (Figure 27, top left panel) would inaccurately show a population that is not increasing if only the first 7 years of data are considered. Likewise, all three yelloweye rockfish simulation plots with a survey sample size of 80 sets (Figure 27, 'Sim 1', 'Sim 2' and 'Sim 3', centre panels) require over 7 years of data for the correct population increase to be detected.

Simulation results indicate the survey's ability to accurately track trends in abundance improved in 2004 compared to 2003, despite the smaller sample size (Table 17). With 64 sets in 2004, the percentage of times the estimated annual rate of change fell within the hypothetically 'true' annual rate of change was 79 % for quillback rockfish, and was 74 % for yelloweye rockfish (Table 17). This accuracy would have required 120 sets in 2003 (Table 17). This result appears to be driven by the lower proportion of zeros and lower catch rate variability observed in 2004, changes stemming from a lower range of catch rate values and perhaps an improved ability to target hard bottom.

4.0 CONCLUSIONS

Overall, the 2003 and 2004 surveys produced similar results. Several consistent trends observed in both survey years included very similar hook yield percentages and overall species composition. Other between-year similarities included higher rockfish species diversity in SA 12 than in SA 13, larger quillback rockfishes and older yelloweye rockfishes in the deep stratum, larger quillback and yelloweye rockfishes in SA 12, and higher yelloweye rockfish catch rates in SA 13. Also, the top ten species in the catch were identical in 2003 and 2004. These same ten species made up 98.6% of the total fish weight in 2003, and 98.8% in 2004, and the percentage make up for each individual species did not vary by more than 2% between years. No significant differences in catch rates were found between years for the ten most frequently encountered species.

Simulation work using 2003 and 2004 catch rate data indicated that this survey could be used to monitor population trends for quillback and yelloweye rockfishes if it continued over the long-term (Lochead and Yamanaka, 2004). At least 7 years of data appear to be required to obtain an accurate population index. The survey's ability to track population trends improved in 2004 when both catch rate variability and proportion of sets with non-zero catch decreased. The low inter-annual variability in mean catch rates for quillback and yelloweye rockfishes between 2003 and 2004 further suggests that this survey provides a reliable index of abundance for these species. In addition to providing population indices for quillback and yelloweye rockfishes, this survey is important for the long-term monitoring of many benthic, shallow water species inhabiting hard bottom substrates.

Habitat is an important influence on the distribution rockfishes. Variation in bottom type and was likely a major contributor to the variation in catch rates among sets. In the future, we propose that single-beam acoustic data could be collected at each of the set locations and analysed for bottom type to enable habitat-specific calibration of catch rates.

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Table 1. Summary of hook observations by description, DFO GFBio database code, number of hooks retrieved and percent of total hooks.

Description	GFBio Code	# hooks	% of total
Unknown	0	0	0
Empty hook	1	5024	35.2
Bait on hook	2	3636	25.5
Animal on hook (fish or invertebrate)	3	5425	38.0
Species head on hook	4	77	0.5
Species dropped off hook	5	102	0.7
Total		**14264**	**100**

Table 2. Summary of total catch and biological samples.

Species Name	Taxonomic Name	Total Weight (kg)	% of Marine Fish Total Weight	Total Count (#)	# of Sets with Species Present	Number of fish Sampled	Sample Types
Spiny Dogfish	*Squalus acanthias*	6317.74	72.84	4048	61	2899	TL/S
Spotted Ratfish	*Hydrolagus colliei*	563.02	6.49	504	39	409	DFL/S
Pacific Halibut	*Hippoglossus stenolepis*	456.20	5.26	38	13	33	TL
Quillback Rockfish	*Sebastes maliger*	385.83	4.45	420	51	415	FL/W/S/M/O
Yelloweye Rockfish	*Sebastes ruberrimus*	363.84	4.19	146	33	146	FL/W/S/M/O
Lingcod	*Ophidon elongatus*	170.54	1.97	24	15	22	FL/W/S/M/F
Longnose Skate	*Raja rhina*	124.95	1.44	30	17	24	TL/S
Sunflower Starfish	*Pycnopodia helianthoides*	103.73	-	83	22	-	-
Big Skate	*Raja binoculata*	85.10	0.98	7	4	6	TL/S
Pacific Cod	*Gadus macrocephalus*	59.81	0.69	52	11	46	FL/W
Sablefish	*Anoplopoma fimbria*	27.21	0.31	38	7	38	FL/W/S/M/O
Canary Rockfish	*Sebastes pinniger*	22.17	0.26	15	7	15	FL/W/S/M/O
Greenstriped Rockfish	*Sebastes elongatus*	21.84	0.25	43	20	42	FL/W/S/M/O
Black Rockfish	*Sebastes melanops*	20.23	0.23	12	1	12	FL/W/S/M/O
Yellowtail Rockfish	*Sebastes flavidus*	17.43	0.20	15	7	13	FL/W/S/M/O
Arrowtooth Flounder	*Atheresthes stomias*	6.84	0.08	5	2	4	TL/S
Red Irish Lord	*Hemilepidotus hemilepidotus*	6.54	0.08	18	4	18	TL
Sandpaper Skate	*Bathyraja interrupta*	4.68	0.05	5	2	5	TL/S
China Rockfish	*Sebastes nebulosus*	4.36	0.05	7	2	7	FL/W/S/M/O
Pacific sanddab	*Citharichthys sordidus*	2.65	0.03	8	3	8	TL/S
Southern Rocksole	*Lepidopsetta bilineata*	2.17	0.03	4	1	3	TL/S
Blue Rockfish	*Sebastes mystinus*	1.97	0.02	1	1	1	FL/W/S/M/O
Copper Rockfish	*Sebastes caurinus*	1.77	0.02	2	1	2	FL/W/S/M/O
Silvergray Rockfish	*Sebastes brevispinis*	1.77	0.02	1	2	1	FL/W/S/M/O
Kelp Greenling	*Hexagrammos decagrammus*	1.59	0.02	2	2	2	FL/S
Starfish	Asteriodea	1.19	-	7	3	-	-
Widow Rockfish	*Sebastes entomelas*	0.84	0.01	1	1	1	FL/W/S/M/O
Tiger Rockfish	*Sebastes nigrocinctus*	0.68	0.01	1	1	1	FL/W/S/M/O
Redstripe Rockfish	*Sebastes proriger*	0.59	0.01	1	1	1	FL/W/S/M/O
Solasteridae	Solasteridae	0.43	-	2	1	-	-
Anemone	Actiniaria	0.41	-	2	2	-	-
Sponge	Porifera	0.40	-	2	2	-	-
Brown Irish Lord	*Hemilepidotus spinosus*	0.38	0.00	2	2	1	TL
Sharpchin Rockfish	*Sebastes zacentrus*	0.25	0.00	1	1	1	FL/W/S/M/O
Blackfin Sculpin	*Malacocottus kincaidi*	0.25	0.00	1	1	-	-
Sea Cucumber	Holothuroidea	0.23	-	1	1	-	-
Spider Crab	Oxyrhyncha	0.07	-	1	1	-	-
Eelpout	Zoarcidae	0.03	0.00	1	1	-	-
Total		**8779.73**	**100.00**	**5551**	**64**	**4176**	**-**

DFL = snout to posterior edge of second dorsal fin length, FL = fork length, TL = total length
W = weight, S = sex, M = maturity, O = otoliths, F = fin rays

Table 3. Rockfish counts by set. Shallow stratum sets (41-70m) are unshaded, and deep stratum sets (71-100m) are shaded grey.

Set #	BLACK ROCKFISH	BLUE ROCKFISH	CANARY ROCKFISH	CHINA ROCKFISH	COPPER ROCKFISH	GREENSTRIPED ROCKFISH	QUILLBACK ROCKFISH	REDSTRIPE ROCKFISH	SHARPCHIN ROCKFISH	SILVERGRAY ROCKFISH	TIGER ROCKFISH	WIDOW ROCKFISH	YELLOWEYE ROCKFISH	YELLOWTAIL ROCKFISH
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	3	-	-	-	-	-	1	-
4	-	-	-	-	-	-	3	-	-	-	-	-	-	-
5	-	-	-	-	-	-	3	-	-	-	1	-	-	-
6	-	-	-	-	-	-	12	-	-	-	-	-	-	-
7	-	-	-	-	1	-	1	-	-	-	-	-	1	-
8	-	-	1	-	-	1	5	-	-	-	-	-	2	-
9	-	-	-	-	-	-	2	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	1	-
11	-	-	-	-	-	2	6	-	-	-	-	-	-	-
12	-	-	-	-	-	2	6	-	-	-	-	-	2	-
13	-	-	3	-	-	3	21	-	1	-	-	-	4	6
14	-	-	-	-	-	7	18	-	-	-	-	-	-	1
15	-	-	-	-	-	3	9	-	-	-	-	-	1	1
16	12	1	-	6	-	-	21	-	-	-	-	1	-	-
17	-	-	5	1	-	-	11	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	1	10	-	-	-	-	-	2	-
22	-	-	-	-	-	-	8	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	16	-	-	-	-	-	2	-
25	-	-	-	-	-	1	13	-	-	-	-	-	4	-
26	-	-	1	-	-	-	1	-	-	-	-	-	-	-
27	-	-	-	-	-	-	10	-	-	-	-	-	1	-
28	-	-	-	-	-	2	6	-	-	-	-	-	3	-
29	-	-	-	-	-	-	14	-	-	-	-	-	2	2
30	-	-	-	-	-	-	2	-	-	-	-	-	1	-
31	-	-	1	-	-	4	27	-	-	1	-	-	8	-
32	-	-	-	-	-	6	9	-	-	-	-	-	4	-
33	-	-	-	-	-	1	2	-	-	-	-	-	-	-
34	-	-	-	-	-	-	22	1	-	-	-	-	-	-
35	-	-	-	-	-	-	6	-	-	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	3	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	2	-	-	-	-	-	-	-
40	-	-	-	-	-	-	1	-	-	-	-	-	-	-
41	-	-	1	-	-	-	17	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	2	-	-	-	-	-	-	-
46	-	-	-	-	1	-	6	-	-	-	-	-	1	1
47	-	-	-	-	-	1	8	-	-	-	-	-	3	-
48	-	-	-	-	-	1	5	-	-	-	-	-	12	2
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	1	-	-	-	-	-	-	-	-
51	-	-	-	-	-	-	2	-	-	-	-	-	6	-
52	-	-	-	-	-	1	6	-	-	-	-	-	2	-
53	-	-	-	-	-	2	14	-	-	-	-	-	6	-
54	-	-	-	-	-	-	21	-	-	-	-	-	12	-
55	-	-	-	-	-	-	7	-	-	-	-	-	5	-
56	-	-	-	-	-	-	1	-	-	-	-	-	-	-
57	-	-	-	-	-	-	2	-	-	-	-	-	1	-
58	-	-	-	-	-	1	16	-	-	-	-	-	7	-
59	-	-	-	-	-	-	16	-	-	-	-	-	7	-
60	-	-	-	-	-	-	3	-	-	-	-	-	5	-
61	-	-	-	-	-	-	2	-	-	-	-	-	5	-
62	-	-	-	-	-	-	3	-	-	-	-	-	7	-
63	-	-	-	-	-	-	8	-	-	-	-	-	7	2
64	-	-	3	-	-	2	5	-	-	-	-	-	18	-
65	-	-	-	-	-	1	3	-	-	-	-	-	3	-
Total	12	1	15	7	2	43	420	1	1	1	1	1	146	15
Shallow	0	0	9	1	2	7	145	1	0	0	1	0	75	1
Deep	12	1	6	6	0	36	275	0	1	1	0	1	71	14

Table 4. Other fish species counts by set. Shallow stratum sets (41-70m) are unshaded, deep stratum sets (71-100m) are shaded grey.

Set #	ARROWTOOTH FLOUNDER	BIG SKATE	BLACKFIN SCULPIN	BROWN IRISH LORD	EELPOUT	KELP GREENLING	LINGCOD	LONGNOSE SKATE	PACIFIC COD	PACIFIC HALIBUT	PACIFIC SANDDAB	RED IRISH LORD	SABLEFISH	SANDPAPER SKATE	SOUTHERN ROCK SOLE	SPINY DOGFISH	SPOTTED RATFISH
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	55	0
2	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	91	2
3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	16	38
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	5
5	0	0	0	0	0	0	0	1	0	3	0	2	0	0	0	35	24
6	0	0	0	0	0	0	0	0		0	0	0	0	0	0	87	14
7	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8	5
8	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	7	19
9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	69	13
10	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0
11	0	0	0	0	0	0	0	1	0	7	0	0	0	0	0	50	22
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	17
14	1	0	0	0	0	0	3	3	7	0	0	0	0	0	0	9	14
15	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	36	16
16	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	12
17	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	25
18	4	0	0	0	0	0	0	1	15	2	5	0	0	3	0	37	6
19	0	0	0	0	0	0	0	5	0	4	2	0	1	2	0	27	11
21	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	48	10
22	0	0	0	0	0	0	0	1	0	4	0	0	7	0	0	50	30
23	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	11
24	0	0	0	0	1	0	0	1	5	0	0	0	0	0	0	1	12
25	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	108	2
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	3
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	3
28	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	132	0
29	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	38	20
30	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	8	27
31	0	0	0	0	0	0	2	3	0	1	0	0	0	0	0	8	24
32	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	29	28
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	0
34	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	58	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	117	0
37	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	101	1
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	71	0
39	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	79	0
40	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	94	0
41	0	0	0	0	0	1	0	0	7	1	0	1	2	0	0	10	12
42	0	0	0	0	0	0	0	2	1	1	0	0	22	0	0	90	5
43	0	0	0	0	0	1	0	3	5	9	0	5	0	0	0	7	9
44	0	0	0	1	0	0	0	0	0	0	0	10	0	0	0	42	5
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66	10
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59	16
47	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	17
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	7
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	169	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	135	0
52	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	97	0
53	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	74	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	124	1
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166	0
57	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	4	1
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98	0
59	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	24	0
60	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	129	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0
63	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	36	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	108	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	171	0
Total	5	7	1	2	1	2	24	30	52	38	8	18	38	5	4	4048	504
Shallow	0	6	0	2	0	1	8	16	7	26	3	17	12	2	4	1773	239
Deep	5	1	1	0	1	1	16	14	45	12	5	1	26	3	0	2275	265

Table 5. Rockfish fork length descriptive statistics.

FORK LENGTH (MM)	Black	Blue	Canary	China	Copper	Greenstriped	Quillback	Redstripe	Sharpchin	Silvergray	Tiger	Widow	Yelloweye	Yellowtail
Mean	460	458	423	331	360	312	357	312	255	526	344	448	491	420
Standard Error	5.9	-	21.4	9.1	3.5	5.1	1.8	-	-	-	-	-	9.0	14.8
Median	465	458	409	331	360	314	359	312	255	526	344	448	493	415
Standard Deviation	20.4	-	82.8	24.1	4.9	31.2	36.0	-	-	-	-	-	107.8	53.5
Sample Variance	416.1	-	6847.9	579.6	24.5	972.7	1292.9	-	-	-	-	-	11621.6	2862.2
Range	74	0	238	78	7	140	190	0	0	0	0	0	435	186
Minimum	406	458	313	300	356	228	264	312	255	526	344	448	280	342
Maximum	480	458	551	378	363	368	454	312	255	526	344	448	715	528
Total Count	12	1	15	7	2	38	405	1	1	1	1	1	145	13
Confidence Level(95.0%)	13.0	-	45.8	22.3	44.5	10.3	3.5	-	-	-	-	-	17.7	32.3

Table 6. Results of two sample t-tests for differences in fork length (mm) between statistical areas, depth strata, and sexes for quillback and yelloweye rockfish captured during the 2004 survey. Significant differences are noted with an asterisk (*).

Quillback Rockfish	Mean	Min	Max	SD	CV	N	t Statistic	p
stat area 12	363.3	264	454	37.1	0.10	306	6.4262	<0.00001*
stat area 13	337.8	285	391	23.3	0.07	99		
shallow (41-70m)	352.6	264	454	39.0	0.11	156	-2.0387	0.0421*
deep (71-100m)	360.0	264	436	33.6	0.09	248		
female	356.4	264	453	37.6	0.11	189	-0.4012	0.6885
male	357.8	264	454	34.5	0.10	215		

Yelloweye Rockfish	Mean	Min	Max	SD	CV	N	t Statistic	p
stat area 12	553.8	311	715	110.9	0.20	55	6.1114	<0.00001*
stat area 13	452.2	280	625	86.7	0.19	88		
shallow (41-70m)	462.8	280	715	98.8	0.21	72	-3.2633	0.0014*
deep (71-100m)	520.1	288	702	110.7	0.21	71		
female	490.3	280	684	107.6	0.22	72	0.1002	0.9204
male	492.2	288	715	109.9	0.22	71		

Table 7. Results of two sample t-tests for differences in fork length (mm) between the 2003 and 2004 survey years for quillback rockfish, yelloweye rockfish and spiny dogfish. Means, coefficients of variation (CV), t statistics, and p values are presented for pooled data and data split by statistical area, depth stratum, and sex. Significant differences are noted with an asterisk (*).

Fork Length (mm)

Quillback Rockfish	2003 Mean	2003 CV	2004 Mean	2004 CV	t Statistic	2-tailed p value
All Data Pooled	363	0.1150	357	0.1007	2.1337	* 0.0331
Statistical Area 12	373	0.1203	363	0.1022	2.7902	* 0.0054
Statistical Area 13	337	0.0899	338	0.0689	-0.2123	0.8321
Shallow (41-70 m)	350	0.1165	353	0.1107	-0.3223	0.7474
Deep (71 - 100 m)	373	0.1072	360	0.0936	4.0034	* < 0.0001
Female	358	0.1276	356	0.1055	0.4555	0.649
Male	365	0.1019	358	0.0965	2.6466	* 0.0084

Yelloweye Rockfish	2003 Mean	2003 CV	2004 Mean	2004 CV	t Statistic	2-tailed p value
All Data Pooled	492	0.1986	491	0.2196	0.1211	0.9037
Statistical Area 12	520	0.2265	554	0.2003	-1.6998	0.0914
Statistical Area 13	469	0.1486	452	0.1902	1.4647	0.1446
Shallow (41-70 m)	477	0.2054	463	0.2111	0.8410	0.4017
Deep (71 - 100 m)	503	0.1949	520	0.2129	-1.0511	0.2948
Female	483	0.2003	490	0.2195	-0.4564	0.6487
Male	505	0.2003	492	0.2232	0.7464	0.4566

Spiny Dogfish	2003 Mean	2003 CV	2004 Mean	2004 CV	T Statistic	2-tailed p value
All Data Pooled	734	0.1378	705	0.1500	10.9630	* < 0.0001
Statistical Area 12	741	0.1366	713	0.1512	8.1668	* < 0.0001
Statistical Area 13	726	0.1382	692	0.1461	8.2587	* < 0.0001
Shallow (41-70 m)	749	0.1287	697	0.1569	13.8021	* < 0.0001
Deep (71 - 100 m)	714	0.1422	713	0.1427	0.3053	0.7602
Female	730	0.1439	691	0.1560	10.1186	* < 0.0001
Male	745	0.1249	718	0.1419	7.4316	* < 0.0001

Table 8. Male and female rockfish maturity stages.

ROCKFISH MALE	Number (Proportion) of Individuals in Each Maturity Stage							Total N
	Immature	Maturing	Developing	Developed	Running	Spent	Resting	
Black	0	0	4 (1.0)	0	0	0	0	4
Blue	0	0	0	0	0	0	0	0
Canary	0	3 (0.38)	3 (0.38)	0	0	2 (0.25)	0	8
China	0	0	1 (0.50)	0	0	0	1 (0.50)	2
Copper	0	0	1 (1.0)	0	0	0	0	1
Greenstriped	0	0	0	0	0	0	0	0
Quillback	0	17 (0.08)	181 (0.82)	12 (0.05)	0	1 (0.01)	9 (0.04)	220
Redstripe	0	0	0	0	0	0	0	0
Sharpchin	0	0	0	0	0	0	0	0
Silvergray	0	0	0	0	0	0	0	0
Tiger	0	0	1 (1.0)	0	0	0	0	1
Widow	0	0	0	0	0	0	0	0
Yelloweye	7 (0.10)	23 (0.33)	37 (0.54)	1 (0.01)	0	1 (0.01)	0	69
Yellowtail	0	1 (0.17)	3 (0.50)	0	0	0	2 (0.33)	6
Total	**7 (0.02)**	**44 (0.14)**	**231 (0.74)**	**13 (0.04)**	**0**	**4 (0.01)**	**12 (0.04)**	**311**

ROCKFISH FEMALE	Number (Proportion) of Individuals in Each Maturity Stage							Total N
	Immature	Maturing	Mature	Fertilized	Larvae	Spent	Resting	
Black	0	0	8 (1.0)	0	0	0	0	8
Blue	0	0	1 (1.0)	0	0	0	0	1
Canary	0	2 (0.29)	4 (0.57)	0	0	0	1 (0.14)	7
China	0	0	4 (0.80)	0	0	0	1 (0.20)	5
Copper	0	0	1 (1.0)	0	0	0	0	1
Greenstriped	0	2 (0.05)	24 (0.65)	0	0	0	11 (0.30)	37
Quillback	0	8 (0.04)	177 (0.93)	0	0	0	5 (0.03)	190
Redstripe	0	0	0	0	0	0	0	0
Sharpchin	0	0	0	0	0	0	1 (1.0)	1
Silvergray	0	0	0	0	0	0	1 (1.0)	1
Tiger	0	0	0	0	0	0	0	0
Widow	0	0	1 (1.0)	0	0	0	0	1
Yelloweye	0	17 (0.24)	49 (0.68)	1 (0.01)	1 (0.01)	0	4 (0.06)	72
Yellowtail	0	0	4 (0.57)	0	0	0	3 (0.43)	7
Total	**0**	**29 (0.09)**	**273 (0.82)**	**1 (0.003)**	**1 (0.003)**	**0**	**27 (0.08)**	**331**

Table 9. Age summary statistics for quillback and yelloweye rockfish.

Age (years)	Quillback	Yelloweye
Mean	21.50	25.95
Standard Error	0.51	1.13
Median	19	22
Standard Deviation	10.34	13.63
Sample Variance	106.97	185.73
Minimum	5	6
Maximum	72	74
Total Count	415	146
Confidence Level(95.0%)	1.00	2.23

Table 10. Results of two sample t-tests for differences in age (years) between statistical areas, depth strata, and sexes for quillback and yelloweye rockfish captured during the 2004 survey. Significant differences are identified with an asterisk (*).

Quillback Rockfish	Mean	Min	Max	SD	CV	N	t Statistic	p
stat area 12	21.4	5	72	10.9987	0.5130	308	-0.2071	0.8360
stat area 13	21.7	7	43	8.2079	0.3786	107		
shallow (41 - 70m)	21.4	6	65	10.7679	0.5038	161	-0.2051	0.8376
deep (71 - 100m)	21.6	5	72	10.0842	0.4671	254		
female	20.4	6	72	10.042	0.4924	190	1.8975	0.0585
male	22.3	5	65	10.532	0.4716	220		

Yelloweye Rockfish	Mean	Min	Max	SD	CV	N	t Statistic	p
stat area 12	29.9	8	74	15.531	0.5199	55	2.7687	* 0.0064
stat area 13	23.6	6	60	11.806	0.5009	91		
shallow (41 - 70m)	24.0	6	74	13.028	0.5420	75	-1.7484	0.0825
deep (71 - 100m)	28.0	8	60	14.046	0.5024	71		
female	26.3	8	60	12.635	0.4814	72	-0.4752	0.6354
male	25.2	6	74	14.514	0.5767	71		

Table 11. Results of two sample t-tests for differences in age (years) between the 2003 and 2004 survey years for quillback and yelloweye rockfish. Means, coefficients of variation (CV), t statistics, and p values are presented for pooled data and data split by statistical area, depth stratum, and sex. Significant differences are identified with an asterisk (*).

Age (years)

Quillback Rockfish	2003 Mean	2003 CV	2004 Mean	2004 CV	t Statistic	2-tailed p value
All Data Pooled	22.3	0.5049	21.5	0.4810	1.0683	0.2857
Statistical Area 12	22.4	0.5446	21.4	0.5130	1.1167	0.2645
Statistical Area 13	21.6	0.3890	21.7	0.3786	-0.0482	0.9616
Shallow (41-70 m)	21.7	0.5009	21.4	0.5038	0.2924	0.7701
Deep (71 - 100 m)	22.7	0.5109	21.6	0.4671	1.2056	0.2285
Female	21.1	0.5016	20.4	0.4924	0.7070	0.4799
Male	23.2	0.5055	22.3	0.4716	0.8633	0.3884

Yelloweye Rockfish	2003 Mean	2003 CV	2004 Mean	2004 CV	t Statistic	2-tailed p value
All Data Pooled	28.3	0.5881	26.0	0.5253	1.1442	0.2533
Statistical Area 12	29.3	0.7180	29.9	0.5199	-0.1703	0.8650
Statistical Area 13	27.0	0.4221	23.6	0.5009	2.0628	* 0.0405
Shallow (41-70 m)	25.4	0.6507	24.0	0.5420	0.5519	0.5818
Deep (71 - 100 m)	30.7	0.5287	28.0	0.5024	1.1223	0.2634
Female	30.4	0.6214	26.3	0.4814	1.6478	0.1012
Male	24.7	0.4702	25.2	0.5767	-0.1990	0.8425

Table 12. von Bertalanffy parameter estimates (L_{∞}, K, and t_0) calculated using pooled biological data from the 2003 and 2004 surveys for male and female quillback and yelloweye rockfish.

Species	Statistical Area	sex	L_{∞}	K	t_0	n
Quillback rockfish	12 and 13	male	417.589	0.0491917	-20.9402	488
Quillback rockfish	12 and 13	female	430.344	0.0530062	-14.9386	435
Yelloweye rockfish	12 and 13	male	689.788	0.0432184	-7.82591	148
Yelloweye rockfish	12 and 13	female	646.144	0.0447654	-6.92761	180

* all parameters calculated using pooled data from 2003 and 2004

Table 13. Rockfish catch rate (kg/skate) summary statistics by statistical area.

Areas 12 and 13	Black	Blue	Canary	China	Copper	Greenstriped	Quillback	Redstripe	Sharpchin	Silvergray	Tiger	Widow	Yelloweye	Yellowtail
Mean	0.1580	0.0153	0.1730	0.0341	0.0138	0.1702	3.0125	0.0045	0.0019	0.0138	0.0053	0.0066	2.8411	0.1359
Standard Error	0.1580	0.0153	0.0782	0.0312	0.0099	0.0461	0.4008	0.0045	0.0019	0.0138	0.0053	0.0066	0.5313	0.0580
Median	0	0	0	0	0	0	2.10	0	0	0	0	0	0.70	0
Standard Deviation	1.2638	0.1225	0.6253	0.2495	0.0788	0.3686	3.2066	0.0363	0.0150	0.1100	0.0425	0.0525	4.2502	0.4638
Sample Variance	1.5971	0.0150	0.3910	0.0623	0.0062	0.1359	10.2820	0.0013	0.0002	0.0121	0.0018	0.0028	18.0643	0.2151
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	10.1100	0.9800	4.2000	1.9900	0.5300	1.9900	12.1100	0.2900	0.1200	0.8800	0.3400	0.4200	20.5400	2.4900
Total Number of Skates	128	128	128	128	128	128	128	128	128	128	128	128	128	128
Confidence Level (95.0%)	0.3157	0.0306	0.1562	0.0623	0.0197	0.0921	0.8010	0.0091	0.0037	0.0275	0.0106	0.0131	1.0617	0.1159
Coefficient of Variation	8.0000	8.0000	3.6149	7.3249	5.7317	2.1662	1.0644	8.0000	8.0000	8.0000	8.0000	8.0000	1.4960	3.4122

Area 12	Black	Blue	Canary	China	Copper	Greenstriped	Quillback	Redstripe	Sharpchin	Silvergray	Tiger	Widow	Yelloweye	Yellowtail
Mean	0.2151	0.0209	0.1462	0.0464	0.0187	0.1889	3.2317	0.0062	0.0026	0.0187	0.0072	0.0089	2.0655	0.1379
Standard Error	0.2151	0.0209	0.0605	0.0424	0.0134	0.0567	0.5051	0.0062	0.0026	0.0187	0.0072	0.0089	0.5699	0.0642
Median	0	0	0	0	0	0	2.24	0	0	0	0	0	0	0
Standard Deviation	1.4747	0.1429	0.4144	0.2910	0.0917	0.3886	3.4626	0.0423	0.0175	0.1284	0.0496	0.0613	3.9071	0.4402
Sample Variance	2.1747	0.0204	0.1718	0.0847	0.0084	0.1510	11.9899	0.0018	0.0003	0.0165	0.0025	0.0038	15.2654	0.1938
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	10.1100	0.9800	1.6900	1.9900	0.5300	1.9900	12.1100	0.2900	0.1200	0.8800	0.3400	0.4200	20.5400	2.4900
Total Number of Skates	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Confidence Level (95.0%)	0.4330	0.0420	0.1217	0.0854	0.0269	0.1141	1.0167	0.0124	0.0051	0.0377	0.0146	0.0180	1.1472	0.1293
Coefficient of Variation	6.8557	6.8557	2.8354	6.2737	4.8983	2.0570	1.0715	6.8557	6.8557	6.8557	6.8557	6.8557	1.8916	3.1931

Area 13	Black	Blue	Canary	China	Copper	Greenstriped	Quillback	Redstripe	Sharpchin	Silvergray	Tiger	Widow	Yelloweye	Yellowtail
Mean	-	-	0.2471	-	-	0.1182	2.4065	-	-	-	-	-	4.9853	0.1306
Standard Error	-	-	0.2471	-	-	0.0755	0.5679	-	-	-	-	-	1.1005	0.1306
Median	-	-	0	-	-	0	1.50	-	-	-	-	-	4.45	0
Standard Deviation	-	-	1.0186	-	-	0.3111	2.3416	-	-	-	-	-	4.5374	0.5384
Sample Variance	-	-	1.0376	-	-	0.0968	5.4829	-	-	-	-	-	20.5881	0.2899
Minimum	-	-	0	-	-	0	0	-	-	-	-	-	0	0
Maximum	-	-	4.2000	-	-	1.2900	7.6600	-	-	-	-	-	16.5600	2.2200
Total Number of Skates	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Confidence Level (95.0%)	-	-	0.5237	-	-	0.1600	1.2039	-	-	-	-	-	2.3329	0.2768
Coefficient of Variation	-	-	4.12311	-	-	2.631292323	0.9730296	-	-	-	-	-	0.9101581	4.1231056

Table 14. Results of Wilcoxon rank sum tests for differences in catch rates between statistical areas and between depth strata for quillback and yelloweye rockfish captured on the 2004 survey.

Quillback Rockfish	Mean	Min	Max	SD	CV	N	U Statistic	two-tailed p value
stat area 12	3.23	0	12.11	3.4626	1.0715	47	419.00	0.7718
stat area 13	2.41	0	7.66	2.3416	0.9730	17	380.00	
shallow (41 - 70 m)	2.25	0	10.55	2.7800	1.2332	32	363.00	*0.0453
deep (71 -100 m)	3.77	0	12.11	3.4613	0.9180	32	661.00	

Yelloweye Rockfish	Mean	Min	Max	SD	CV	N	U Statistic	two-tailed p value
stat area 12	2.07	0	20.54	3.9071	1.8916	47	204.00	*0.0016
stat area 13	4.99	0	16.56	4.5374	0.9102	17	595.00	
shallow (41 - 70 m)	2.43	0	16.56	3.8518	1.5861	32	466.00	0.5164
deep (71 -100 m)	3.25	0	20.54	4.6394	1.4259	32	558.00	

Table 15. Results of Wilcoxon rank sum tests for differences in catch rates (kg/skate) between the two survey years, 2003 and 2004, for the top ten most frequently encountered species on the surveys. Means, coefficients of variation (CV), U statistics, and p values are presented for each species. No significant differences were found.

Species	2003 Mean	2004 Mean	2003 CV	2004 CV	2003 U Statistic	2004 U Statistic	2-tailed p value
Spiny Dogfish	58.45	49.35	0.73	0.75	2278.0	2342.0	0.3819
Spotted Ratfish	8.70	4.40	1.53	1.25	2511.0	2609.0	0.8404
Quillback Rockfish	3.25	3.01	1.51	1.06	2415.5	2704.5	0.5598
Yelloweye Rockfish	2.78	2.84	1.81	1.50	2355.0	2765.0	0.3717
Pacific Halibut	2.35	3.56	2.88	3.33	2557.0	2563.0	0.9886
Longnose Skate	1.64	0.98	2.09	2.37	2797.0	2323.0	0.2437
Lingcod	1.40	1.33	2.57	2.36	2605.0	2515.0	0.8121
Pacific Cod	0.94	0.47	3.92	3.18	2891.5	2228.5	0.0801
Sablefish	0.48	0.21	4.54	4.81	2639.5	2480.5	0.5804
Greenstriped Rockfish	0.11	0.17	2.56	2.17	2324.5	2795.5	0.2186

Table 16. Simulation model parameters for quillback and yelloweye rockfish, summarized by year and statistical area. Parameters: P = proportion of sets with zero catch, μ = mean density of fish in non-zero sets (kg/km^2), ρ = coefficient of variation of μ in non-zero sets. Constants: N= number of sets used to derive parameters, A = bottom area (km^2).

Year	Species	Stat Area	P	μ	ρ	N	A
2003	Quillback rockfish	12	0.2400	1138.3111	1.1689	50	1119
2004	Quillback rockfish	12	0.2340	1018.3625	0.7850	47	1119
2003	Quillback rockfish	13	0.2500	860.8695	0.8013	24	486
2004	Quillback rockfish	13	0.1176	653.3269	0.8889	17	486
2003	Yelloweye rockfish	12	0.6400	1300.3970	0.9487	50	1119
2004	Yelloweye rockfish	12	0.5957	1220.2787	0.8902	47	1119
2003	Yelloweye rockfish	13	0.4167	1801.4207	0.9433	24	486
2004	Yelloweye rockfish	13	0.1765	1437.8033	0.7156	17	486

Table 17. Simulation results for quillback and yelloweye rockfish showing the percentage of times the estimated annual rate of change for simulated surveys fell within ± 20% of the true annual rate of change. 'Year' indicates the survey year whose dataset was used to calculate simulation input parameters. 'K' represents the total number of sets completed on the hypothetical survey.

Year	Species	K = 64	K = 80	K = 100	K = 120
2003	Quillback rockfish		75.5%	78.8%	79.0%
2004	Quillback rockfish	79.3%	80.6%	83.2%	84.8%
2003	Yelloweye rockfish		65.7%	73.0%	74.7%
2004	Yelloweye rockfish	73.7%	77.7%	79.1%	80.8%

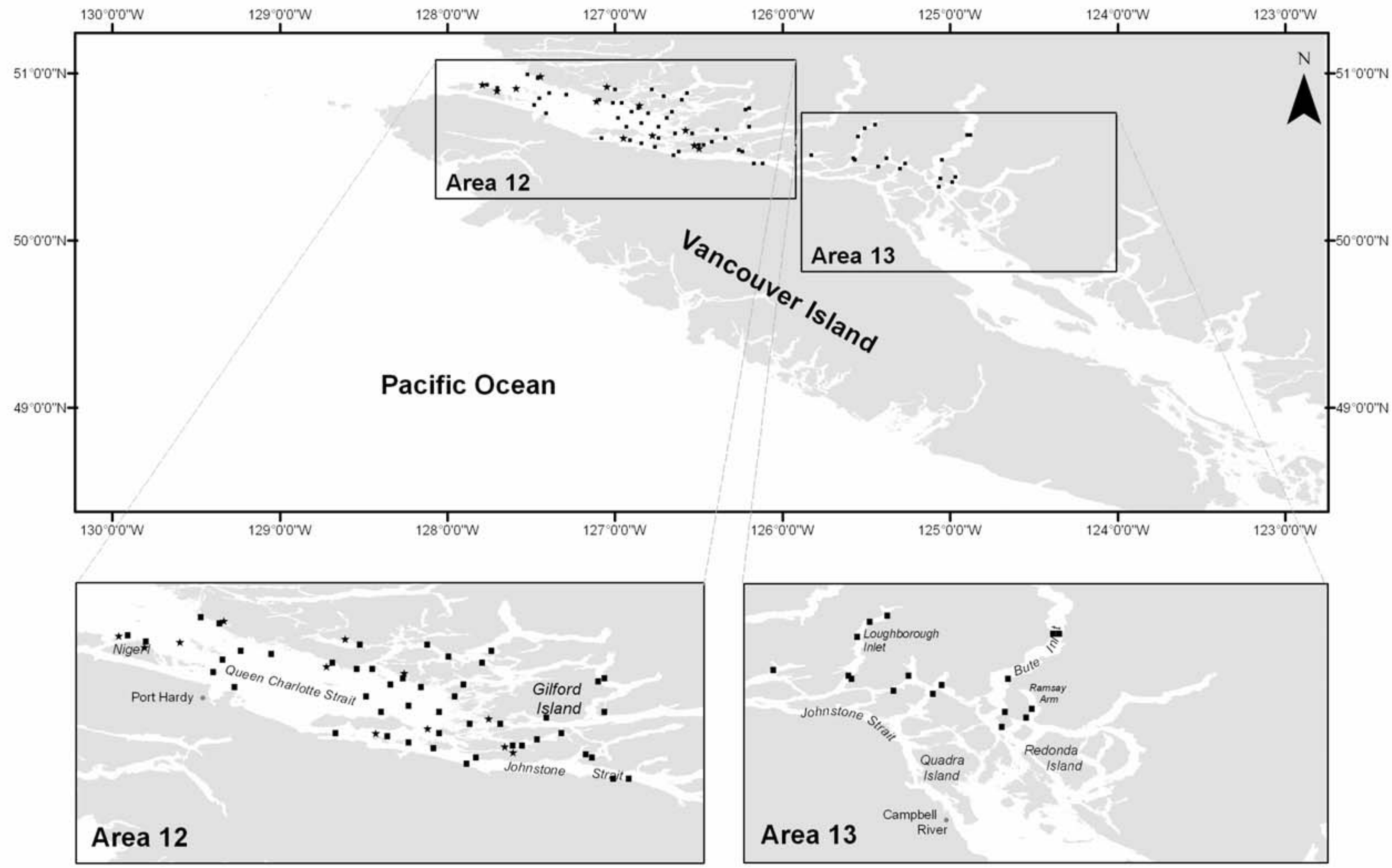


Figure 1. Survey block locations: black squares illustrate the 64 surveyed sites, and black stars illustrate the 12 rejected blocks. The lower left panel shows a close up of the 12 rejected blocks and the 47 sets conducted in SA 12, and the lower right panel shows a close-up of the 17 sets conducted SA 13.

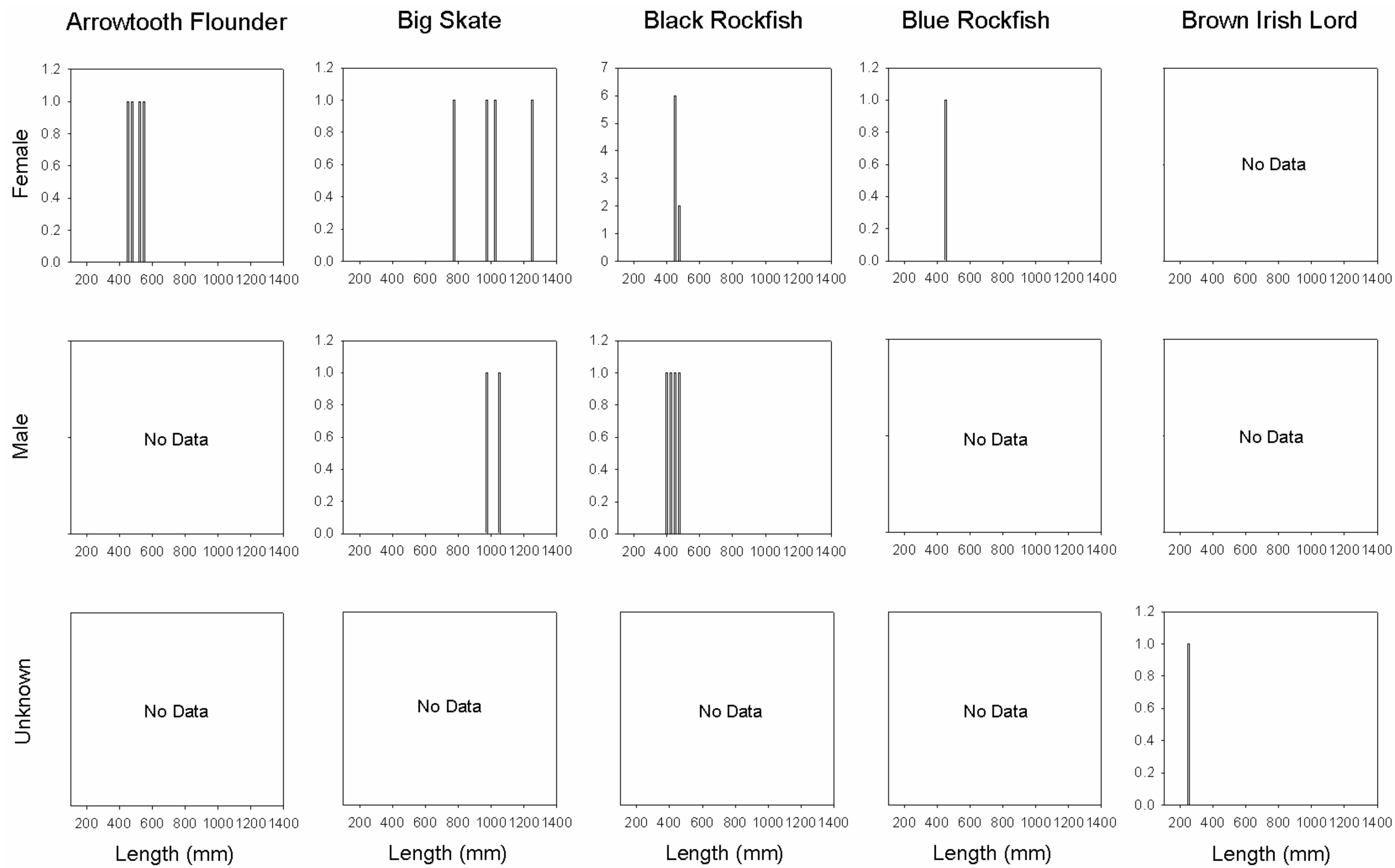


Figure 2. Length frequency histograms for males, females, and unknown sexes of all fish species.

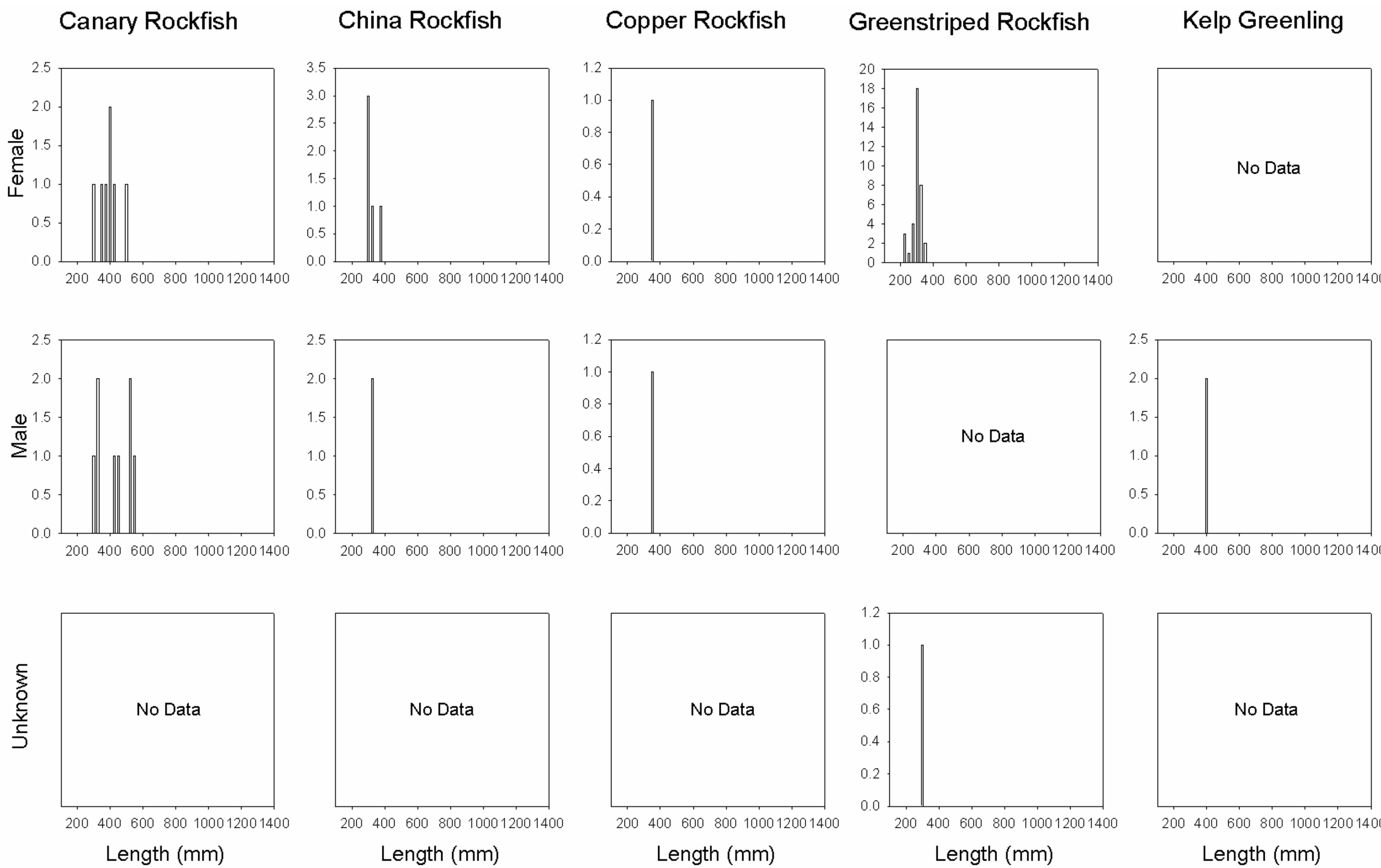


Figure 2. (continued) Length frequency histograms for males, females, and unknown sexes of all fish species.

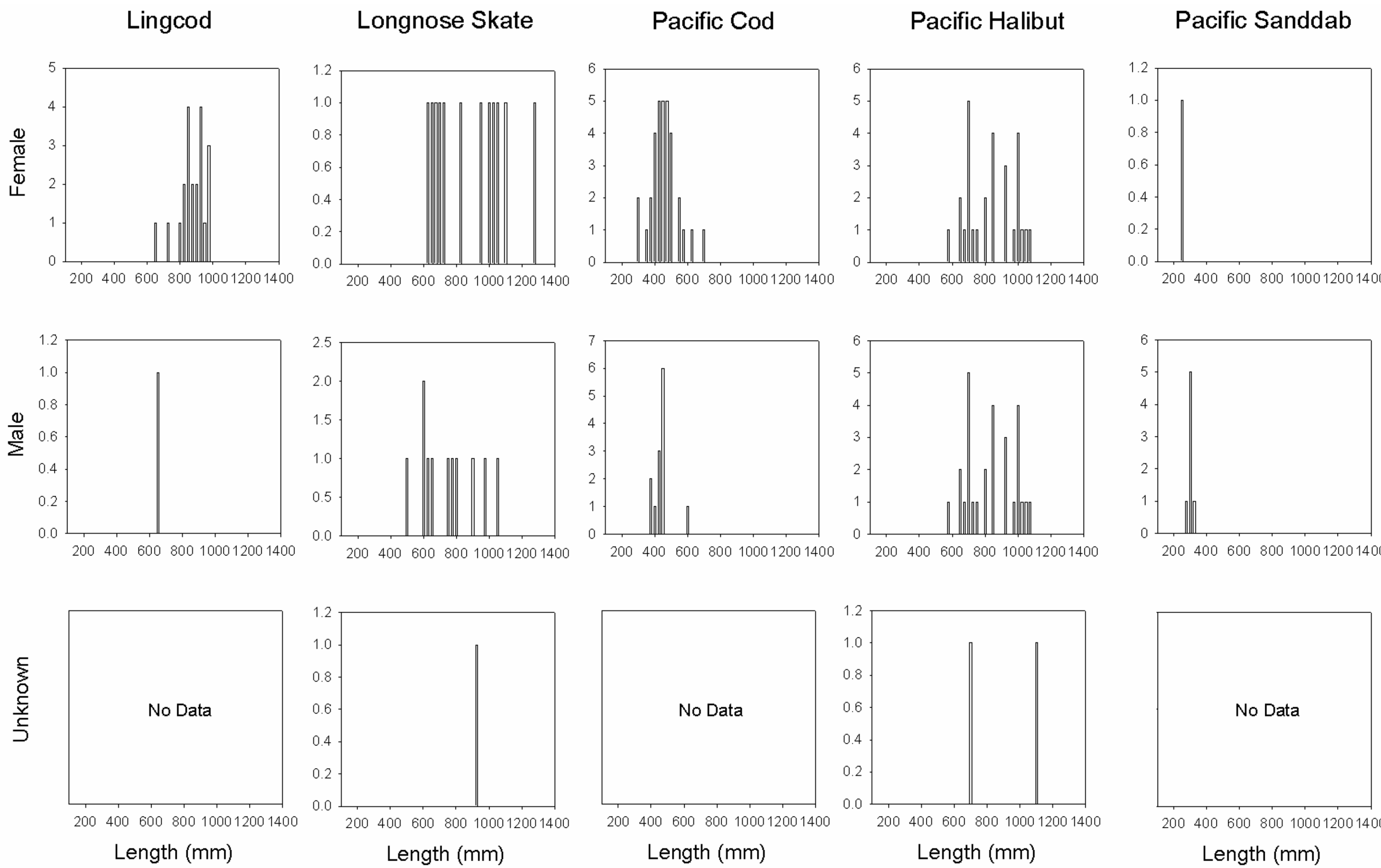


Figure 2. (continued) Length frequency histograms for males, females, and unknown sexes of all fish species.

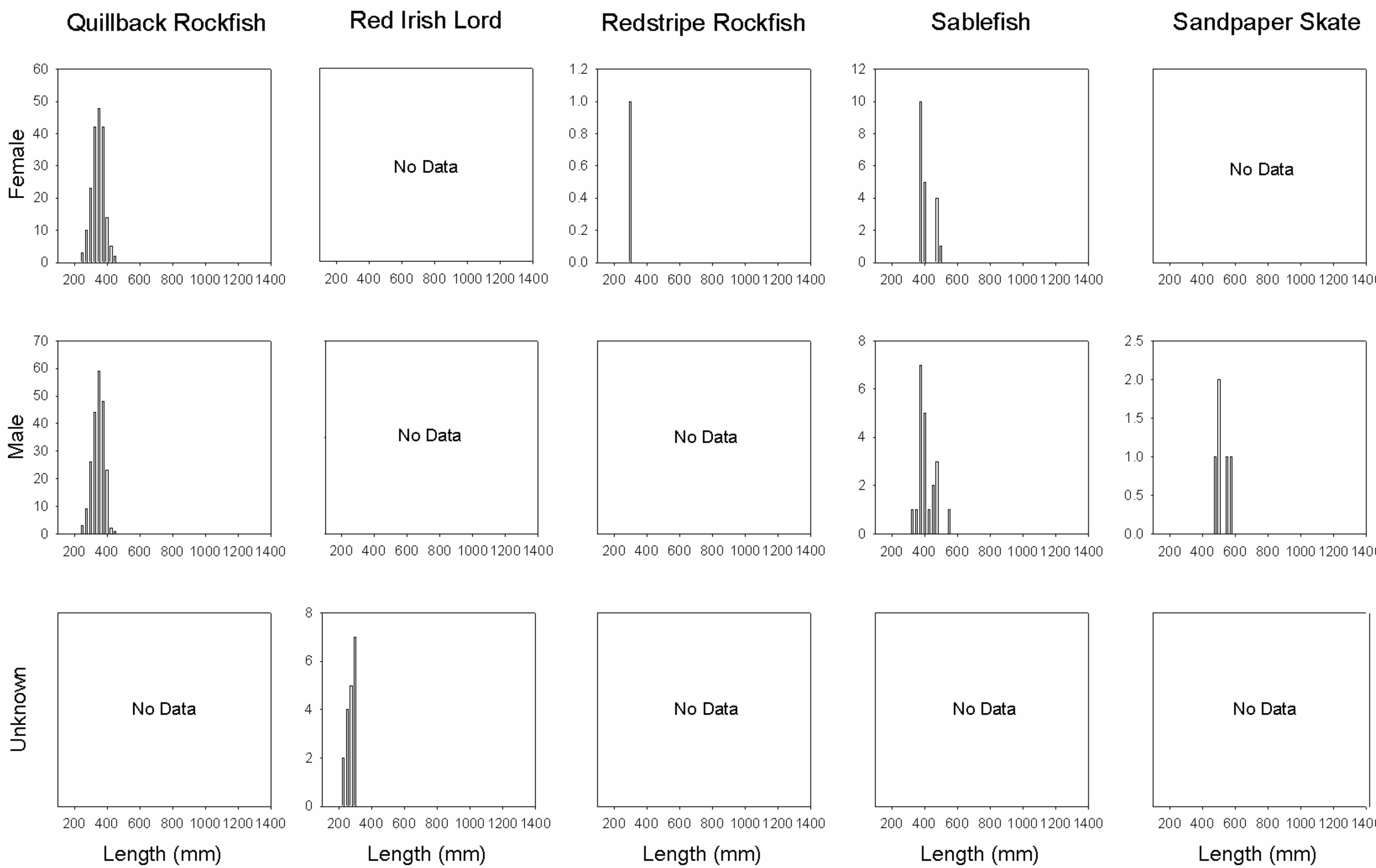


Figure 2. (continued) Length frequency histograms for males, females, and unknown sexes of all fish species.

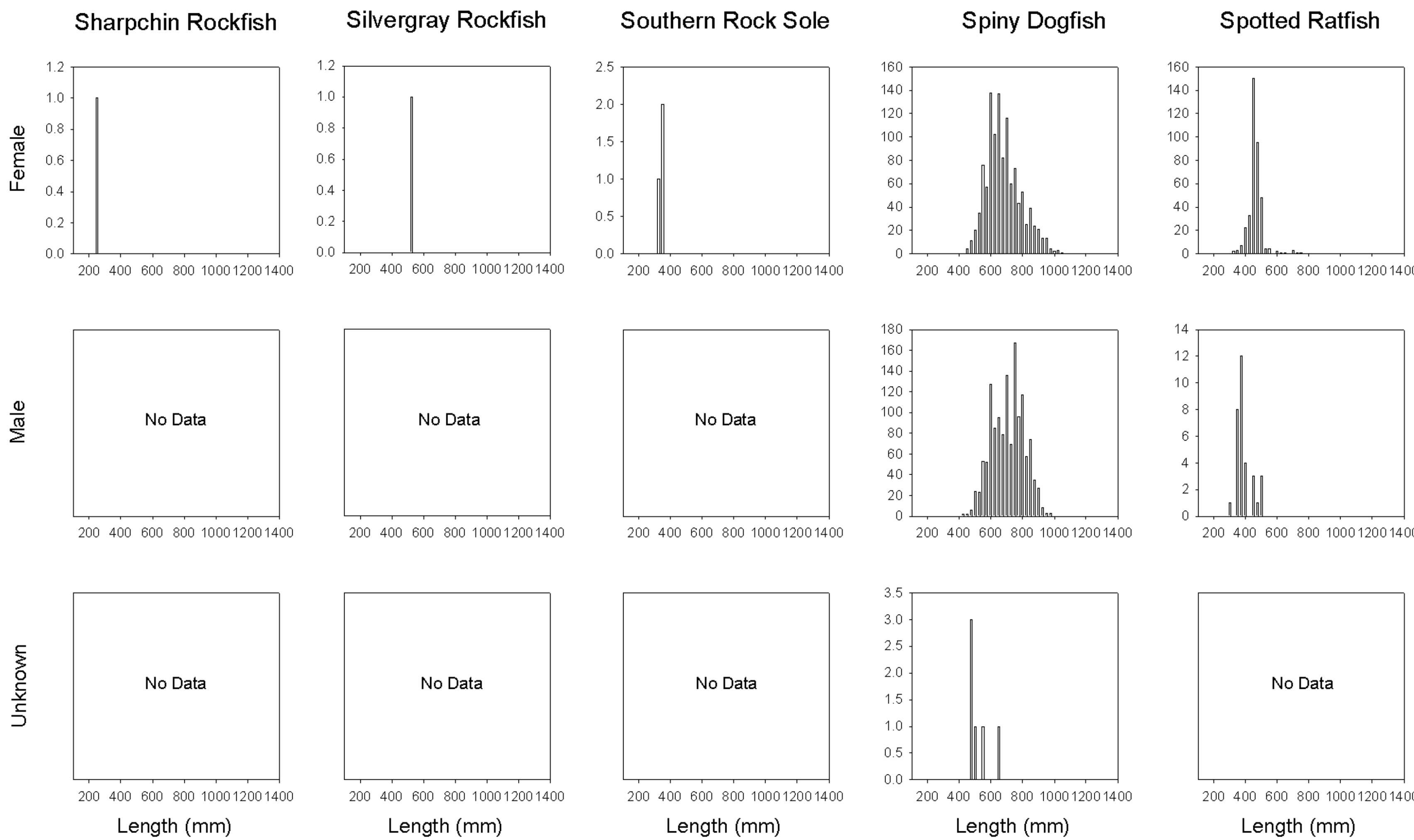


Figure 2. (continued) Length frequency histograms for males, females, and unknown sexes of all fish species.

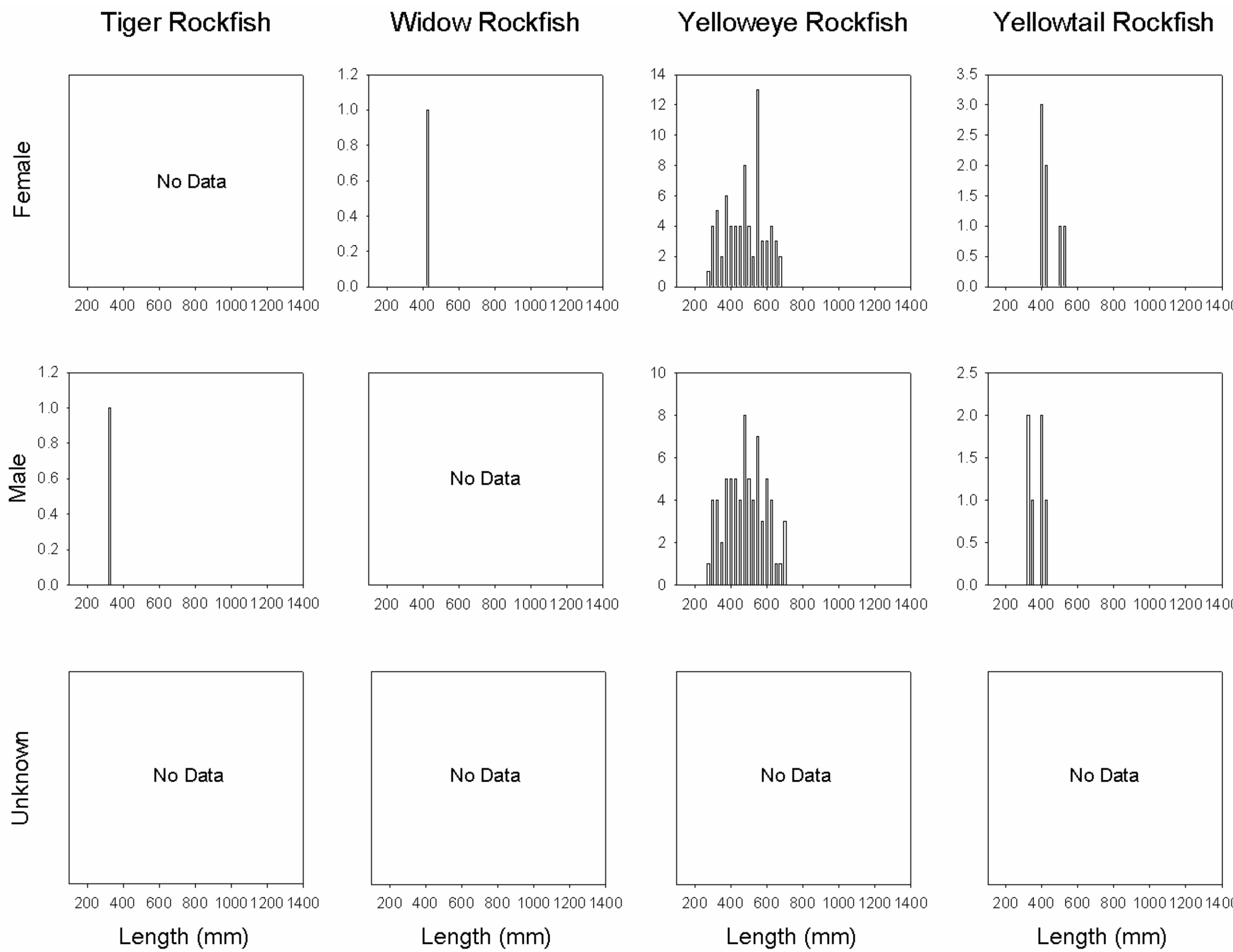
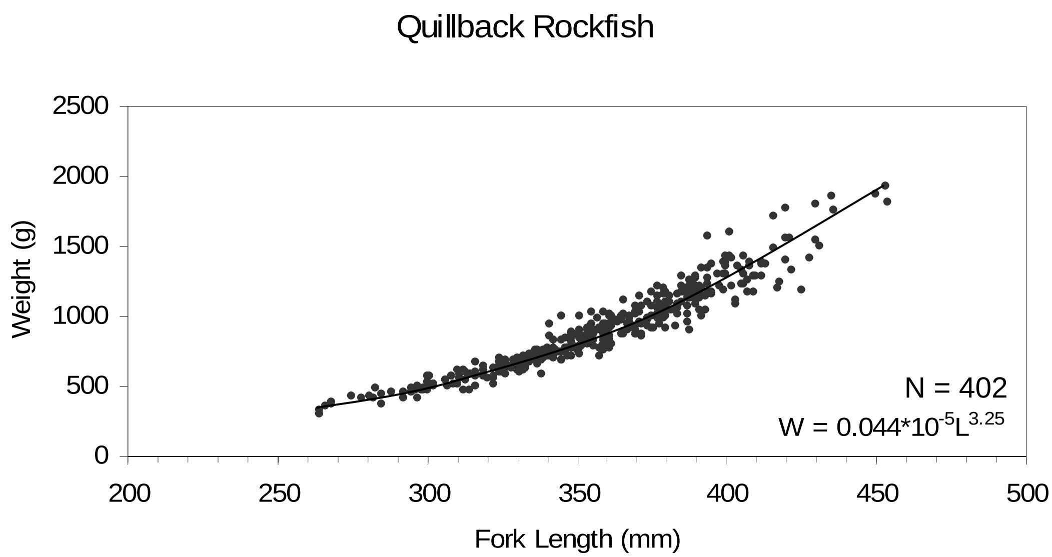


Figure 2. (continued) Length frequency histograms for males, females, and unknown sexes of all fish species.



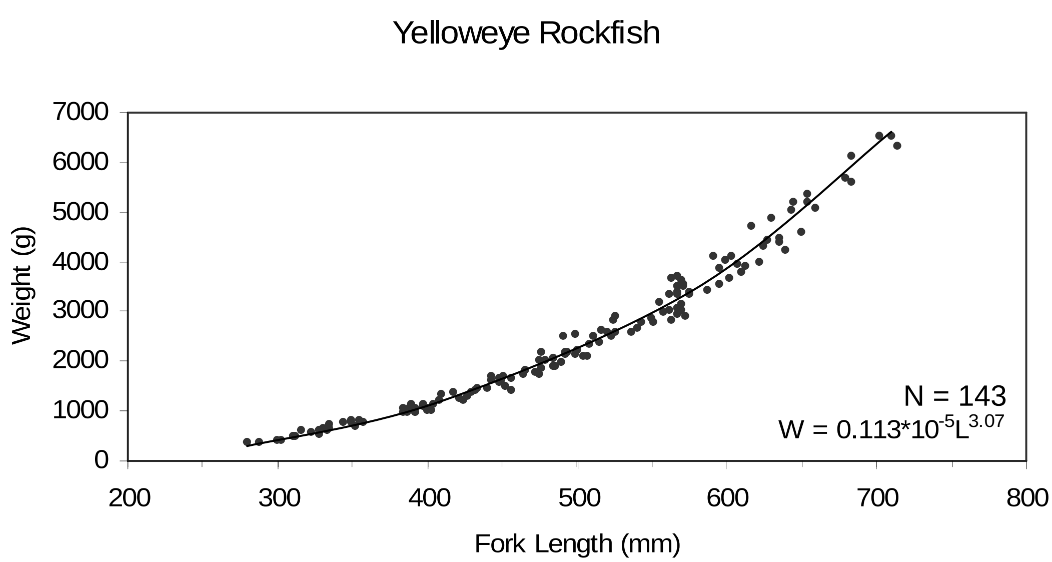


Figure 3. Length – weight relationship for quillback and yelloweye rockfish. Line equations are shown where 'W' equals weight in grams, 'L' equals fork length in millimetres and 'n' equals sample size.

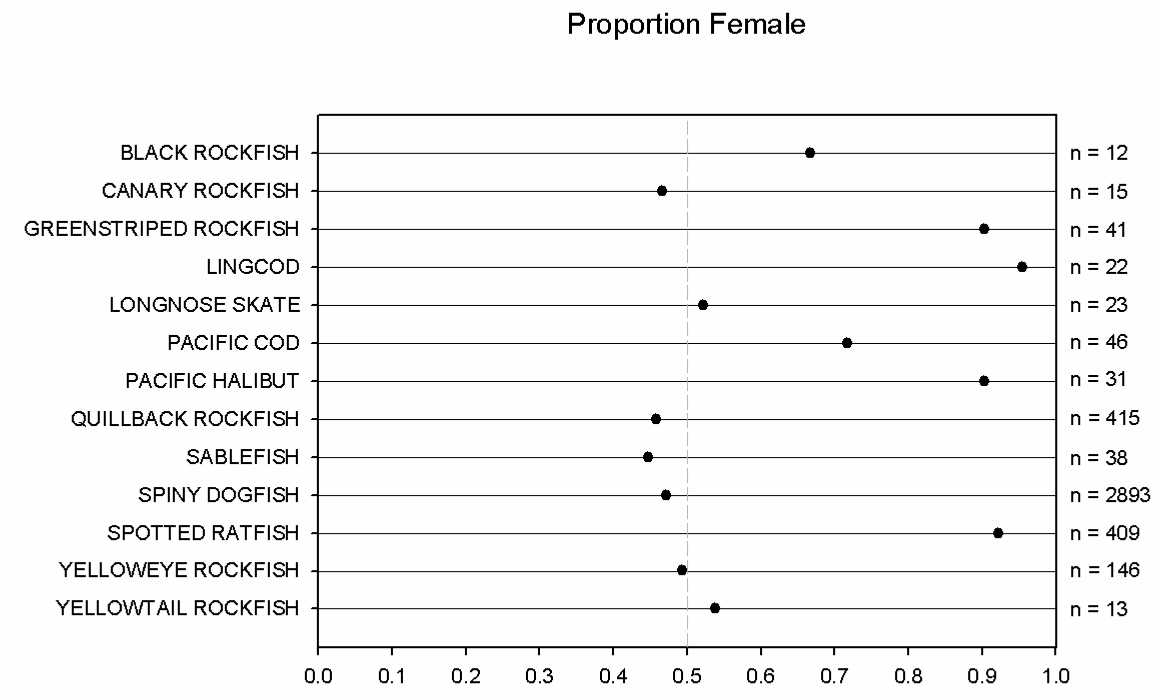


Figure 4. Proportion female for species where sample size (n) was greater than 10.

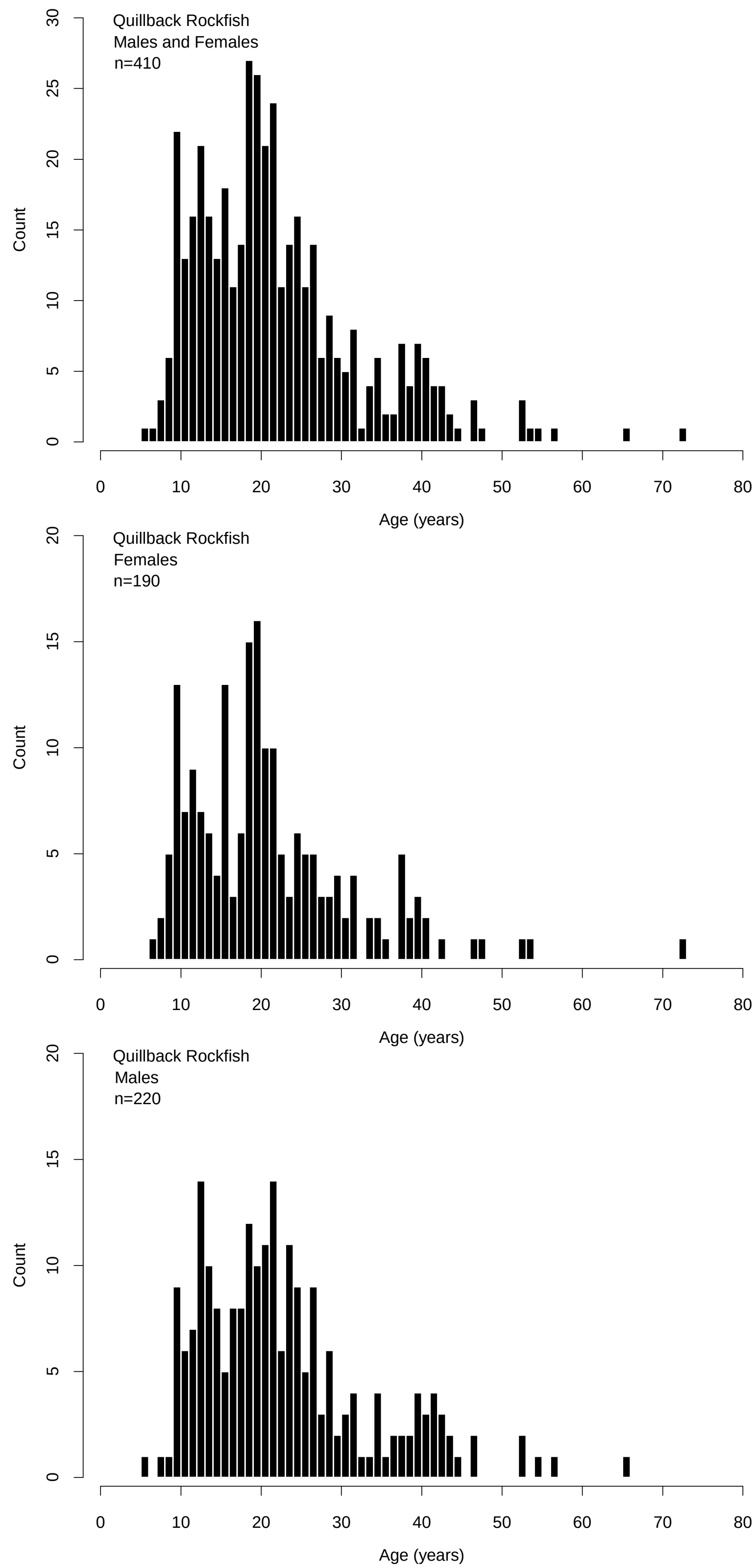


Figure 5. Age frequency distribution of quillback rockfish plotted with sexes combined (top), with males only (middle), and females only (bottom).

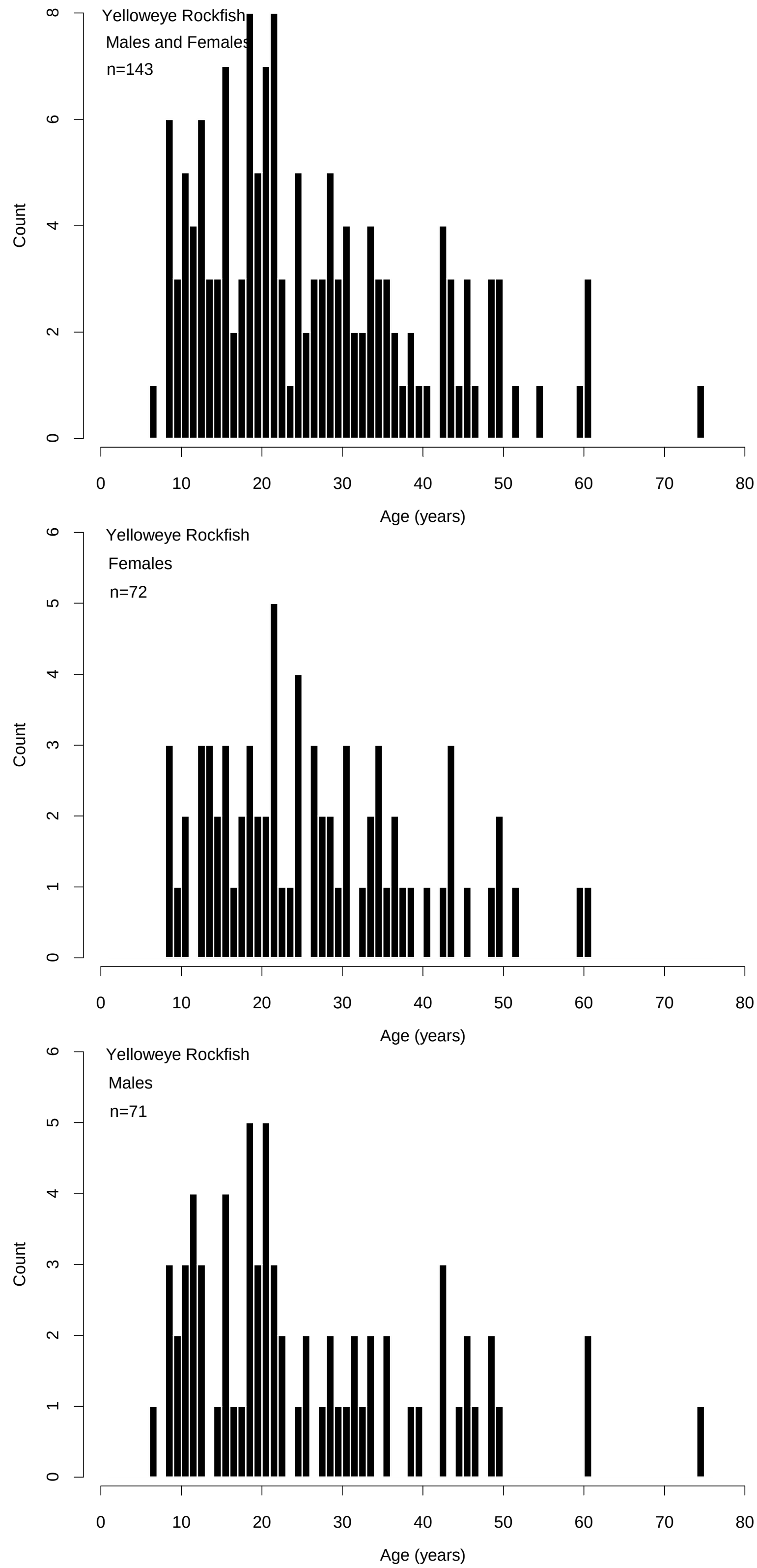


Figure 6. Age frequency distribution of yelloweye rockfish plotted with sexes combined (top), with males only (middle), and females only (bottom).

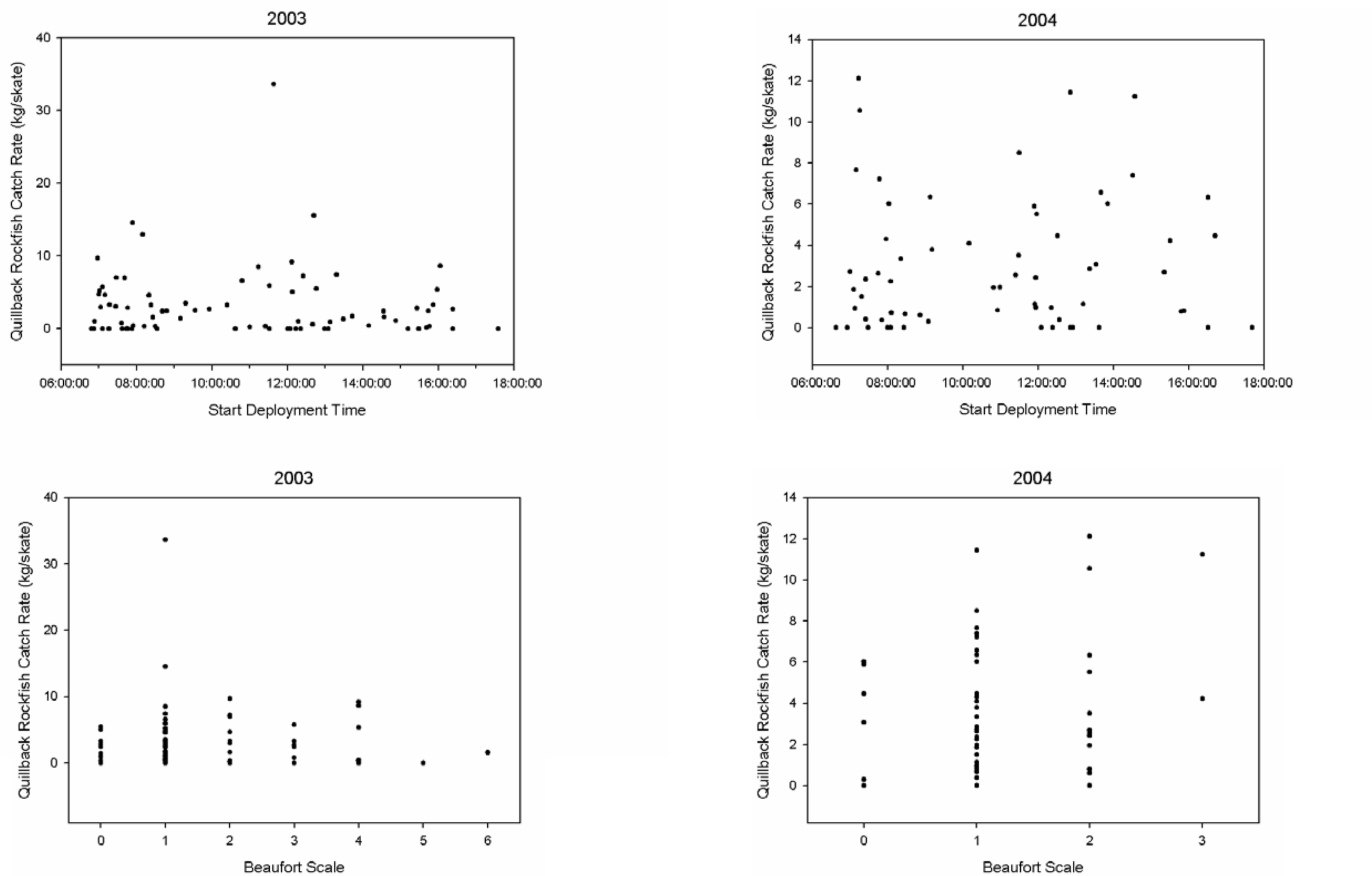


Figure 7. Quillback catch rates (kg/skate) from 2003 (left panels) and 2004 (right panels) plotted against deployment time and Beaufort scale.

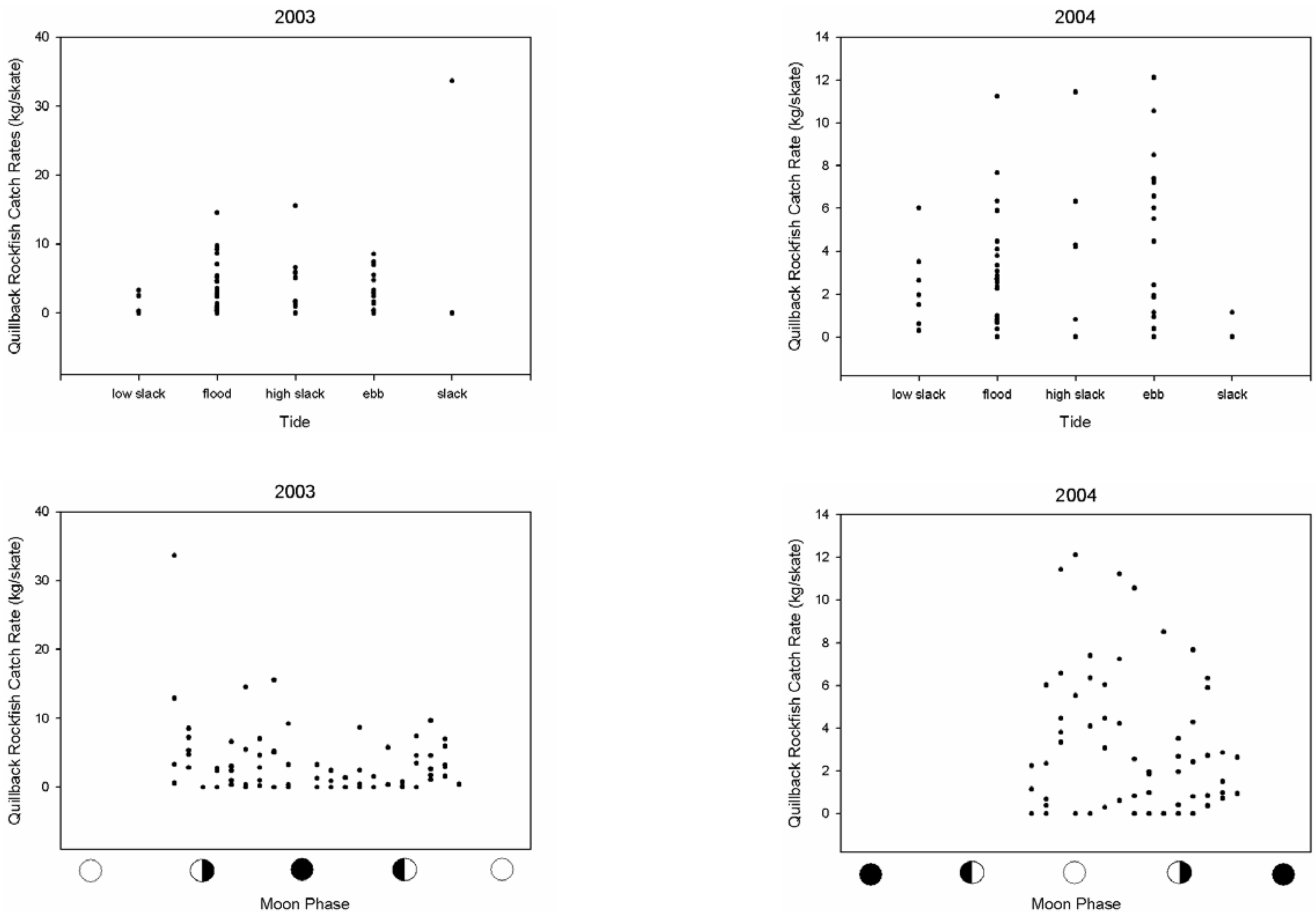


Figure 8. Quillback catch rates (kg/skate) from 2003 (left panels) and 2004 (right panels) plotted against tide and moon phase.

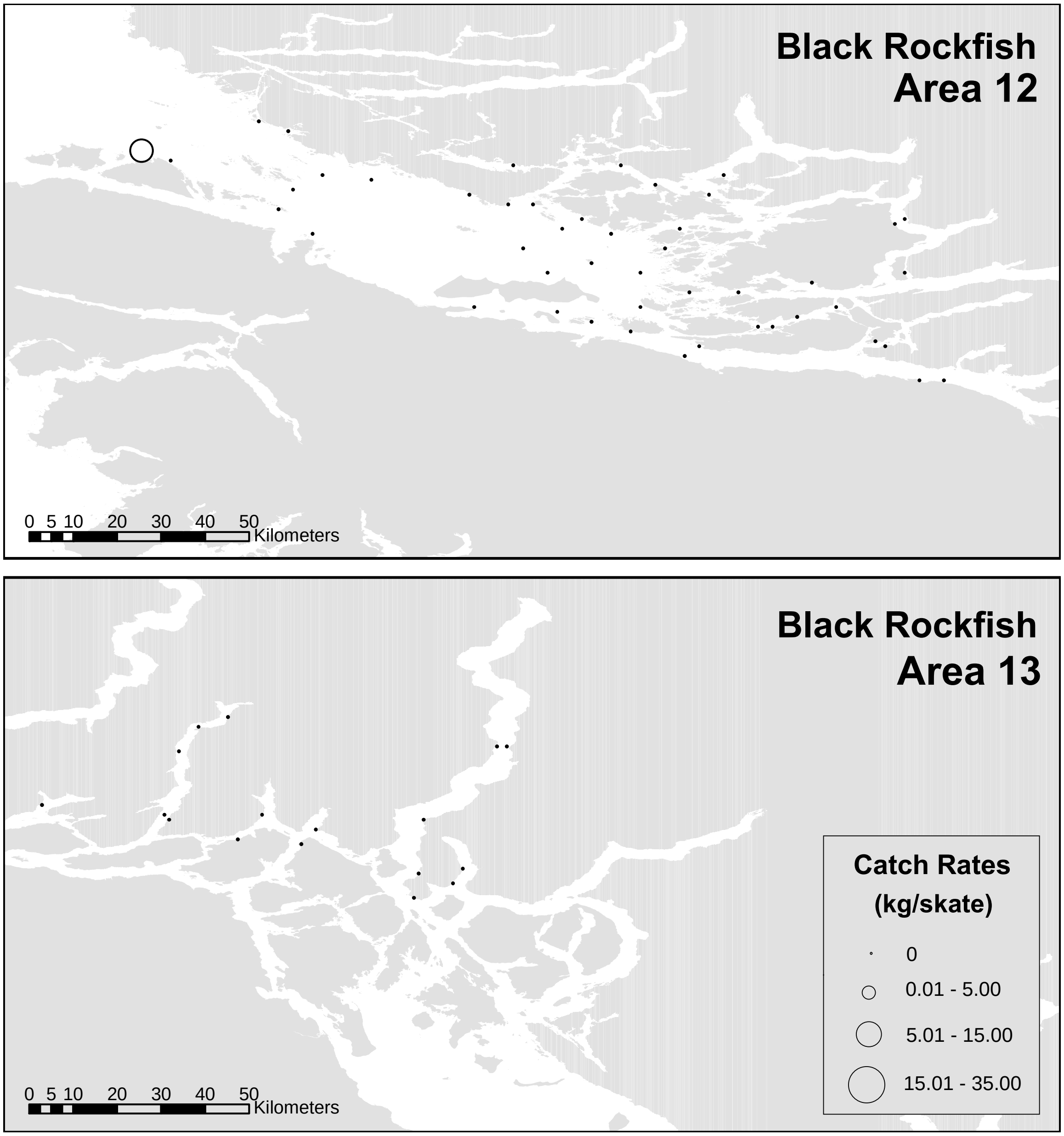


Figure 9. Spatial distribution of black rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

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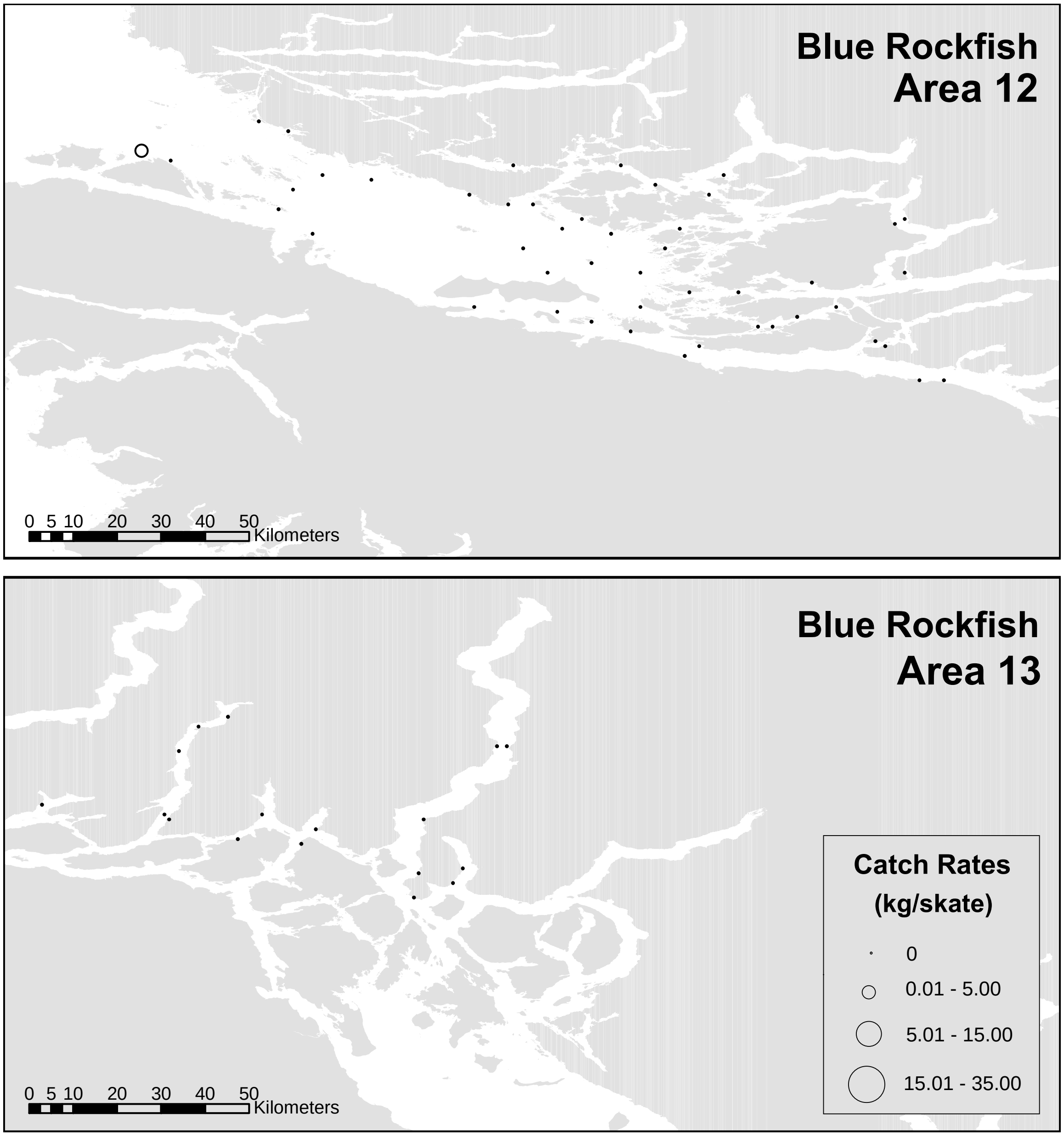


Figure 10. Spatial distribution of blue rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

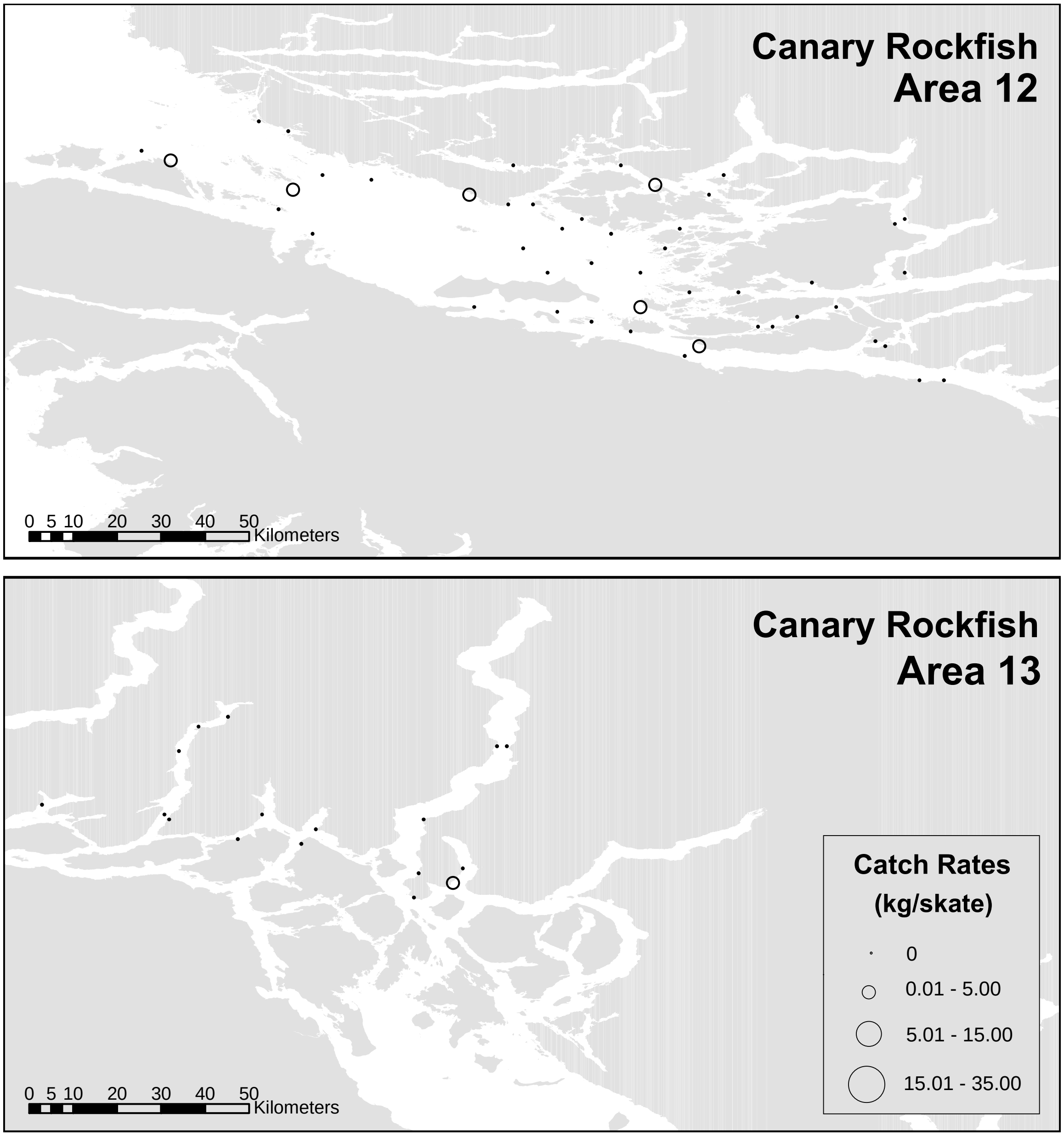


Figure 11. Spatial distribution of canary rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

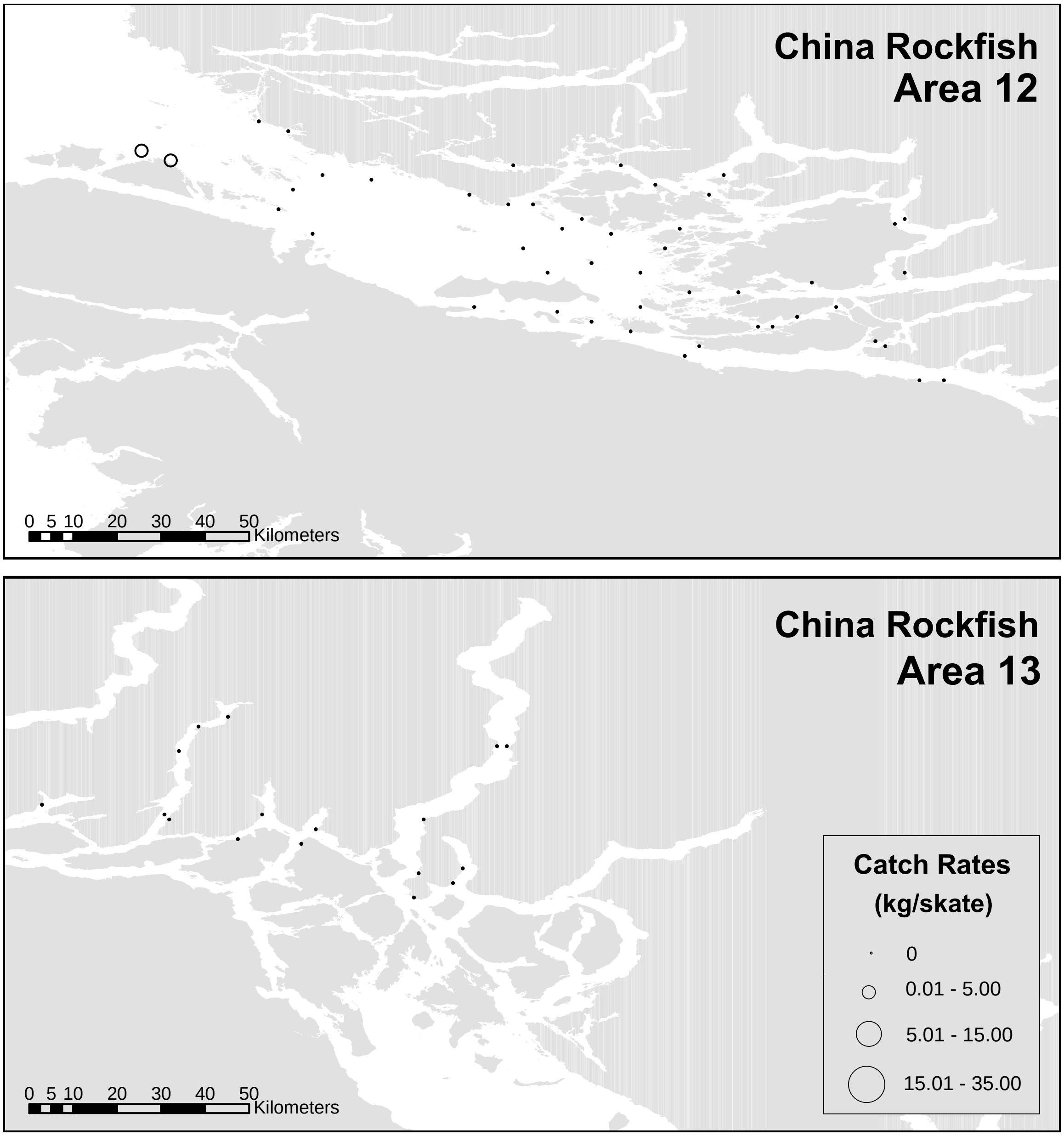


Figure 12. Spatial distribution of china rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

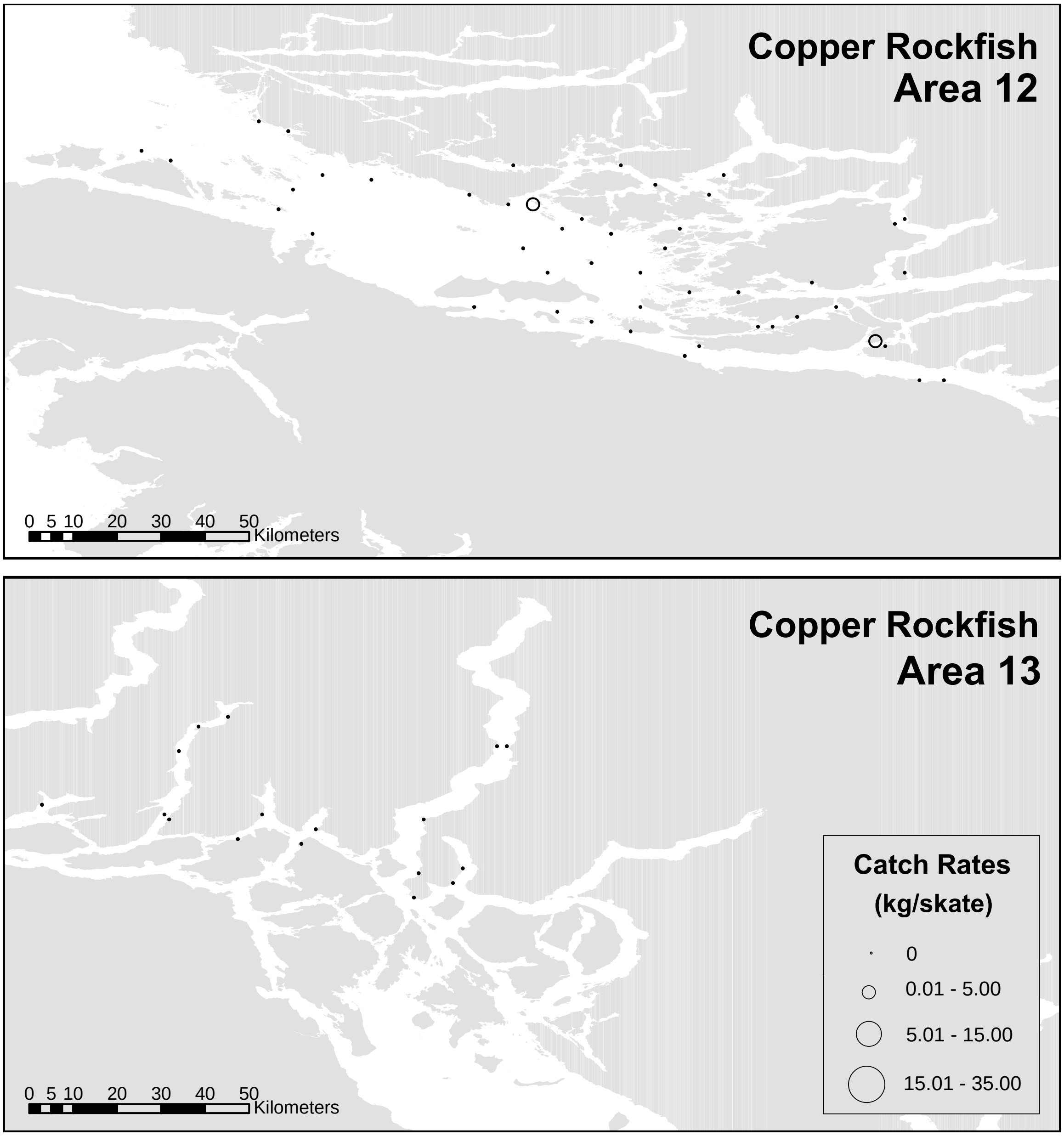


Figure 13. Spatial distribution of copper rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

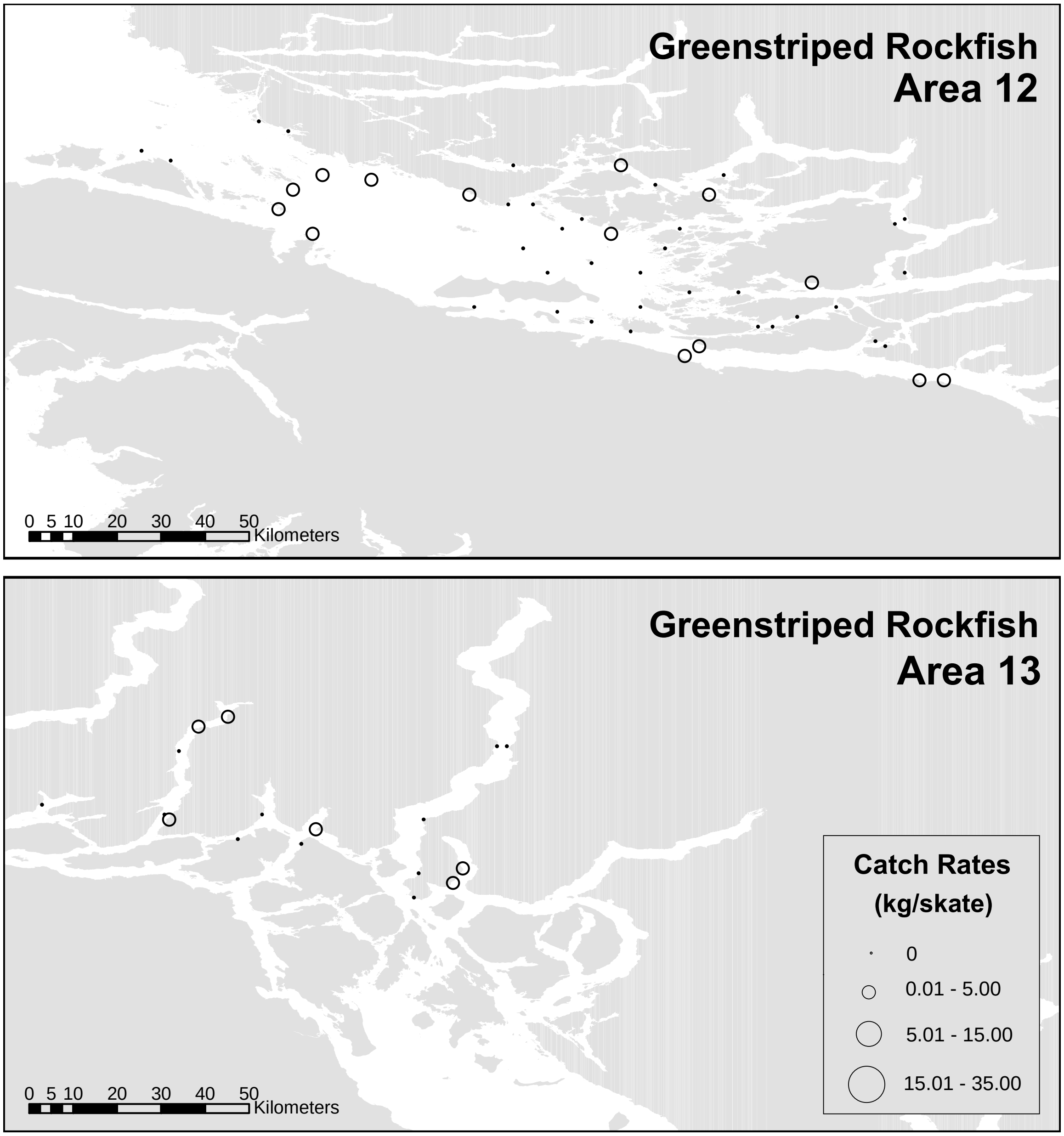


Figure 14. Spatial distribution of greenstriped rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

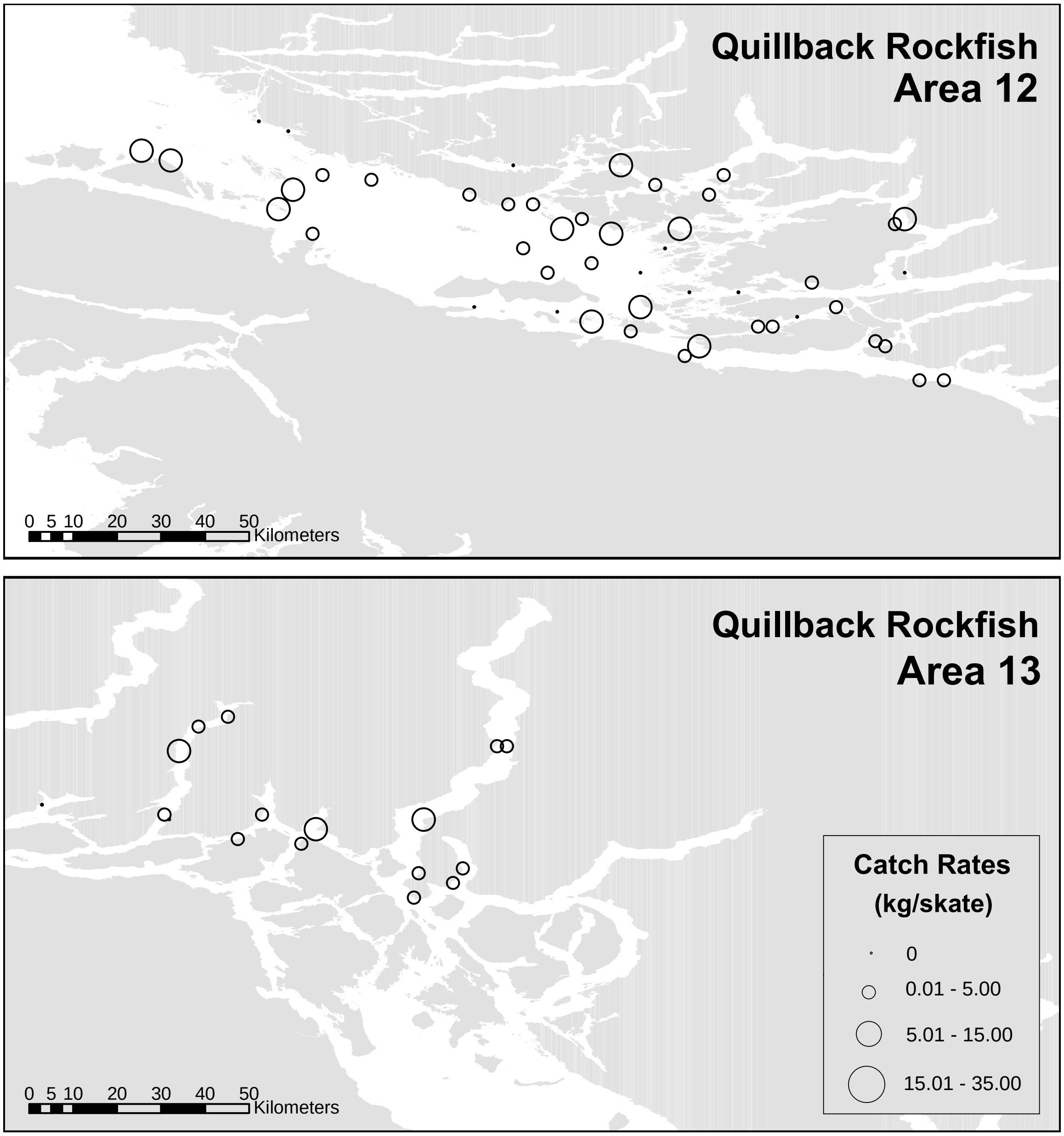
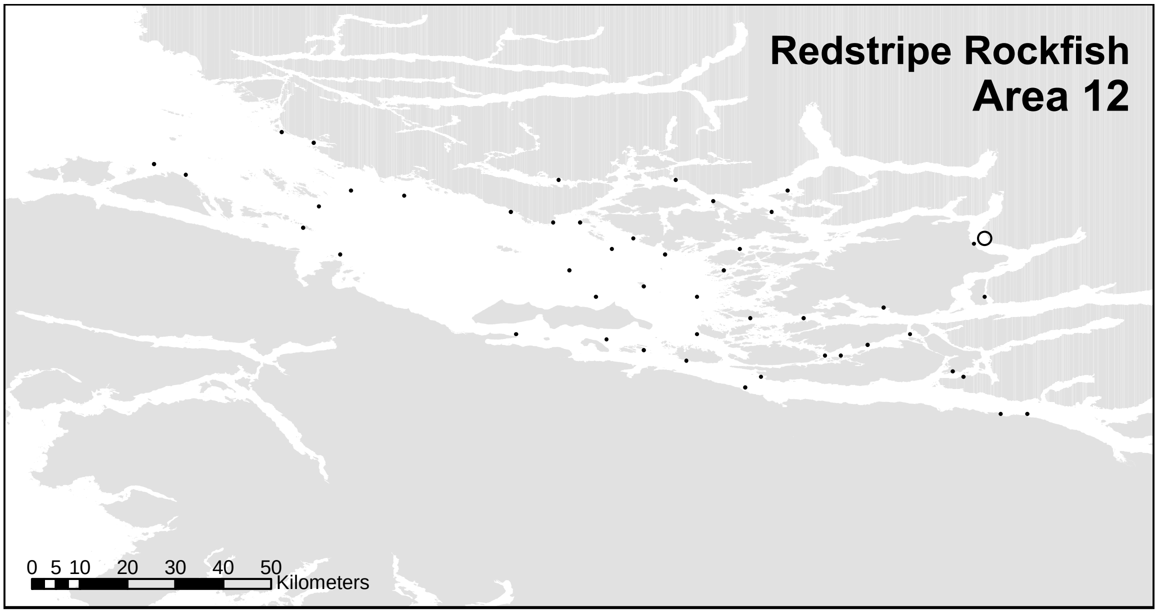


Figure 15. Spatial distribution of quillback rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).



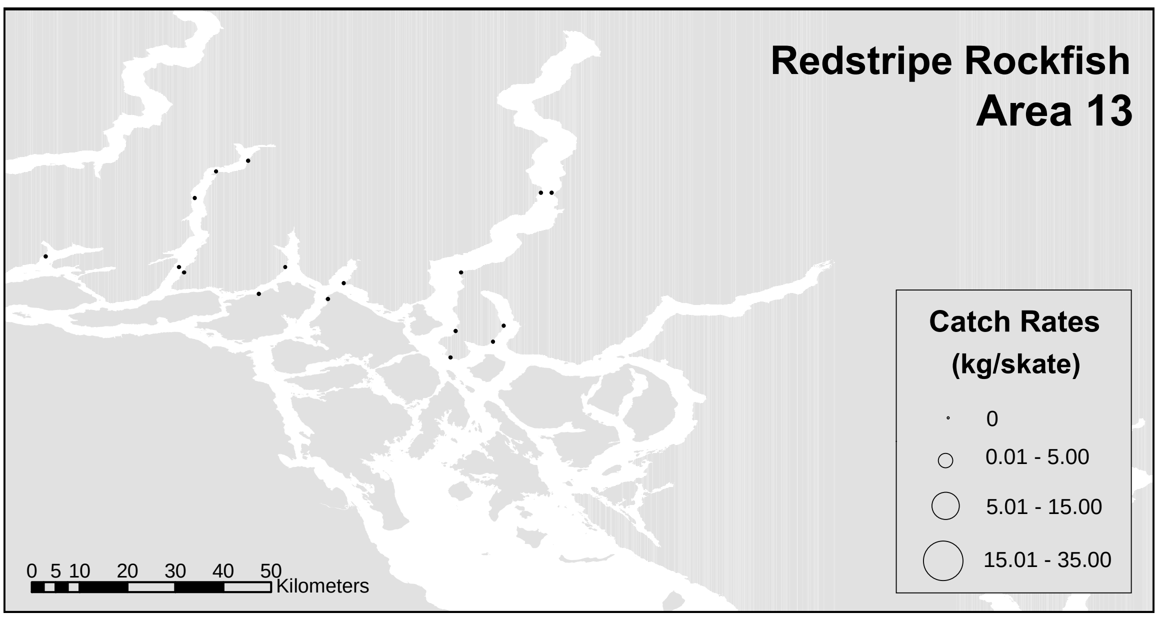


Figure 16. Spatial distribution of redstripe rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

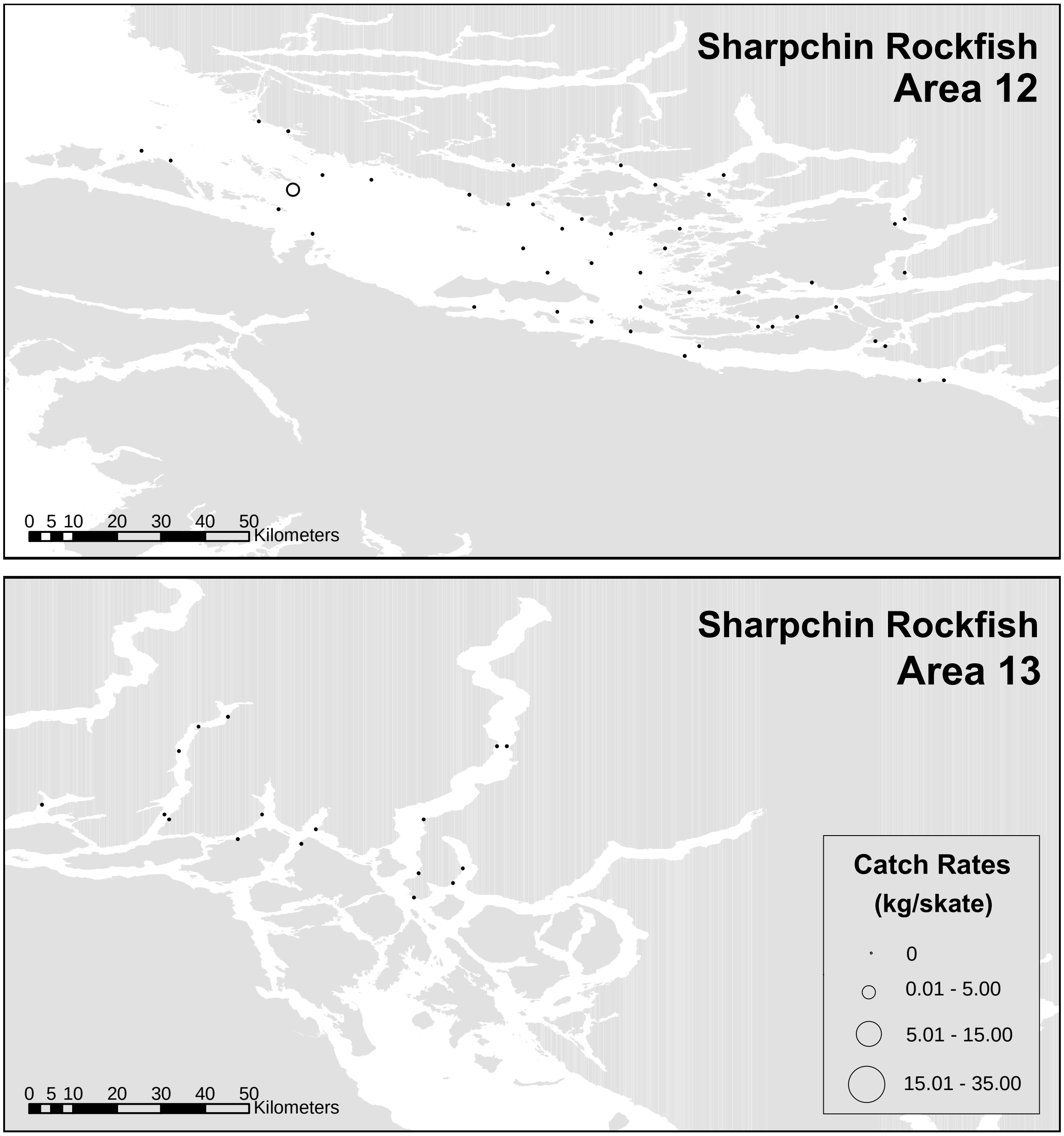


Figure 17. Spatial distribution of sharpchin rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

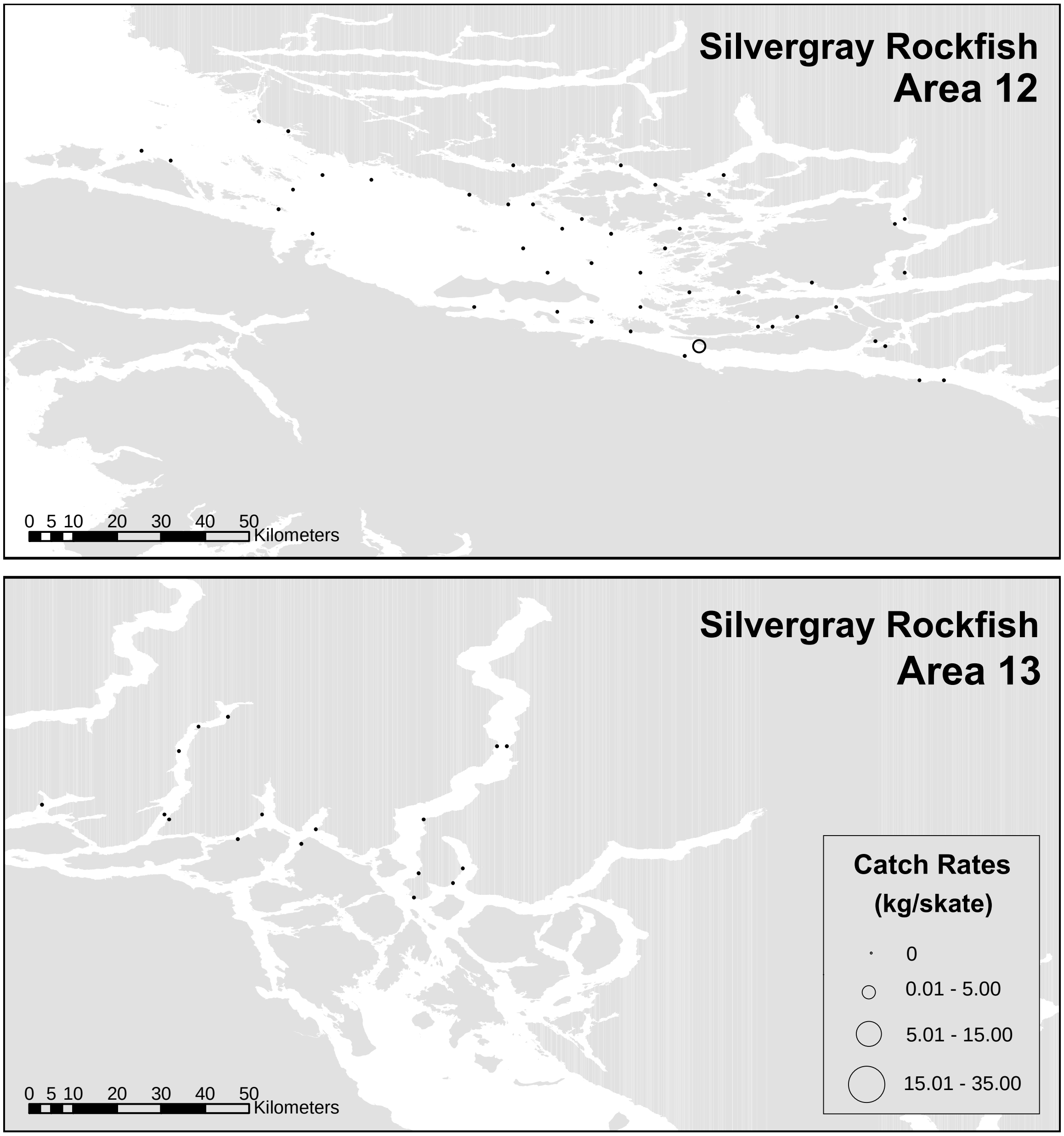


Figure 18. Spatial distribution of silvergray rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

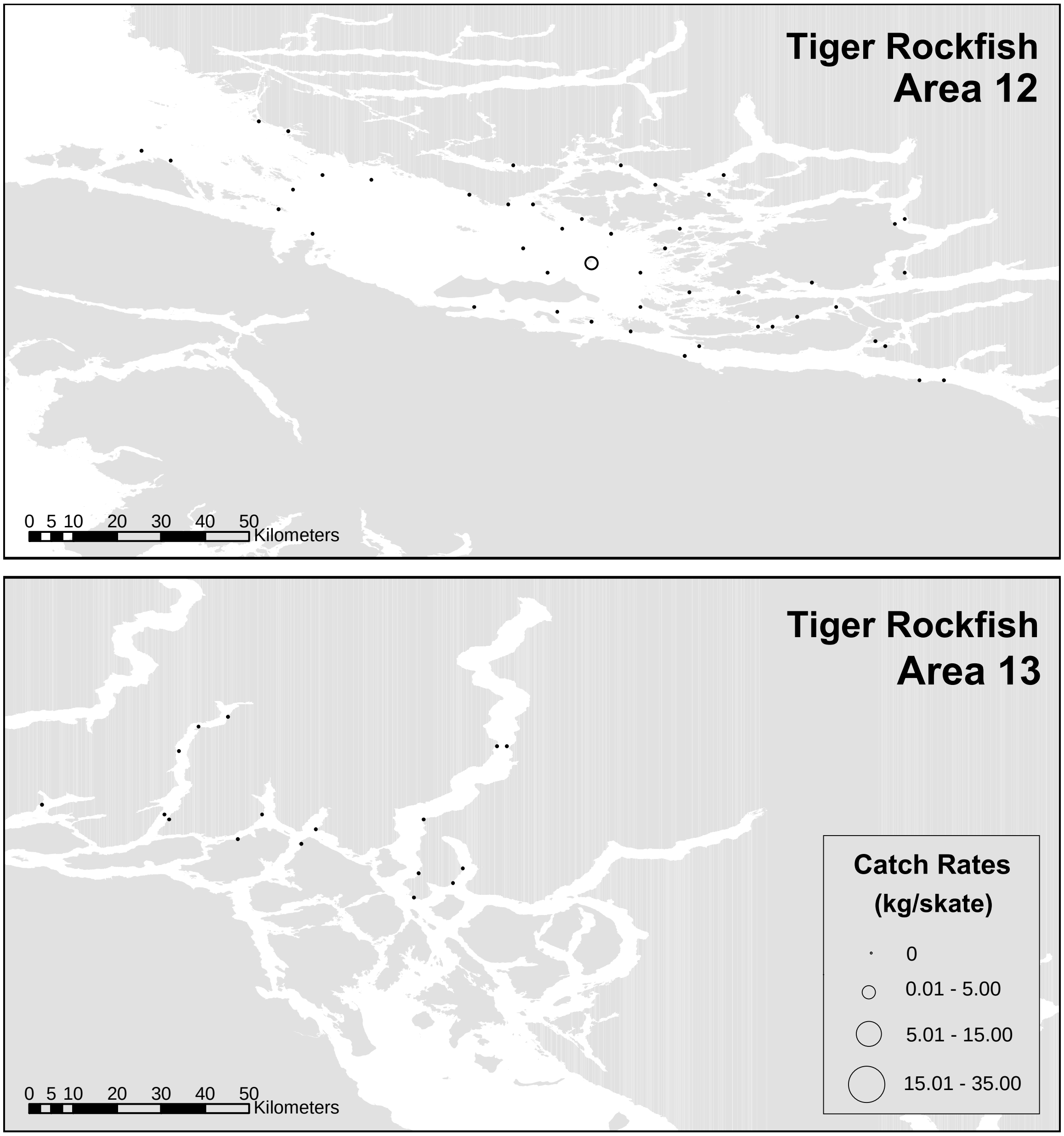


Figure 19. Spatial distribution of tiger rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

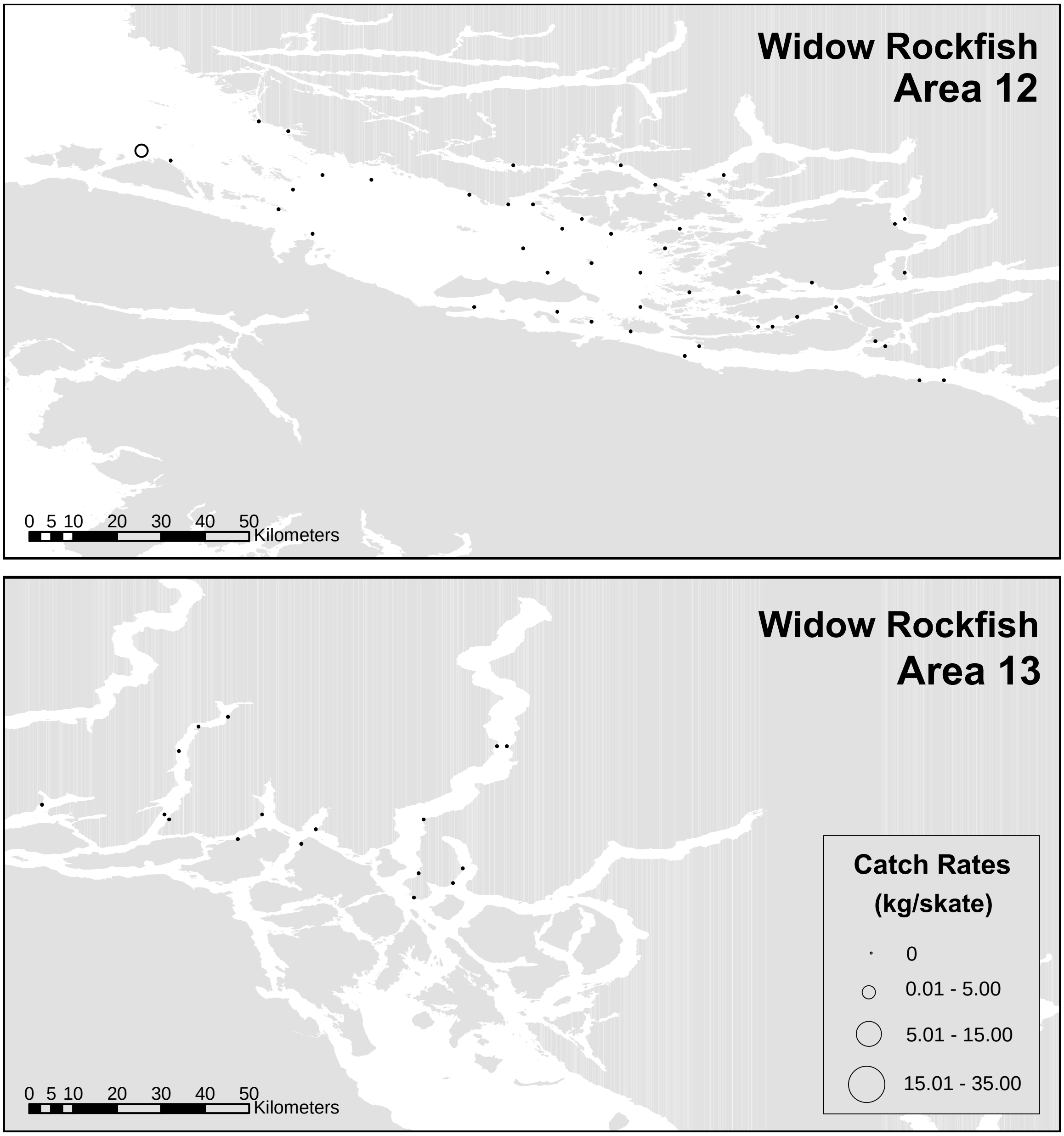


Figure 20. Spatial distribution of widow rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

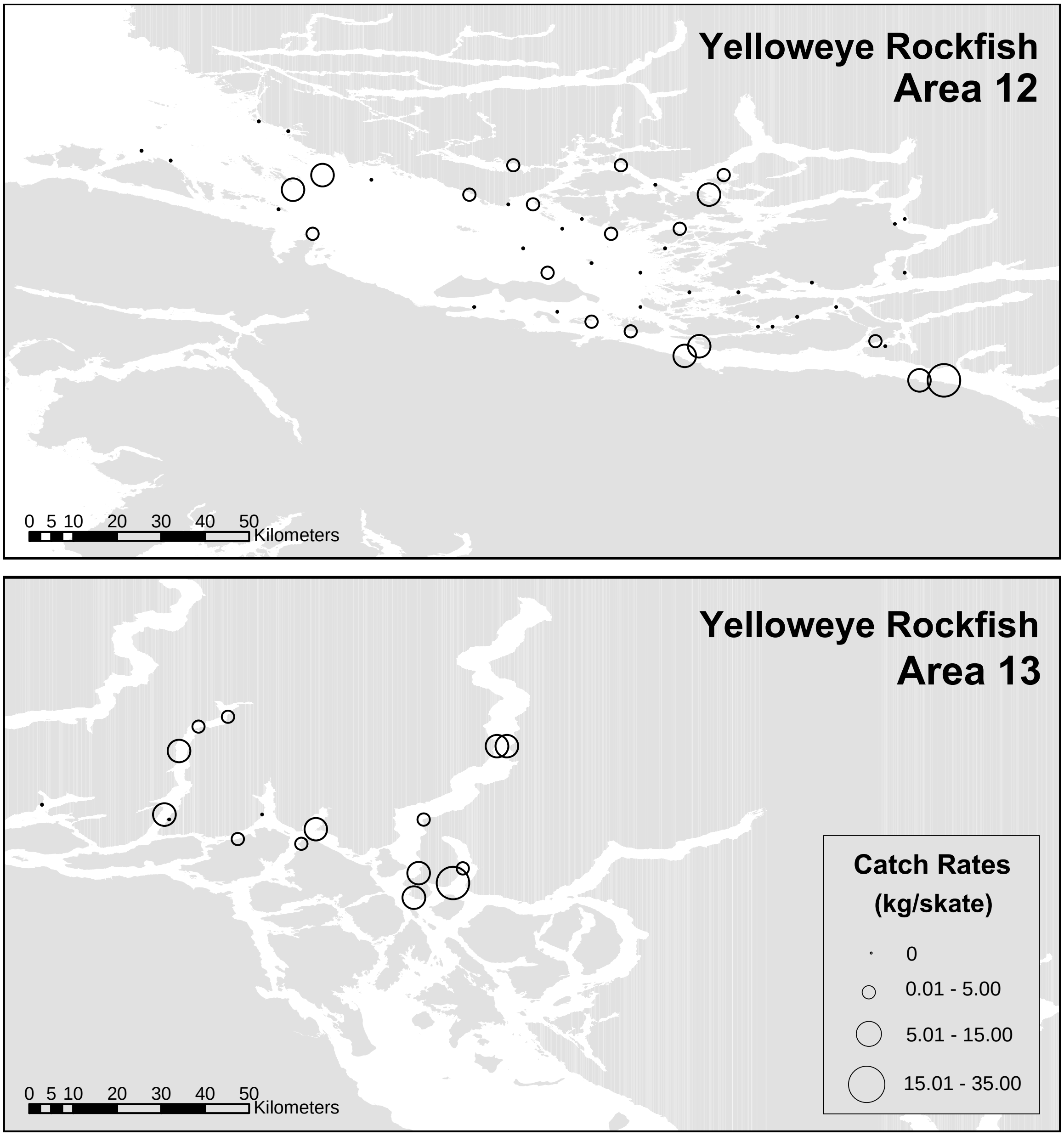


Figure 21. Spatial distribution of yelloweye rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

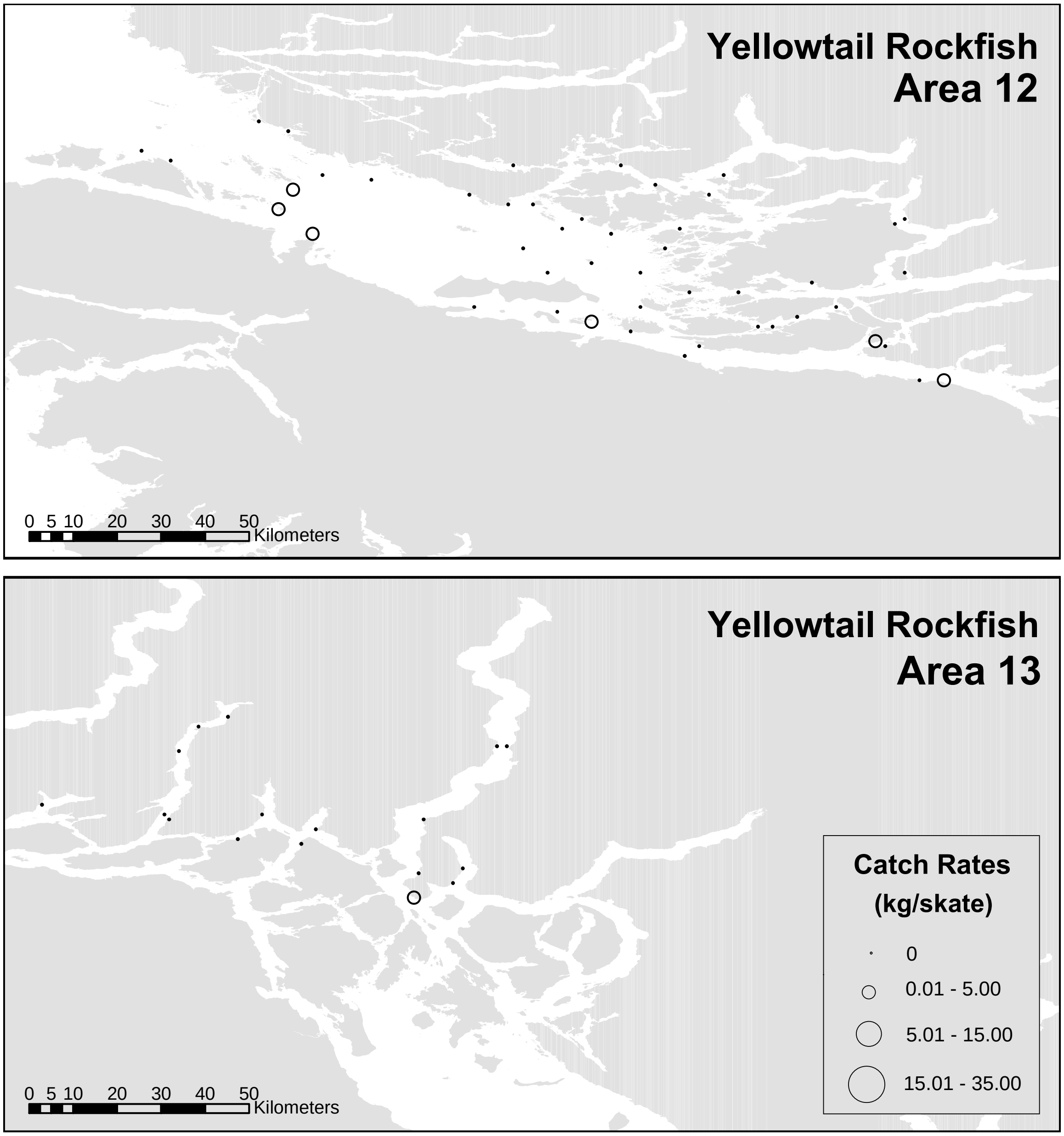


Figure 22. Spatial distribution of yellowtail rockfish catch rates in units of kilograms per skate for survey sites in SA 12 (top panel) and SA 13 (lower panel).

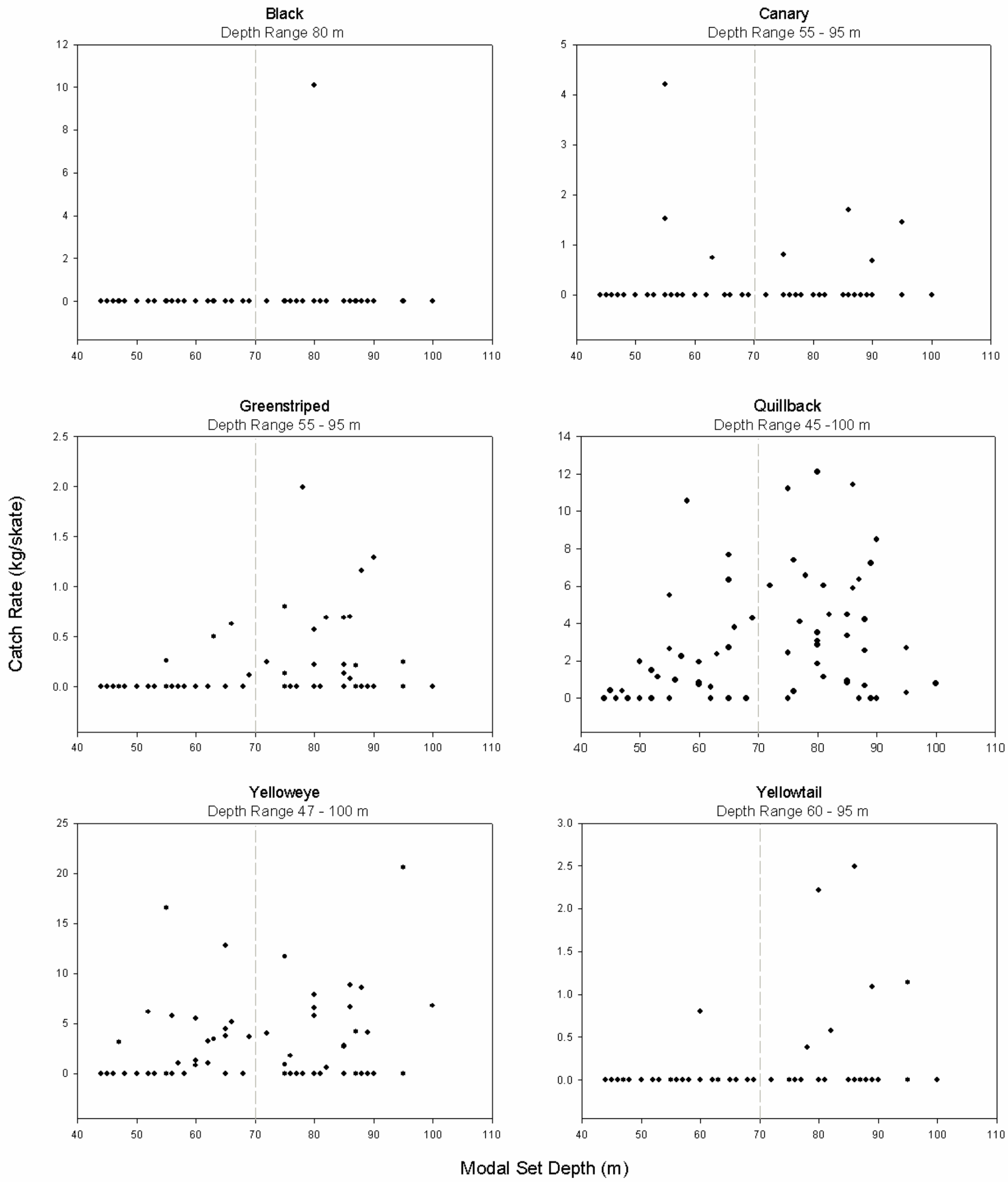


Figure 23. Relationships between catch rates (kg/skate) and modal set depth (m) for the six most frequently encountered rockfish on the survey. Depth ranges are for non-zero catch rates. The grey dotted line represents the boundary between the shallow stratum (41-70m) and the deep stratum (71-100m).

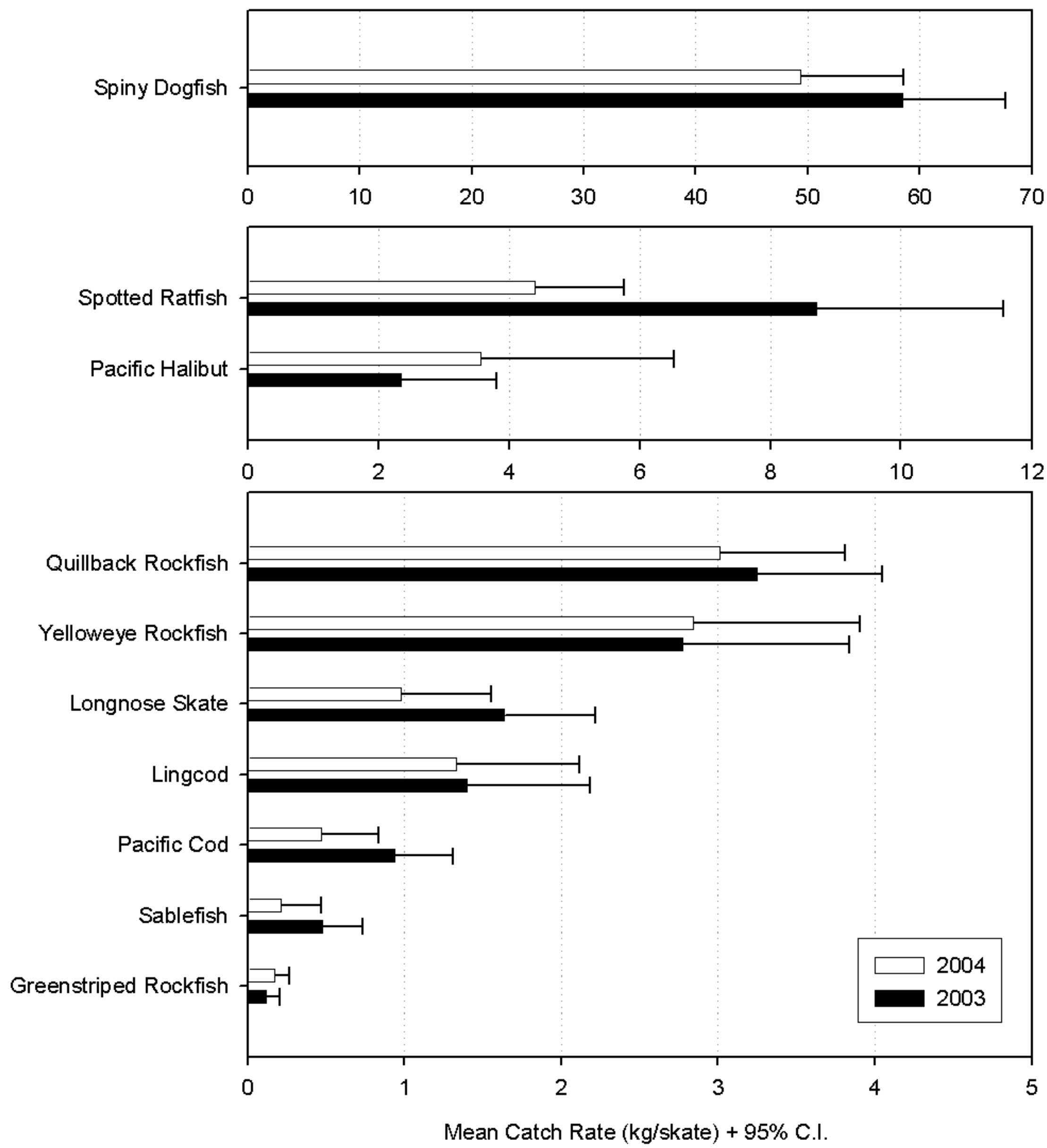


Figure 24. Mean catch rates (kg/skate) with 95% confidence intervals for the top ten most frequently encountered species on the 2003 and 2004 surveys.

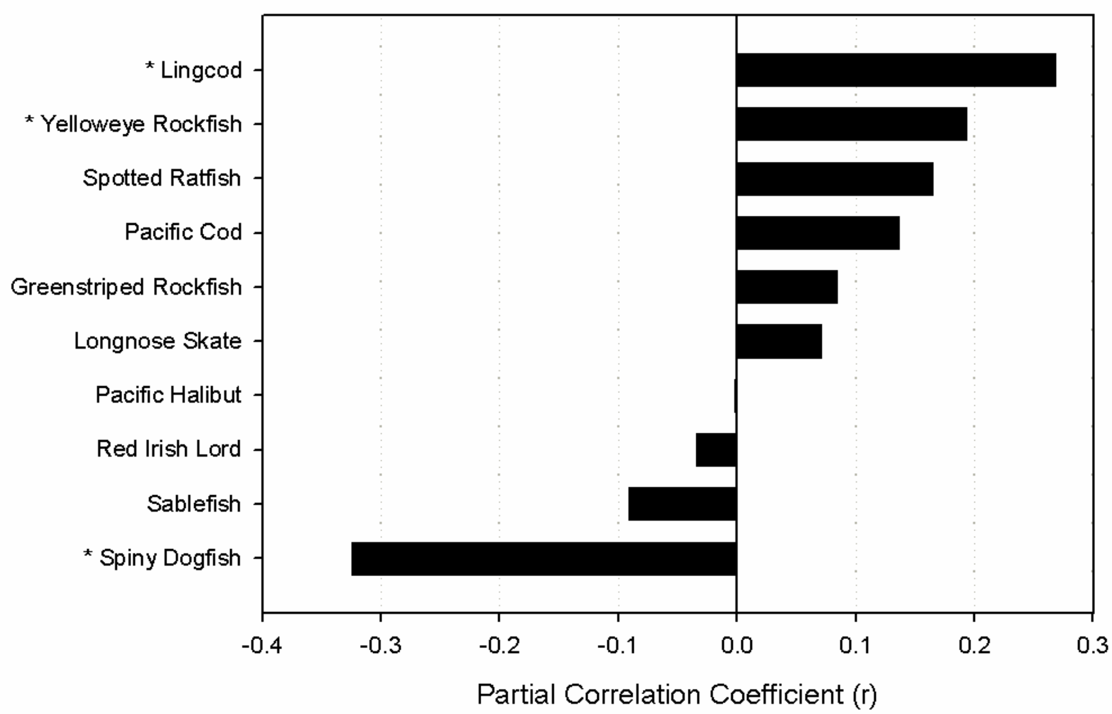


Figure 25. Partial correlation of quillback rockfish catch rates (kg/skate) with catch rates of the top ten most frequently encountered species on the surveys, controlled for modal set depth. Statistics were performed using data from the 2003 and 2004 surveys combined. Statistically significant partial correlation coefficients are labelled with an '*'.

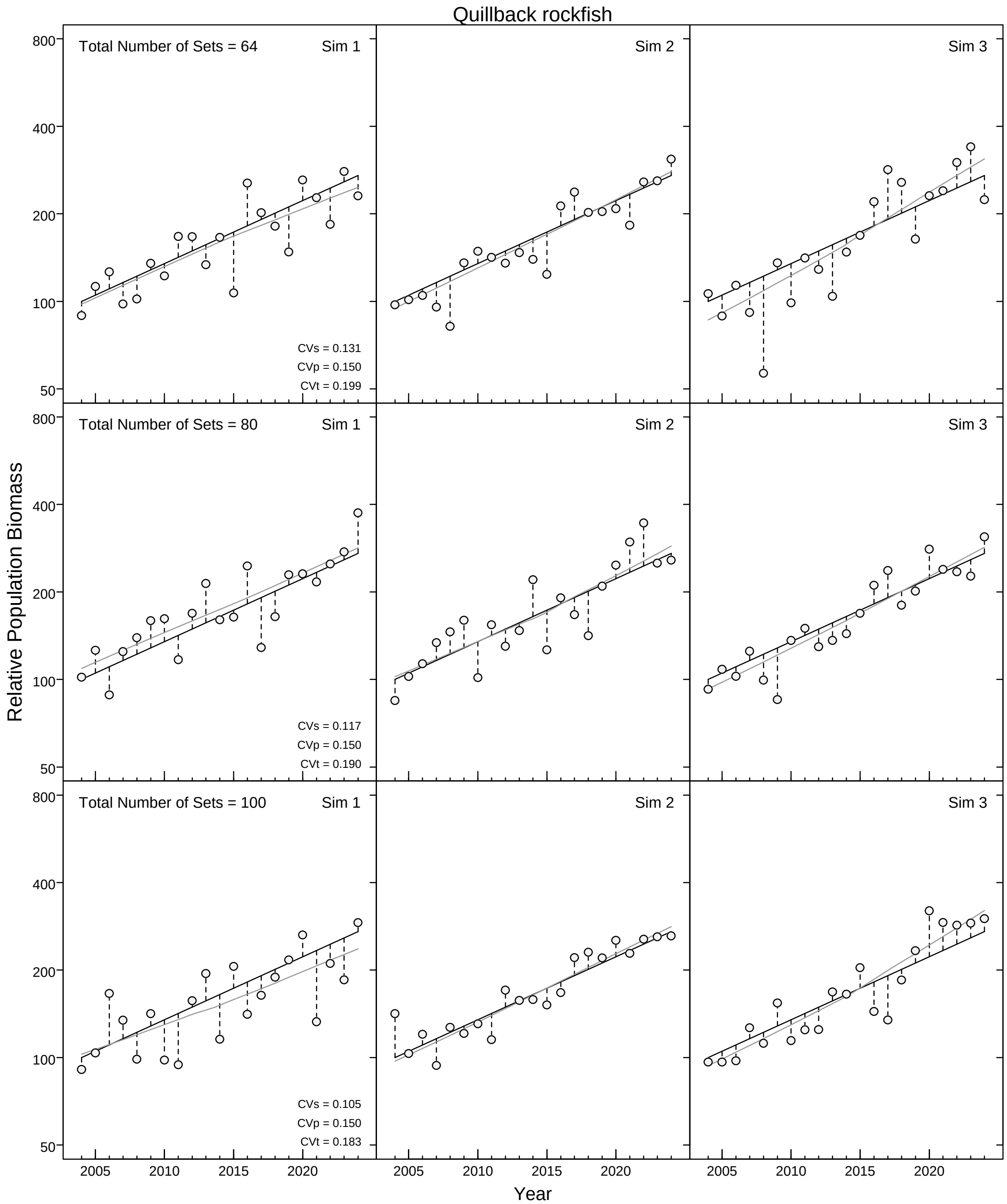


Figure 26. Quillback rockfish simulation results showing a 20-year projection of the relative population biomass. The known population density increases at 5% compounded per year and is shown as a black line. Biomass estimates are adjusted with a 15% random process error and are shown as circles. Departure of the biomass estimates are shown as a vertical dashed line and the loess fit of the simulated biomass estimates is shown as a grey line.

$$CVt = \sqrt{(CVs)^2 + (CVp)^2}$$

where CVt = the total coeffient of variation, CVs = the survey coefficient of variation, and CVp = 15% random process error.

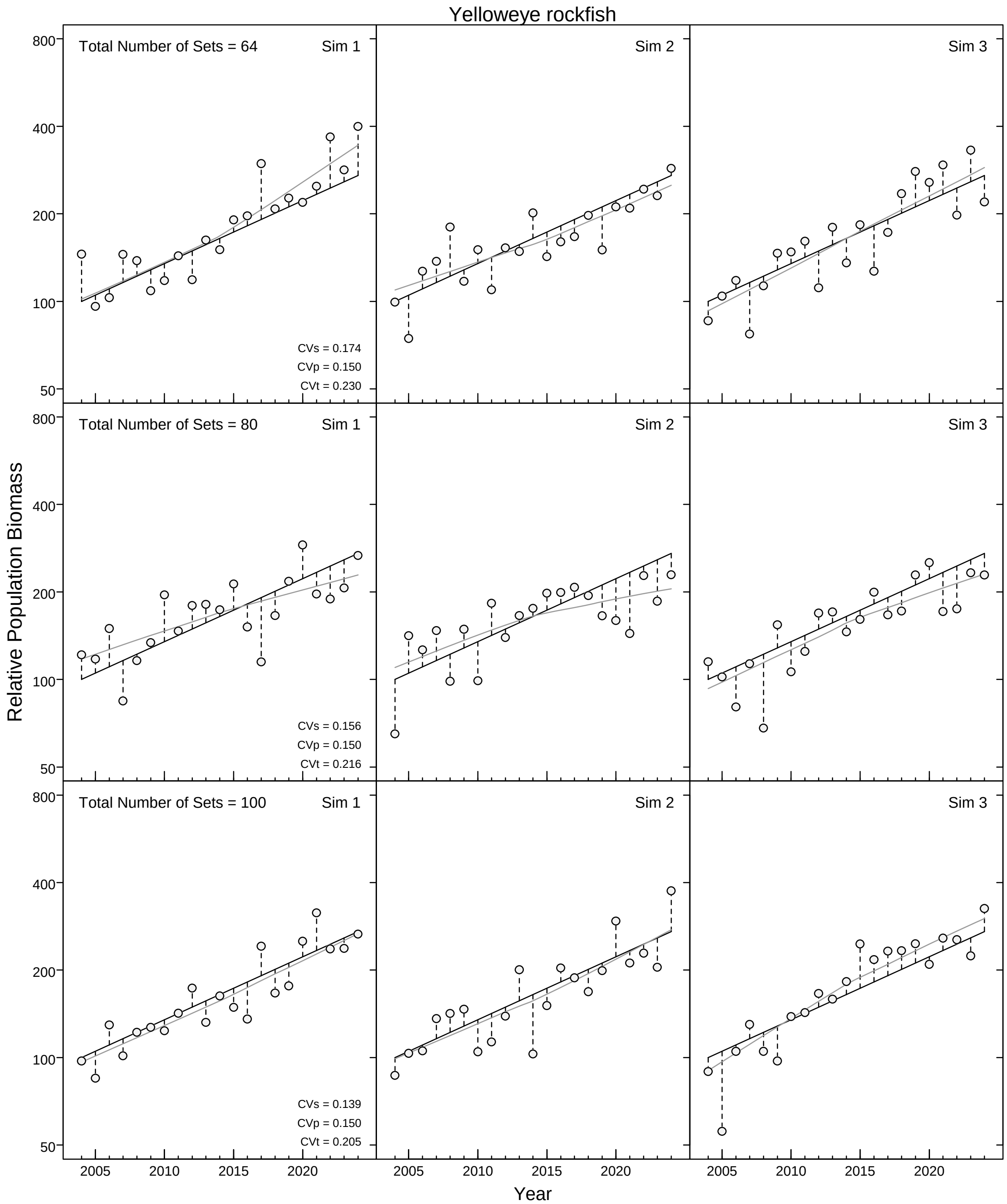


Figure 27. Yelloweye rockfish simulation results showing a 20-year projection of the relative population biomass. The known population density increases at 5% compounded per year and is shown as a black line. Biomass estimates are adjusted with a 15% random process error and are shown as circles. Departure of the biomass estimates are shown as a vertical dashed line and the loess fit of the simulated biomass estimates is shown as a grey line.

$$CVt = \sqrt{(CVs)^2 + (CVp)^2}$$

where CVt = the total coeffient of variation, CVs = the survey coefficient of variation, and CVp = 15% random process error.

Appendix A. Set Specifications.

Set #	Start Lattitude	Start Longitude	End Lattitude	End Longitude	Distance Travelled (km)	Modal Depth (m)	Min Depth (m)	Max Depth (m)	Begin Deployment Time	End Deployment Time	Begin Retrieval Time	End Retrieval Time	Soak Time (minutes)
1	50 61.40	127 07.93	50 61.53	127 09.30	*not recorded*	52	51	56	6:56:00 AM	7:06:00 AM	9:06:00 AM	9:31:00 AM	120
2	50 59.95	126 91.17	50 59.37	126 90.48	0.832	89	86	89	8:05:00 AM	8:12:00 AM	10:12:00 AM	10:33:00 AM	120
3	50 67.98	126 93.43	50 67.57	126 94.67	0.745	57	52	67	11:55:00 AM	12:06:00 PM	2:08:00 PM	2:30:00 PM	122
4	50 72.83	126 97.62	50 72.62	126 98.92	1.023	81	79	100	1:12:00 PM	1:22:00 PM	3:23:00 PM	3:41:00 PM	121
5	50 69.60	126 84.38	50 70.17	126 83.63	0.803	53	44	63	4:31:00 PM	4:40:00 PM	6:40:00 PM	6:58:00 PM	120
6	50 77.42	126 89.67	50 78.07	126 90.57	0.975	81	66	100	7:25:00 AM	7:34:00 AM	9:35:00 AM	9:55:00 AM	121
7	50 82.35	126 96.25	50 82.68	126 97.27	0.821	47	35	60	8:28:00 AM	8:37:00 AM	10:43:00 AM	11:09:00 AM	126
8	50 84.00	127 09.07	50 84.60	127 09.70	0.706	63	50	81	12:34:00 PM	12:42:00 PM	2:44:00 PM	3:04:00 PM	122
9	50 81.78	127 00.75	50 81.23	127 01.38	0.763	88	75	94	1:51:00 PM	1:58:00 PM	3:59:00 PM	4:18:00 PM	121
10	50 90.28	127 00.13	50 90.22	127 01.33	0.884	62	48	68	5:41:00 PM	5:49:00 PM	7:49:00 PM	8:12:00 PM	120
11	50 87.40	127 28.78	50 87.63	127 29.92	0.666	85	61	96	8:21:00 AM	8:30:00 AM	10:30:00 AM	10:52:00 AM	120
12	50 88.50	127 39.48	50 88.05	127 38.67	0.794	66	56	89	9:11:00 AM	9:21:00 AM	11:21:00 AM	11:43:00 AM	120
13	50 84.57	127 44.93	50 85.15	127 45.72	0.850	86	83	101	12:51:00 PM	12:59:00 PM	2:59:00 PM	3:20:00 PM	120
14	50 80.78	127 48.23	50 80.42	127 47.42	0.743	78	49	78	1:40:00 PM	1:49:00 PM	3:52:00 PM	4:13:00 PM	123
15	50 75.63	127 41.37	50 75.17	127 40.67	0.631	82	62	90	4:42:00 PM	4:50:00 PM	6:50:00 PM	7:11:00 PM	120
16	50 92.70	127 75.83	50 93.32	127 76.80	1.016	80	67	83	7:14:00 AM	7:22:00 AM	9:22:00 AM	9:44:00 AM	120
17	50 90.77	127 70.12	50 91.60	127 71.25	1.223	55	46	69	8:05:00 AM	8:15:00 AM	10:24:00 AM	10:47:00 AM	129
18	50 98.62	127 51.97	50 98.25	127 50.78	0.937	75	71	77	11:58:00 AM	12:07:00 PM	2:05:00 PM	2:27:00 PM	118
19	50 96.97	127 46.20	50 97.35	127 47.32	0.907	65	62	69	12:55:00 PM	1:03:00 PM	3:02:00 PM	3:25:00 PM	119
20	50 54.05	127 36.41	50 53.84	127 36.90	0.718	65	63	72	4:13:00 PM	4:20:00 PM		*Lost gear, no catch*	
21	50 75.97	126 80.47	50 76.58	126 81.60	1.156	87	64	100	9:08:00 AM	9:18:00 AM	11:18:00 AM	11:38:00 AM	120
22	50 79.17	126 85.62	50 78.50	126 85.37	0.952	77	64	88	10:10:00 AM	10:20:00 AM	12:22:00 PM	12:42:00 PM	122
23	50 72.87	126 68.57	50 73.30	126 69.63	0.904	46	43	52	1:37:00 PM	1:46:00 PM	3:46:00 PM	4:03:00 PM	120
24	50 76.83	126 66.27	50 77.02	126 67.57	0.965	76	64	83	2:31:00 PM	2:40:00 PM	4:46:00 PM	15:04:00 PM	126
25	50 89.82	126 78.32	50 89.90	126 79.67	0.970	72	65	82	8:02:00 AM	8:12:00 AM	10:12:00 AM	10:32:00 AM	120
26	50 85.60	126 71.48	50 86.13	126 70.37	0.981	95	45	118	9:05:00 AM	9:15:00 AM	11:15:00 AM	11:32:00 AM	120
27	50 87.88	126 56.60	50 87.62	126 57.82	0.915	85	46	100	12:31:00 PM	12:42:00 PM	2:42:00 PM	3:00:00 PM	120
28	50 84.45	126 60.17	50 84.97	126 61.23	0.962	80	68	95	1:32:00 PM	1:42:00 PM	3:42:00 PM	4:02:00 PM	120
29	50 58.07	126 84.10	50 57.52	126 84.98	0.882	89	62	115	7:47:00 AM	7:57:00 AM	9:52:00 AM	10:08:00 AM	115
30	50 55.85	126 75.88	50 56.13	126 77.15	0.973	62	60	72	8:52:00 AM	9:02:00 AM	11:02:00 AM	11:19:00 AM	120
31	50 52.55	126 61.60	50 52.67	126 62.78	0.945	75	64	84	2:34:00 PM	2:42:00 PM	4:42:00 PM	4:58:00 PM	120
32	50 50.65	126 65.07	50 50.13	126 63.97	0.977	88	73	97	3:30:00 PM	3:40:00 PM	5:41:00 PM	5:57:00 PM	121
33	50 65.80	126 39.17	50 65.28	126 38.18	1.014	85	68	88	7:16:00 AM	7:26:00 AM	9:25:00 AM	9:41:00 AM	119
34	50 78.52	126 19.57	50 79.35	126 19.62	0.963	58	52	86	11:24:00 AM	11:34:00 AM	1:34:00 PM	1:52:00 PM	120
35	50 78.23	126 22.03	50 78.88	126 22.67	0.863	88	75	95	12:05:00 PM	12:14:00 PM	2:15:00 PM	2:33:00 PM	121

Appendix A. Set Specifications (continued).

Set #	Start Lattitude	Start Longitude	End Lattitude	End Longitude	Distance Travelled (km)	Modal Depth (m)	Min Depth (m)	Max Depth (m)	Begin Deployment Time	End Deployment Time	Begin Retrieval Time	End Retrieval Time	Soak Time (minutes)
36	50 68.28	126 19.78	50 67.85	126 19.32	0.999	68	54	83	3:52:00 PM	4:01:00 PM	6:01:00 PM	6:18:00 PM	120
37	50 60.58	126 33.72	50 61.08	126 32.83	0.956	80	57	96	7:06:00 AM	7:16:00 AM	9:16:00 AM	9:34:00 AM	120
38	50 58.83	126 41.95	50 59.32	126 40.88	0.948	55	52	61	8:00:00 AM	8:10:00 AM	10:10:00 AM	10:25:00 AM	120
39	50 57.13	126 49.75	50 57.53	126 48.57	0.932	50	36	54	10:59:00 AM	11:10:00 AM	1:10:00 PM	1:25:00 PM	120
40	50 56.90	126 47.20	50 56.83	126 46.92	0.990	56	42	74	11:56:00 AM	12:08:00 PM	2:08:00 PM	2:25:00 PM	120
41	50 61.30	126 73.98	50 60.83	126 72.97	0.888	90	42	92	7:29:00 AM	7:39:00 AM	9:39:00 AM	9:55:00 AM	120
42	50 68.28	126 74.10	50 65.98	126 73.45	0.845	87	86	92	8:26:00 AM	8:35:00 AM	10:35:00 AM	10:51:00 AM	120
43	50 63.97	126 64.05	50 63.90	126 62.75	0.914	48	35	55	11:30:00 AM	11:40:00 AM	1:39:00 PM	1:55:00 PM	119
44	50 64.50	126 54.08	50 64.37	126 55.38	0.956	44	41	49	12:23:00 PM	12:33:00 PM	2:33:00 PM	2:47:00 PM	120
45	50 53.22	126 24.23	50 53.37	126 22.83	1.022	45	42	52	6:38:00 AM	6:49:00 AM	8:49:00 AM	9:05:00 AM	120
46	50 53.62	126 25.52	50 53.52	126 26.70	0.916	60	43	63	7:25:00 AM	7:37:00 AM	9:37:00 AM	9:53:00 AM	120
47	50 45.93	126 16.75	50 45.83	126 15.50	0.931	80	68	107	10:49:00 AM	10:59:00 AM	12:58:00 PM	1:18:00 PM	119
48	50 45.93	126 12.50	50 46.00	126 13.83	0.952	95	74	114	11:29:00 AM	11:41:00 AM	1:41:00 PM	1:57:00 PM	120
49	50 50.92	125 83.42	50 50.15	125 84.03	0.973	50	41	54	3:21:00 PM	3:32:00 PM	5:32:00 PM	5:59:00 PM	120
50	50 48.22	125 57.48	50 48.95	125 56.92	0.973	90	76	95	7:10:00 AM	7:22:00 AM	9:22:00 AM	9:37:00 AM	120
51	50 49.47	125 58.48	50 50.27	125 57.98	0.975	100	63	112	7:58:00 AM	8:09:00 AM	10:10:00 AM	10:31:00 AM	121
52	50 68.87	125 45.35	50 69.65	125 45.07	0.944	75	41	84	11:56:00 AM	12:07:00 PM	2:06:00 PM	2:21:00 PM	119
53	50 66.95	125 50.72	50 67.02	125 49.48	0.929	69	46	87	12:51:00 PM	1:02:00 PM	3:02:00 PM	3:16:00 PM	120
54	50 61.93	125 55.43	50 61.20	125 55.55	0.846	65	45	94	3:48:00 PM	3:59:00 PM	6:01:00 PM	6:18:00 PM	122
55	50 44.30	125 42.57	50 44.85	125 41.42	1.040	65	55	89	7:00:00 AM	7:10:00 AM	9:10:00 AM	9:26:00 AM	120
56	50 48.53	125 37.78	50 49.33	125 37.55	0.882	76	68	78	7:51:00 AM	8:02:00 AM	10:03:00 AM	10:20:00 AM	121
57	50 43.28	125 30.43	50 43.93	125 29.77	0.922	60	37	84	10:55:00 AM	11:07:00 AM	1:06:00 PM	1:22:00 PM	119
58	50 45.90	125 27.42	50 46.47	125 25.02	0.975	86	81	102	11:54:00 AM	12:05:00 PM	2:05:00 PM	2:23:00 PM	120
59	50 48.00	125 05.35	50 46.70	125 04.32	0.855	65	43	98	4:31:00 PM	4:41:00 PM	6:41:00 PM	6:55:00 PM	120
60	50 63.15	124 90.08	50 62.40	124 90.63	0.913	52	38	70	7:19:00 AM	7:32:00 AM	9:31:00 AM	9:46:00 AM	119
61	50 62.57	124 87.62	50 61.98	124 87.05	0.799	60	51	155	8:06:00 AM	8:17:00 AM	10:17:00 AM	10:32:00 AM	120
62	50 37.28	125 05.62	50 38.08	125 05.88	0.952	56	46	102	12:21:00 PM	12:32:00 PM	2:31:00 PM	2:47:00 PM	119
63	50 31.98	125 07.08	50 32.37	125 08.18	0.923	80	37	120	1:22:00 PM	1:35:00 PM	3:33:00 PM	3:48:00 PM	118
64	50 35.03	124 99.30	50 35.70	124 98.48	0.955	55	50	69	7:08:00 AM	7:20:00 AM	9:20:00 AM	9:54:00 AM	120
65	50 38.00	124 96.90	50 38.85	124 97.45	1.029	85	50	95	7:45:00 AM	7:58:00 AM	10:12:00 AM	10:28:00 AM	134

Appendix B. Description of Beaufort scale sea state categories.

Beaufort Scale	Description
0	Calm, winds <1 knot, sea like mirror
1	Light air, winds 1 - 3 knots, ripples, no foam crests
2	Light breeze, winds 4 - 6 knots, small wavelets
3	Gentle breeze, winds 7 - 10 knots, cress breaking
4	Moderate breeze, winds 11 - 16 knots, whitecaps
5	Fresh breeze, winds 17 - 21 knots, moderate waves-spray
6	Strong breeze, winds 22 - 27 knots, large waves
7	Moderate gale, winds 28 - 33 knots, sea heaps up
8	Fresh gale, winds 34 - 40 knots, moderately high waves
9	Strong gale, winds 41 - 47 knots, high waves, spray
10	Whole gale, winds 48 - 55 knots, overhanging crests, sea white
11	Storm, winds 56 - 63 knots, exceptionally high waves
12	Hurricane, winds 64 - 118 knots, sea white