Fisheries and Oceans Science | Pêches et Océans Sciences

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Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2001/148 | **Document de recherche 2001/148**

Preliminary status report on bocaccio (*Sebastes paucispinis*)

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ISSN 1480-4883
Ottawa, 2001

Canada

Abstract

Bocaccio is one of over 35 species of rockfish found in marine waters of British Columbia (BC). It is distinguished from other rockfish (*Sebastes* spp.) by its large jaw and size. It ranges in colour from olive orange to burnt orange or brown on the back becoming pink to red on the underside. Other common names for bocaccio include rock salmon, salmon rockfish, Pacific red snapper, Pacific snapper, and Oregon snapper. Bocaccio are found in coastal waters of the eastern Pacific Ocean from the Gulf of Alaska to Baja California, Mexico. Most BC catches come from the outer Pacific coast near the edge of the continental shelf, with the largest catches coming from the northwest end of Vancouver Island and Queen Charlotte Sound. They are occasionally reported from some inlets and the Strait of Georgia.

In California, larval bocaccio have been caught up to 480 km from the coast. Young of the year reside near the surface for a few months then settle in nearshore areas where they form schools and are found over bottom depths of 30-120 m. Adult bocaccio can be semi-pelagic and are found over a variety of bottom types, between bottom depths of 60-200 m. In BC they are caught with several other groundfish species including Pacific ocean perch, yellowtail rockfish, and canary rockfish.

Bocaccio are live-bearers like all members of their genus. Fecundity ranges from 20,000-2,300,000 eggs and increases with the size of the female. Copulation occurs in early fall, young are released in the winter. Settlement to the littoral and demersal habitat extends from late spring through the summer. Bocaccio are thought to mature at 4 to 5 years of age and can reach a weight of almost 7 kg and a length of over 90 cm. Females tend to be larger than males. Maximum age is unknown but radiometric dating of the ear-bones has indicated a maximum of 40 years.

Juvenile bocaccio feed on larvae, euphausiids, young rockfish, surfperch, mackerel and various small inshore fishes. Adult bocaccio prey on other rockfish, sablefish, anchovies, lanternfish and squids. Bocaccio are host to a number of parasites including a myxosporean that occurs in the muscle tissue and has given bocaccio a market reputation for “worminess”. Bocaccio may also be the only host for one species of tapeworm.

The abundance of bocaccio is unknown in BC waters. Its low commercial importance has resulted in no directed research, and the low catches of bocaccio in the fisheries limit the utility of fishery-dependent data for tracking abundance. Catches do indicate that the population is present in all coastal waters at the edge of the continental shelf. The distribution in inshore waters is unknown, however, bocaccio continue to be reported from several inlets as well as the Strait of Georgia. The abundance trend is unknown for the outer north coast where bocaccio have never been caught in large numbers, but appears stable for the central coast. It has possibly declined off the west coast of Vancouver Island over the last two decades but it appears stable over the last five years.

Current commercial catches of bocaccio in BC are low. Sport and First Nations catches are probably negligible. The commercial harvests in the Strait of Georgia are also negligible, if not zero. The population of bocaccio in BC is probably continuous with populations in Washington State. Therefore, harvests in waters off Washington likely have an impact on the regional population of bocaccio in BC. However, U.S. landings are now negligible due to restrictive trip limits.

There are no means for ascertaining the impact of the two parasites on bocaccio abundance and distribution over time. Nor is there information on how other types of environmental change may influence bocaccio populations. We know of no special economic, cultural or ecosystem significance of bocaccio. It may be the unique host for the adult phase of one species of tapeworm, however, the presence of this tapeworm in BC waters has not yet been documented. We are not aware of any special cultural or legal status afforded to this species in Canadian waters.

Résumé

Le bocaccio compte parmi les plus de 35 espèces de sébaste retrouvées dans les eaux marines de la Colombie-Britannique. Il se distingue des autres sébastes (*Sebastes* sp.) par sa grosse mâchoire et sa grande taille. Le dos va du orange olive au orange brûlé ou brun, pâlissant pour devenir rose à rouge sur le ventre. Ce sébaste porte le même nom commun en anglais, quoiqu'il soit aussi connu sous le nom de rock salmon, salmon rockfish, Pacific red snapper, Pacific snapper et Oregon snapper. Le bocaccio fréquente les eaux côtières du secteur est de l'océan Pacifique, du golfe de l'Alaska à la Basse-Californie, au Mexique. La plus grande partie des prises issues des eaux de la Colombie-Britannique proviennent des eaux extérieures du Pacifique gisant près de l'accore de la plate-forme continentale, les prises les plus fortes étant issues de l'extrémité nord-ouest de l'île de Vancouver et du bassin Reine-Charlotte. L'espèce est signalée de temps à autre dans certains inlets et le détroit de Georgia.

En Californie, des larves de bocaccio ont été capturées jusqu'à 480 km des côtes. Les jeunes de moins d'un an restent dans les eaux de surface pendant quelques mois, puis migrent vers les eaux semi-hauturières de 30 à 120 m de profondeur, où ils se rassemblent en bancs. Les adultes peuvent être semi-pélagiques, fréquentant une gamme de fonds allant de 60 à 200 m de profondeur. Le bocaccio est capturé dans les eaux de la Colombie-Britannique en compagnie de plusieurs autres espèces de poisson de fond, dont le sébaste à longue mâchoire, le sébaste à queue jaune et le sébaste canari.

Le bocaccio est vivipare comme tous les membres du même genre. La femelle peut produire de 20 000 à 2 300 000 oeufs selon sa taille. L'accouplement a lieu au début de l'automne et les jeunes sont libérés en hiver. Ils descendent sur le fond dans les eaux littorales et démersales de la fin du printemps jusqu'à la fin de l'été. On croit que le bocaccio atteint la maturité à l'âge de 4 ou 5 ans. Il peut peser jusqu'à 7 kg et mesurer plus de 90 cm de longueur. Les femelles ont tendance à être plus grosses que les mâles. On ne connaît pas son âge maximal, mais la datation isotopique des otolithes a révélé un maximum de 40 ans.

Les juvéniles se nourrissent de larves, d'euphausiacés, de jeunes sébastes, de ditrèmes et de maquereaux, ainsi que de divers petits poissons côtiers. Les adultes font leurs proies d'autres sébastes, de la morue charbonnière, d'anchois, de lanternes et de calmars. Le bocaccio est l'hôte de plusieurs parasites, dont une myxosporidie qui attaque les tissus musculaires, donnant à ce poisson la réputation sur les marchés d'être « verreux ». Il peut aussi être l'hôte unique d'un cestode.

L'abondance du bocaccio dans les eaux de la Colombie-Britannique est inconnue. Sa faible importance commerciale fait qu'il n'a jamais été l'objet de recherches dirigées et les prises faibles limitent l'utilité des données sur la pêche pour suivre l'évolution de l'abondance. Les prises révèlent toutefois que l'espèce est présente dans toutes les eaux côtières au niveau de l'accore de la plate-forme continentale. La distribution de l'espèce dans les eaux côtières est inconnue, bien qu'elle soit signalée dans plusieurs

inlets ainsi que dans le détroit de Georgia. L'abondance dans les eaux extérieures de la côte nord, où le bocaccio n'a jamais été capturé en grand nombre, est inconnue, mais elle semble stable sur la côte centrale. Elle a peut-être diminué sur la côte ouest de l'île de Vancouver au cours des deux dernières décennies, mais elle semble stable depuis cinq ans.

En ce moment, les prises commerciales de bocaccio en Colombie-Britannique sont faibles, alors que les prises sportives et autochtones sont probablement négligeables. Les prises commerciales dans le détroit de Georgia sont de même négligeables, sinon nulles. La population de bocaccio de la Colombie-Britannique et les populations de l'État de Washington étant probablement continues, les prises réalisées sur les côtes américaines ont probablement une incidence sur la population canadienne. Par contre, les débarquements américains sont négligeables à l'heure actuelle en raison des limites de prises par sortie.

Il n'existe aucun moyen d'établir avec précision les incidences des deux parasites sur l'abondance et la distribution du bocaccio au fil du temps. Nous ne possédons en outre aucun renseignement sur l'incidence d'autres modifications de l'environnement sur les populations de bocaccio et nous ne lui connaissons aucune importance particulière au plan économique, culturel ou écosystémique. Il est peut-être l'unique hôte de la phase adulte d'une espèce de cestode, mais la présence de ce dernier dans les eaux de la province n'a pas encore été documentée. À ce que nous sachions, aucun statut légal ou culturel particulier n'a été conféré au bocaccio retrouvé dans les eaux canadiennes.

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SPECIES INFORMATION

Bocaccio (*Sebastes paucispinis* Ayres, 1854) is a member of the order Scorpaeniformes and family Scorpaenidae. It is one of over 60 species of rockfish (*Sebastes* spp.) known to occur on the Pacific coast of North America (Eschmeyer *et al.* 1983). It is one of at least 35 species known to occur in British Columbia (BC) waters (Graham Gillespie, pers. comm). Other common or market names include rock salmon, salmon rockfish, Pacific red snapper, Pacific snapper, Oregon red snapper, and Oregon snapper (Love *et al.* 2002). BC commercial fishers often use the terms longjaw and andy-gump.

Bocaccio is one of the largest of the rockfishes (Figs. 1 and 2). The principal field diagnostic is the long maxillary (upper jaw) which extends to, or beyond, the eye. There is some thickening of the lower jaw but no obvious symphyseal knob. Adult bocaccio range in colour from olive orange to burnt orange or brown on the dorsal surface becoming pink to red ventrally. Specimens less than 25 cm in length are light bronze with small brown spots on their sides (see Moser 1967, 1996 for description of larval stages). As the juveniles mature, their colour darkens and the spots disappear. It is quite common for adult bocaccio and other rockfish, to develop black, melanistic blotches (Fig. 2). These have been suggested to be a pre-cancerous melanoma (Love *et al.* 2002).

There is no information on genetic structure within BC waters. U.S. research indicates a lack of genetic mixing between Southern California and Washington populations (MacCall *et al.* 1999). We treat bocaccio as one evolutionarily significant unit (ESU) based on presumed dispersal during the planktonic phases, known movements by juveniles (see below), and their continuous distribution along the outer coast. It could be argued that the Strait of Georgia might contain a self-perpetuating population but we have no evidence to resolve this contention.

DISTRIBUTION

Range

Bocaccio are found in the eastern Pacific Ocean from Stepovak Bay, Alaska (west of Kodiak Island), to Punta Blanca, Baja California, Mexico (Eschmeyer *et al.* 1983).

Commercial trawl fishery catches indicate that bocaccio are present along the entire outer Pacific coast of BC waters (Fig. 3, Table 2, Appendix Table 1). The largest reported catches have come from the northwest end of Vancouver Island and Queen Charlotte Sound. Most commercial groundfish fishing is conducted on the outer coast near the continental shelf break; thus there is little information on species distribution in the inlets and nearshore waters of BC. They have been reported from the Strait of Georgia, Juan de Fuca Strait, Queen Charlotte Strait, Barkley Sound and Fitz Hugh Sound (Fig. 4, Table 3). Note in Figs. 3-5, that most of the trawl catch comes from tows

conducted near the break-in-slope of the continental shelf, as well as the edges of Sea Otter, Reed and Moresby Troughs. U.S. catches have traditionally come from the California and Washington trawl fisheries with small amounts from Alaska (Table 4). The history of landings implies that California and Washington represent the abundance center with abundance declining to the north.

If we assume that the available habitat extends for the entire outer BC coast and includes the adult bottom depth range from 60-200 m (Fig. 6), then we estimate that the available habitat area exceeds 40,000 km2 (Fig. 7). This excludes semi-enclosed waters and inlets, as well as shallower nearshore waters, which are known habitat for juvenile stages (Gillespie *et al.* 1993).

Trends in Range

There are no obvious trends in the distribution of bocaccio catches in the outer coast trawl fishery since 1996 (Figs. 8 and 9). We assume that this species has been present throughout this range since the development of the fishery (Table 2). Longer-term comparisons of the distribution are problematic owing to inadequate geospatial data prior to 1991 (see Rutherford 1999), and species composition, prior to 1967.

Information on the species composition of rockfish catches in traditional fisheries by First Nations is not available. However, a First Nation's spokesperson indicated that bocaccio have always been a part of the Native fishery on the west coast of Vancouver Island (A. Amos, pers. comm.). Results from middens are inconclusive owing to the difficulty in identifying rockfish remains to species. However, we refer readers or authors of reports on other species to a list of marine species encountered in middens within the in Nuu-chah-nulth lands (D. Hall, pers. comm.).

We have no records of trawl landings of bocaccio from the Strait of Georgia since 1983 (Minor Areas 13-18, 28, 29) (Table 3, Fig. 10). However, retention of rockfish is now prohibited and no trips have observers. Bocaccio have been observed in recent shrimp surveys in the Strait of Georgia (Fig. 4). One trawl-fisher commented that, over the last 20 years, he has captured 8-10 bocaccio from the lower part of the Strait of Georgia (Minor Areas 17-19) and in the last few years has captured two adults from Minor Area 18. He also commented that bocaccio are common in Juan de Fuca Strait (Minor Area 20) (T. McDermid, pers. comm.).

Commercial salmon troll fishers commented that while they captured bocaccio in the Strait of Georgia during the 1970s (Minor Area 17) they did not recall catching them in the same area in the 1990s (R.N. Best and R.A. Best, pers. comm.). There is qualitative evidence that bocaccio were common in recreational catches of the Strait of Georgia and in Howe Sound (Minor Area 28) from the 1940-1960s (Pierrepont 2001, R. North, pers. comm.). One respondent commented that bocaccio continue to be captured while sportfishing off Nanaimo (Minor Area 17), as recently as 2000 (T. G. Brown, pers. comm.).

HABITAT REQUIREMENTS and TRENDS

Larval bocaccio have been captured up to 480 km from the California coast. Young of the year may reside in the upper water column for a few months, most settle by 3.5 months (Love *et al*. 2002). Young bocaccio generally inhabit shallower depths than the adults and often form schools (Eschmeyer *et al.* 1983). Young bocaccio have been captured in gillnets in nearshore sub-tidal depths off the west coast of Vancouver Island (Gillespie *et al*. 1993). Off southern California, juveniles are generally captured in depths of 30-120 m, occasionally to 200 m, and may be associated with kelp beds (Moser 1967).

Adult bocaccio are found over a variety of substrata in California, including rocky reefs and open bottom (Eschmeyer *et al*. 1983). Fish size seems to increase with depth (Love *et al.* 1990). In BC, the maximum reported capture depth in the commercial fishery is greater than 800 m, but these few data probably represent mistakes in recording or identification (Fig 6). Most specimens are captured in depths of 60-340 m during bottom trawling, while midwater trawl catches tend to occur over bottom depths of 60-200 m. Their presence in midwater catches and salmon troll catches indicate they can be semi-pelagic in habitat (A. Amos, F. Crabbe, R.N. Best, R.A. Best, pers. comm.).

Bocaccio appear to cohabit with a wide variety of groundfish species (Fig. 11). The incidental catches in midwater trawling are associated with targeting on yellowtail (*Sebastes flavidus*) and widow rockfish (*S. entomelas*). They are observed less frequently in the much more extensive midwater trawl fishery for Pacific hake (*Merluccius productus*), which tends to occur more over deeper waters or off the edge of the continental shelf.

There is no information on trends in the amount of habitat available to bocaccio. The widespread distribution of bocaccio on the outer coast and Hecate Strait implies that the coastwide population is not at risk from loss of habitat. We cannot comment on possible impacts of habitat loss or environmental change in enclosed waters such as the Strait of Georgia. The widespread distribution of bocaccio over the continental shelf implies that protection/ownership issues do not currently pertain to the viability of this population.

BIOLOGY

General

The biological research on bocaccio in BC waters has been limited. GFBio, the groundfish biological specimen database of Fisheries and Oceans contains information on only 1,503 specimens collected from 1967-2000 (Table 1). These data were collected from all regions from both midwater and bottom trawl, research and commercial catches. There is obviously not enough information to examine trends. The cumulative length frequency histogram in Fig. 12 shows that most specimens are

greater than 30 cm, the minimum acceptable commercial size for rockfish. Thus, there has been negligible discarding of juveniles in the trawl fishery. There is virtually no age data. Most of the biological information on this species comes from research conducted in California.

Bocaccio are ovoviviparous like all members of their genus. Copulation occurs in the early fall (Moser 1967) but there is delayed fertilization (Wyllie Echeverria 1987). The fertilized eggs are retained in the body of the female where the larvae undergo much of their development prior to release. Fecundity ranges from 20,000 to 2,300,000 eggs and increases with size of the female (Phillips 1964). Embryonic development takes approximately one month (Moser 1967).

Parturition occurs in the winter in BC waters (Westrheim 1975). More southern populations appear to have a longer period of parturition and may release multiple broods in a single year (Moser 1967). Settlement to the littoral and demersal habitat begins in late spring in California and extends throughout the summer. Estimates of length at 50% maturity for females have varied from 36 to 50 cm in three different U.S. studies (summarized by Haldorson and Love 1991). Rogers (1995) suggests an age of between 4 and 5 years for the age of 50% maturity.

Growth and Mortality

At the time of parturition, larvae are approximately 4-5 mm in length (Moser 1967). The larvae metamorphose into pelagic juveniles at between 19 and 40 mm over several months (Moser and Boehlert 1991, Woodbury and Ralston 1991). Larval development has been described and illustrated by Moser (1967). Growth of juveniles is rapid, 0.56-0.97 mm/day (Love *et al.* 2002), and they can reach 24 cm by the end of their first year (MacCall *et al.* 1999). Females grow to a larger size than males. Maximum recorded size is 91 cm for females and 75 cm for males. The maximum reported weight is 6.8 kg (Love *et al.* 2002).

Little is known about the mortality rates of younger stages. MacCall *et al.* (1999) used a range of 0.15-0.25 for the estimate of adult instantaneous natural mortality rate (M). Their model tended to indicate a better fit at M=0.20, but the fit was sensitive to which input data were used. Bocaccio are difficult to age and their maximum age is unknown. Radiometric dating of otoliths has indicated a maximum age of 40 but they may live as long as 50 years (Love *et al.* 2002). The estimates of M, age at maturity, and maximum age imply a generation time of about 10 years (4+1/0.2). Thus, a 3-generation window for assessing extinction risk would be about 30 years.

Like all species in the genus, bocaccio have physoclistic swim bladders that cannot rapidly accommodate the sudden change in pressure as they are brought to the surface. The resulting barotrauma causes death for almost all fish when captured from waters deeper than 20-30 m (Starr *et al.* 2001). Little is known about their adaptability to other possible changes in their environment.

Movements/dispersal

There have been two tagging studies of bocaccio off California. During the 1977-1981 study, 1,149 bocaccio, both juveniles and adults, were tagged (Hartman 1987). Starr *et al.* (2001) tagged 16 bocaccio, ranging in size from 35 to 58 cm, during the 1997-1998 study. Of the 66 bocaccio recaptured in the 1977-1981 study, 19 traveled 0.9 to 148 km. Seven of the individuals, all juveniles, moved between 13 and 148 km. The adults tagged during that study moved very little, with all being recaptured at their tagging site after periods at liberty of up to 827 days. During the 1997-1998 study some individuals showed site fidelity by remaining within the study area or by leaving and returning, while others moved large distances during the three and a half-month monitoring period. The authors suggested there was not a large enough size range to analyze movements by fish length or state of maturity. The results of these two tagging studies indicate that bocaccio are mobile during the first few years of life but are perhaps more sedentary with age. Movement appears to decrease significantly after they reach a length of about 47cm (Hartmann 1987).

During the 1997-1998 study, eight bocaccio were also fitted with depth transmitters. Four of the eight fish with depth transmitters made rapid vertical movements. Three of these fish rose vertically to the surface and then returned to depth while a fourth fish dove to 220 m and rose back to 100 m in less than one day.

Nutrition and interspecific interactions

Bocaccio are primarily piscivorous. Juveniles feed on the young of other rockfish, surfperch, mackerel and various other small inshore fishes (Phillips 1964). They also consume larvae and euphausiids. The adult diet includes other rockfish, sablefish, anchovies, lanternfish and squids (Phillips 1964, Eschmeyer *et al.* 1983). The main predators of juvenile bocaccio are sea birds such as least terns and the main predators of adults are marine mammals such as harbor seals and northern elephant seals (Love 1996).

Jensen (1976) comments that bocaccio may be the only host of one species of tapeworm, *Parabothriocephalus sagitticeps.* These conclusions were based on an examination of 19 species of rockfish captured in southern California. The presence of this parasite has not been confirmed in BC waters, however, no one has looked specifically for this tapeworm (D. Whitaker, pers. comm.). A second tapeworm, *Bothriocephalus scorpii*, has been reported in bocaccio from BC waters.

A myxosporean parasite (*Kudoa miniauriculata*) has been reported in California specimens of bocaccio. Its presence in BC waters has not been documented (D. Whitaker, pers. comm.). This species of *Kudoa* differs from the *K. thrysites* and *K. paniformis*, the two species which infect Pacific hake.

The reputation of "worminess" for this species is derived from the presence of the "cod/seal worm" nematode also known as *Pseudoterranova* (*Phocanema decipiens*) in

the musculature. Bocaccio is one of the intermediate hosts. Once encysted, the parasite can live for long periods in the fish and, therefore, is accumulated over time such that an older fish can carry large numbers of the worm. The final host is a mammal (seal).

Behaviour/adaptability

The semi-pelagic distribution in the water-column, the likelihood of daily vertical migration, and the degree of movement by juvenile stages implies that bocaccio have significant capacity to accommodate localized habitat disruption. This movement may also facilitate re-colonization as would the larval planktonic phase.

POPULATION SIZES AND TRENDS

The following discussion focuses on trends in landings or catch, or catch-per-unit-effort (CPUE) in the commercial fishery. We emphasize that the catch and CPUE time series have marginal utility as abundance indices for bocaccio. Readers should note a management plan based on Individual Vessel Quotas (IVQ) was introduced for the BC trawl fishery in 1997. Thus, harvests for all species managed through quotas prior to 1997 are now controlled by assigning area-specific annual catch limits (retained and discarded) to each vessel. Bocaccio catches are not limited through IVQs but are constrained by a 15,000-lb trip limit for all non-quota rockfish combined.

Commercial trawl landings and CPUE

Recorded coastwide catches of bocaccio have varied form 90 to 1,322 t with a mean of 418 t since 1967 (Table 2, Fig. 13, Appendix Tables 1 and 2). Coastwide commercial catches have averaged about 265 t since the introduction of 100% observer coverage in the trawl fleet in 1996. Not included in commercial statistics are the discards in the commercial hook-and-line fisheries and recreational fisheries. There are thought to be minimal.

The trawl landings from the southwest coast of Vancouver Island (Fig. 13, Areas 3C and 3D, panel a) and Queen Charlotte Sound (Fig. 13, Areas 5A and 5B, panel b) appear stable in recent years (1996-2001). While bocaccio are spatially widespread in northern waters, trawl landings have historically been relatively low and are currently negligible, averaging less than two-thirds the long-term average (Fig. 13, Areas 5C and 5D, panel c, and Fig. 13, Area 5E, panel d). However, landings in all areas are constrained by the 15,000-lb trip limit for “non-quota” rockfish. We received comments from some fishers that bocaccio can be a nuisance while salmon trolling in Area 5E (F. Crabbe and A. Amos, pers. comm.) and that trawl fishers could return to the long-term average landings of 400 t if the restrictions were relaxed (R. Gorman, pers. comm.). Thus, bocaccio may be more numerous in northern waters that what can be inferred from current trawl catches.

We were also informed by trawlers (B. Dickens, pers. comm.) that bocaccio are often caught when targeting on canary rockfish (*S. pinniger*). The current IVQ's for canary rockfish are currently so low, that they rarely, if ever, target on them. They catch their canary rockfish IVQ's as incidental to other targeting. Thus, the low IVQ's of canary rockfish constrain the trawl catches of bocaccio.

We derived four abundance indices. These were based on all bottom trawl tows for which the midpoint of bottom depth was between 60 and 200m. The first two indices were derived from all of the depth-selected tows. We calculated a simple proportion of tows which contained bocaccio (P), and total CPUE (kg/h), calculated as total catch of bocaccio over the total number of hours bottom trawled. The third and fourth CPUE indices were based only on the tows that contained bocaccio, from which we calculated mean and median kg/hr (Fig. 14).

The trends in proportion of occurrence and CPUE appear stable for the west coast of Vancouver Island and Queen Charlotte Sound (Fig. 14, panels a and b). The negligible catches of bocaccio for the two northern areas indicate that these indices should not be used to infer abundance trends (Fig. 14, panels c and d). Furthermore, we suggest that it is incorrect to infer abundance trends from these indices over the longer term of greater than 10 years. We argue that one cannot assume comparability between 1996-2000 and the 1985-1995 periods, or even assume comparability within the latter period (see Stanley and Kronlund 2001). Note, for example, the increase in frequency of observations of bocaccio in tows coincident with the onset of observer coverage in 1996. Note also the significant decline in landings in 1994 associated with the introduction of dockside monitoring (Rutherford 1999). Similarly, it is probably unreasonable to compare landings and catch rates from periods prior to and following 1985. During earlier decades, the fishery was gradually expanding up the coast under few or no catch restrictions. U.S. trawlers fishing in Canadian waters produced relatively large landings in the mid-1970s. As the U.S. trawlers were gradually excluded (1977-1981), the Canadian trawl fleet expanded but did not initially have access to the same markets. The increase in landings in the late 1980s was probably a combination of improved markets and the mis-reporting of other rockfish as bocaccio to avoid increasingly restrictive trip limits on the quota species of rockfish. The distribution of catches by total weight of bocaccio in the tow is shown in Fig. 15. Current total catches of 265 t correspond to about 66,000 individuals, assuming a mean weight of 4 kg (PacHarvHL database, see Appendix Table 2). This indicates that the Regional adult population should be at least 1-2 orders of magnitude greater.

There have been no reported trawl landings of bocaccio from the Strait of Georgia (Minor Areas 13-19, 28 and 29) since 1983 (Table 3). However, in recent years commercial trawlers have been prohibited from retaining rockfish from all of Major Area 4B and no observers have been placed on these vessels. Landings in the hook-and-line fishery are too small to provide abundance indices for more recent years (see Appendix Table 1 in "unknown" category). Salmon trollers comment that there is some bocaccio discarded in the outer coast salmon troll fishery (A. Amos, R.A. Best, R.N. Best, I. Bryce, F. Crabbe, pers. comm.).

Survey-based Indices

A number of groundfish surveys have been conducted on the B.C. coast. Although the surveys were not designed to focus on bocaccio, we examined them for utility in tracking bocaccio abundance. We summarize below the catch rate trends in four of these surveys.

U.S. Triennial bottom trawl survey (1980-2001)

The U.S. triennial bottom trawl survey began in 1977 and typically covers northern California to the U.S./Canada border in northern Washington (Shaw *et al.* 2000). For the years 1980, 1983, 1989, 1992, 1995 and 1998 it was extended into southern BC waters. The first two surveys extended to 49°15' N; the latter four surveys extended to 49°40' N (Fig. 16). Biomass estimates are computed for all depths combined. In spite of the greater spatial coverage in the recent surveys, the survey indicates a decline in biomass. However, we suggest that these estimates, while unbiased, are highly sensitive to single large tows. This is obvious from Figs. 17 and 18 (figures provided by M. Wilkins). From Fig. 17 it is also obvious that sampling density at the 100-fathom edge (183 m) is limited to about 10-20 tows. Finally, it is to be remembered that a bottom trawl survey is not the appropriate tool for assessing a species of rockfish frequently found in midwater trawl catches. Note, for example, that no tows conducted just south of the Canada/U.S. border in 1995 caught bocaccio, while numerous tows in this area captured bocaccio in 1998. It may be reasonable to infer from these results that bocaccio abundance has declined over the last two decades, but we have no confidence in the implied extent of the decline.

Area 3C+3D Shrimp bottom trawl survey (1973-2001)

Results of all shrimp trawl surveys were examined for presence of bocaccio (Fig. 4). Many of these surveys now use fish excluders; however, they did reveal the presence of bocaccio in semi-enclosed waters.

We also show bocaccio biomass estimates generated from the annual shrimp trawl survey on the west coast of Vancouver Island, where fish excluders were not employed (Fig. 19) (Boutillier *et al.* 1998 and Appendix 3). The index is imprecise, again owing to the leverage of occasional large tows. The slope of the regression is not significantly different from 0 ($p<0.05$). The catchability of bocaccio in this survey can be presumed to be very low, owing to the low towing speed, thus, as with the U.S. survey, the estimates should only be viewed as imprecise and relative.

Areas 5A and 5B Pacific ocean perch bottom trawl survey (1966-1995)

Pacific ocean perch (*Sebastes alutus*) surveys have been conducted intermittently since 1966 (Yamanaka *et al.* 1996) (Fig. 16b) in Queen Charlotte Sound. Bocaccio have been a minor component of the catch. Proportion of occurrence and catch rate

estimates are summarized in Fig 16b. Catch rates are very low but appear stable, except for some larger tows in 1976. The proportion of tows with bocaccio can be high and has tended to increase but catch rates are too low to provide a meaningful index.

Hecate Strait bottom trawl assemblage survey (Areas 5C and 5D)

The assemblage surveys are part of a long-term ecosystem study of Hecate Strait (Workman *et al.* 1997). The focus of the survey has been to classify species assemblages by depth. Bocaccio are a minor component of the total catch (Fig. 16c). The small proportion of tows which contain bocaccio and the low catch rates (Fig. 16c), indicate that this survey is useful only for inferring presence/absence, which is provided by the commercial fishery data.

Other groundfish related surveys in BC waters

Excluded from this document are summaries from acoustic and midwater trawl surveys directed at inshore and offshore hake populations. Incidence of bocaccio was limited to only a few fish per survey (M. Saunders pers. comm.). Similarly, extensive midwater and surface trawling has been conducted in the Strait of Georgia as part of an ecosystem study, but they reported no bocaccio in their catches (R. J. Beamish, pers. comm.).

We also did not include results from the International Pacific Halibut Commission (IPHC) standardized hook-and-line survey (Kronlund 2001). Until the early 1990s, rockfishes were most often lumped into a general rockfish category. Attempts to identify rockfish have gradually increased since the early 1990s to the point where most are recorded to species. However, the total catch of fish identified as bocaccio from 1993 to 1999 was 23 animals. Because of the IPHC practice of sub-sampling for species composition, these animals are a lower limit to the number of bocaccio actually intercepted by the gear. This survey could be useful for indicating the presence/absence of bocaccio in the survey area; however, the trawl fishery already confirms this.

Recreational Creel Survey

Fisheries and Oceans, Canada conducts creel surveys of the recreational angling fishery in the Strait of Georgia and elsewhere (K. Hein, pers. comm.). The focus of the monitoring has been chinook and coho salmon but in the last couple of few years, the survey has increased the focus on groundfish. Nevertheless, bocaccio are still not explicitly enumerated. We suspect that sport fishers and enumerators will usually identify bocaccio as “other” rockfish.

ABUNDANCE IN ADJACENT WATERS

Populations in U.S. waters off California have been designated as overfished by the Pacific Fisheries Management Council (MacCall *et al.* 1999). In a recent legal ruling (August 2001) the National Marine Fisheries Service (NMFS) was ordered to reassess catch limits for bocaccio (Pacific Marine Conservation Council). The NMFS was also ordered to address the lack of information on discarding of this and other species in recreational and commercial fisheries. Bocaccio is listed as an endangered species by the World Wildlife Fund (1999). The International Union for the Conservation of Nature (IUCN) has categorized bocaccio in the Pacific-eastern central and Pacific northeast as "critically endangered" (Hilton-Taylor 2000).

Evidence for the decline in abundance is based on declines in biomass estimates of the U.S. triennial bottom trawl survey, the commercial trawl CPUE, the recreational CPUE index and a juvenile abundance index based on research surveys (MacCall *et al.* 1999). The authors of that document comment that there has been consistent recruitment failure in California from 1990-1998. An update on the status of this species in U.S. waters will be presented in 2002 (A. MacCall, pers. comm.).

Bocaccio, once reported to have been common in Puget Sound (immediately contiguous to the Strait of Georgia), are now thought to be very rare (Love *et al.* 2002) and were on an Endangered Species Act (ESA) petition list for consideration by NMFS. However, NMFS did not include this species on the candidate list that was reviewed by the Biological Review Teams, apparently because the data were too limited to make a determination (W. Palsson, pers. comm.).

LIMITING FACTORS AND THREATS

It is likely that the bocaccio population in BC is somewhat continuous with populations in Washington. It can therefore be assumed that harvests in U.S. waters off Washington have an impact on the regional population of bocaccio of BC. In response to the apparent decline in abundance in U.S. waters, U.S. harvests are severely restricted. The Optimum Recommended Yield (OY) for 2001 for central and southern California is 100 t. For the combined northern section of the U.S. coast, there is a recommended OY of 3,137 t for a rockfish aggregate that includes all minor rockfish species. This includes predicted recreational catch and discards in the commercial fishery (Pacific Fishery Management Council). Catches are constrained by monthly trip limits, which can be altered in the event of overages. For example, in the southern region, bocaccio monthly trip limits are 200-500 lbs/month depending on month and gear type. Note that the prevailing restrictions (and low abundance) have limited trawl landings in northern Washington State to 2 t in 2000 (Table 4). However, as commented above, discards are not reported.

The BC bocaccio population may also be continuous with the population in southeastern Alaska. However, the trawl prohibition for these waters and the low

market value for bocaccio will presumably act to limit harvests in waters of southeastern Alaska (Table 4).

The harvests in the Strait of Georgia are negligible, but the growing recreational fishery for groundfish could pose a longer-term threat.

SPECIAL SIGNIFICANCE OF THE SPECIES

We know of no special economic, cultural or ecosystem significance of bocaccio other than its possible specificity as a host for one species of tapeworm. However, the presence of this tapeworm in bocaccio from BC bocaccio waters has not yet been documented.

EXISTING PROTECTION OR OTHER STATUS

We are not aware of any special cultural or legal status afforded to this species in Canadian waters (see above for U.S. waters).

SUMMARY

We suggest that the total regional population of bocaccio in BC waters be considered as one ESU. This suggestion is based on the biology of bocaccio; there are no genetic studies available on the species for BC waters. The status of bocaccio in this ESU is unknown. No biological or population abundance research has been directed on this species owing to its limited economic, recreational and cultural importance. Furthermore, the low catches, combined with a lack of comparability among years in how the trawl fishery was prosecuted, limit the utility of fishery-dependent statistics for inferring abundance trends. Nevertheless, the available fishery-dependent and fishery-independent data provide some insight into the status of the population in BC waters.

The trawl fishery continues to harvest bocaccio from the traditional areas on the outer coast. The annual known harvest of approximately 260 t reflects approximately 66,000 pieces per year. This number indicates coastwide adult populations of at least 10^5, and, presumably 1-2 orders of magnitude greater. Much of the landings come from Queen Charlotte Sound, which shows no indication or reports of a decline. Lower landings continue to come from the west coast of Vancouver Island and overall catch rates appear stable over the last half-decade. The U.S. triennial survey and a shrimp survey both provide weak evidence of a declining trend for the central/southern portion of this region over the last 20-30 years. This is consistent with the well-documented decline in U.S. populations to the south. However, these two surveys, while unbiased, are too sensitive to the catches in single tows to have significant credibility. Data are too limited to comment on northern BC waters although bocaccio continue to be present

in trawl catches in small amounts from Hecate Strait and the west coast of the Queen Charlotte Islands.

Nothing is known about trends in abundance of bocaccio in the enclosed waters of BC. The status in the Strait of Georgia is unknown, although they continue to be present in commercial and recreational catches.

The status of bocaccio in BC waters is poorly known, however, we note the current widespread distribution over the entire outer BC coast. The weak indication of a decline on the south and central west coast of Vancouver Island is a concern but possibly an artifact of the imprecision in the surveys. The combination of significant dispersal of larval and juvenile stages with a more sedentary adult phase may account for localized depletion of adult abundance.

ACKNOWLEDGEMENTS

We appreciate the assistance of the various respondents from the commercial, native and recreational fisheries and other agencies. The Canadian Wildlife Service and Fisheries and Oceans, Canada provided funding and support. Jim Boutillier provided a biomass estimate from the shrimp survey and Mark Wilkins provided the graphical summary of bocaccio catches from the U.S. triennial survey. The document was improved was much improved through reviews provided by Chris Wood, Graham Gillespie and Mark Saunders.

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(Unless otherwise noted, all interviews were conducted in September-October 2001)

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COLLECTIONS EXAMINED

No archived collections were examined, but fresh specimens were examined for presence of the tapeworm *Parabothriocephalus sagitticeps* and the myxosporean parasite (*Kudoa miniauriculata*). None were found. The tapeworm *Bothriocephalus scorpii* and "cod/seal worm" nematode *Phocanema decipiens* were present.

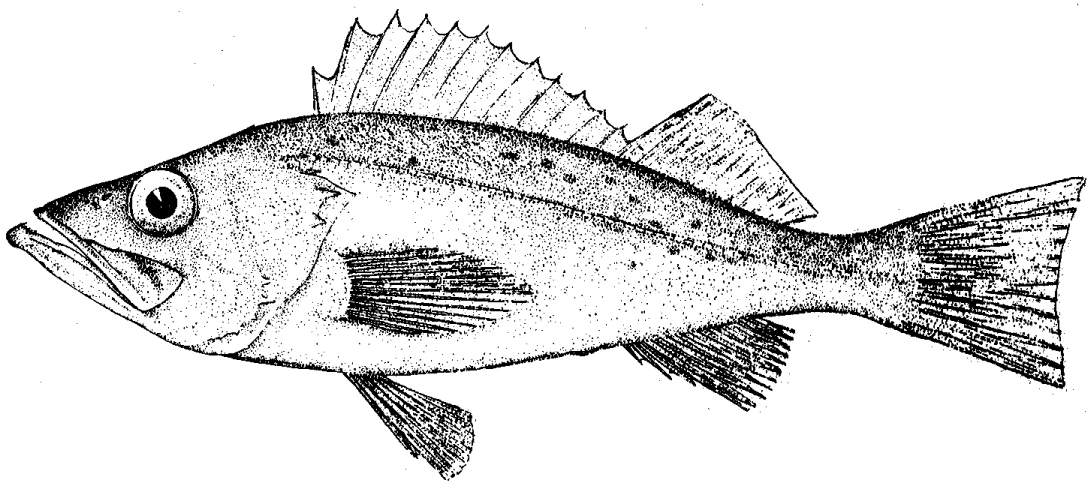

Figure 1. Line drawing of Bocaccio (from Hart 1973).

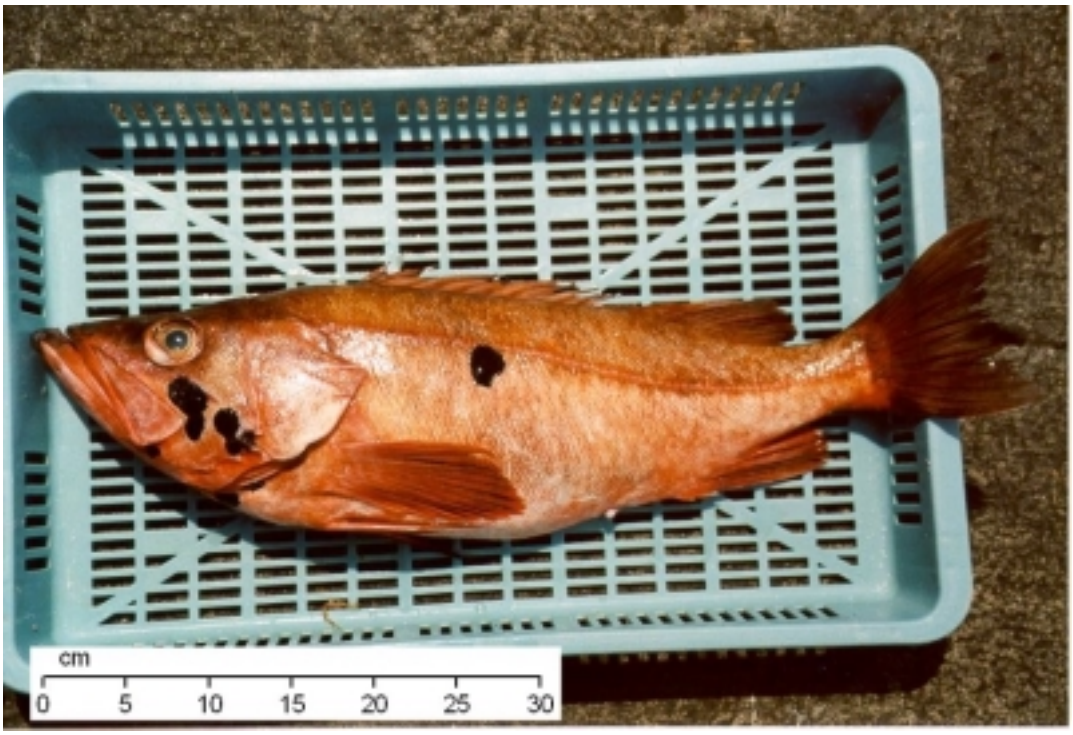

Photo courtesy of Steve Sviatko, Fisheries and Oceans Canada

Photo courtesy of Terri Bonnet, Fisheries and Oceans Canada

Figure 2. Pictures of adult bocaccio (Fisheries and Oceans photo archives, Groundfish Section, Science Branch).

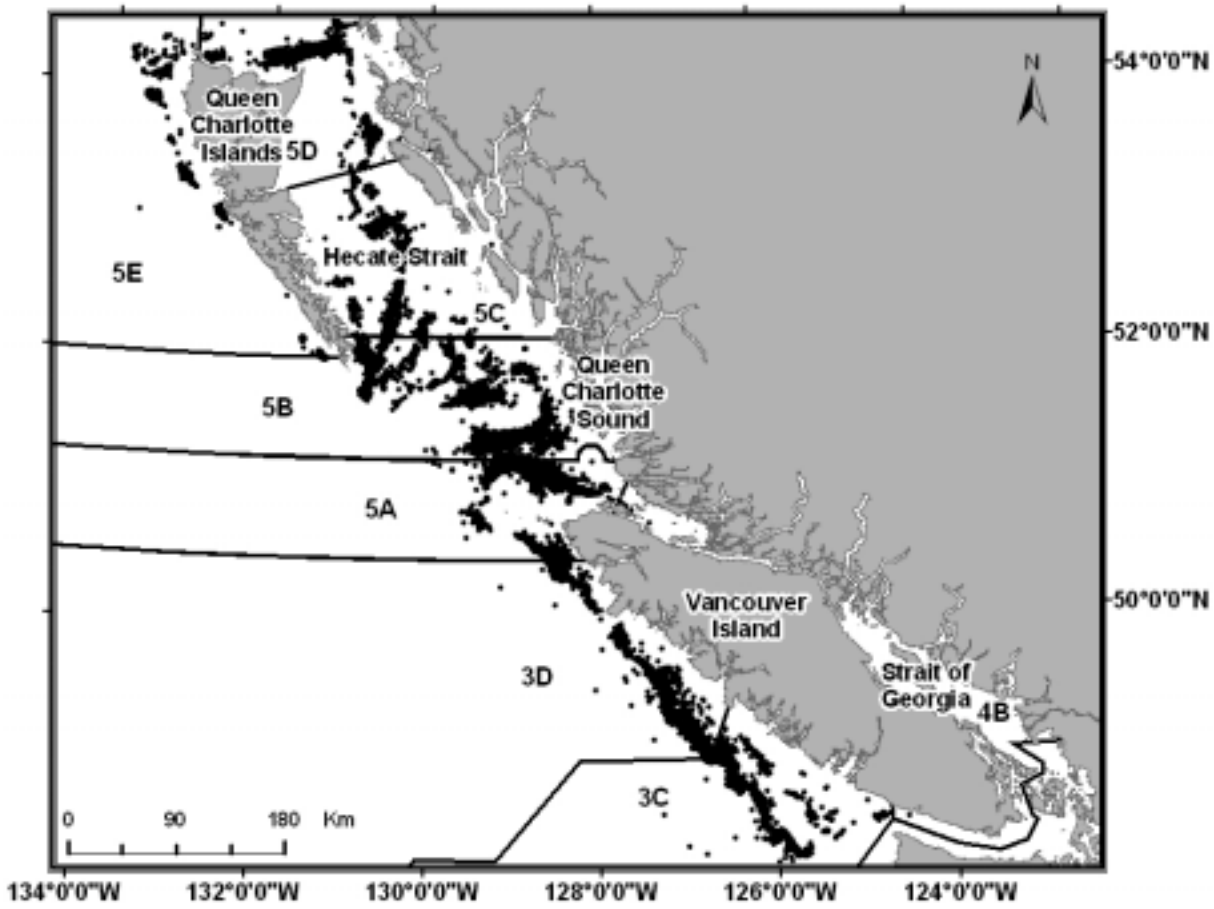

Figure 3. Chart of coastal BC waters showing spatial distribution of all trawl tows which captured bocaccio (1996-June, 2001) and boundaries of Major Areas.

Figure 4. Chart showing presence of bocaccio in *research shrimp trawl tows conducted from 1973 to 2001. Year of capture is noted for the observations in enclosed waters. *The point labeled “1997” in Barkley Sound was recorded on an observed commercial shrimp trawl trip.

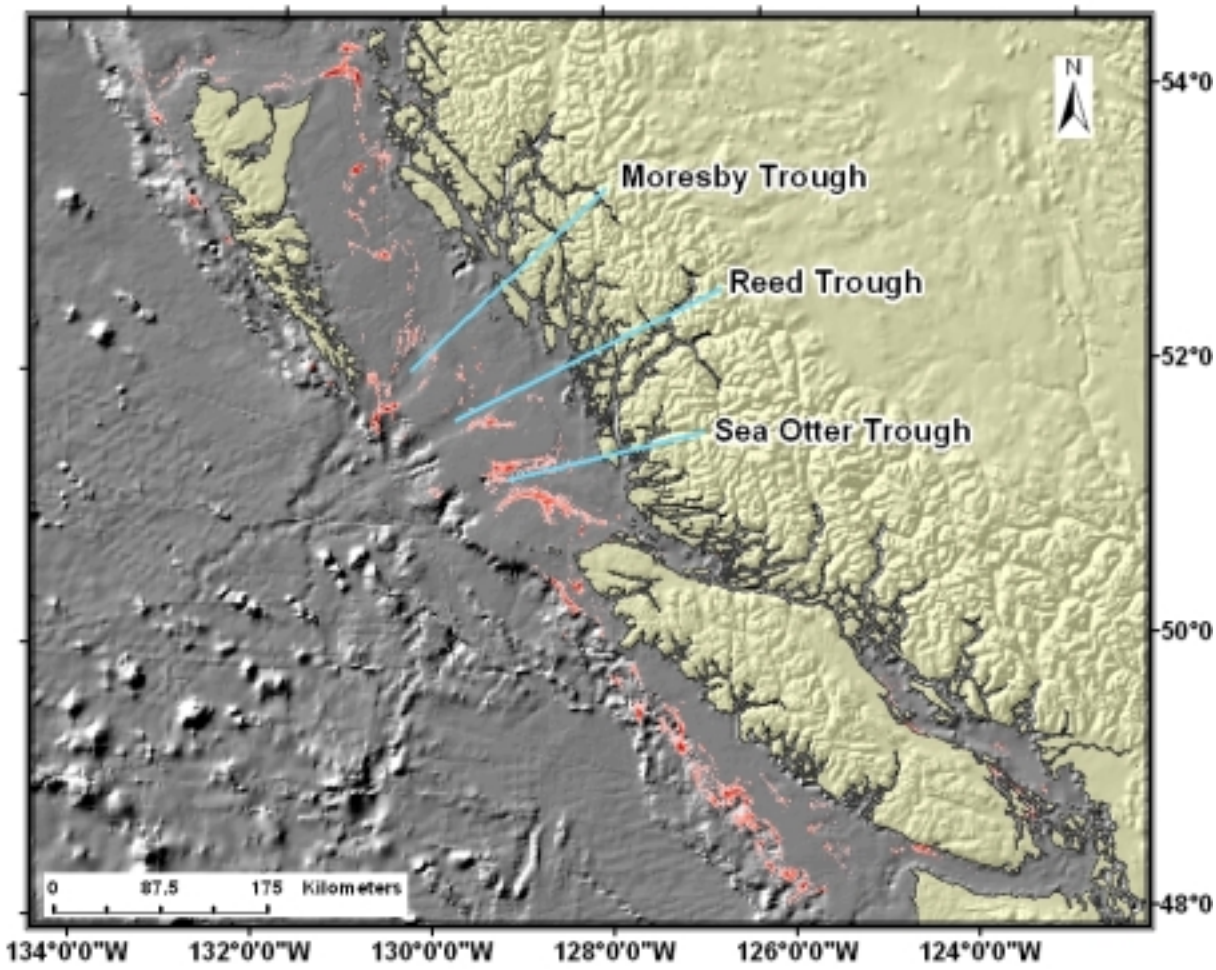

Figure 5. Chart of BC coastal waters showing continental shelf, break-in-slope and the location of major troughs. Areas frequently impacted by bottom trawling are indicted in red; the intensity of which varies proportionally with the number of trawls in a given 1km^2 block.

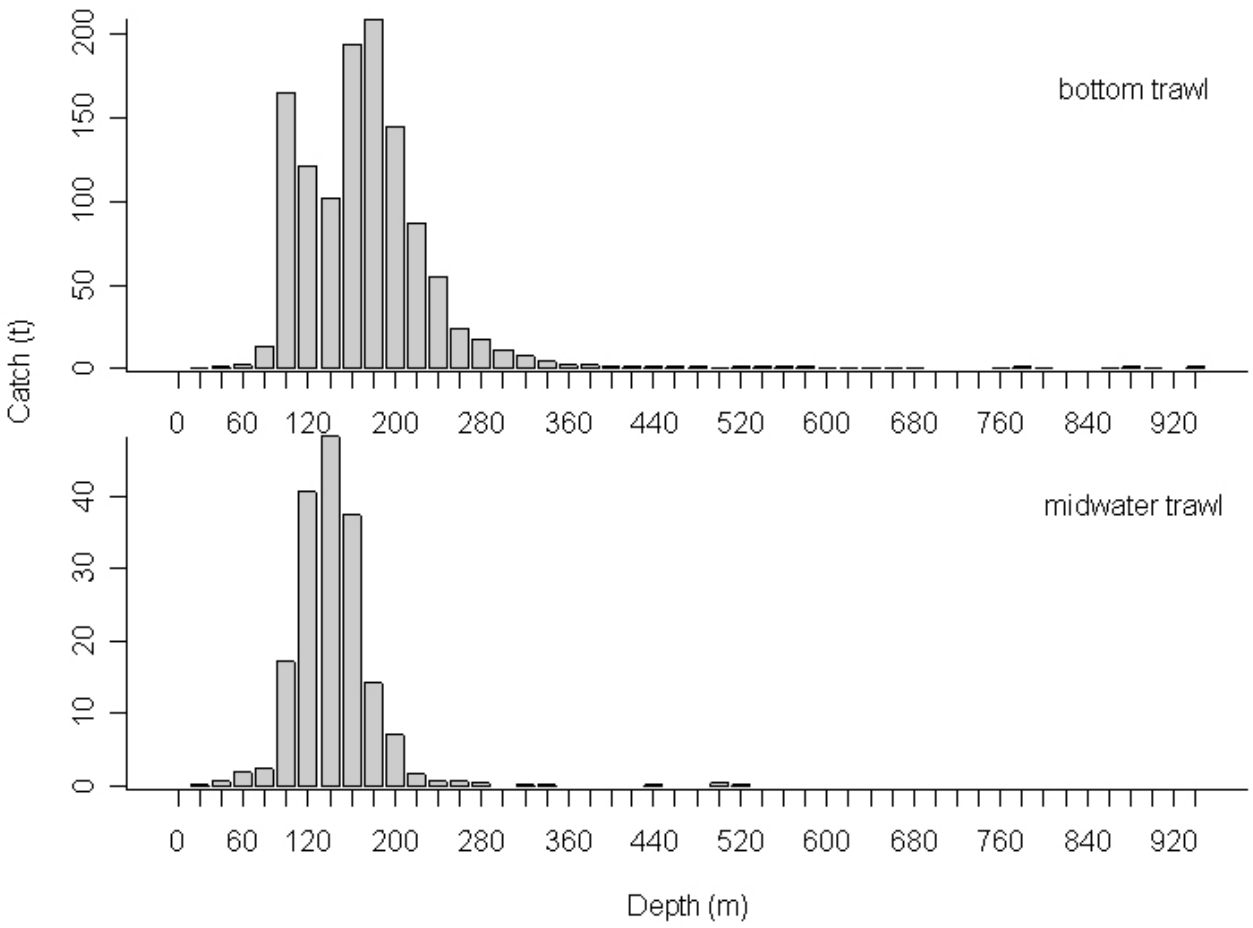

Figure 6. Distribution of bocaccio catches by 20-m depth interval for bottom or midwater trawling.

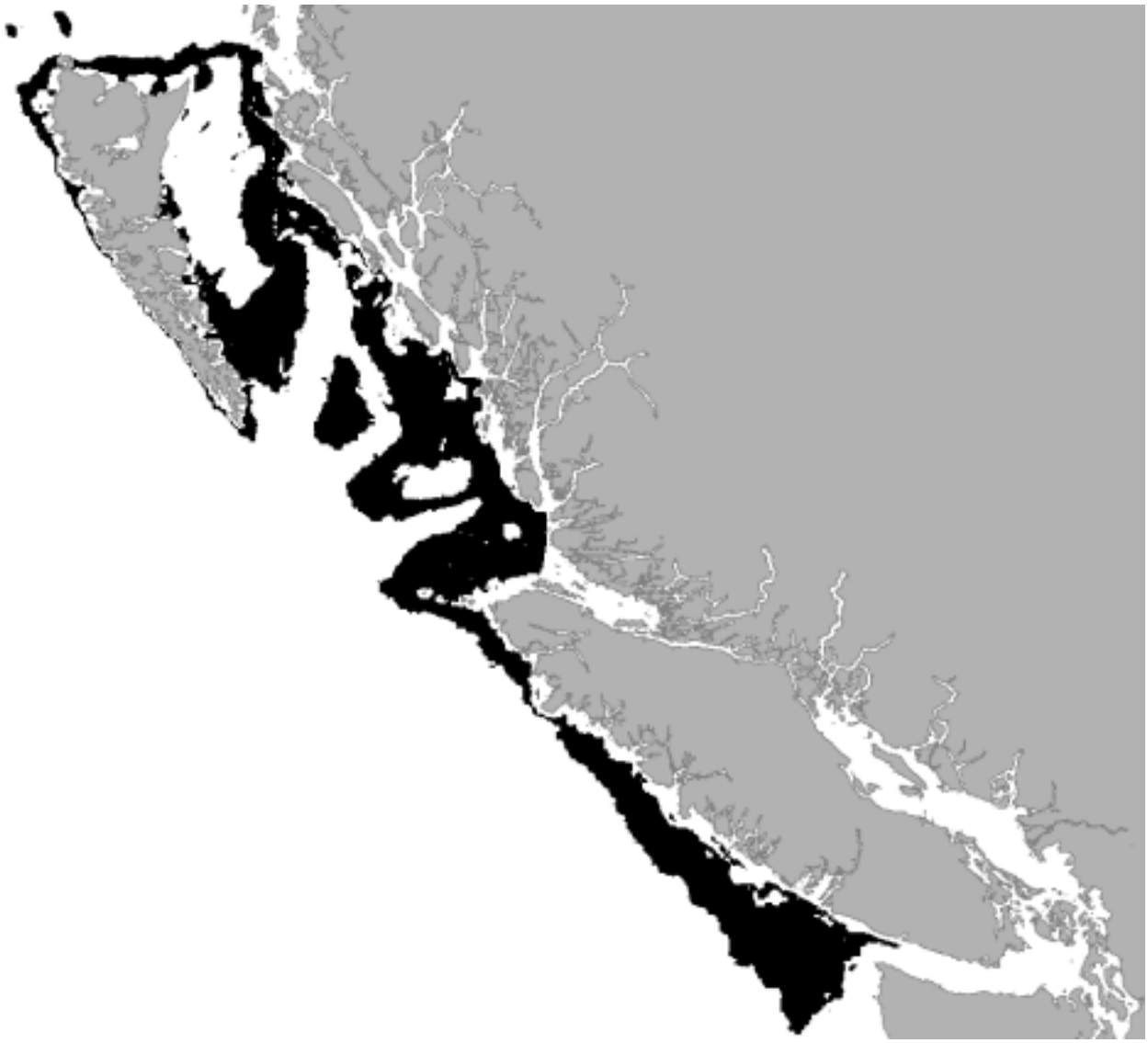

Figure 7. Projected habitat area for bocaccio based on preferred bottom depth zone for adults of 60-200 m. Shaded area equals 40,836 km^2. Note that the shaded area excludes enclosed waters and inlets, some of which have proven to be habitat for adult and young bocaccio, and shallower coastal waters which are probably habitat for juveniles.

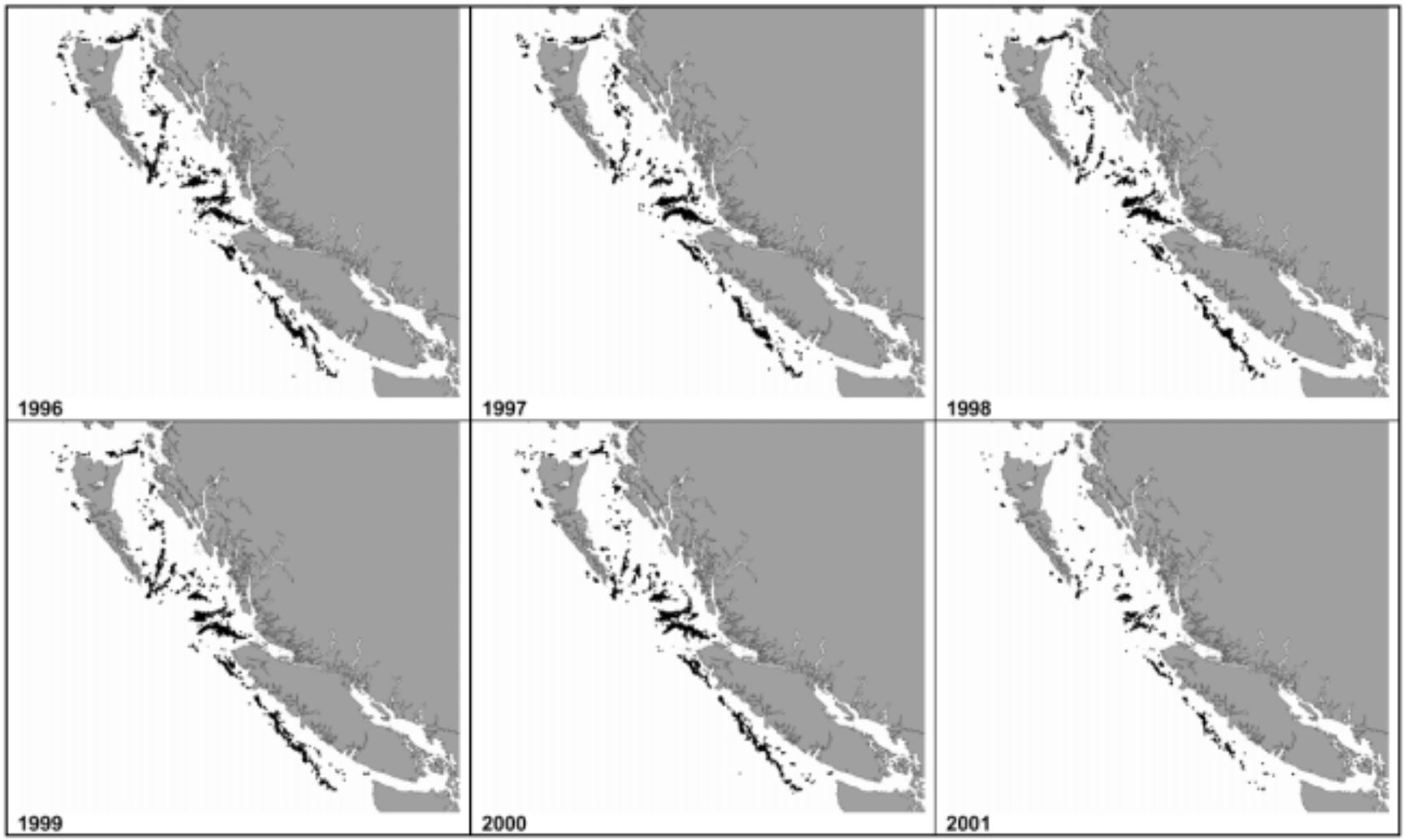

Figure 8. Charts of BC waters showing the spatial distribution of bottom trawl catches of bocaccio by fishing year since 1996.

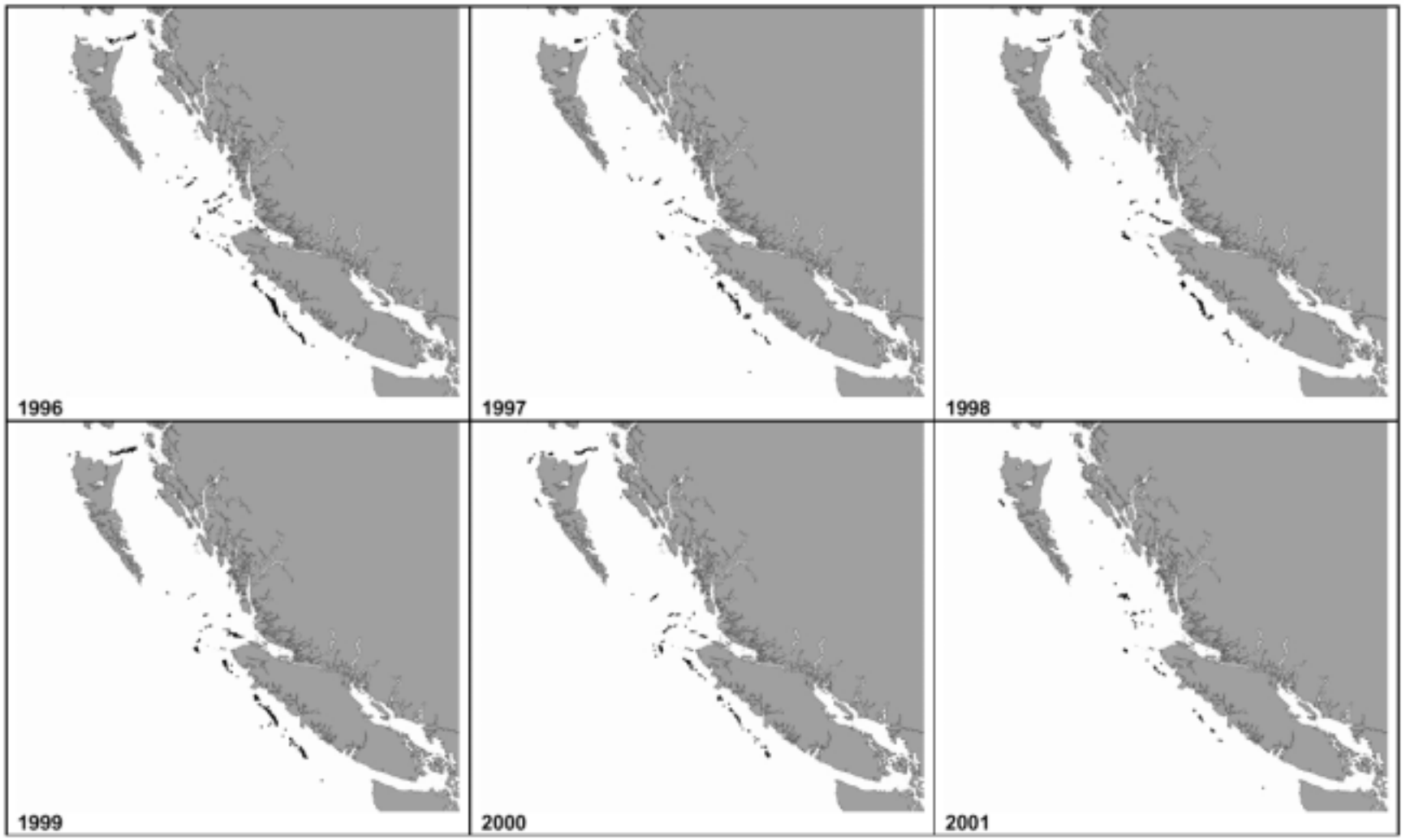

Figure 9. Charts of BC waters showing the spatial distribution of midwater trawl catches of bocaccio by fishing year since 1996.

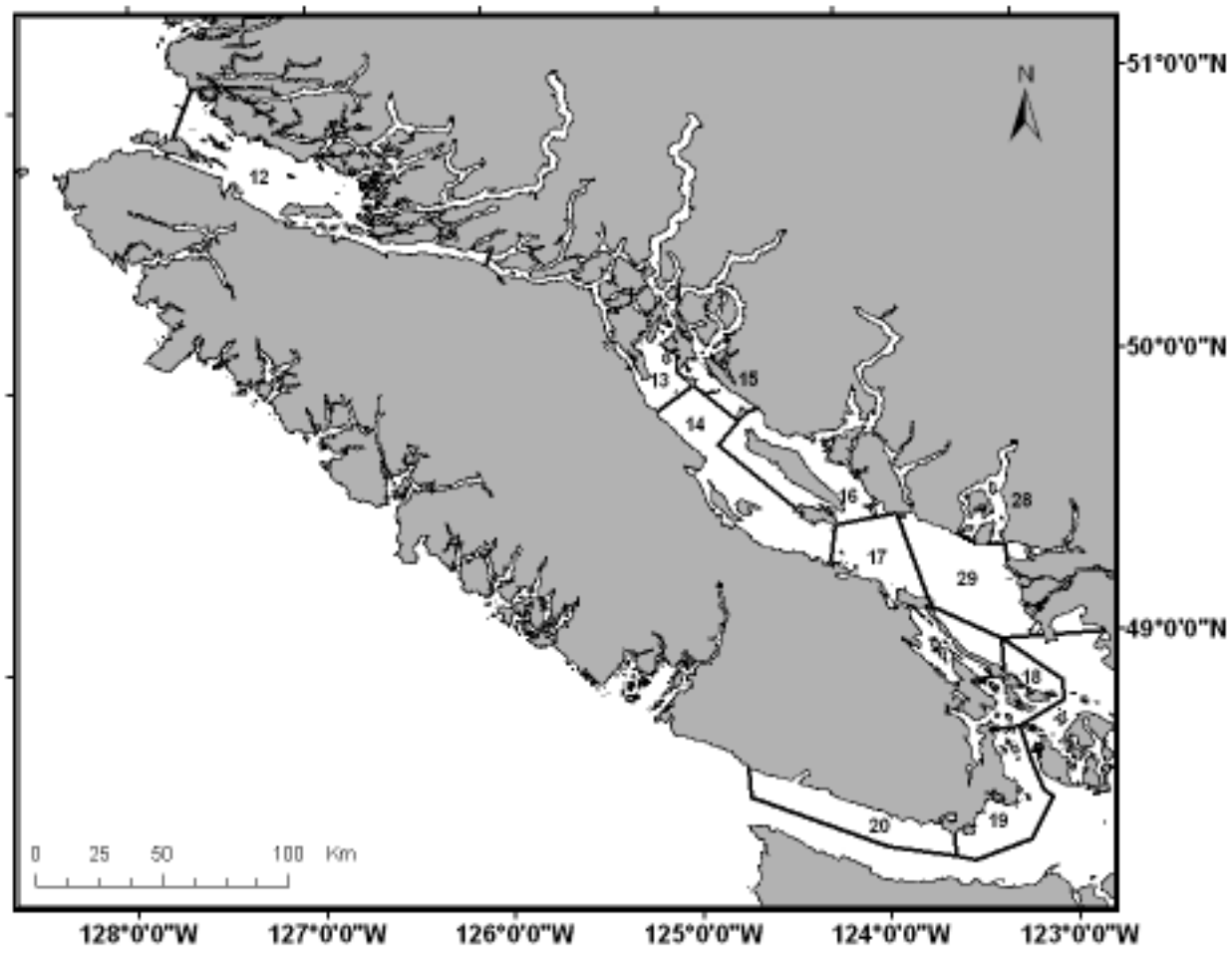

Figure 10. Chart of Minor Areas between Vancouver Island and the mainland.

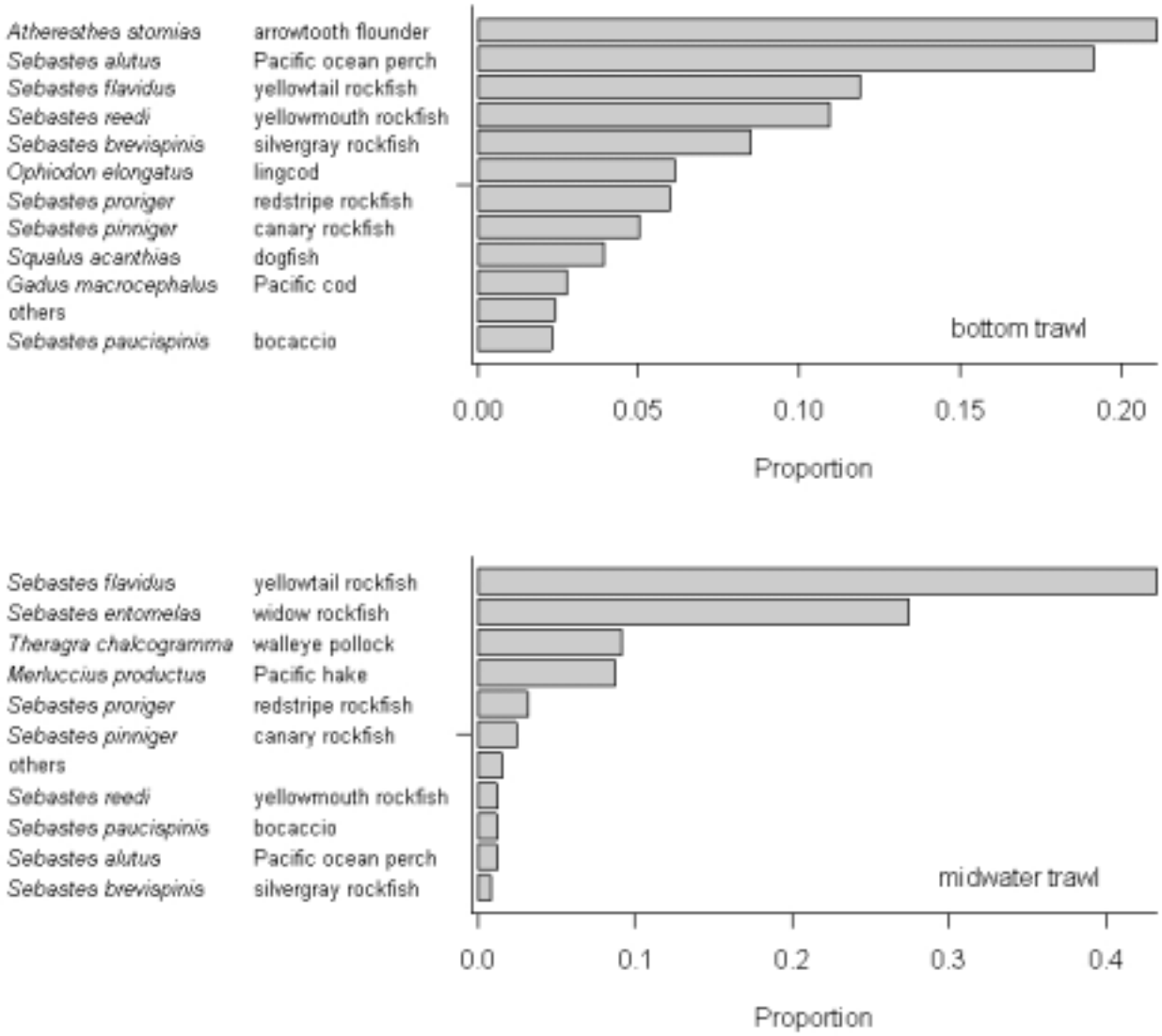

Figure 11. Species composition ranked by weight of catch in all bottom and midwater trawl tows which captured bocaccio (1996-June 2001).

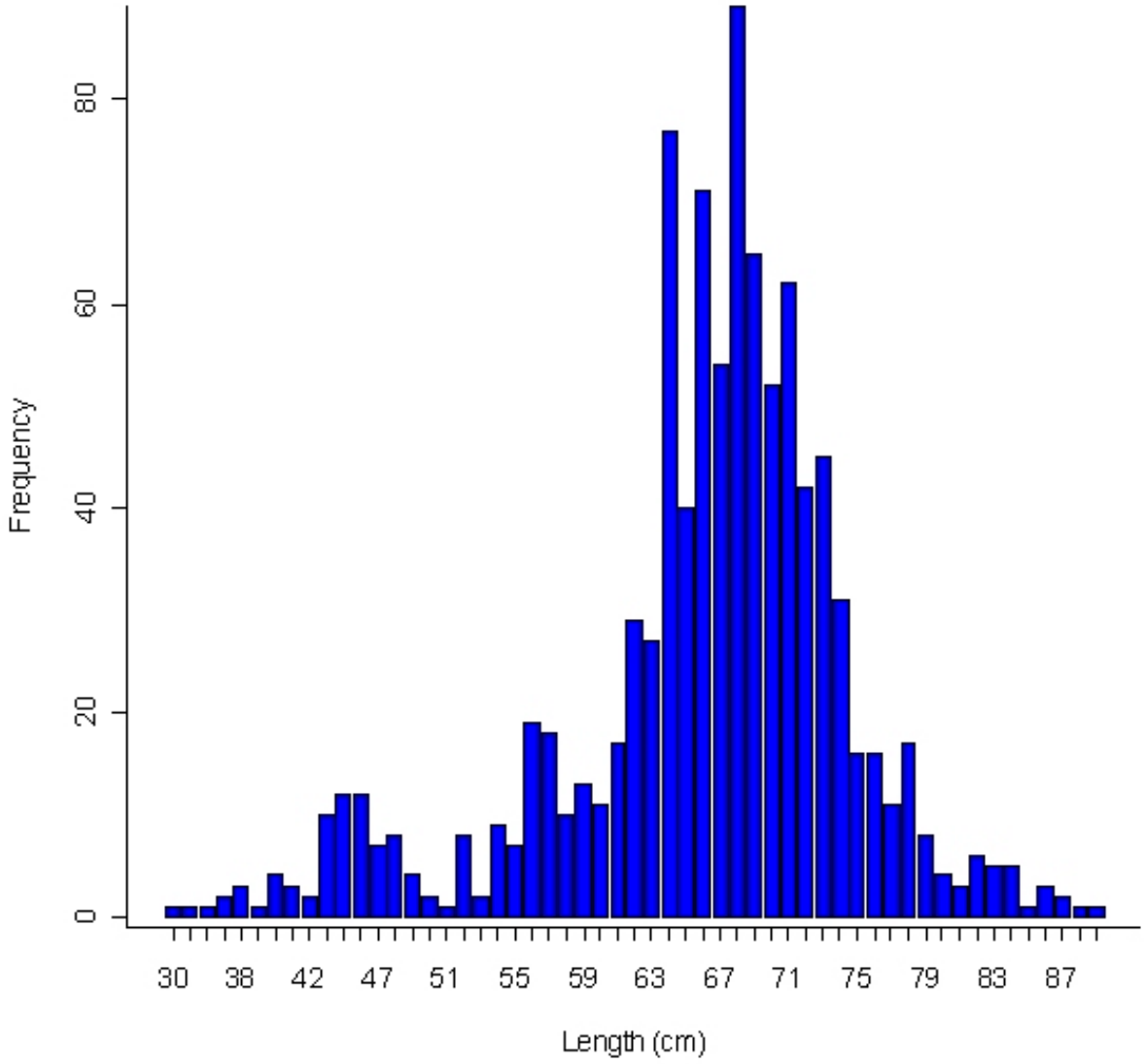

Figure 12. Cumulative length-frequency histogram of all Bocaccio lengths from the Groundfish Biological Database (GFBio).

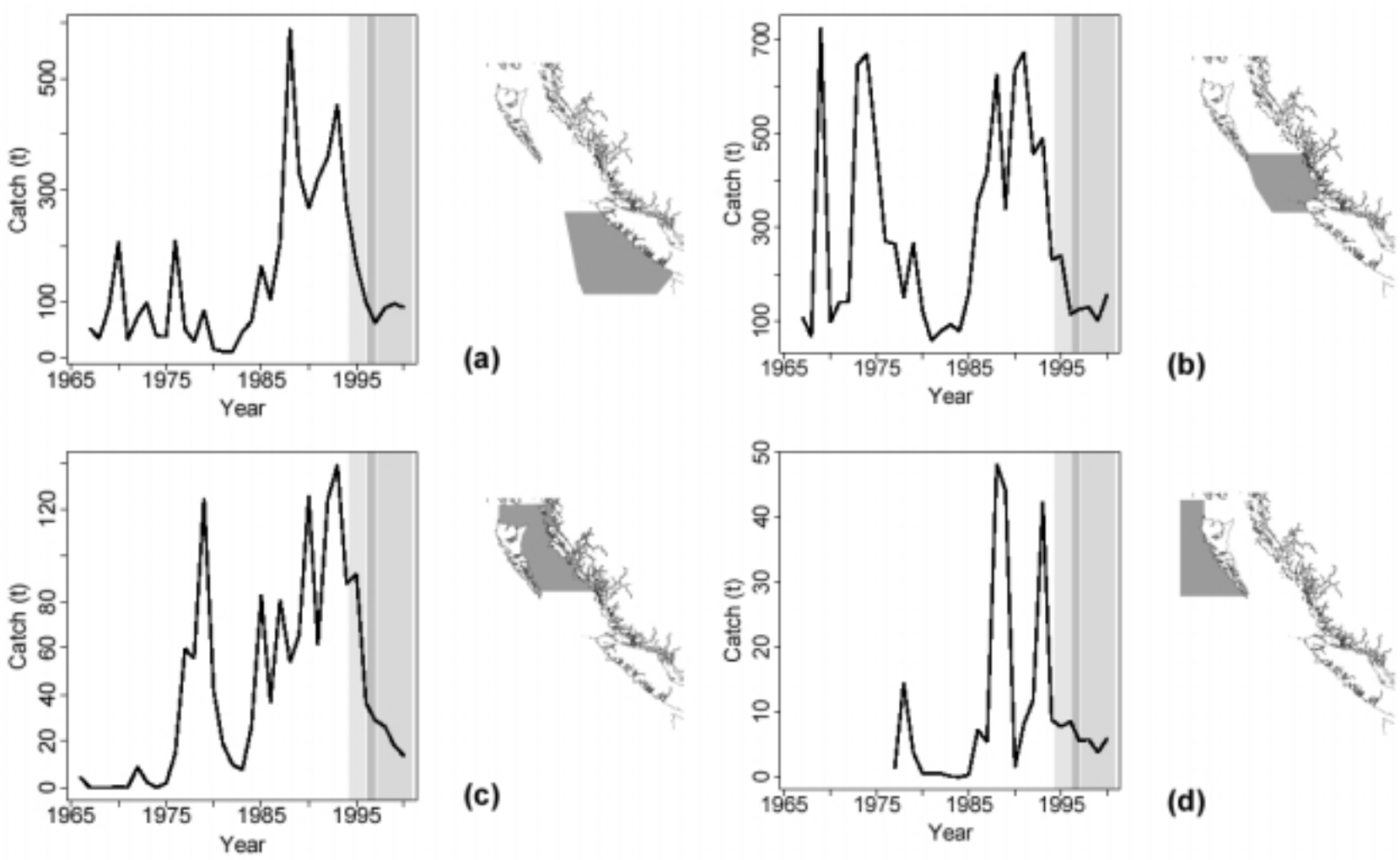

Figure 13. Total catch of bocaccio by region, (a) west coast of Vancouver Island (Major Area 3C and 3D), (b) central coast (Major Areas 5A and 5B), (c) Hecate Strait (Major Areas 5C and 5D), (d) west coast of Queen Charlotte Islands (Major Area 5E). Shaded areas indicate initiation of dockside monitoring (1994), 100% observer coverage (1996) and individual vessel quotas (April 1997).

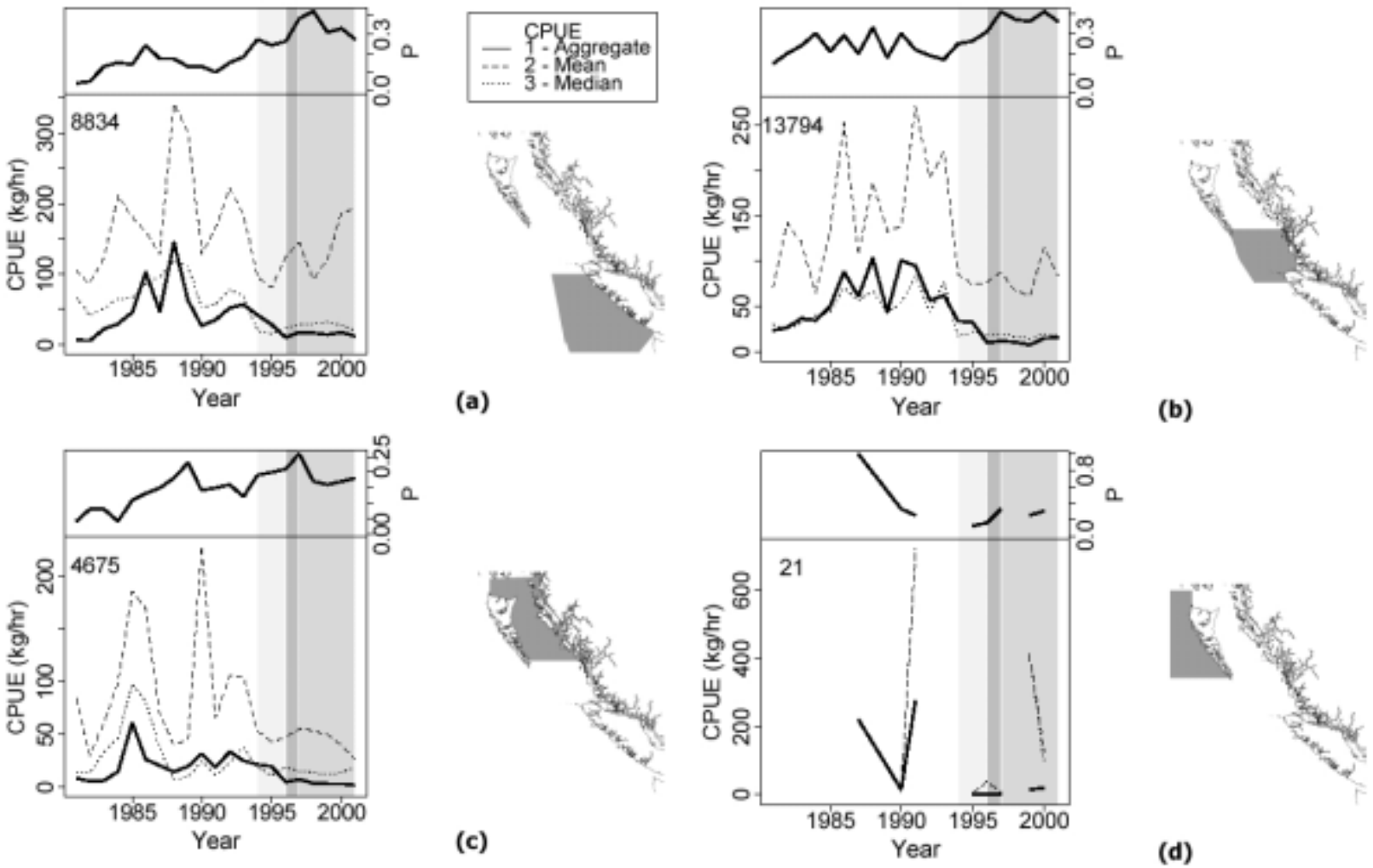

Figure 14. Catch per unit effort (CPUE) of bocaccio by region, (a) west coast of Vancouver Island (Major Areas 3C and 3D), (b) central coast (Major Areas 5A and 5B), (c) Hecate Strait (Major Areas 5C and 5D), (d) west coast of Queen Charlotte Islands (Major Area 5E). Shaded areas indicate initiation of dockside monitoring (1994), 100% observer coverage (1996) and individual vessel quotas (April 1997). The top panel of each plot indicates the proportion of all bottom trawl tows conducted in bottom depths of 60-200 m that have catches of bocaccio. The lower panel indicates (1) total catch divided by total effort for all tows, 60-200 m, (2) mean catch rate per hour of bocaccio for all tows with bocaccio (60-200 m), and, (3) median catch rate per hour for all tows with bocaccio (60-200 m).

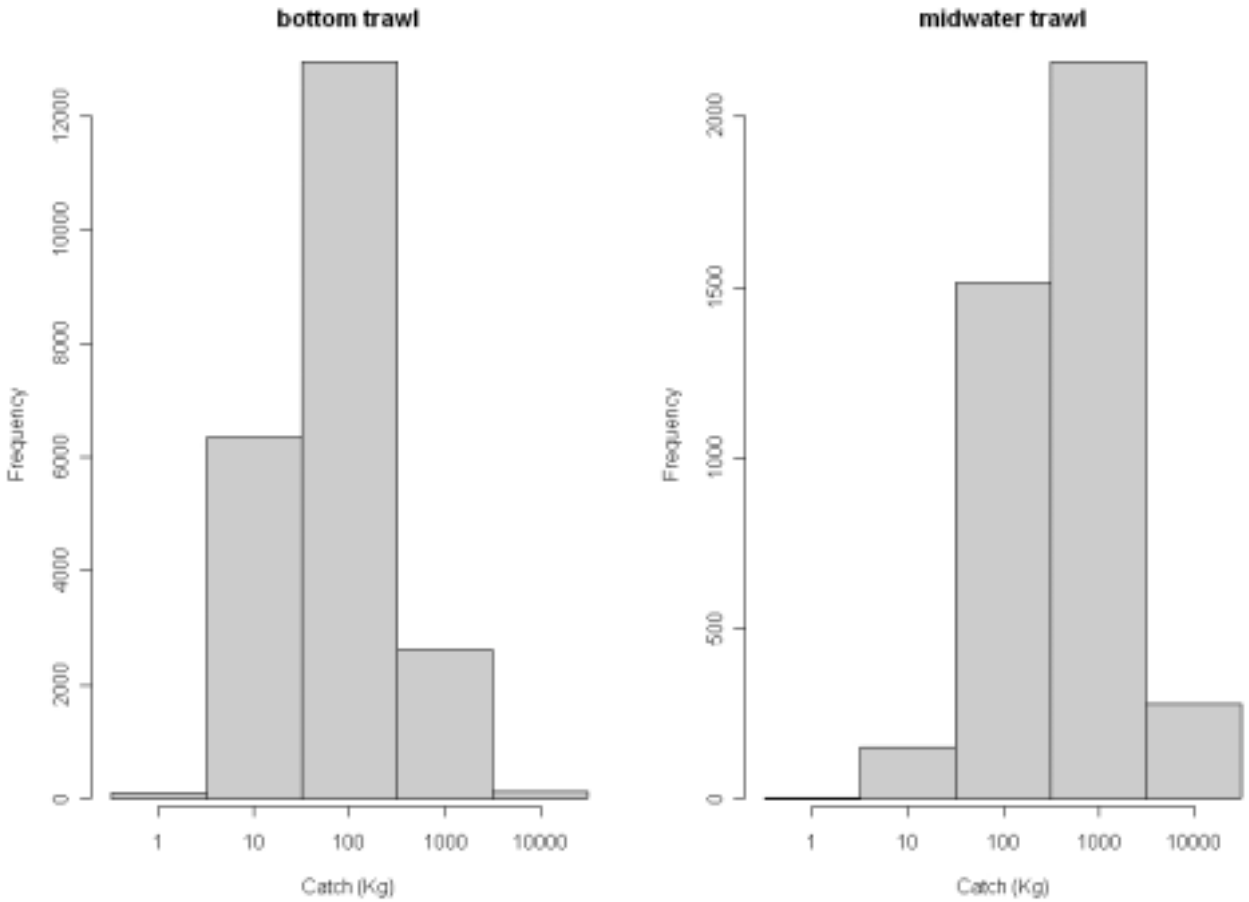

Figure 15. Frequency distribution of catch weights of bocaccio in bottom and midwater tows.

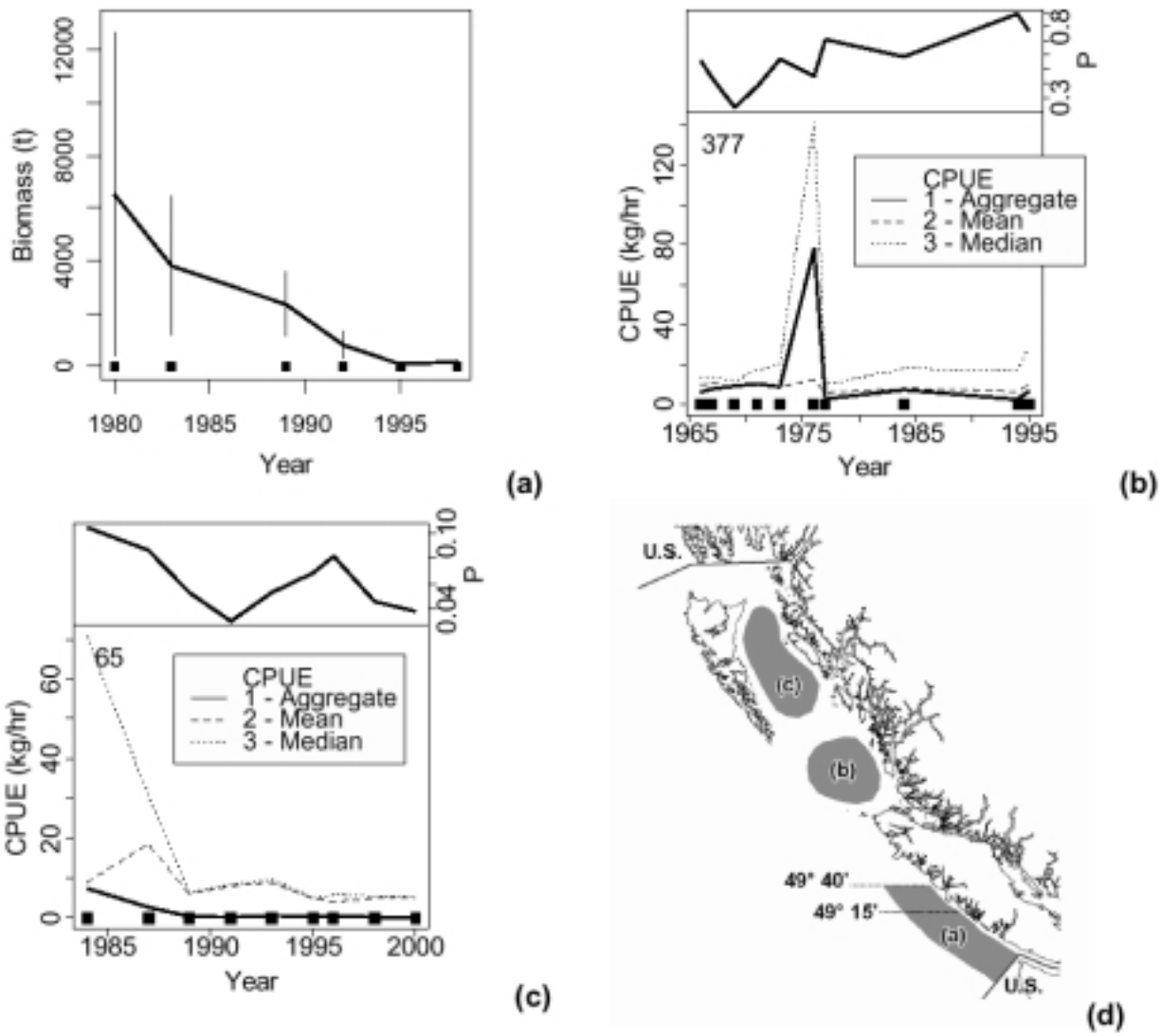

Figure 16. Abundance indices from (a) biomass estimates of the U.S. triennial survey in Area 3C and part of Area 3D (estimates of relative error for recent years are too small to show on the figure), (b) bocaccio CPUE (catch/tow) in the Queen Charlotte Sound Pacific ocean perch survey, (c) CPUE (catch/tow) in the Hecate Strait multispecies assemblage survey. The top panel of plots (c) and (b) indicates the proportion of all bottom trawl tows that have catches of bocaccio. The lower panel of plots (c) and (b) indicates (1) total catch divided by total number of tows (2) mean catch rate per tow of bocaccio for all tows with bocaccio, and, (3) median catch rate per tow for all tows with bocaccio.

Figure 17. Trawl locations for the northern portion of the U.S. Triennial Survey.

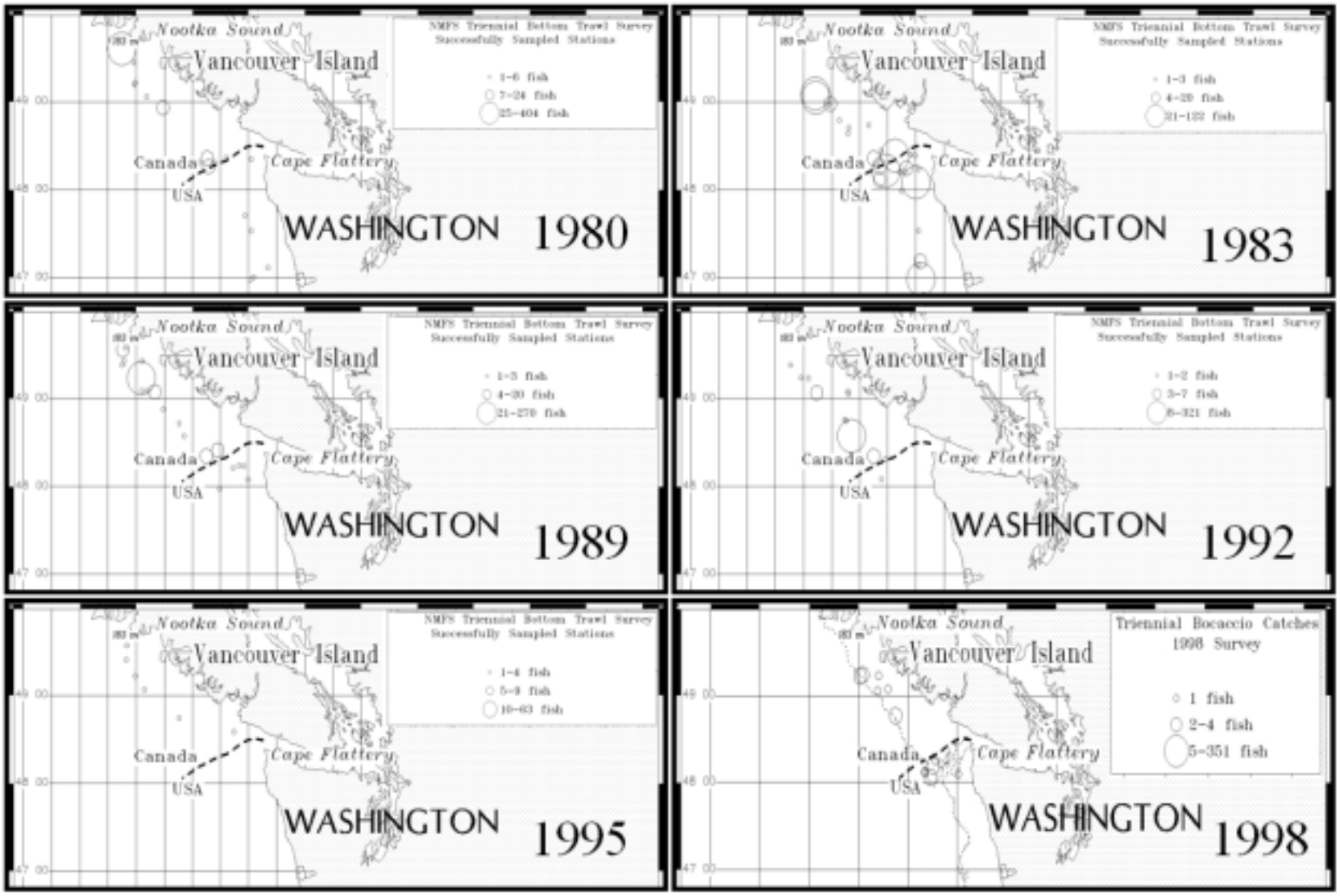

Figure 18. Number of Bocaccio caught in Canadian waters during the U.S. Triennial Surveys of 1980, 1983, 1989, 1992, 1995, and 1998.

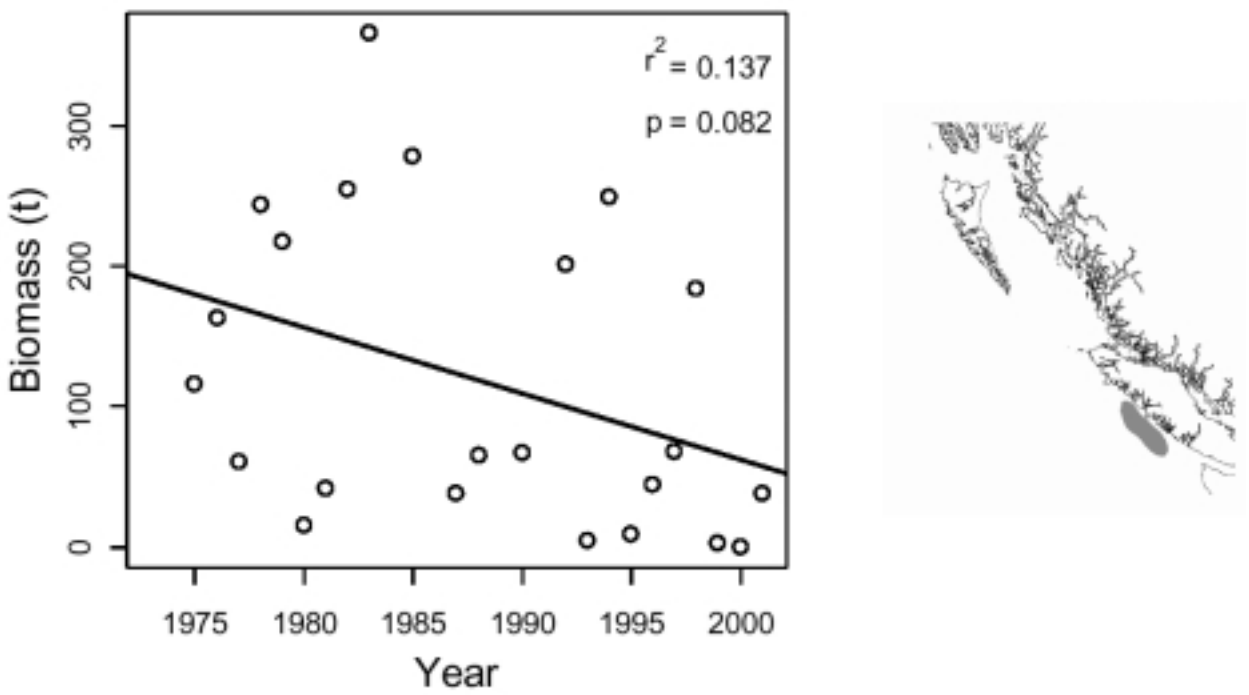

Figure 19. Bocaccio biomass estimates from shrimp trawl surveys of the west coast of Vancouver Island. The shaded region on the inset chart indicates the area that was surveyed.

Table 1. Summary of all bocaccio samples currently in the groundfish biological database, GFBio, at the Pacific Biological Station.

Region	4B			3C + 3D				5A + 5B		5C + 5D			5E		
Gear	HL	BT		MW		HL	GN	BT		BT		LL	LL		
Source	Comm.	Res.	Comm.	Res.	Comm.	Res.	Res.	Res.	Comm.	Res.	Comm.	Comm.	Res.	Comm.	Total
1967								21							21
1969		1						9							10
1970		1													1
1984										15					15
1987										8					8
1988	1														1
1989										5					5
1990	1														1
1991		3		2		1	7			3					16
1993										5		4			9
1996														1	1
1997													1		1
1998											1				1
1999			1		1				1		1				4
2000			1										2		3
2001				1					2						3
Total	2	5	2	3	1	1	7	30	3	36	2	4	3	1	100

Table 2. Catches (t) of bocaccio by Major Area.

	Major area									
Year	**4B**	**3C**	**3D**	**5A**	**5B**	**5C**	**5D**	**5E**	**Unknown**	**Total**
1966	0	0	0	0	0	0	4.51	0	0	4.5
1967	0	0	51.96	89.13	19.84	0	0	0	0	160.9
1968	0	0.08	34.16	19.03	48.61	0	0	0	0	101.9
1969	0	2.27	87.25	247.79	477.28	0	0	0	0	814.6
1970	0	78.69	129.43	55.27	41.98	0	0.63	0	0	306.0
1971	0	12.11	19.89	36.45	103.63	0	0	0	0	172.1
1972	0	9.26	63.00	11.21	130.31	0	9.02	0	0	222.8
1973	0	24.18	74.07	170.47	475.20	0	2.37	0	0	746.3
1974	0	8.53	30.02	205.06	464.09	0	0	0	0	707.7
1975	0	17.20	20.07	253.39	211.51	0	2.03	0	0	504.2
1976	0	48.17	161.98	186.98	82.78	0.05	14.84	0	0	494.8
1977	0	29.43	20.88	47.69	216.98	0.23	59.46	1.37	0	376.0
1978	0.06	8.36	19.67	89.30	61.83	7.89	47.82	14.39	0	249.3
1979	0.29	17.02	67.05	86.50	179.58	67.65	56.65	3.75	0	478.5
1980	0.07	3.03	11.63	27.03	93.38	23.57	18.30	0.46	0	177.5
1981	0.08	3.56	7.47	13.94	44.92	3.43	15.71	0.59	0	89.7
1982	0	1.56	9.78	26.80	52.33	1.87	7.79	0.52	0	100.7
1983	1.52	9.30	36.74	28.76	65.00	4.61	3.11	0.09	0	149.1
1984	0	14.90	50.08	42.52	35.87	16.32	9.56	0	0	169.3
1985	0	35.46	128.18	85.25	74.54	75.41	7.44	0.33	0	406.6
1986	0.43	81.48	22.90	157.00	194.78	25.99	10.84	7.25	0	500.7
1987	0	33.19	172.73	171.21	246.38	57.77	22.95	5.39	0	709.6
1988	0	293.29	301.18	233.82	392.26	35.92	18.29	48.15	0	1322.9
1989	0.01	103.61	232.13	162.49	176.50	43.29	22.57	44.03	0	784.6
1990	0	83.39	186.19	256.94	378.50	95.61	30.34	1.48	0	1032.5
1991	0.11	78.63	242.86	304.24	367.84	45.75	15.88	8.17	0	1063.5
1992	0.25	152.28	208.93	258.46	196.96	50.96	72.98	11.81	0	952.6
1993	0.75	133.99	323.85	250.06	239.49	49.27	89.71	42.34	0	1129.5
1994	0.29	103.64	176.99	118.78	111.31	46.74	41.19	8.77	0	607.7
1995	0.20	57.43	112.84	147.17	93.08	63.93	27.97	7.71	29.24	539.6
1996	0.08	42.80	58.19	51.61	62.88	18.76	17.49	8.52	36.64	297.0
1997	0.01	21.14	42.49	72.31	53.96	11.58	17.48	5.53	14.81	239.3
1998	0	32.05	57.88	74.09	55.42	10.54	15.67	5.74	14.47	265.9
1999	0	30.84	66.79	53.74	46.21	11.56	6.69	3.73	17.55	237.1
2000	0	24.68	66.03	48.22	109.81	6.66	6.90	6.31	25.99	294.6

Table 3. Commercial landings and discards (t) of bocaccio by minor area from the Strait of Georgia (Major Area 4B).

	Minor area						
Year	**12**	**14**	**16**	**17**	**19**	**20**	**Total**
1978						0.06	0.06
1979				0.29			0.29
1980			0.01			0.05	0.06
1981					0.08		0.08
1982							0
1983	1.52	0.01					1.53
1984							0
1985							0
1986						0.43	0.43
1987							0
1988							0
1989	0.01						0.01
1990							0
1991						0.11	0.11
1992	0.03					0.22	0.25
1993	0.30					0.45	0.75
1994	0.17					0.12	0.29
1995	0.16					0.03	0.19
1996	0.06					0.02	0.08
1997						0.01	0.01

Table 4. Landings (t) of bocaccio in U.S. waters (n.a. = not available).

	INPFC Area							
Year	**Alaska**	**Vancouver-US**	**Columbia**	**Eureka**	**Monterey**	**Conception**	**Unknown**	**Total**
1967		4.1						4.1
1968		19.1						19.1
1969		6.2						6.2
1970		1.2						1.2
1971		11.5						11.5
1972		3.8						3.8
1973								0
1974		0.5						0.5
1975								0
1976		2.8						2.8
1977		14.9						14.9
1978		1.7	9.5					11.3
1979		27.5	27.1					54.6
1980								0
1981		39.0	644.1	322.0	2716.7	1222.4	2.6	4946.8
1982		31.8	634.8	643.8	2933.6	1503.7	1.5	5749.2
1983		157.5	763.5	468.6	3421.0	1154.3	2.6	5967.5
1984		147.1	251.8	238.6	3143.7	647.6	2.8	4431.6
1985		128.7	478.6	261.1	1274.6	441.6	0.8	2585.4
1986		81.9	273.1	124.7	1267.7	634.5	2.5	2384.4
1987		116.5	242.6	132.0	1497.3	665.1	7.9	2661.4
1988		99.5	189.4	119.9	1449.1	425.5	2.2	2285.6
1989		283.9	217.3	135.1	1781.8	587.3	2.5	3007.9
1990		304.7	143.6	171.9	1441.3	670.6	1.4	2733.5
1991	1.3	355.1	25.6	48.6	878.9	386.1	2.1	1697.7
1992	1.4	215.9	143.2	63.0	753.6	722.6	6.3	1906.0
1993	1.0	139.8	144.9	120.5	666.3	643.3		1715.8
1994	3.0	52.7	105.1	55.8	444.2	526.2		1187.0
1995	3.0	51.4	95.7	61.1	424.7	246.6		882.5
1996	5.9	35.8	83.5	39.2	280.1	162.0		606.5
1997	3.7	56.9	67.0	11.1	250.1	59.9		448.7
1998	6.2	47.7	90.3	15.5	94.0	38.8		292.5
1999	n.a	10.6	25.7	30.6	74.4	12.9		154.2
2000	n.a	2.0	0.3	2.5	19.5	4.8		29.1

Appendix 1. Recorded landings and discards (t) by fishery and major area (Offshore hake refers to catches in the joint venture and foreign nation supplemental fisheries).

		4B				3C						3D		
Nation	Canada	Canada		Canada	Canada	USA	Offshore hake		Canada	Canada	USA	Canada	Offshore hake	
Gear	Trawl	Trawl		Trawl	Trawl	Trawl	Trawl		Trawl	Trawl	Trawl	Troll	Trawl	
Year	landed	discarded	Total	landed	discarded	USA	catch	Total	landed	discarded	landed	landed	catch	Total
1966			0					0						0
1967			0					0			51.96			51.96
1968			0			0.08		0.08	1.43		32.73			34.16
1969			0			2.27		2.27	1.03		86.22			87.25
1970			0			78.69		78.69	3.04		126.39			129.43
1971			0			12.11		12.11			19.89			19.89
1972			0			9.26		9.26			63.00			63.00
1973			0			24.18		24.18			74.07			74.07
1974			0	0.37		8.16		8.53	3.01		27.01			30.02
1975			0	0.54		16.66		17.20			20.07			20.07
1976			0	2.59		45.58		48.17	6.24		155.74			161.98
1977			0	28.97		0.46		29.43	10.14		10.74			20.88
1978	0.06		0.06	3.81	3.06	1.49		8.36	19.15		0.52			19.67
1979	0.29		0.29	1.42	13.58	2.02		17.02	31.78		35.27			67.05
1980	0.05	0.02	0.07	3.03				3.03	11.63					11.63
1981	0.08		0.08	3.56				3.56	7.47					7.47
1982			0	1.56				1.56	9.78					9.78
1983	1.52		1.52	9.30				9.30	30.84	5.90				36.74
1984			0	14.90				14.90	50.08					50.08
1985			0	33.60	1.86			35.46	128.08	0.10				128.18
1986	0.43		0.43	81.48				81.48	22.90					22.90
1987			0	33.19				33.19	172.73					172.73
1988			0	288.95			4.34	293.29	300.58				0.60	301.18
1989	0.01		0.01	101.23			2.38	103.61	228.98	0.45			2.70	232.13
1990			0	81.08			2.31	83.39	185.79				0.40	186.19
1991	0.11		0.11	75.80	0.91		1.92	78.63	241.93	0.45			0.48	242.86
1992	0.25		0.25	148.92	0.90		2.46	152.28	208.91				0.02	208.93
1993	0.72	0.03	0.75	130.95			3.04	133.99	322.57				1.28	323.85
1994	0.29		0.29	97.07			6.57	103.64	172.88	0.02			4.09	176.99
1995	0.20		0.20	55.82	0.01		1.60	57.43	112.75	0.09				112.84
1996	0.08		0.08	39.80	0.07		2.93	42.80	57.88	0.31				58.19
1997	0.01		0.01	18.56	1.32		1.26	21.14	41.83	0.66				42.49
1998			0	30.06	0.58		1.41	32.05	57.75	0.13				57.88
1999			0	28.97	0.25		1.62	30.84	66.59	0.20				66.79
2000			0	24.11	0.35		0.22	24.68	64.54	1.48		0.01		66.03

Appendix 1. Continued.

			5A					5B				5C	
Nation Gear Year	Canada Trawl landed	Canada Trawl discarded	USA Trawl USA	Offshore hake Trawl catch	Total	Canda Trawl landed	Canada Trawl discarded	USA Trawl USA	Offshore hake Trawl catch	Total	Canada Trawl landed	Canada Trawl discarded	Total
1966					0					0			0
1967	0.22		88.91		89.13			19.84		19.84			0
1968	2.03	3.63	13.37		19.03			48.61		48.61			0
1969	1.11		246.68		247.79	3.22		474.06		477.28			0
1970	0.39		54.88		55.27			41.98		41.98			0
1971			36.45		36.45			103.63		103.63			0
1972			11.21		11.21			130.31		130.31			0
1973			170.47		170.47			475.20		475.20			0
1974	1.48		203.58		205.06			464.09		464.09			0
1975	3.41		249.98		253.39			211.51		211.51			0
1976	8.24		178.74		186.98	18.96		63.82		82.78	0.05		0.05
1977	17.41		30.28		47.69	24.50		192.48		216.98	0.23		0.23
1978	74.88	1.16	13.26		89.30	58.43	3.40			61.83	7.44	0.45	7.89
1979	42.60	1.74	42.16		86.50	108.06	9.78	61.74		179.58	67.65		67.65
1980	27.03				27.03	59.81	33.57			93.38	18.78	4.79	23.57
1981	13.94				13.94	35.85	9.07			44.92	3.31	0.12	3.43
1982	24.38	2.42			26.80	33.91	18.42			52.33	1.39	0.48	1.87
1983	28.76				28.76	64.55	0.45			65.00	4.59	0.02	4.61
1984	42.52				42.52	35.87				35.87	14.05	2.27	16.32
1985	85.25				85.25	74.54				74.54	70.87	4.54	75.41
1986	157.00				157.00	194.78				194.78	25.76	0.23	25.99
1987	166.45	4.76			171.21	246.38				246.38	57.77		57.77
1988	233.82				233.82	388.63	3.63			392.26	35.92		35.92
1989	162.26	0.23			162.49	175.09	1.41			176.50	43.29		43.29
1990	256.40	0.54			256.94	378.50				378.50	95.61		95.61
1991	304.24				304.24	367.84				367.84	45.75		45.75
1992	258.46				258.46	196.96				196.96	50.96		50.96
1993	250.06				250.06	239.49				239.49	49.27		49.27
1994	117.72	1.06			118.78	111.20	0.11			111.31	46.74		46.74
1995	146.67	0.50			147.17	92.91	0.17			93.08	63.93		63.93
1996	51.34	0.27			51.61	61.47	1.41			62.88	18.54	0.22	18.76
1997	72.10	0.21			72.31	53.91	0.05			53.96	11.58		11.58
1998	74.00	0.09			74.09	55.20	0.22			55.42	10.53	0.01	10.54
1999	53.47	0.27			53.74	46.10	0.11			46.21	11.54	0.02	11.56
2000	45.58	0.01		2.63	48.22	106.01	0.09		3.71	109.81	6.65	0.01	6.66

Appendix 1. Continued.

	5D				5E					Unknown			Grand total
Nation	Canada	Canada	Offshore hake		Canada	Canada	Offshore hake	Canada		Canada	Canada		
Gear	Trawl	Trawl	Trawl		Trawl	Trawl	Trawl	Troll		Trawl	H & L		
Year	landed	discarded	catch	Total	landed	discarded	catch	landed	Total	landed	landed	Total	
1966	4.51			4.51					0			0	4.51
1967				0					0			0	160.93
1968				0					0			0	101.88
1969				0					0			0	814.59
1970	0.63			0.63					0			0	306.00
1971				0					0			0	172.08
1972	9.02			9.02					0			0	222.80
1973	2.37			2.37					0			0	746.29
1974				0					0			0	707.70
1975	1.58	0.45		2.03					0			0	504.20
1976	14.84			14.84					0			0	494.80
1977	52.88	6.58		59.46	1.37				1.37			0	376.04
1978	46.19	1.63		47.82	14.31	0.08			14.39			0	249.32
1979	46.90	9.75		56.65	3.63	0.12			3.75			0	478.49
1980	18.28	0.02		18.30	0.45	0.01			0.46			0	177.47
1981	3.92	11.79		15.71	0.27	0.32			0.59			0	89.70
1982	7.69	0.10		7.79	0.52				0.52			0	100.65
1983	1.75	1.36		3.11	0.09				0.09			0	149.13
1984	9.56			9.56					0			0	169.25
1985	7.44			7.44	0.33				0.33			0	406.61
1986	10.84			10.84	7.25				7.25			0	500.67
1987	22.95			22.95	5.39				5.39			0	709.62
1988	18.29			18.29	48.15				48.15			0	1322.91
1989	22.57			22.57	44.03				44.03			0	784.63
1990	19.00	11.34		30.34	1.48				1.48			0	1032.45
1991	13.97	1.91		15.88	8.17				8.17			0	1063.48
1992	72.53	0.45		72.98	11.81				11.81			0	952.63
1993	89.71			89.71	42.34				42.34			0	1129.46
1994	41.19			41.19	8.77				8.77			0	607.71
1995	27.97			27.97	7.71				7.71		29.24	29.24	539.57
1996	17.33	0.16		17.49	8.49	0.03			8.52	13.45	23.19	36.64	296.97
1997	17.30	0.18		17.48	5.48	0.05			5.53	3.61	11.20	14.81	239.31
1998	15.62	0.05		15.67	5.61	0.13			5.74	4.17	10.30	14.47	265.86
1999	6.68	0.01		6.69	3.28	0.45			3.73	4.21	13.34	17.55	237.11
2000	6.70	0.02	0.18	6.90	5.43	0.02	0.49	0.37	6.31	6.54	19.45	25.99	294.60

Appendix 2. Data sources used for the preparation of the bocaccio status report.

Catch and landings data

1) **GFCatch.** Canadian trawl landings, 1954-1995 (Rutherford 1999).
2) **PacHarvTrawl.** Canadian trawl landings, 1996-2000. SQL Server database, Groundfish Section, Stock Assessment Division, Science Branch, Fisheries and Oceans, Canada. Pacific Biological Station.
3) **PacHarvHL.** Canadian hook and line landings, 1995-2000. SQL Server database, Groundfish Section, Stock Assessment Division, Science Branch, Fisheries and Oceans, Canada. Pacific Biological Station.
4) **Pacharv3.** Canadian troll landings from sales slips, 1982-2000. Oracle database, Regional Data Unit, Information Management, Corporate Services Branch, Fisheries and Oceans, Canada.
5) **U.S. trawl landings** from Canada and Washington, 1967-1979, from Tagart and Kimura (1982).
6) **PACFIN.** U.S. commercial landings from Washington, Oregon and California, 1981-2000 (www.psmfc.org/pacfin/data.html).
7) **AKFIN.** U.S. commercial landings from Alaska, 1991-1998 (www.psmfc.org/akfin/Reports/reports.html).
8) **Washington Department of Fish and Wildlife**. Commercial trawl landings for 1980.

Biological data

1) **GFBio.** Biological samples. Oracle database, Groundfish Section, Stock Assessment Division, Science Branch, Fisheries and Oceans, Canada. Pacific Biological Station.

Appendix 3. Biomass estimation from the 3C and 3D shrimp survey (J. Boutillier, pers. comm.)

This section summarizes the survey and estimation procedures for bocaccio using data collected from the shrimp trawl surveys conducted off the West Coast of Vancouver Island (WCVI) since 1973 for Minor Areas 124, and 125 (Fig. 4). The systematic survey was established using grid patterns based on LORAN lines. Inner and outer boundaries were determined by fishing this grid system until shrimp catches were negligible or the bottom became too rough to trawl.

Over the history of the survey, there has been an evolution in the methodology. While sapling effort has been calibrated with respect to catchability of shrimp, there are no means to standardize catchability with respect to finfish. All tows were of 30 minutes duration unless shortened due to gear malfunction. The distance traveled was calculated using the technology of the day. In the early years, this was start and stop LORAN locations while more recent surveys have used DGPS. This has resulted in a trend towards a shorter distance traveled for a 30-minute tow over the years. The estimation did not attempt to account for the errors or differences among surveys with respect to distance towed. There was also a modest variation in timing of the survey. Surveys were generally completed in the spring although an additional survey was conducted 1977 and 1978.

The density of bocaccio in kg/m2 was calculated for all tows. These data, with the location of the center point of each tow, was imported into a GIS. The total area of fishable shrimp grounds for each survey area was then “masked” into a grid of 300x300-m cells. The catch density was then assigned to the appropriate grid cell using the center point location. The biomass indices were calculated by interpolating values for the blank grid cells and then summing the values in each grid within the larger masked area. Interpolation was conducted using with an inverse distance weighting procedure and a radial search routine. The size of the radius was chosen as the lower boundary of the third category determined within the “Find Distance” routine in the spatial analyst menu. The biomass calculations were made within the GIS software package (ArcView).

Appendix 4. The original "Request for Working Paper" for the current document, as accepted by the PSARC Groundfish Subcommittee.

PSARC GROUNDFISH SUBCOMMITTEE

Request for Working Paper

Date Submitted: June 26, 2001

Individual or group requesting advice: Groundfish Management Unit

Proposed PSARC Presentation Date: November 2001

Subject of Paper (title if developed):

Evaluation of a the Rapid Assessment Approach for Data Limited Fisheries

Stock Assessment Lead Author: R. Stanley

Fisheries Management Author/Reviewer: D. Trager

Rational for request:

Hook and line and trawl fisheries for groundfish are generally non species specific. TAC's have been established for ____ target species. An additional _____ species are caught in the trawl fishery based on at-sea observer reports. Less information is available on other species encountered in the hook and line fisheries.

To date, no assessments have been conducted on the non-TAC species and for some areas/stocks of the TAC species. Catches (including discards in the trawl fishery) are reported and informally monitored. An assessment may be promulgated if there is a noticeable increase in catch, expansion of effort (fishing and/or processing) or fishermen or observers have raised concerns.

Funding is limited for groundfish species and assessments are generally limited to target species (surveys, biological sampling, ageing, etc). To ensure that conservation objectives are met that adhere to precautionary principles, an assessment approach, utilising the limited available data, is required.

Question(s) to be addressed in the Working Paper:

1. Using the available data for ___ species (need to discuss which species should be considered), can a preliminary assessment technique be developed to monitor the stock status for the data-limited, non-assessed groundfish species? The intent of this approach would be to alert managers and scientists to species, which may require a focused assessment or alternative management measures.

2. More specifically, can the following elements for the specified species be compiled:
    - Annual landings (1996-2000 or 1954-2000 if available)
    - Total catch, separating catch and discards
    - 1996-2000 annual CPUE by species/area/year
    - summary of biological characteristics (SPR graphs)
    - charts of the distribution of catch locations
    - Listing of samples in GFBIO
    - Summarize biomass estimates, quotas and other stock assessment information from US fisheries.

Objective of Working Paper: *(StAD staff to develop further jointly with management)*

1. To evaluate the feasibility of using a rapid assessment approach for data limited, non-assessed groundfish species.
2. To report on the information complied for the species evaluated.
3. To recommend research and/or management measures for any species where a particular concern is identified.