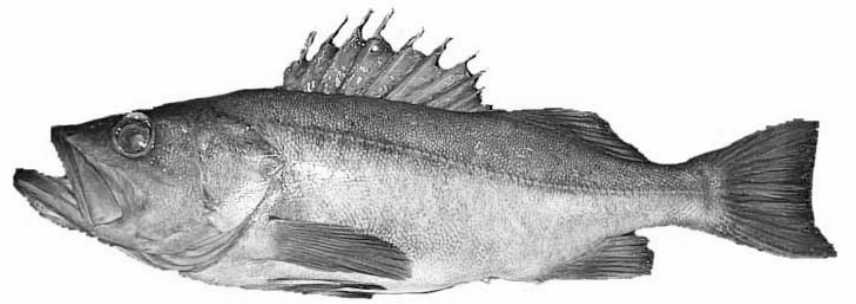
COSEWIC
Assessment and Status Report

on the

Bocaccio
Sebastes paucispinis

in Canada



THREATENED
2002

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE IN
CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC
Assessment Summary

Assessment Summary – November 2002

Common name
Bocaccio

Scientific name
Sebastes paucispinis

Status
Threatened

Reason for designation
A combination of low recruitment and impact by harvest has resulted in severe declines and low spawning abundance of this Canadian species.

Occurrence
Pacific Ocean

Status history
Designated Threatened in November 2002. Assessment based on a new status report.

COSEWIC
Executive Summary

Bocaccio
Sebastes paucispinis

Species information

Bocaccio is one of over 35 species of rockfish found in marine waters off British Columbia (B.C.). It is distinguished from other rockfish (Sebastes spp.) by its large jaw. 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. This report treats all the bocaccio of the BC coast as a single population; there has been no research to address evolutionarily significant units within BC.

Distribution

Bocaccio are found in coastal waters of the eastern Pacific Ocean from the Gulf of Alaska to Baja California, Mexico. The population of bocaccio in B.C. probably overlaps to some extent with U.S. populations to the north and south. Most B.C. catches come from the outer Pacific coast near the edge of the continental shelf, with the largest catches coming from the northwest coast of Vancouver Island and from Queen Charlotte Sound. They have been reported from some inlets and the Strait of Georgia.

Habitat

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, most commonly over depths of 60-340m. In B.C., they are caught with several other groundfish species including Pacific ocean perch, yellowtail rockfish, and canary rockfish.

Biology

There has been limited research on bocaccio in B.C. waters. Most of the biological information comes from studies done in California. Bocaccio are livebearers. Fecundity, during the egg stage, ranges from 20,000-2,300,000 eggs and increases with the size of the female. Copulation occurs in early fall but fertilization is delayed. Fertilized eggs are retained in the body of the female through hatching and much of

larval development. Embryonic development takes about one month and, in B.C. waters, young are released in the winter. Settlement to the littoral and demersal habitat extends from late spring through the summer. Larvae are approximately 4-5 mm long at release and then metamorphose into pelagic juveniles over the next several months. 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. Radiometric dating of the otoliths suggests a maximum age of 40 or more years.

Juvenile bocaccio feed on fish and invertebrate larvae, pelagic shrimp, young rockfish, surfperch, mackerel and various small inshore fishes. Adult bocaccio prey on other rockfish, sablefish, anchovies, lanternfish and squids. The main predators of juvenile bocaccio in California are sea birds and the main predators of adults are marine mammals. Bocaccio are host to a number of parasites including a nematode 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.

Population sizes and trends

The abundance of bocaccio is poorly known in B.C. waters. Its low commercial importance has inhibited directed research; and the low catches of bocaccio in the fisheries limit the utility of fishery-dependent data for tracking abundance. Catches indicate that the population is present in coastal waters at the edge of the continental shelf from the Washington to Alaska state borders. The distribution in inshore waters is less well known, although adults continue to be caught in several inlets and the Strait of Georgia. The trend in abundance is unknown for the outer north and central coasts.

Off the west coast of Vancouver Island, numbers appear to have declined by more than 95% in the last two decades, and by more than 90% over the last 10 years. No trend is apparent over the last five years. Numbers may be declining in the Strait of Georgia, however quantitative data are lacking. In neighbouring U.S. waters to the south, abundance is thought to have declined by over 90% over the last two decades.

Limiting factors and threats

Commercial trawl fisheries landings (1996-2000) have ranged from 200-300 t/y. Trawl discarding was 9 t in 2000. Landings from hook and line fisheries are approximately 2 t/y. Discards have been reported in the hook-and line fisheries, but the extent is unknown. If significant, it would affect productivity as bycatch usually results in death due to expansion of the swimbladder. Aboriginal and recreational catches are probably negligible at present, but recreational catches could increase as the recreational fishery grows and shifts to targeting on non-salmonid species.

The decline in abundance of bocaccio in Washington State probably means that fewer U.S. recruits are entering B.C. waters, however, the extent to which the Canadian population relies on this immigration is unknown. U.S. harvests are now significantly restricted through reduced trip limits, but discarding is not monitored.

There are no means for estimating the impact of the two parasites on bocaccio populations. There is also no information regarding other biotic or abiotic environmental impacts on bocaccio populations, however, it is generally perceived that the 1990's produced poor recruitment for most species of groundfish in B.C. and neighbouring U.S. waters. Whether recruitment will improve in the 2000s is yet unknown.

Special significance of the species

Bocaccio were part of aboriginal fisheries, have played a minor economic role in B.C. fisheries, and may become of interest to some anglers as rockfishes attract greater attention. They may be the unique host for one species of tapeworm; however, the presence of this tapeworm in B.C. waters has not been confirmed.

Existing protection or other status designations

There is no specific protection or status for this species in Canadian waters. In U.S. waters, it has been petitioned for listing under the Endangered Species Act. It is considered to be critically endangered by the IUCN, and endangered by WWF.

Summary of status report

The biology of bocaccio in B.C. waters is poorly known. It is a marine fish found along the Pacific coast but captured primarily along the edge of the continental shelf. It is difficult to infer population abundance trends. Where some of the best data exist, the west coast of Vancouver Island, there is evidence of a decline of over 90% in the last 10 years and 95% over the last 20 years (data to 2001). A strong decline in the overlapping population in neighbouring U.S. waters raises further concern about the status of bocaccio in B.C. Threats primarily include the harvest and bycatch of fisheries, and poor recruitment.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.
** Formerly described as “Not In Any Category”, or “No Designation Required.”
*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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2002

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SPECIES INFORMATION

Name and classification

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 along the Pacific coast of North America (Eschmeyer *et al.* 1983). It is one of at least 35 species known to occur in British Columbia (B.C.) waters (Graham Gillespie, pers. comm. Appendix 1). 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). B.C. commercial fishers often call them longjaws.

Description

Bocaccio is one of the largest of the rockfishes (Figs. 1 and 2). The principal field diagnostic of this species is the long maxillary (upper jaw) that extends to, or beyond, the orbit. 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 and 1996 for a description of the 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).

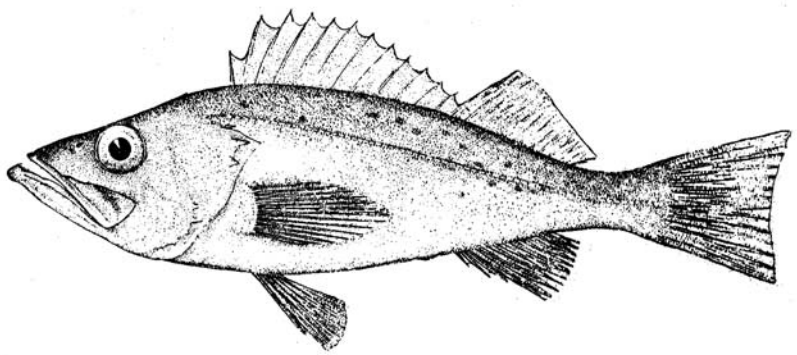
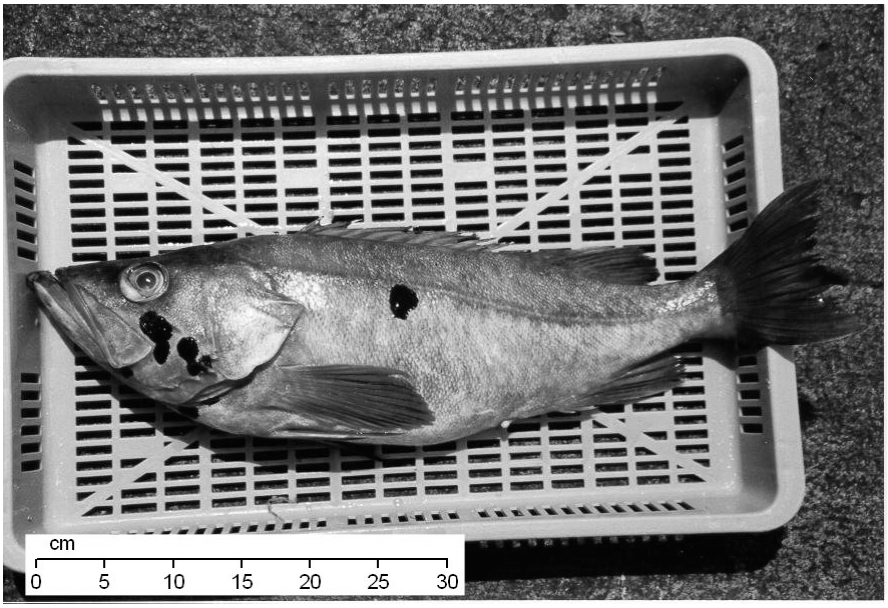


Figure 1. Line drawing of Bocaccio (from Hart 1973).



Steve Sviatko, Fisheries and Oceans Canada

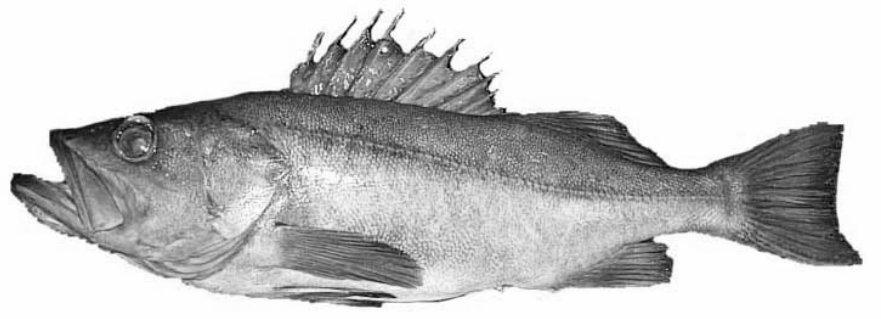

Terri Bonnet, Fisheries and Oceans Canada

Figure 2. Pictures of adult bocaccio (photo archives, Groundfish Section, Science Branch, Pacific Region).

Nationally significant population

In this report, we treat B.C. bocaccio as one evolutionarily significant unit (ESU). U.S. research indicates a genetic difference between Southern California and Washington populations (MacCall *et al*. 1999). However, there has been no study of genetic structure yet conducted within B.C. waters. Our hypothesis of a single ESU is based on presumed dispersal during the planktonic phase, movements by juveniles, and possible continuous distribution of adults along the outer coast (see below). However, we have no genetic data to test this hypothesis. The Strait of Georgia might contain a self-perpetuating population, as this area is distinct from the outer coast, but we lack data to determine or refute this.

DISTRIBUTION

Global 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).

Canadian range

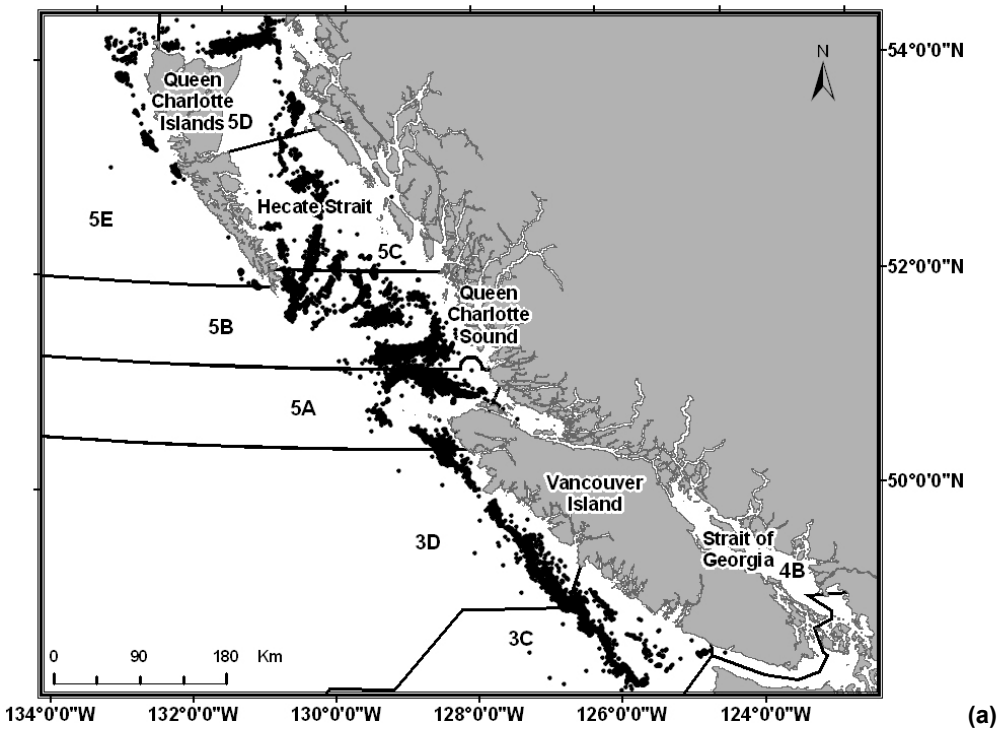
Commercial trawl catches indicate that bocaccio are present along the entire outer Pacific coast of Canada (Fig. 3a, Table 1). The largest reported catches have come from the northwest end of Vancouver Island and Queen Charlotte Sound. As most commercial groundfish fishing is conducted on the outer coast near the continental shelf break, there is little information on the distribution in the inlets and nearshore waters of B.C. However, 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 2). 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 in Queen Charlotte Sound. Like many of the deeper water rockfishes, highest catch densities are found over rocky high relief bottom near the edge of the continental shelf. U.S. catches have traditionally come from the California and Washington trawl fisheries with small amounts from Alaska (Table 3).

Trends in Range

There are no obvious trends in the distribution of bocaccio catches in the outer coast trawl fishery since 1996 (Figs. 6 and 7). We assume that this species has been present throughout this range since the development of the fishery (Table 1). Longer-term comparisons of the distribution are problematic owing to inadequate geospatial data prior to 1991 (see Rutherford 1999), and lack of data on rockfish species composition, prior to 1967 (Tagart and Kimura 1982).

Detailed catch data from rockfish fisheries by First Nations are not available. However, a First Nations spokesperson indicated that bocaccio have always been a part of the aboriginal fisheries on the west coast of Vancouver Island (A. Amos, pers. comm. Appendix 1). Results from middens are inconclusive owing to the difficulty in identifying rockfish remains to species.

There have been no trawl landings of bocaccio reported in sales slips or dockside monitoring from the Strait of Georgia since 1983 (Minor Areas 13-18, 28, 29) (Table 2, Fig. 3b). 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. Appendix 1).



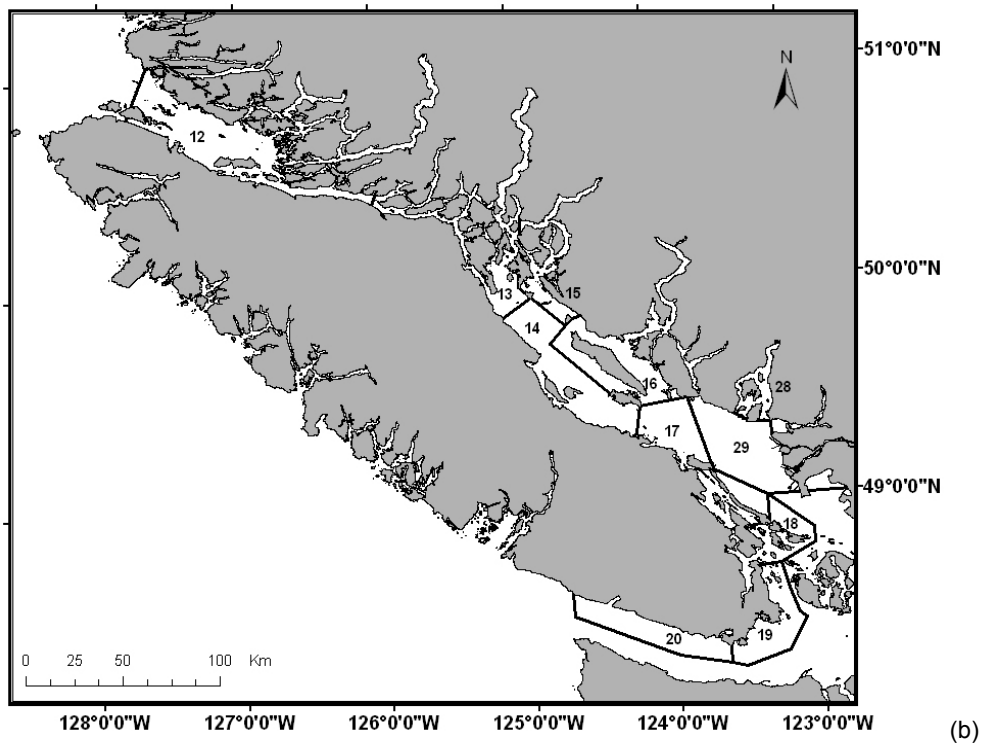


Figure 3. (a) A chart of coastal B.C. waters showing spatial distribution of all trawl tows which captured one or more bocaccio (January, 1996-June, 2001). Also shown are the boundaries of Major Areas used by DFO fisheries management. (b) Minor Area boundaries in the Strait of Georgia used by DFO Fisheries Management

Table 1. Total commercial catches (t) of bocaccio by Major Area. Includes trawl discards but hook and line discards and aboriginal and recreational catches unknown.

	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

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. Appendix 1). There is qualitative evidence that bocaccio were more 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. Appendix 1). Nevertheless, bocaccio continue to be captured in the recreational fishery in Minor Area 17 (T.G. Brown, pers. comm. Appendix 1) (Fig. 3b).

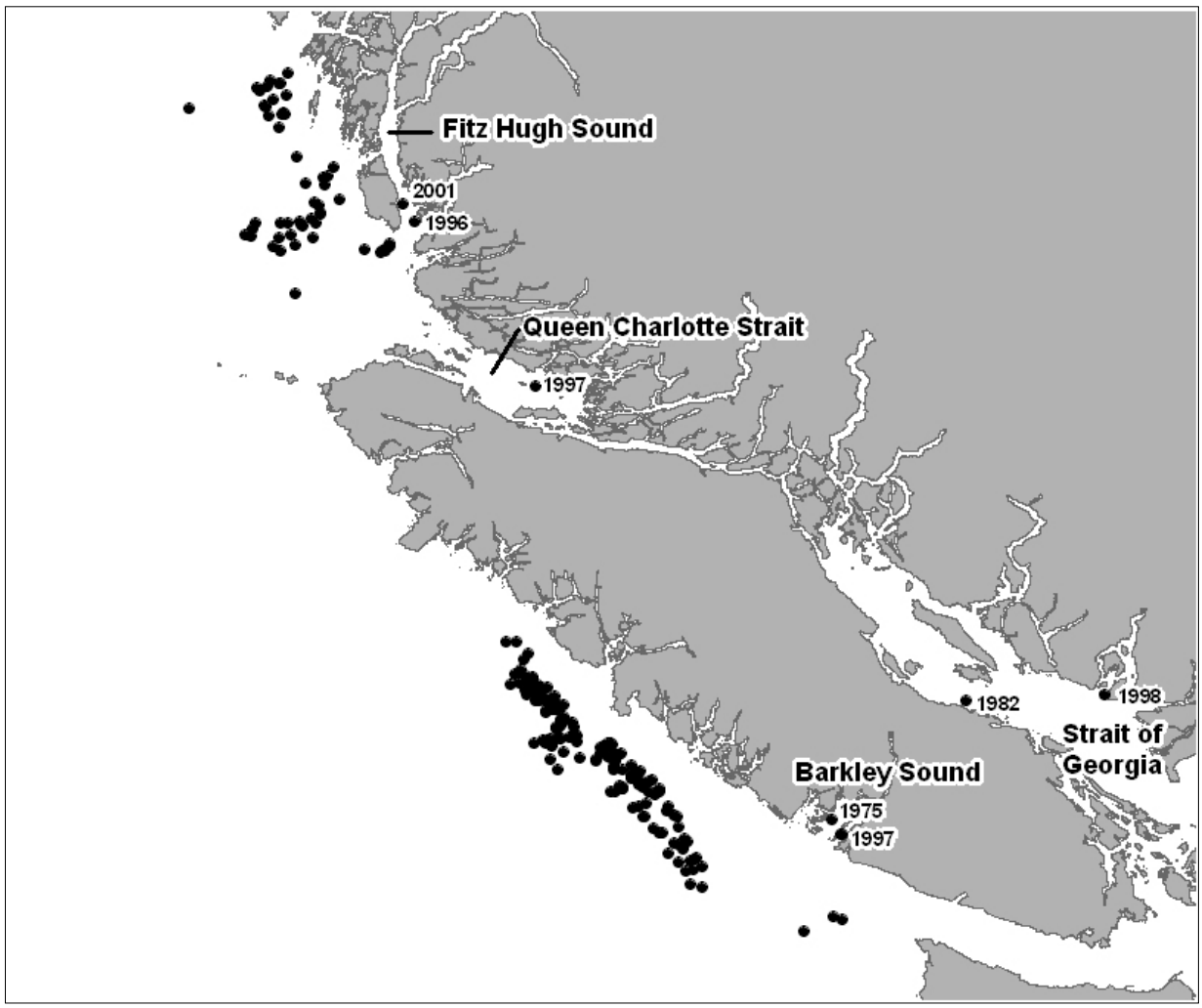


Figure 4. Chart showing presence of bocaccio in *research shrimp trawl tows conducted from 1973 to 2001. Year of capture is noted for the observations in enclosed waters (* the point labeled “1997” in Barkley Sound was recorded on an observed commercial shrimp trawl trip).

Table 2. Commercial landings and discards (t) of bocaccio by minor area from the Strait of Georgia (Major Area 4B) (se Figure 3 for chart of Minor Areas). Aboriginal and recreational catches not included.

	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

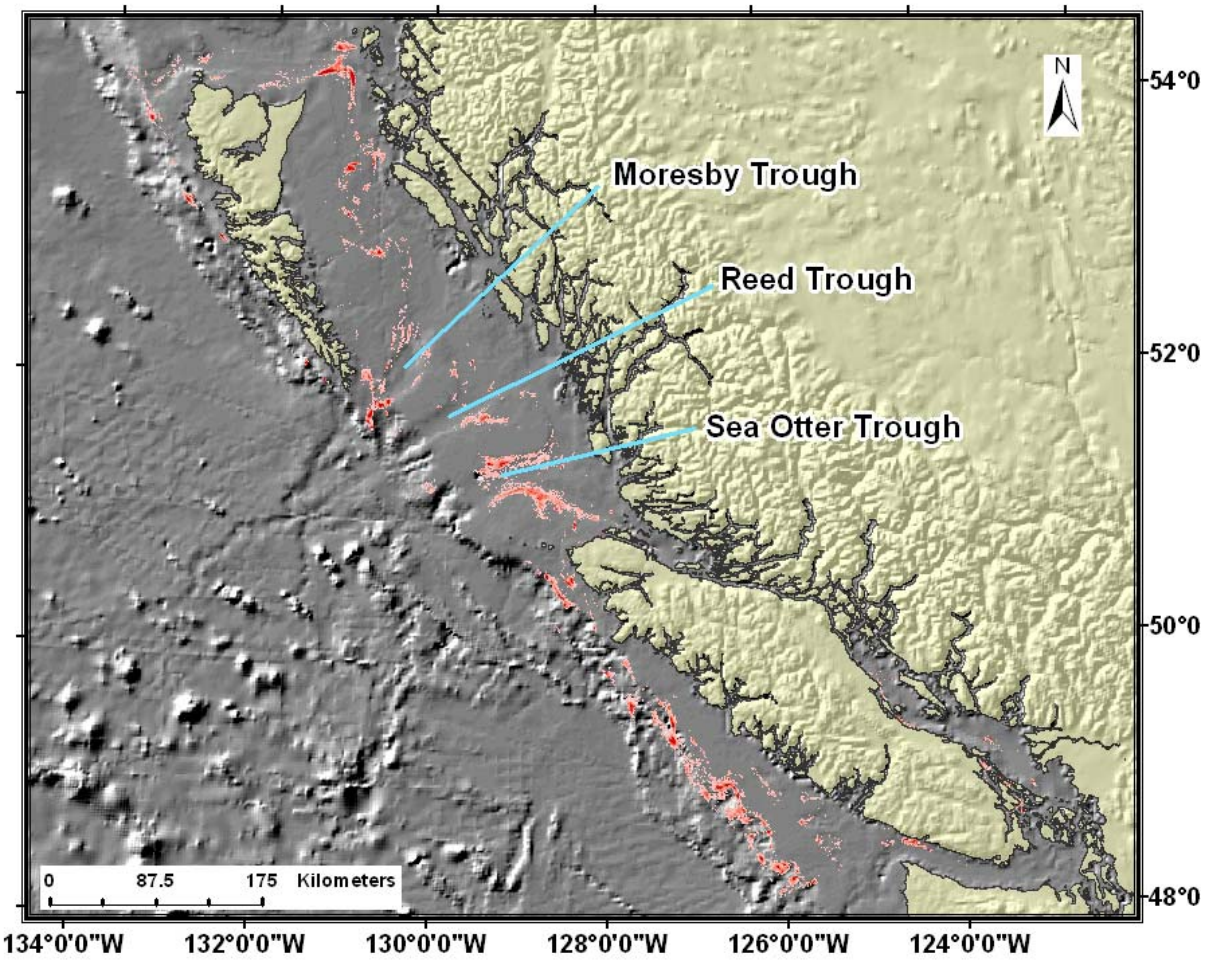


Figure 5. Chart of B.C. coastal waters showing continental shelf, break-in-slope and the location of major roughs. Trawled areas are indicated in red. The intensity in colour varies proportionally with the number of trawls in each 1km^2 block.

Table 3. Landings (t) of bocaccio in U.S. waters (n.a. = not available).

Year	INPFC Area							
	Alaska	Vancouver-US (N. Wash.)	Columbia (S. Wash.-N. Ore.)	Eureka (S. Ore.-N. Cal.)	Monterey (Cen. Cal.)	Conception (S. Cal.)	Unkn.	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								na
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

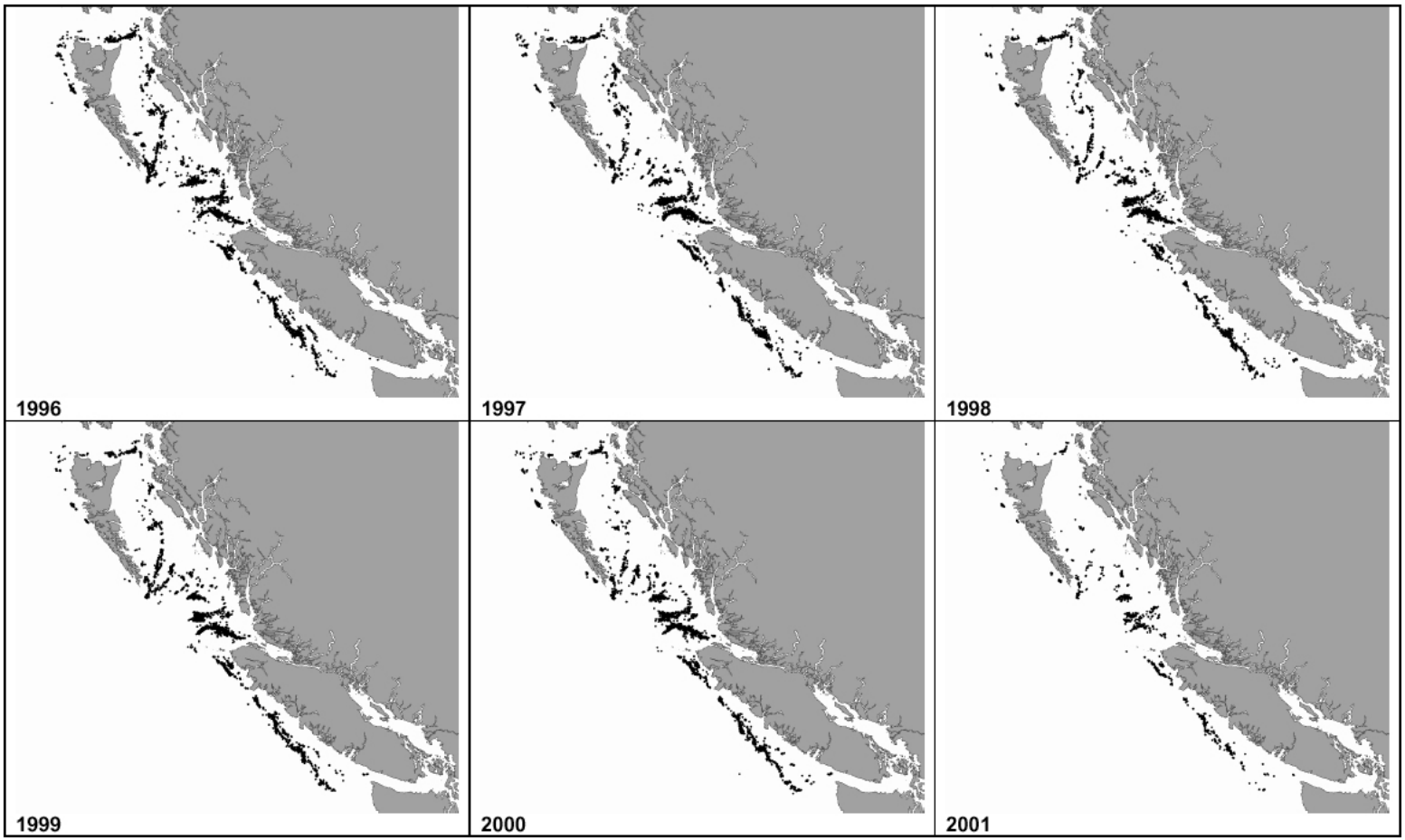


Figure 6. Charts of B.C. waters showing the spatial distribution of bottom trawl catches of bocaccio by fishing year since 1996 (2001 data incomplete).

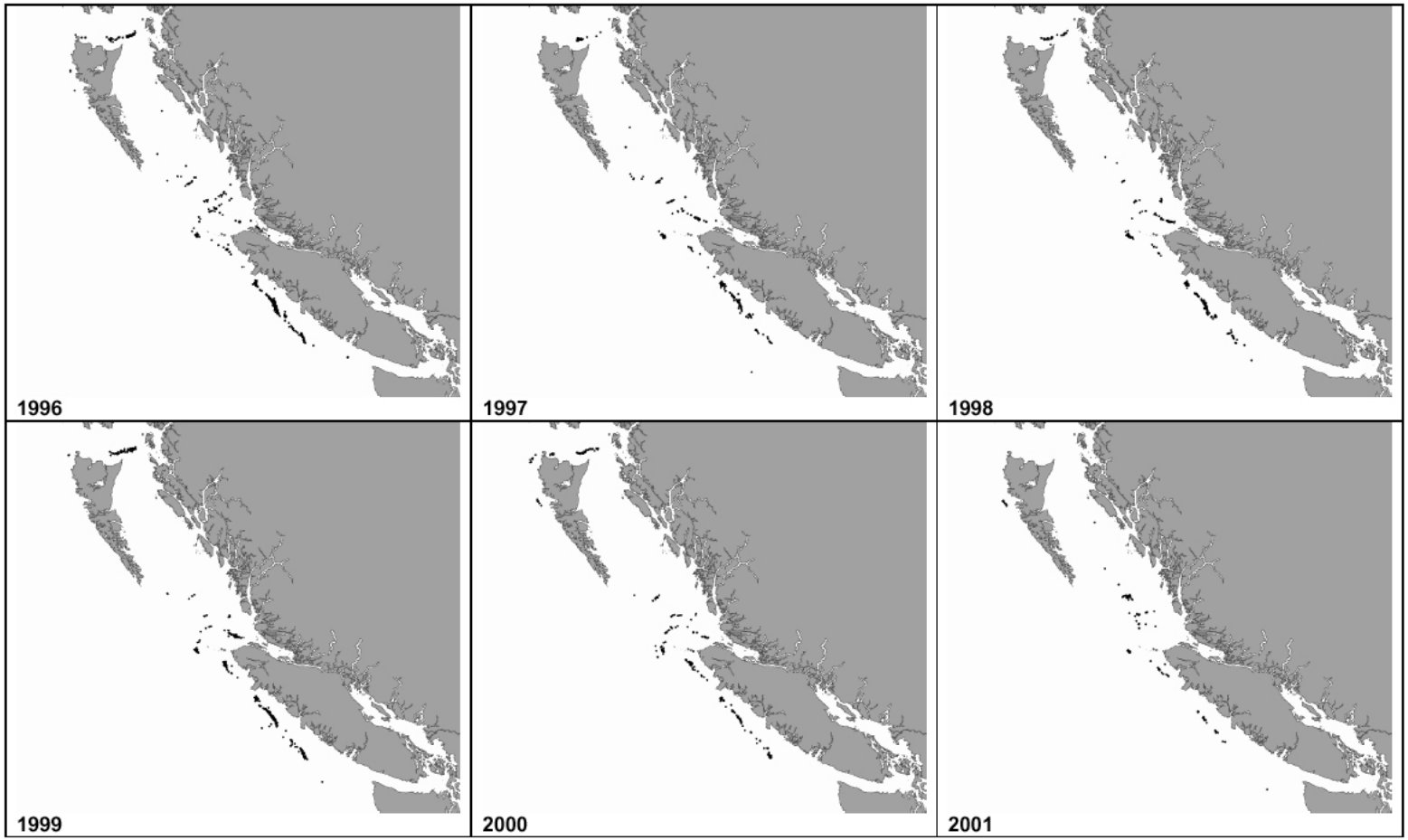


Figure 7. Charts of B.C. waters showing the spatial distribution of midwater trawl catches of bocaccio by fishing year since 1996 (2001 data incomplete).

HABITAT

Habitat Requirements

Larval bocaccio have been caught 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 to the bottom by the age of 3-4 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 substrates in California, including rocky reefs and open bottom (Eschmeyer *et al*. 1983). In B.C., the maximum recorded depth of capture in the commercial fishery is greater than 800 m (Fig. 8), but these few data probably represent mistakes in depth recording or species identification by observers. 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 trawl catches and salmon troll catches indicate they can be semi-pelagic in behaviour (A. Amos, F. Crabbe, R.N. Best, R.A. Best, pers. comm. Appendix 1).

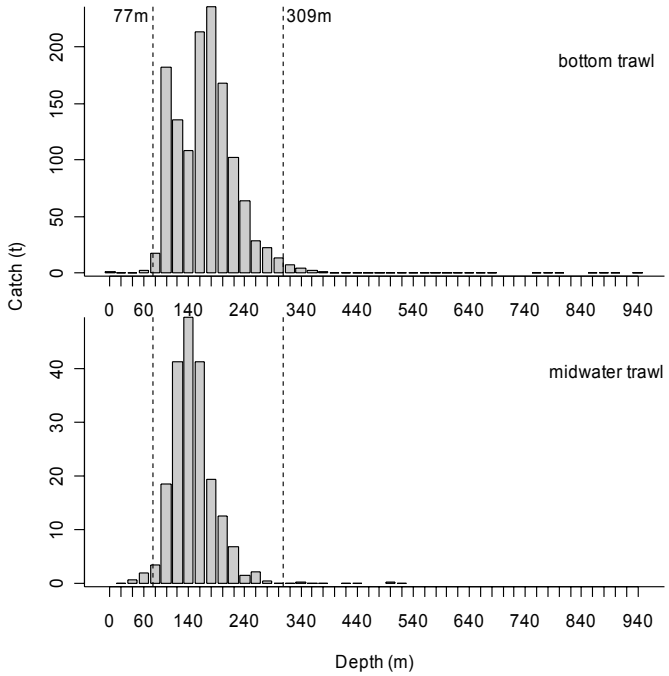


Figure 8. Distribution of bocaccio catches by 20-m depth interval for bottom and midwater trawling. The vertical lines at 77m and 309m demark the depth zone where 95% of all sets that captured bocaccio were conducted (January1996-June 2001).

Bocaccio cohabit with a wide variety of groundfish species (Fig. 9). Catches in midwater trawling occur while targeting on yellowtail (*Sebastes flavidus*) and widow rockfish (*S. entomelas*). They are observed less frequently in the more extensive midwater trawl fishery for Pacific hake (*Merluccius productus*), which tends to occur over deeper waters or off the edge of the continental shelf.

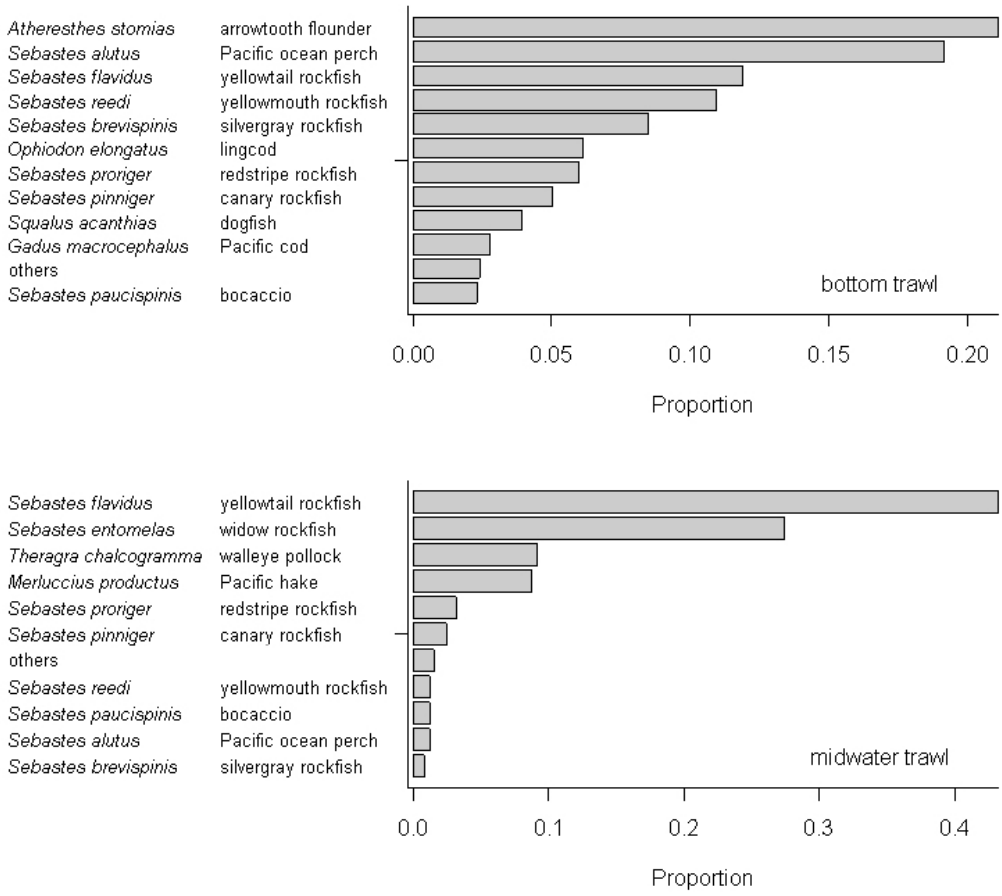


Figure 9. Species composition ranked by weight of catch in all bottom and midwater trawl tows that captured bocaccio (January1996-June 2001).

Area of Habitat

From Figure 8, we note that 95% of the bottom trawl landings come from tows conducted in bottom depths of 77-309 m. If we assume that this depth stratum reflects "preferred" habitat for bocaccio, and that the available habitat extends for the entire outer B.C. coast, then a simple expansion indicates that the area of available habitat exceeds 48,000 km^2 (Fig. 10). This excludes semi-enclosed waters and inlets known to be adult habitat, as well as the shallower nearshore waters, which are known habitat for juveniles (Gillespie *et al.* 1993).

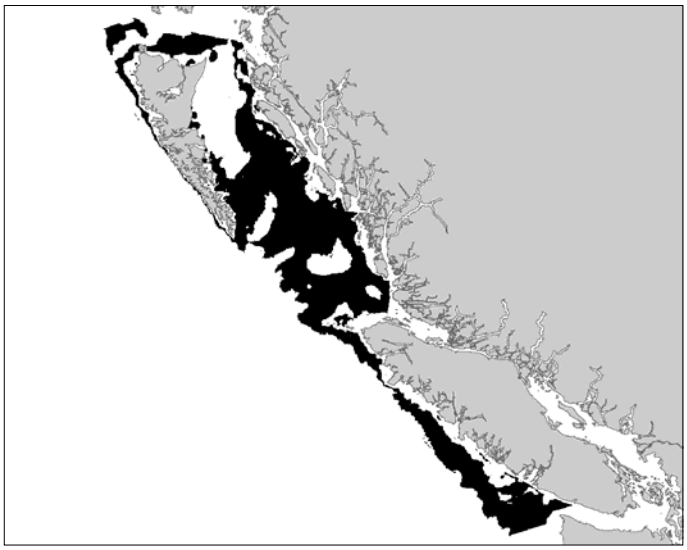


Figure 10. Projected habitat area for adult bocaccio based on preferred bottom depth zone of 77-309 m. Shaded area equals 48,346 km^2. Note that the shaded area excludes enclosed waters and inlets, some of which have proven to be habitat for adult and young bocaccio, and shallower coastal waters, which may be habitat for juveniles.

Trends

There is no information on trends in the amount of habitat available to bocaccio. The widespread distribution of bocaccio on the outer coast and in Hecate Strait implies that the coastwide population is not at risk from loss of habitat. Possible impacts of habitat loss or environmental change in enclosed waters such as the Strait of Georgia are unknown.

Protection/ownership

The widespread distribution of bocaccio over the continental shelf implies that protection/ownership issues do not currently threaten this population.

BIOLOGY

General

There has been very little directed research on bocaccio in B.C. waters. GFBio, the groundfish specimen database of Fisheries and Oceans contains information on only 1,503 specimens collected from 1967-2000 (Table 4). These data were collected from all regions, in different seasons, with different gears, and from both research and commercial catches. There is obviously not enough information to examine trends in mean size. The available data, however, are sufficient to indicate that most bocaccio caught during trawling are nearly fully grown and well above the acceptable market size limit for rockfish of approximately 32 cm (Fig. 11 and 12). There are virtually no age data from Canadian specimens. Most of the biological research on this species was conducted in California.

Table 4. 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

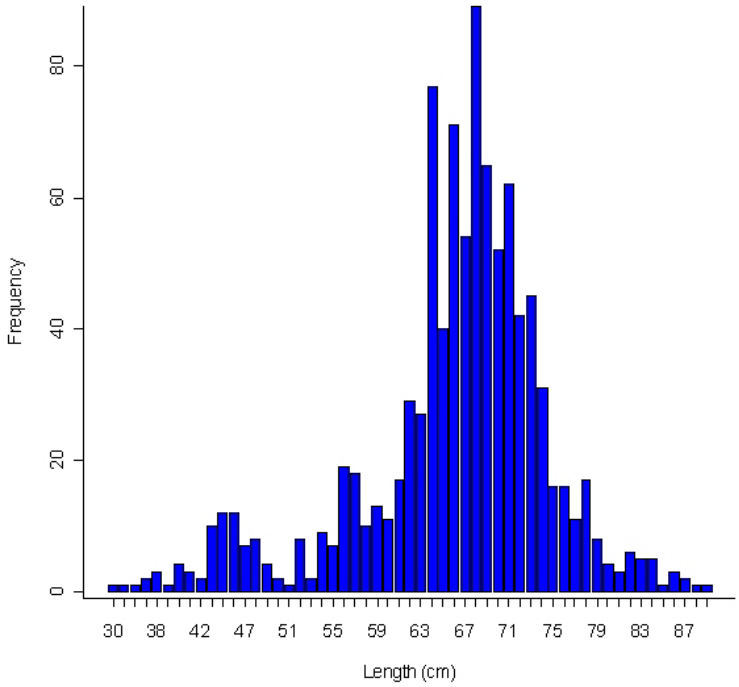


Figure 11. Cumulative length-frequency histogram of all Bocaccio lengths from the Groundfish Biological Database (GFBio).

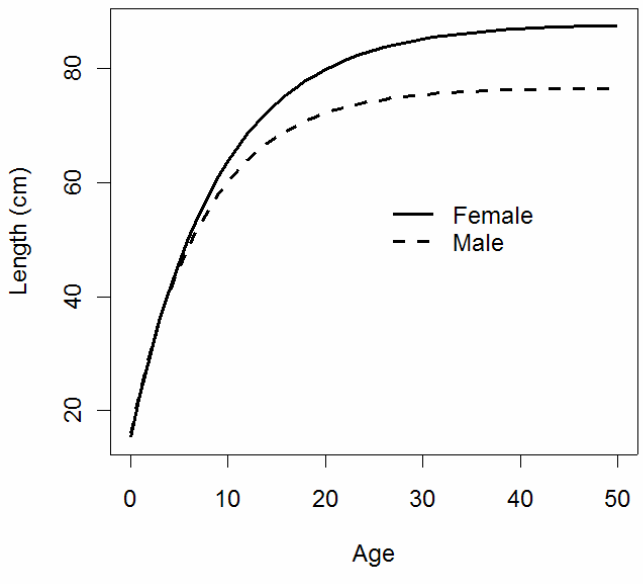


Figure 12. Von Bertalanffy growth curves for male and female bocaccio. Parameters for males and females respectively are: $L\infty$ = 76.6, 87.8; K = 0.130, 0.110; t_0 = -1.81, -1.73 (from Froese and Pauly 2000).

Reproduction/Life History

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 B.C. waters (Westrheim 1975). More southern populations appear to have a longer period of parturition and may also release multiple broods in a single year (Moser 1967). Settlement to the littoral-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 (Haldorson and Love 1991). Rogers (1995) suggests an age of between 4 and 5 years for the age of 50% maturity.

Growth

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 1967, Moser and Boehlert 1991, Woodbury and Ralston 1991). Growth of juveniles is rapid at 0.56-0.97 mm/day (Love *et al.* 2002). They can reach 24 cm by the end of their first year (MacCall *et al.* 1999). Females grow to a larger size than males. The maximum recorded length is 91 cm for females and 75 cm for males. The maximum reported weight is 6.8 kg (Love *et al.* 2002). Growth curves are shown in Figure 12 (Froese and Pauly 2000).

Survival

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 supported an estimated 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 9 years (4+1/0.2). Thus, a 3-generation window for assessing extinction risk would be about 27 years.

Physiology

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.* 2002). Little is known about their adaptability to other types of environmental change.

Movements/dispersal

There have been two tagging studies of bocaccio off California. During a 1977-1981 study, 1,149 juvenile and adult bocaccio were tagged (Hartman 1987). Of these, 66 bocaccio were recaptured. Nineteen traveled 0.9 to 148 km. Seven of these, all juveniles, traveled from 13 to 148 km. The adults tagged during that study moved very little; all were recaptured at their tagging site after periods at liberty of up to 827 days.

Starr et al. (2002) tagged 16 bocaccio, ranging in size from 35 to 58 cm, during a 1997-1998 study. Some of these showed site fidelity by remaining within the study area or by leaving and returning, while others moved large distances during the 3.5-month monitoring period. The authors suggested the sample size was too small to analyze movements by fish length or state of maturity. The results of these two 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 47 cm (Hartmann 1987).

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

Nutrition and interspecific interactions

Based on feeding studies conducted in California, bocaccio are primarily piscivorous. Juveniles feed on the young of other rockfishes, surfperches, mackerel and various other small inshore fishes (Phillips 1964). They also consume larvae and euphausiids. The adult diet includes rockfishes, sablefish, anchovies, lanternfishes and squids (Phillips 1964, Eschmeyer et al. 1983). The main predators of juvenile bocaccio are sea birds such as least terns. 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. It is one of two tapeworm species in this genus. 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 B.C. waters, however, no one has looked specifically for this tapeworm (D. Whitaker, pers. comm. Appendix 1). A second tapeworm, Bothriocephalus scorpii, has been reported in bocaccio from B.C. waters.

The reputation of “worminess” for this species in B.C. specimens results from a high prevalence and intensity of infection of a “cod/seal worm” or nematode (Phocanema decipiens). Once encysted it can live for long periods in the fish and is therefore accumulated by the fish over time such that an older fish can carry large numbers of the worm. Because the final host is a mammal (seal), it is a parasite that can be a human-health concern. However, freezing at –20° C for 72 hr, or cooking, removes that concern (D. Whitaker, pers. comm. Appendix 1).

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 can respond to localized habitat disruption. This movement may also facilitate re-colonization, at least by juvenile stages, as would the larval planktonic phase.

POPULATION SIZES AND TRENDS

Commercial fishing trawl landings and abundance indices

The initial part of the discussion, regarding trends in population abundance, 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 questionable utility as abundance indices for bocaccio. Catch statistics, since the introduction of 100 % dockside and observer coverage by 1996, are considered reliable. Prior to this period, and particularly in the 1985-1995 period, estimates of catches are unreliable (see Stanley and Kronlund 2001).

Readers should note that a management plan based on Individual Vessel Quotas (IVQ) was introduced for the B.C. trawl fishery in 1997. Thus, harvests for all species managed through quotas prior to 1997 are now controlled by assigning area-specific annual catch (retained and discarded) limits to each vessel. Bocaccio are not limited through IVQ's but are constrained by a 15,000 lb trip limit for all non-quota rockfish combined. The frequency distribution of catch weights of bocaccio in bottom and midwater tows is shown in Fig. 13. Current total coastwide catches of 295 t (Table 1) correspond to about 74,000 individuals, assuming a mean weight of 4 kg (PacHarvHL database, see Appendix Table 2).

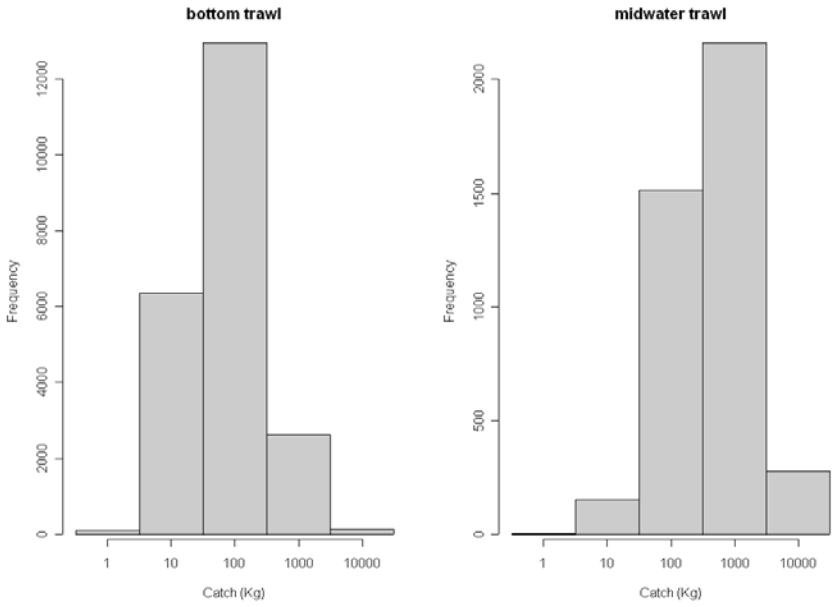


Figure 13. Frequency distribution of catch weights of bocaccio in bottom and midwater tows.

Recorded coastwide catches of bocaccio have varied from 90 to 1,322 t with a mean of 418 t since 1967 (Table 1, Appendix Tables 1 and 2). Coastwide commercial trawl catches have ranged between 200 and 300 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. While bocaccio are reported as a nuisance during salmon troll fishing, particularly in Area 5E (F. Crabbe and A. Amos, pers. comm. Appendix 1), actual catches are probably low relative to reported commercial trawl catches.

The trawl landings from the southwest coast of Vancouver Island (3C) and Queen Charlotte Sound (5A and 5B) show no consistent trend in recent years (1996-2001) (Table 1). While catches of bocaccio are widespread in northern waters, they have always been much lower than in the central and southern areas (Table 1). They currently average less than two-thirds their long-term mean. Landings are constrained by the 15,000-lb trip limit for "non-quota" rockfish. Trawl fishers report that landings could return to the long-term average of 400 t if the restrictions were relaxed (R. Gorman, pers. comm. Appendix 1). Thus, bocaccio may be more numerous in northern waters than what can be inferred from current trawl catches.

We were also informed by trawl fishers that bocaccio are often caught when targeting on canary rockfish (*S. pinniger*) (B. Dickens, pers. comm. Appendix 1). The current IVQ's for canary rockfish are so low that fishers rarely target on them. They catch their canary rockfish IVQ's as incidental to other targeting. Thus, the low IVQ's of canary rockfish and the 15,000 rockfish trip limit act to constrain the trawl catches of bocaccio.

We present median CPUE by region for the 1996 to 2001 time period (Fig. 14). Earlier catch rate data cannot be used to infer abundance trends owing to the large variation in management actions that acted to change fishing strategies over time, the variable amounts of mis-reporting of catches over time, and inadequate data on species composition and effort from earlier years (see Stanley and Kronlund 2001). The CPUE indices were derived from bottom trawl tows for which the midpoint of bottom depth was between 77 and 309 m. The commercial CPUE indices show little change since 1996 for all four areas.

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 have commented that there can be a significant by-catch of bocaccio discarded in the outer coast salmon troll fishery (A. Amos, R.A. Best, R.N. Best, I. Bryce, F. Crabbe, pers. comm. Appendix 1), however this fishery is much smaller than in previous years.

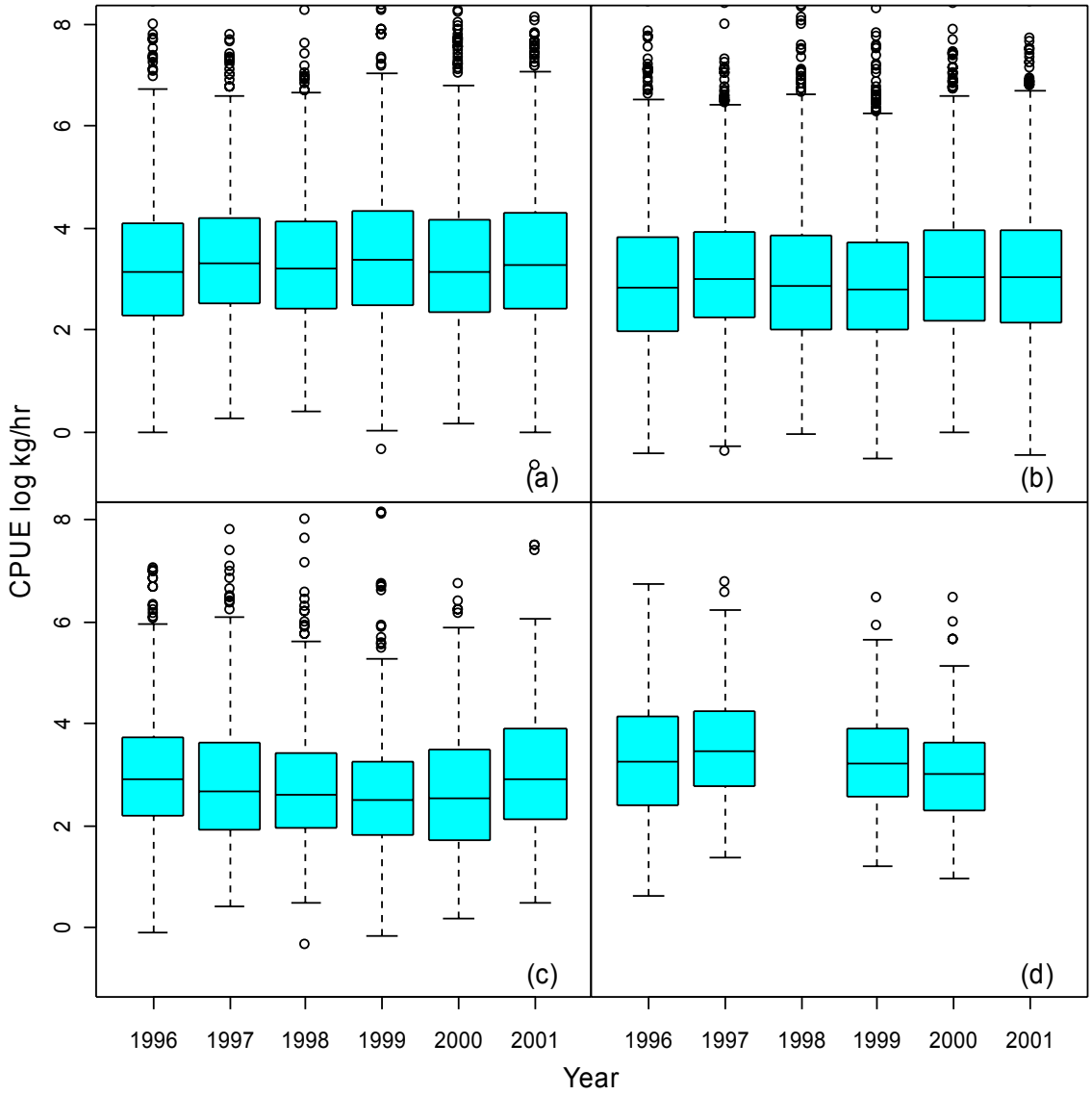


Figure 14. Box and whiskers plot of bocaccio CPUE (log kg/hr) in the commercial trawl fishery in each coastal region: (a) 3CD; (b) 5AB; (c) 5CD; (d) 5E. For each box, the upper and lower bounds indicate the 75th and 25th percentiles, respectively; the central horizontal line indicates the median; the upper and lower whiskers are positioned at 1.5 times the inter-quartile range; and the open circles indicate values that fall outside the whiskers. However, these data may have questionable utility as abundance estimates.

Survey-based Indices

A number of 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 the results below.

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

The strongest data set on population trends is the U.S. triennial bottom trawl survey, which began in 1977 and typically covers northern California to the U.S./Canada border in northern Washington (Shaw *et al*. 2000). It was extended into southern B.C. waters for 7 sampling years. The first two surveys extended to 49°15' N; the latter four surveys extended further north to 49°40' N (Fig. 15a and d). Biomass estimates are computed for all depths combined with 95% confidence limits. The initial trawl catch rate data are extrapolated to a biomass estimate based on an area-swept logic. While presented as biomass estimates in Fig. 15a, the presumed low catchability in bottom tows for a semi-pelagic species implies that the survey is used best as a relative index. The survey is also imprecise owing to the low number of tows conducted in bocaccio depths near the 100-fathom contour (see Figs. 16 and 17).

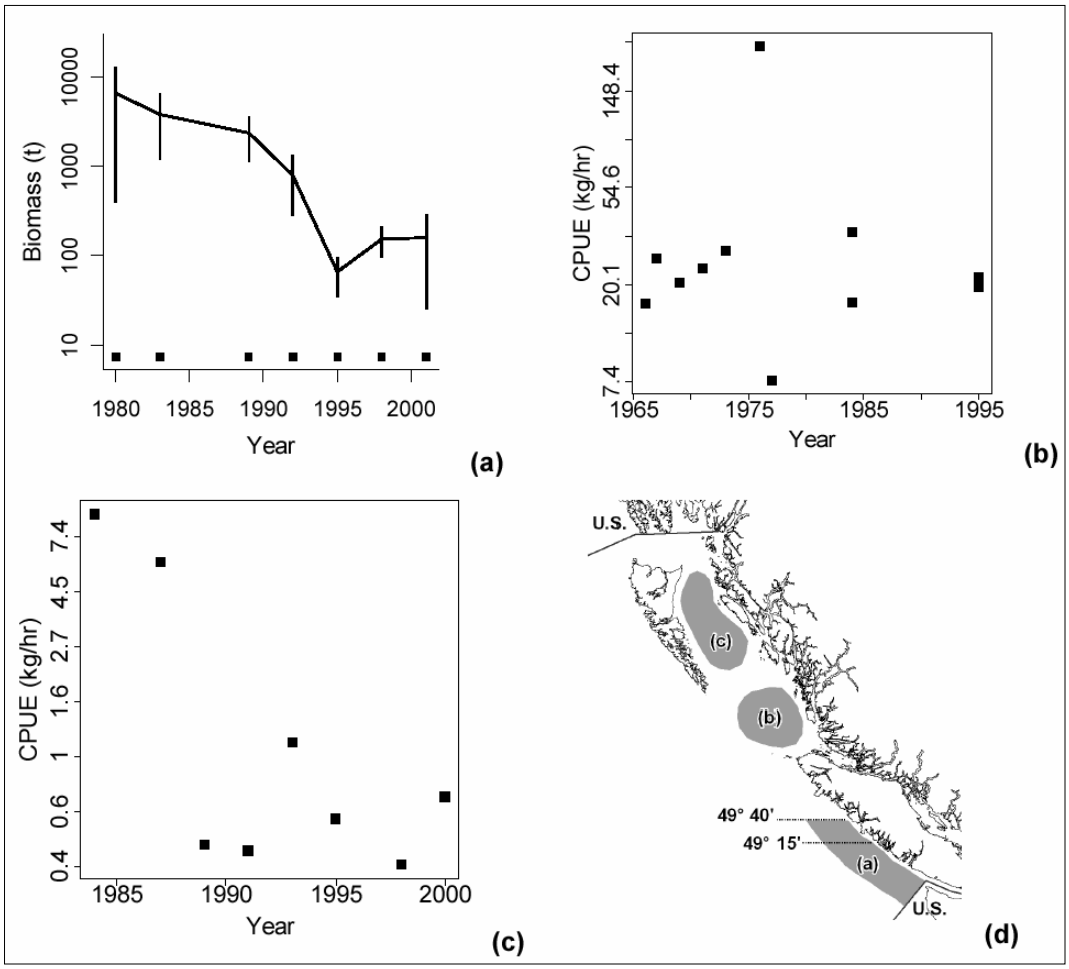


Figure 15. Abundance indices from (a) biomass estimates of the U.S. triennial survey in Area 3C and part of Area 3D plotted on a natural log scale, (b) bocaccio stratified mean CPUE (kg/hr; natural log scale) in the Queen Charlotte Sound Pacific ocean perch survey, (c) bocaccio stratified mean CPUE (kg/hr; natural log scale) in the Hecate Strait multispecies assemblage survey.

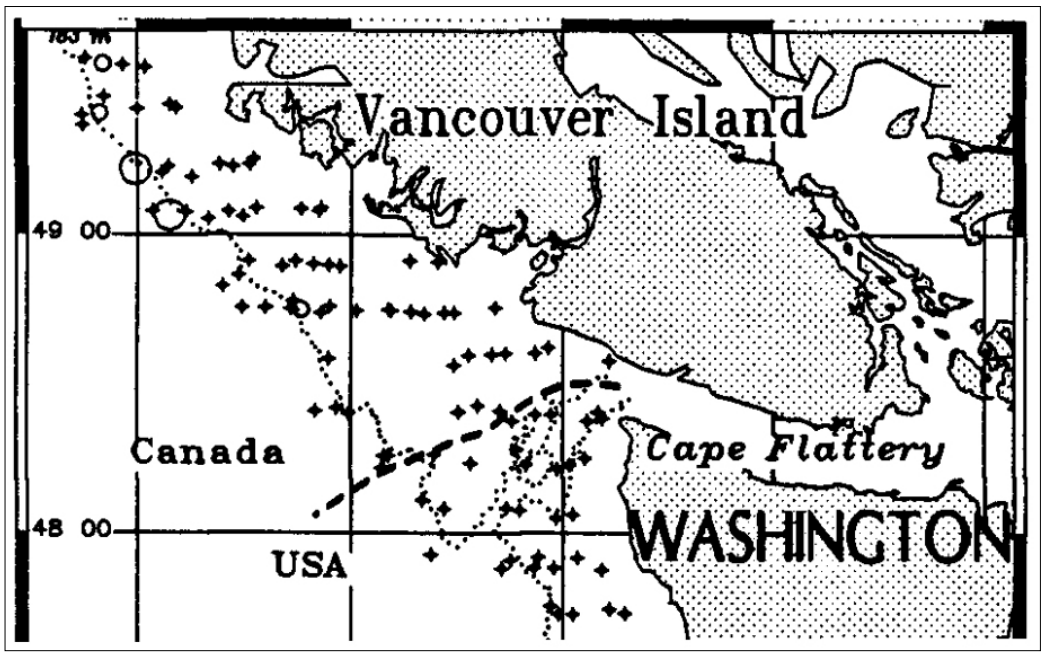


Figure 16. Trawl locations for the northern portion of the U.S. Triennial Survey. Zero catch represented by "+"'s (figure provided by Mark Wilkins, pers. comm. Appendix 1.

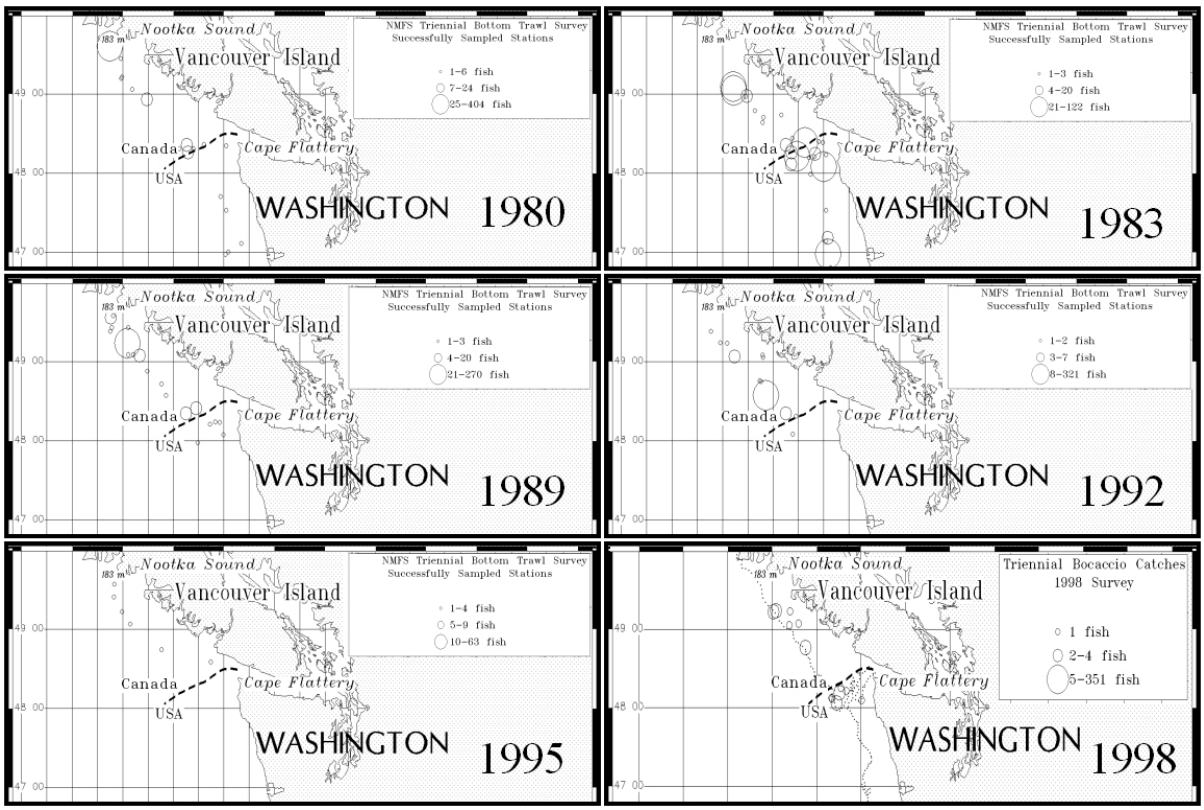


Figure 17. Number of Bocaccio caught in Canadian waters during the U.S. Triennial Surveys of 1980, 1983, 1989, 1992, 1995, and 1998 (figure provided by Mark Wilkins, NMFS).

Over the past 10 years, the decline has been over 90% (1989 = 2348 t (CV = 0.52), 2001 = 157 t (CV = 0.84), 93.3% decline). Over the past 20 years, the decline has been over 95% (1980 = 6541 t (CV=0.94), 2001 = 157 t (CV = 0.84), 97.6%). These results (Fig. 15a) indicate a decline of almost two orders of magnitude over the last two decades.

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

Results of all shrimp trawl surveys conducted by DFO 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, when fish excluders were not employed (Fig. 18) (Boutillier *et al*. 1998 and Appendix 3). The B.C. area covered in this survey is roughly similar to that of the U.S. survey.

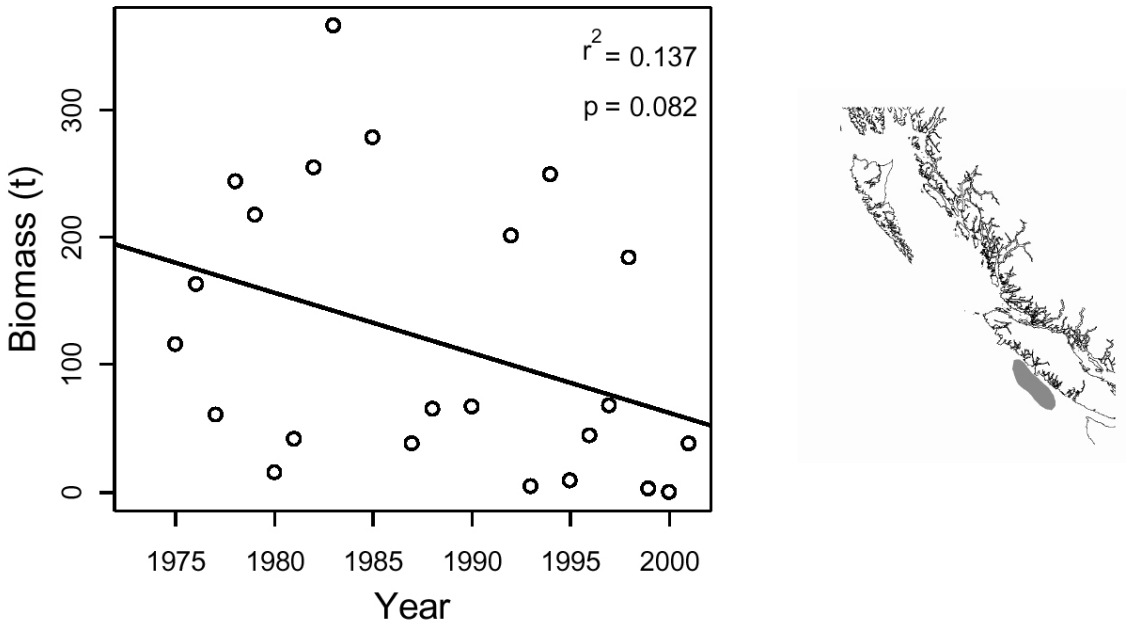


Figure 18. Bocaccio biomass estimates from shrimp trawl surveys of the west coast of Vancouver Island. The shaded region on the inset chart indicates the area that was surveyed.

While regression analysis of the time series indicates a negative slope, the slope is not significantly different from 0 ($p>0.05$). The catchability of bocaccio in this survey must be very low, owing to the low towing speed, thus, as with the U.S. survey, the estimates are imprecise and should only be viewed as relative. The variation precludes inferring a decline, although it does not refute the decline indicated by the U.S. survey for the same general area.

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) in Queen Charlotte Sound (Table 5, Fig. 15b, d). Bocaccio have been a minor component of the catch. The depth-stratified catch rate estimates are imprecise and low but do not show any trend, unlike the west coast of Vancouver Island (Table 5).

Table 5. Bocaccio CPUE (log kg/h): stratified mean and coefficient of variation (%) from surveys conducted in Queen Charlotte Sound and Hecate Strait.

Survey Area	Year	Number of Sets	Mean CPUE (kg/h)	CV (%)
Queen Charlotte Sound	1966	13	16.5	28.6
	1967	33	26.3	15.0
	1969	32	20.5	21.6
	1971	39	23.7	24.3
	1973	33	28.5	36.7
	1976	36	235.5	77.4
	1977	49	7.5	30.0
	1984	27	34.6	59.5
	1984	37	16.7	31.0
	1995	54	21.6	61.5
	1995	57	19.6	36.8
Hecate Strait	1984	82	9.1	65.2
	1987	87	5.8	50.7
	1989	90	0.4	55.9
	1991	97	0.4	68.9
	1993	95	1.1	53.2
	1995	102	0.6	39.8
	1998	86	0.4	50.5
	2000	106	0.7	64.5

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 very minor component of the total catch (Table 5, Fig. 15c,d). The first surveys in the late 1980s encountered more bocaccio, but there has been no apparent trend since 1989.

Other groundfish related surveys in B.C. waters

Excluded from this document are summaries from acoustic and midwater trawl surveys directed at inshore and offshore hake (*Merluccius productus*) populations. Incidence of bocaccio was limited to only a few fish per survey (M. W. Saunders, pers. comm. Appendix 1). 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. Appendix 1).

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. 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. Appendix 1). The focus of the monitoring has been chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*). There are no records of bocaccio in the database but we suspect that bocaccio are still not explicitly enumerated apart from “other” rockfish.

Abundance in adjacent waters

The World Wildlife Fund (1999) lists bocaccio as an endangered species and 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). These conclusions are based on declining trends in the U.S. triennial bottom trawl survey, the commercial trawl CPUE, the recreational CPUE index and a juvenile abundance index (MacCall et al. 1999). Authors of the stock assessment (MacCall et al. 1999) which summarizes this material commented 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. Appendix 1).

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 included in an Endangered Species Act (ESA) petition list for consideration by NMFS.

LIMITING FACTORS AND THREATS

It is likely that the bocaccio population in B.C. is at least somewhat continuous with the population in Washington. Therefore it can be assumed that U.S. harvests have an impact on the population of bocaccio of B.C. 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, the recommended OY is 3,137 t for a rockfish aggregate that includes all the less important commercial rockfish species. This includes predicted recreational catch and discards in the commercial fishery (Pacific Fishery Management Council). Commercial catches are constrained by monthly trip limits. 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 3). However, discards are not reported.

The B.C. 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 minimize harvests in these waters (Table 3).

In BC, the recent annual commercial harvest of about 295 t (1996-2000) translates into approximately 74,000 individuals. There is additional hook-and-line discard, and recreational and First Nations catch. The growing recreational fishery for groundfish could pose a long-term threat. As in the U.S., difficulties with recruitment are not well understood.

SPECIAL SIGNIFICANCE OF THE SPECIES

Bocaccio are reported to have been harvested in aboriginal fisheries, but no information is available on the extent of the fishery. Bocaccio may be the unique host for one species of tapeworm, but this tapeworm has not been described in B.C. specimens.

EXISTING PROTECTION OR OTHER STATUS

Apparently there is no special cultural or legal status afforded for the protection of this species in Canadian waters (unlike U.S. waters, see above).

SUMMARY OF STATUS REPORT

In this report, all bocaccio in B.C., are considered to be a single population or ESU, although this hypothesis remains untested and U.S. data show genetic differences between California and Washington. The biology and demography of bocaccio are poorly known in B.C. because they have had a limited economic role in the fishery. The trawl fishery harvests bocaccio from the edge of the continental shelf from Alaska to the Washington State borders. The commercial and recreational fisheries probably kill over 74,000 individuals per year; this is largely due to the trawl fisheries.

The best data set is taken from the west coast of Vancouver Island (U.S.-based survey) and indicates a decline of over 90% in the past 10 years and 95% in the past 20 years for data up to 2001. There is also a well documented decline of bocaccio in adjacent U.S. waters, where individuals may be part of the same population. Lack of a fishery-independent index and difficulty in interpreting fishery-dependent statistics makes the status of the population uncertain in the rest of B.C.

TECHNICAL SUMMARY

***Sebastes paucispinis* Ayres, 1854**
Bocaccio
B.C. Marine Waters

Extent and Area information	
• *extent of occurrence (EO)(km²)*	Coastal marine waters of B.C. (perhaps >48,000 km^2)
• *specify trend (decline, stable, increasing, unknown)*	Perhaps stable
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
• *area of occupancy (AO) (km²)*	Coastal marine waters of B.C. (perhaps >48,000 km^2)
• *specify trend (decline, stable, increasing, unknown)*	Perhaps stable
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *number of extant locations*	Known from outer coast, Hecate Strait, Strait of Georgia, some inlets.
• *Specify trend in # locations (decline, stable, increasing, unknown)*	Unknown
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Overall perhaps stable, but declining in Strait of Georgia.
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	9 years (@M=0.2, age at maturity=4)
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	Unknown
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	Overall unknown. Significant decline off central and southwest coast of Vancouver Island.
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Overall unknown; off west coast of Vancouver Island, > 90% over last 10 years and > 95% over last 20 years (data to 2001).
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Unlikely over short term.
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	Probably not
• *list each population and the number of mature individuals in each*	Not applicable
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Not applicable
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats) [add rows as needed]	
- Commercial harvest, recreational harvest, bycatch from fisheries	

Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes (outside Canada)
• *status of the outside population(s)?*	In serious decline in U.S. states (Washington, Oregon, California). Unknown in Alaska.
• *is immigration known or possible?*	Probably as larvae and juveniles
• *would immigrants be adapted to survive here?*	Probably
• *is there sufficient habitat for immigrants here?*	Probably
Quantitative Analysis	No

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Appendix 2. Collections examined

No collections were examined.

Appendix 3. Biomass estimation from the 3c and 3d shrimp survey

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 sampling 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/m^2 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 300 x 300-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. 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 4. Continued.

			5A					5B				5C	
Nation	Canada	Canada	USA	Offshore hake		Canda	Canada	USA	Offshore hake		Canada	Canada	
Gear	Trawl	Trawl	Trawl	Trawl		Trawl	Trawl	Trawl	Trawl		Trawl	Trawl	
Year	landed	discarded	USA	catch	Total	landed	discarded	USA	catch	Total	landed	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 4. Continued.

			5D				5E				Unknown		Grand total
Nation Gear Year	Canada Trawl landed	Canada Trawl discarded	Offshore hake Trawl catch	Total	Canada Trawl landed	Canada Trawl discarded	Offshore hake Trawl catch	Canada Troll landed	Total	Canada Trawl landed	Canada H & L 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 5. 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, 1995-2001. 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, 1982-2001. 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) **U.S. trawl landings** from Canada and Washington, 1980, unpublished data from Washington State Department of Fish and Wildlife (Jack Tagart, pers. comm. Appendix 1)
7) **PACFIN.** U.S. commercial landings from Washington, Oregon and California, 1981-2000 (www.psmfc.org/pacfin/data.html).
8) **AKFIN.** U.S. commercial landings from Alaska, 1991-1998 (www.psmfc.org/akfin/Reports/reports.html).
9) **Washington Department of Fish and Wildlife**. Commercial trawl landings for 1980.

Biological data

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