prepared by the Western and Northern Service Centre

An assessment of methods for inventorying young-of-the-year of the special concern Bocaccio *(Sebastes paucispinis)* in nearshore waters of National Parks along the Pacific coast of Canada

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Parks Canada / Parcs Canada

Canada

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PHOTOS :
Front cover - Jennifer Yakimishyn / Parks Canada

WNSC RESOURCE CONSERVATION TECHNICAL REPORT

An assessment of methods for inventorying young-of-the-year of the special concern Bocaccio *(Sebastes paucispinis)* in nearshore waters of National Parks along the Pacific coast of Canada

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Executive Summary

Bocaccio (*Sebastes paucispinis*) numbers have precipitously declined in the last 25 years and they are now considered 'critically endangered' by the International Union for Conservation of Nature and Natural Resources. The species is listed as Threatened by COSEWIC and is currently going through the SARA-listing process. Recovery planning will likely begin very soon after listing, since rockfishes are important fish stocks and their conservation is a high-profile issue on the Pacific Coast.

Parks Canada conducted surveys to obtain information about young of the year bocaccios in nearshore waters in 2005- 2006 in four of the Canadian Pacific coast national parks with marine components. Methods used included beach seines in eelgrass beds, sampling floating algal mats, snorkel surveys, videotaping in kelp beds and the use of standardized monitoring units for reef fishes. This yielded information about bocaccio young of the year habitat use, length-weight relationship, and growth rate. Our data suggest that bocaccios spawn in early April and that their larvae remain in the plankton from April to early May in the area of Barkley Sound, Vancouver Island. Less than two dozens bocaccios were found during two years of extensive sampling through various methods and habitats, lending us to concur with earlier statements that there is strong evidence of significant decline in bocaccios relative abundance in southwestern British Columbia. Recommendations for inventory methods and future actions are included.

Acknowledgements

In alphabetical order, Brian Bauer, Christine Bentley, Tanya Dowdall, Eric Genest, Scott Giroux, Angela Holmes, Heather Holmes, Clint Johnson, Rundi Koppang, Sue Kronen, Richard Lamy, Jay Leopkey, George Mercer, Janet Mercer, Cameron Sanjivi, Leila Sumi, Pernell Tarnowski, Scott Toews, and Jennifer Yakimishyn all helped to collect data from eelgrass meadows in 2005 and 2006 in various regions.
Dr. Norm Sloan and Mr. Judson Brown respectively provided administrative and logistical support for the Gwaii Haanas sampling efforts. Jennifer Yakimishyn was of a great help with the surface trawls. Sharon Jeffery, UBC, graciously sent us some unpublished bocaccio data and photos. Scott Toews, Theresa Douthwright and Nicole Höher helped with field logistics during the 2006 video surveys.

Alice Gavin did the formatting of the document. Apologies to anyone we may have forgotten. Rest assured that your contribution was still important. Finally, a special thanks to Scott Giroux and Clint Johnson for their continued support and efforts in ensuring that the eelgrass sampling (from which some parts of this report stem) continue.

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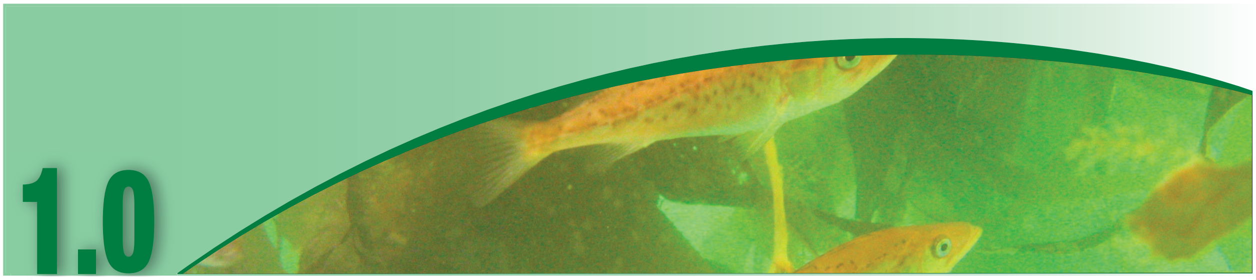


1.0 INTRODUCTION

Nearshore Pacific rockfishes (*Sebastes* spp.) inhabit shallow rocky reef and kelp forest habitats of the northeast Pacific and are characterized by complex life histories patterns that include elaborate courtship behaviours, internal fertilization, live birth, extended pelagic larval stages, metamorphosis to juvenile forms which may or may not coincide with settlement to benthic habitats, age-related shifts in habitat use, high site fidelity as adults, delayed reproductive maturity, and longevity exceeding 200 years in some species (Love et al. 2002). Many of these life history characteristics make rockfishes highly susceptible to overfishing.

Bocaccio (*S. paucispinis*; "bocaccio" is an Italian term referring to its large mouth) numbers in the US have declined 96% in the last 25 years and they are now considered 'critically endangered' by the International Union for Conservation of Nature and Natural Resources (IUCN) (Levin et al cited in Tolimieri and Levin 2005). The species is listed as Threatened by COSEWIC (COSEWIC 2006) and is currently going through the SARA-listing process (one of the DFO species given an extended period of consultation). Recovery planning will likely begin very soon after listing, since rockfishes are important fish stocks and their conservation is a high-profile issue on the Pacific Coast. The bocaccio is likely to be listed under SARA – the socio-economic impacts of conservation measures for bocaccio will not be as large as for the Sakinaw and Cultus lake sockeye salmon populations that were refused listing this year.

Given that little is known about the nearshore distribution of this threatened species, it behooves the Parks Canada Agency (PCA) to conduct an inventory of the waters under its jurisdiction (National Parks and National Marine Conservation Areas). Inventory work of this nature would identify important nearshore juvenile rearing and foraging habitats. Parks Canada may then be in a position to play an important role in the recovery of this threatened species by contributing to the recovery planning process and by protecting critical nearshore rearing and foraging habitats of juvenile bocaccio and other potential rockfishes of concern such as yelloweye (*S. ruberrimus*) , canary (*S. pinniger*), quillback (*S. maliger*), and rougheye rockfish (*S. aleutianus*). These four species are among the most recent list of species that COSEWIC has put out a call for bids to assess, and they are among nine Pacific rockfishes currently sitting on the COSEWIC high priority candidate list for marine fishes.

The main objectives of this report were to describe the sampling methods used to determine the presence of bocaccio in Parks Canada's Pacific marine nearshore ecosystems and to report information obtained on young of the year bocaccios in nearshore waters. Recommendations for inventory methods and future actions are included at the end.

1.1 Bocaccio Life History

Bocaccios go through four distinct life history stages: extrusion or parturition, pelagic stage in plankton, settlement on substrate and age-related habitat shifts (*Figure 1*).

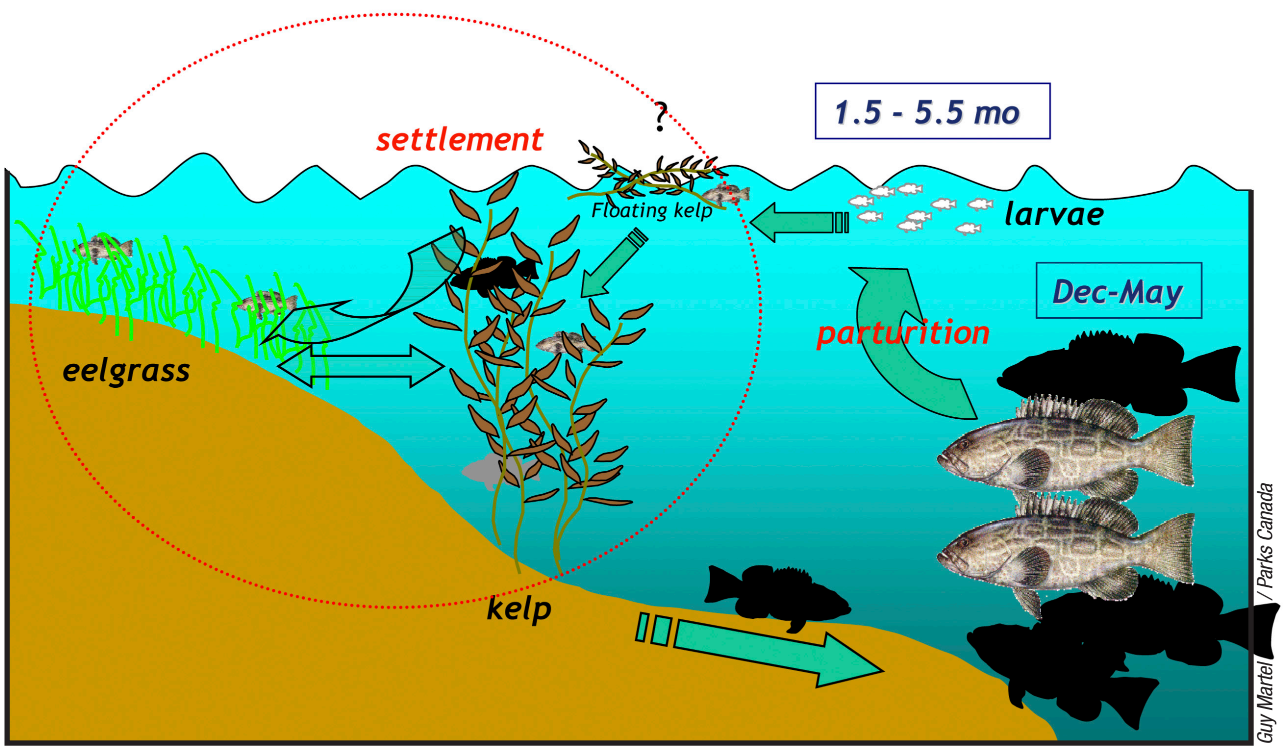
Bocaccio larvae are extruded into the plankton from December to May in southern California, ranging from 3 to 9 mm long at parturition (MacGregror 1986). Larvae are found in euhaline waters, and may congregate in areas of high salinity (Sakuma and Ralston 1995). They may remain in the plankton for as long as 5.5 months, most settling around 3.5 months or less (Love et al. 2002). Bocaccio larvae transform into pelagic juveniles at sizes ranging from 15 to 40 mm, but more often in the 15-30 mm range (Love et al 2002). These pelagic juveniles settle in recruitment habitats in California from February to August, with a peak in May-July (Love et al 2002).

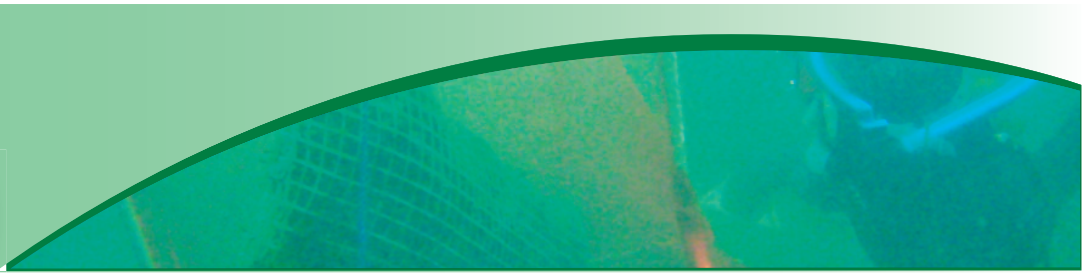
They are positively thigmotaxic during their early settlement phase (like most juvenile rockfishes, they have an affinity for physical structures; Carr 1994). Many juvenile rockfishes thus recruit to macroalgal canopies (primarily giant kelp, *Macrocystis* spp. and bull kelp, *Nereocystis leutkeana*; Bodkin 1988, Carr 1991). Juvenile rockfishes and bocaccios in particular are occasionally sampled in eelgrass beds (*Zostera marina*; e.g., Robinson et al. 2006), which points to their use of this habitat (Love et al. 2002). In California, young-of-the-year bocaccios are primarily piscivorous and feed heavily on other species of young-of-the-year rockfish inhabiting the kelp forest, primarily blue and kelp rockfishes. (Lea et al. 1999).

Bocaccios show strong age-related habitat use, with smaller juveniles reported primarily in midwater and larger adults on the bottom (Love et al. 2000). Adult bocaccios occupy substrates such as rocky reefs and open bottom (Eschmeyer et al. 1983). Adults will school with widow, yellowtail, vermillion, and speckled rockfish, although the largest ones tend to be sedentary (Love et al. 2002). Bocaccios appear to prefer marine waters with salinities of 31–34 ppt, temperatures of 6–15.5 °C and dissolved oxygen concentrations of 1.0–7.0 ppm (McCain et al. 2005).

This report is mostly concerned with young-of-the-year bocaccios (YOY), encompassing stages from early settlement from plankton to onset of habitat shifts.

FIGURE 1. Bocaccio life cycle





2.0 METHODS AND RESULTS

2.1 Beach Seining in Eelgrass Beds

The presence of juvenile bocaccios in eelgrass beds was assessed in 2005 and 2006 through beach seining in four areas, from north to south: Gwaii Haanas National Park Reserve (GH), Clayoquot Sound (CS), Barkley Sound (BS) and southern Gulf Islands (GI). Sampling in CS and BS encompassed sites within the Pacific Rim National Park Reserve and sites in GI in the Gulf Islands National Park Reserve of Canada. Each eelgrass bed was sampled during daylight hours within a two hour window before or after a low tide of 0.6 m (2.0 ft) or less. Typically, two beds were sampled per day.

Fishes were sampled with a beach seine[1] manned by two individuals wearing chest waders (*Figure* 2). One person was dropped on the bed and held one end of the seine while the net was stretched perpendicular to shore from the boat until fully extended. The boat then described an arc parallel to shore and dropped the second individual on shore, with the two individuals then pulling the seine net on shore. There were three (3) such sets per bed, each covering an area approximately 10 m x 10 m (100 m^2).

All rockfishes caught were kept in large totes, one per set. All bocaccios caught were measured (Total Length) and weighed. All fishes were released unharmed at the site of their capture.

FIGURE 2. Sampling eelgrass bed with a beach seine net

Clint Johnson/ Parks Canada

[1] Beach seine dimensions were 10 m long, 3 m in height at the centre and tapering to a 1.0 m height at either end with 4 mm mesh throughout the net, with a 3 m drop in the centre, and tapering to 1m at the wings. Two 15 m long lines were attached at each end, one on the lead line and the other on the float line.

2.1.1 Distribution of bocaccios caught in eelgrass beds

There were 5 juvenile bocaccios caught in all eelgrass beds sampled in 2005, all in either Barkley Sound or Gwaii Haanas (*Table 1*). An additional 3 were caught in 2006, in Clayoquot Sound and Gwaii Haanas. Thus 7 out of 8 juvenile bocaccios caught in eelgrass beds came from Gwaii Haanas or Barkley Sound, and none from the Gulf Islands. (*Figures 3A - 3D*)

2.2 Underwater Video

EELGRASS BEDS. A SplashCam™ camera linked to a digital video camera (Canon NTSC ZR40) was towed from 1 to 2 m (depth varied according to location and distance from shore) above the substrate within eelgrass beds. Most eelgrass beds sampled with beach seines were filmed. The duration of footage filmed varied from five (5) to approximately twelve (12) minutes per site. All videos were reviewed on computer in the laboratory and notes were taken about all fishes which could be identified. Very few rockfishes were seen among eelgrass beds (3 in Clayoquot Sound, 3 in Barkley Sound, 2 in Gwaii Haanas and possibly one in the Gulf Islands) none of which were bocaccio.

KELP BEDS. The same video camera was lowered vertically among kelp beds (giant kelp - *Macrocystis integrifolia* and bull kelp - *Nereocystis luetkeana*). Depth varied from three (3) to approximately ten (10) m. As was the case for the videotaping of eelgrass beds, there was no standard methodology. In most cases the camera was lowered slowly and attempted to film a few cm under the canopy and near the stipes of the macrophytes (bottom). Kelp beds were filmed in Clayoquot Sound (1 bed), Barkley Sound (4), Gwaii Haanas (5) and the Gulf Islands (4). The only rockfish captured on film were in Gwaii Haanas and Barkley Sound. Juvenile and 1+ copper and black rockfish were abundant in Gwaii Haanas whereas one black rockfish was filmed in a giant kelp bed in Barkley Sound. No bocaccio were visible on tape.

2.3 Surface Trawls (ST)

Some juvenile rockfishes use drifting vegetation in the early stages of their recruitment (c.f. references in Introduction), and bocaccio young-of-the-year have been found under floating kelp mats (Love et al. 2002).

A 1.5 x 1 x 5 m trawl net towed behind a boat at a depth of 0.75 m was used to sample floating kelp mats.

TABLE 1. Number of juvenile bocaccios (*Sebastes paucispinis*) sampled in eelgrass beds during 2005-2006 as part of the eelgrass ecological integrity monitoring program.

REGION	YEAR	SAMPLING PERIOD	NUMBER OF SITES	NUMBER OF SETS PER SITE	TOTAL NUMBER OF SEINE SETS	NUMBER OF BOCACCIOS COLLECTED
Clayoquot Sound	2005	June 21- 27	12	3	36	0
Barkley Sound	2005	July 5-8	8	3	24	2
Gwaii Haanas	2005	July 19-25	12	3	36	3
Gulf Islands	2005	Aug 01-05	8	3	24	0
Gulf Islands	2005	Sept 14-15	4	3	12	0
Clayoquot Sound	2006	June 25-30	12	3	36	1
Barkley Sound	2006	July 23-29	12	3	35[1]	0
Gwaii Haanas	2006	July 10-15	11	3	33	2
Gulf Islands	2006	Aug 5-10	12	3	36	0
TOTAL			**91**		**272**	**8**

FIGURE 3A. Approximate locations of eelgrass beds sampled - Gwaii Haanas. Sites where bocaccios were caught are in red.

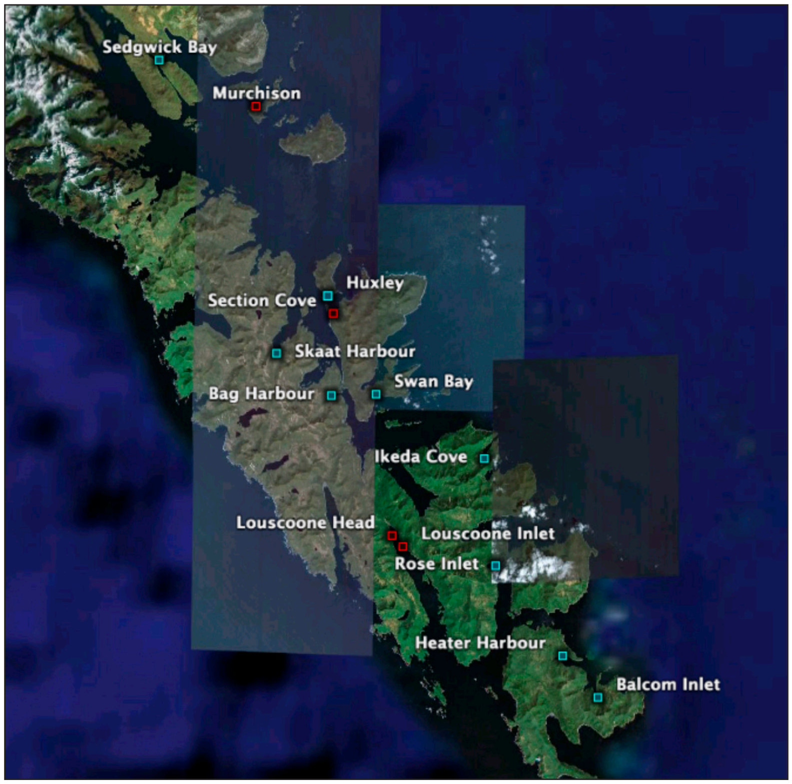


FIGURE 3B. Approximate locations of eelgrass beds sampled - Clayoquot Sound. No bocaccios were caught.

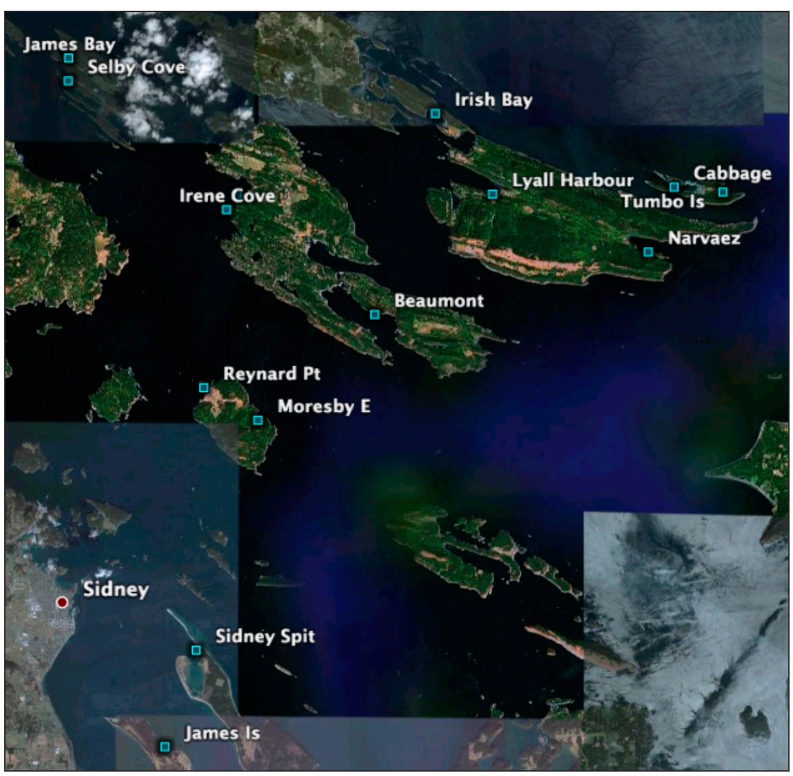
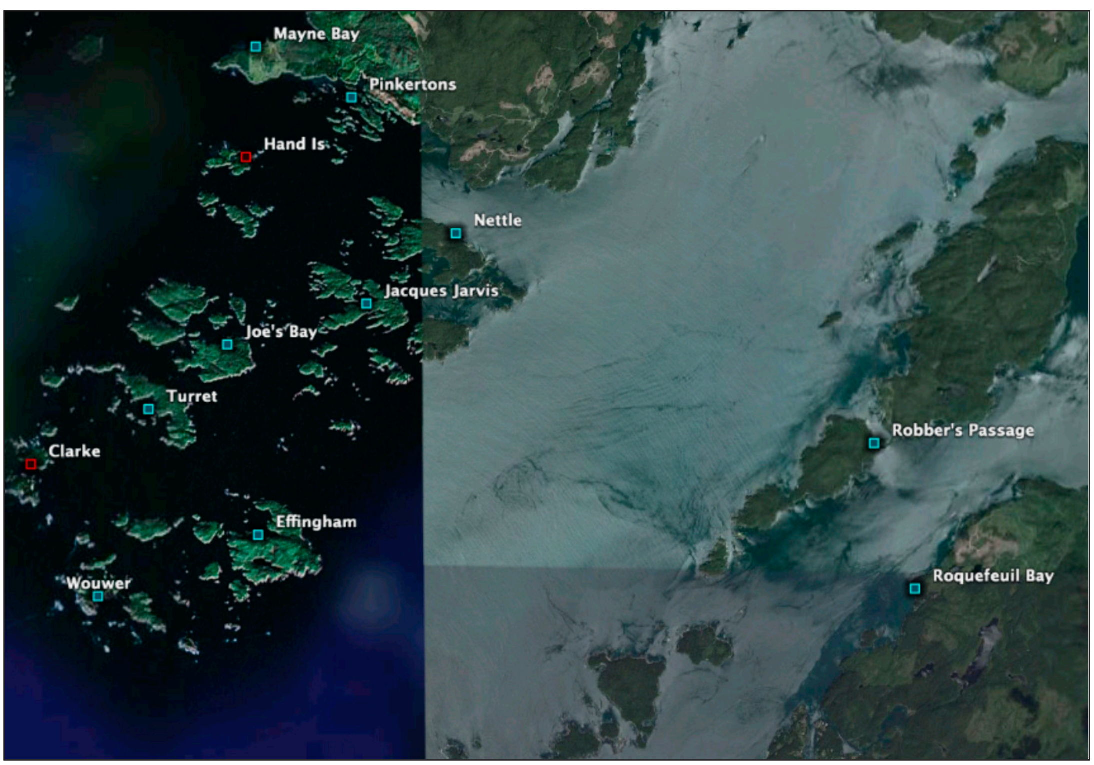
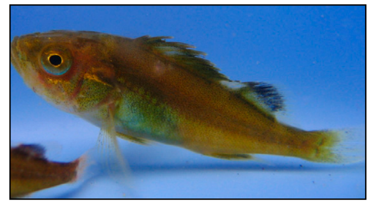


FIGURE 3C. Approximate locations of eelgrass beds sampled - Barkley Sound. Sites where bocaccios were caught are in red.

FIGURE 3D. Approximate locations of eelgrass beds sampled - southern Gulf Islands. Sites where bocaccios were caught are in red.



Twenty one (21) kelp mats were sampled in Barkley Sound on Aug 16, 2005 (*Figure 4*). The volume of the net was estimated and the contents were immediately sorted. All fishes caught were identified, measured and released shortly after their capture. There were five (5) juvenile rockfish caught with this method: 1 black rockfish, 3 splitnose rockfish and 1 tiger rockfish. No bocaccio were caught nor seen. Splitnose rockfish are known to occupy floating kelp mats in Puget Sound (Shaffer et al. 1995) and their presence in Barkley Sound drift vegetation was therefore expected.



Juvenile splitnose rockfish (*S. diploproa*) caught with trawl net

Juvenile tiger rockfish (*S. nigrocinctus*) caught with trawl net.

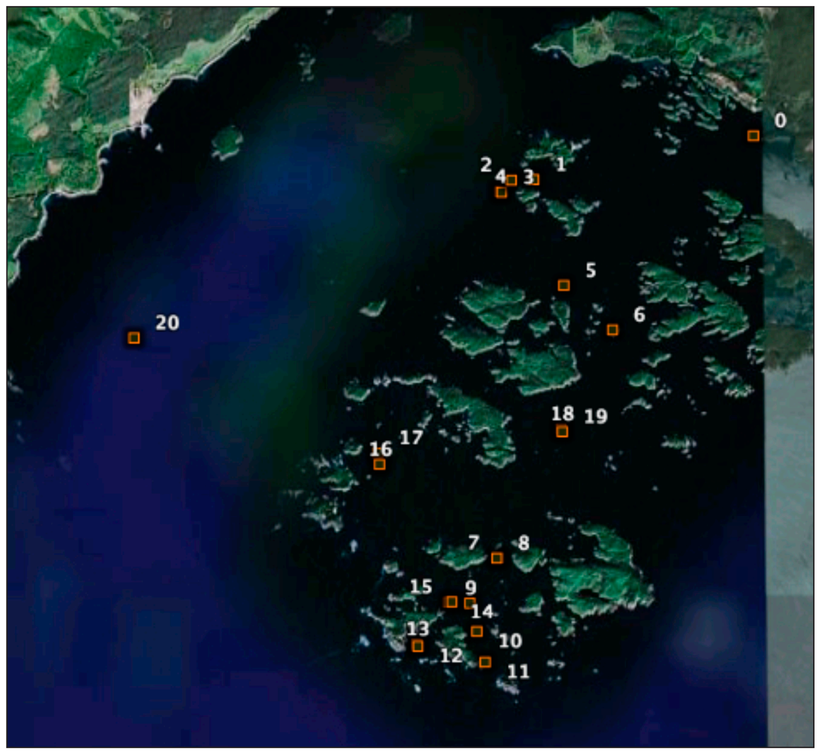
Photos: J. Yakimishyn / Parks Canada

2.4 SMURFs

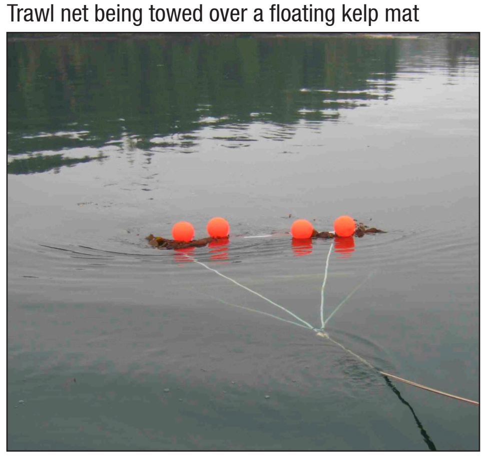
Standardized Monitoring Units for Reef Fishes (SMURFs) are designed to mimic the physical structure provided by kelp canopies (Ammann 2004). They consist of a mesh bag anchored to the substrate and floating approximately 1.5 m below the surface. They are best sampled by snorkelers equipped with BINCKE (Benthic Ichthyofauna Net for Coral/Kelp Environments; Anderson and Carr 1998) nets. Refer to Ammann (2004) for further details.

We used tidal model results (cf. next section) to help select the general area of deployment of the SMURFs (*Figure 5*). SMURF deployment was focused on the southern Loudon Channel area and adjacent islands such as Clarke, Turret, and Willis, as it is likely that most oceanic rockfish larvae that enter the Broken Group will do so there because of the underlying clockwise circular tidal flows. Because these islands and their habitats would, in theory, be encountered first, one would not expect larval bocaccios to be caught further northeast in the Sechart Channel area or in the northern portion of Imperial Eagle Channel.

FIGURE 4. Approximate locations of surface tows in Barkley Sound, August 16, 2005.



Trawl net being towed over a floating kelp mat



Trawl net being emptied of its contents

Photos: J. Yakimishyn / Parks Canada

Twelve (12) SMURFs were installed in the western part of Barkley Sound, four inside the PRNPR and eight outside (*Figures 5* and *6A*). Most units outside the PRNPR were installed on April 1-2, 2006 and those inside by June 1st, 2006. There were sampled approximately every 15 days (*Table 2*). If no rockfish were present in a unit, an effort was made to collect 10 fish from the site with a BINCKE net manned by a snorkeler (*Figure 6B*).

More than 85% of all juvenile rockfishes were caught West of Page Is. The Loudoun Reef unit caught most of the fish in the latter part of the sampling program. There were only two juvenile bocaccios caught in SMURFs, in Bocco and in Loudoun Reef. There were however 15 bocaccios caught with BINCKE nets in the same sites (*Table 3*).

FIGURE 5. Approximate locations of SMURFs installed in the western portion of Barkley Sound. Sites in red are where juvenile bocaccios were caught, either in SMURFs or with BINCKE nets.

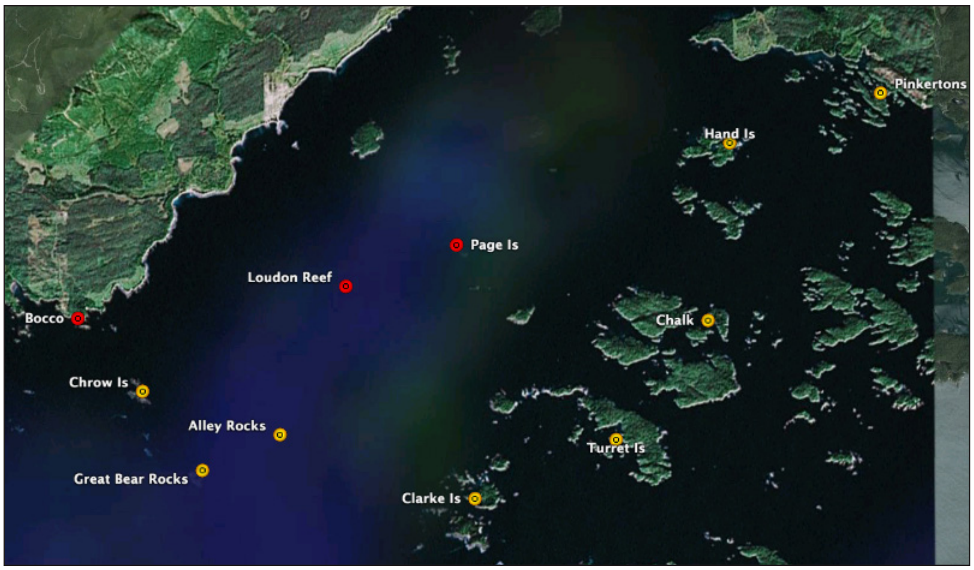
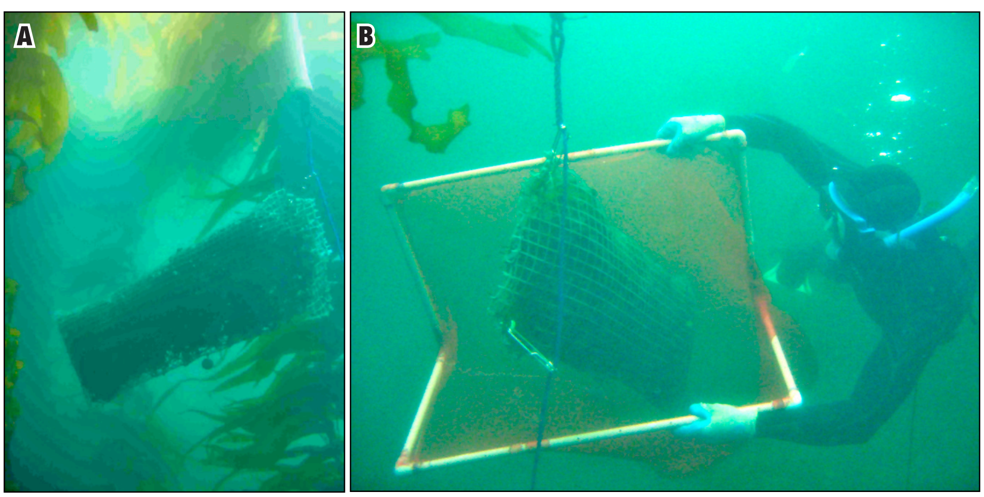


FIGURE 6. A: Standardized Monitoring Unit for Reef Fishes (SMURF) in kelp bed, Barkley Sound. B: Snorkeler retrieving a SMURF with a BINCKE net.



Photos: Russell Markel / UBC

2.5 Snorkel surveys and underwater video

Bocaccio juveniles were sampled in the area of Barkley Sound in 2005 and 2006 through SMURFs (cf. previous section). While it has merits for juvenile rockfishes, the method does not however appear to be efficient to record the presence of juvenile bocaccios in particular. Incidental observations showed that juvenile bocaccios school in the area (RM, pers. obs.) and can sometimes be caught with other methods. It was therefore felt that the investigation of alternative methods was justified.

TABLE 2. Juvenile rockfishes (black, yellowtail, copper and bocaccio) captured in SMURFs, April 15-Sept 16, 2006. Refer to Figure 5 for locations. The two juvenile bocaccios caught are shown in **red**.

Date	Alley	Great Bear	Chrow	Bocco	Loudoun	Page	Pinkertons	Hand	Chalk	Turret	Clarke
Apr 15	0	0	0	0	0	0	0	n/a	n/a	n/a	n/a
Apr 29	0	0	0	0	0	0	0	n/a	n/a	n/a	n/a
May 12	0	0	0	**1**	0	0	0	n/a	n/a	n/a	n/a
May 27	0	stolen	1	0	3	0	0	n/a	n/a	n/a	n/a
Jun 07	4	49	19	0	12	0	0	0	0	0	3
Jun 25	17	15	27	0	45 (**1**)	0	0				
Jul 06	20	18	20	6	3	4	0	1	1	n/a	n/a
Jul 21	21	6	18	10	10	9	0	0	3	6	6
Aug 04	44	19	19	7	18	3	0	6	4	0	12
Aug 21	3	5	4	2	36	1	0	3	5	2	7
Sep 16	6	14	n/a	9	167	20	n/a	n/a	n/a	n/a	n/a

TABLE 3. Juvenile bocaccios caught in SMURFs and with BINCKE nets. Refer to Figure 5 for location of sampling sites.

Date	Location	Method	Length (mm)	Weight (g)
12 May	Bocco	SMURF	38.00	0.50
12 May	Bocco	BINCKE	34.00	0.39
12 May	Bocco	BINCKE	34.40	0.43
25 May	Bocco	BINCKE	37.50	0.56
25 May	Bocco	BINCKE	39.25	0.61
07 Jun	Bocco	BINCKE	34.40	0.40
25 Jun	Bocco	BINCKE	54.00	1.45
25 Jun	Bocco	BINCKE	72.50	3.61
25 Jun	Bocco	BINCKE	81.40	5.47
25 Jun	Bocco	BINCKE	97.80	8.65
25 Jun	Loudoun	SMURF	49.60	1.02
21 Jul	Page	BINCKE	85.60	6.72
04 Aug	Bocco	BINCKE	114.00	15.45
04 Aug	Page	BINCKE	107.50	10.59
04 Aug	Page	BINCKE	94.00	7.42
21 Aug	Bocco	BINCKE	147.10	37.11
16 Sep	Bocco	BINCKE	178.85	61.11

Juvenile bocaccio caught in SMURF in June, 2005.

Photo: Russell Markel / UBC

Snorkel surveys were conducted in the Barkley Sound area from August 20 -23, 2006 (*Figure 7*). There were two goals to these surveys:

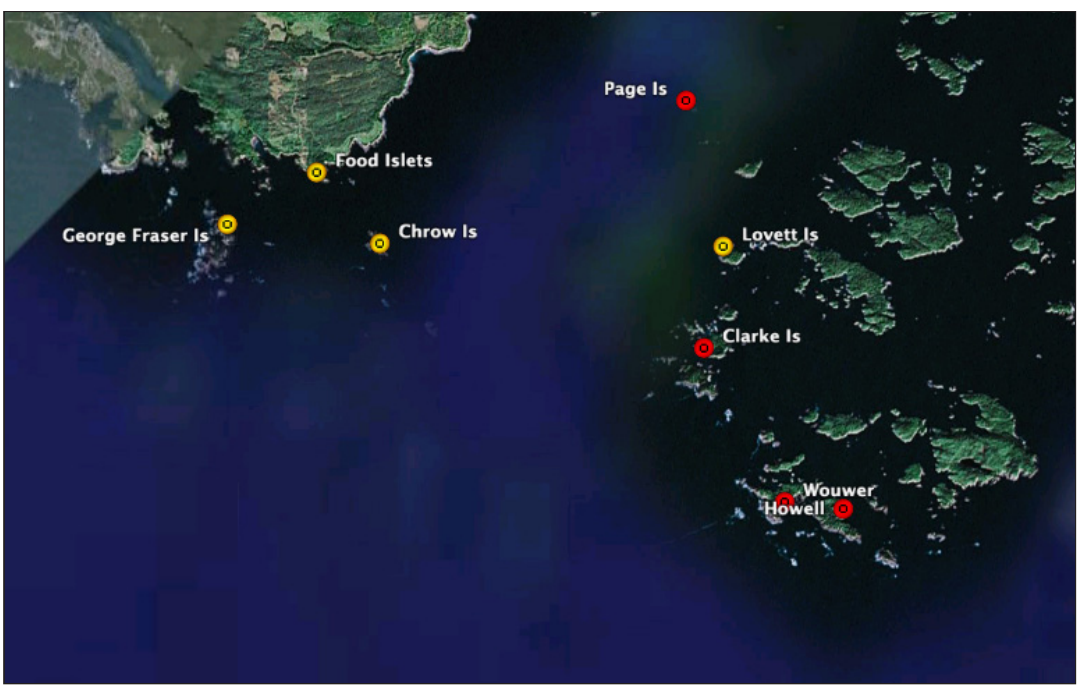
1. Determine whether bocaccios use particular areas. This is akin to a broad brush survey; and,
2. Sample juvenile rockfish

Sites were chosen on the basis of their probability of harbouring juvenile rockfish (as determined from sampling through SMURFs and beach seine), and on their location along tidal currents. Tidal flows without winds have been modelled in Barkley Sound in summer (June – August) as part of an assessment of the possible dispersal of larval northern abalone (Robinson, unpublished data). Examination of the particle flow results indicates that the main tidal flow in Barkley Sound is a clockwise circular flow with particles moving from areas such as Hand and Nettle Islands (cf. *Figure 3D*), out via Sechart Channel into Imperial Eagle Channel and ultimately seaward. Particles from Dempster and Effingham move seaward as well, but also move northward along the outer Broken Group (BGI) and then re-enter the BGI via strong inland flow on the southern side of Loudon Channel or Coaster Channel. Finally, particles from islands along southern Loudon Channel like Clarke and Turret move towards Toquart Bay and Hand Island. Some of these particles enter the BGI via Thiepval and Peacock Channels. Wind direction and velocity can greatly modify these underlying tidal flows. Strong SE winds can move particles against the clockwise circular tidal flow, while NW winds tend to enhance the movement of particles of the southern BGI sending them (eventually) further out into the Pacific Ocean.

All survey locations harboured giant kelp (*Macrocystis integrifolia*) beds. Rockfish were first sampled with a BINCKE net (Anderson and Carr 1998) manned by a snorkeler swimming by the edge of the bed. The area immediately below the surface of the bed (from 0.2 to 1.5 m depth) was subsequently filmed with an underwater video camera[2] for approximately 10 min. Videotapes were later reviewed in the laboratory to estimate number of and species of rockfish and record habitat types. These latter analyses were still on-going at the time of this writing.

There were four bocaccios seen but only one caught (*Table 4*). All bocaccios seen were solitary and wary of divers, probably because of their size (approx. 130-150 mm).

FIGURE 7. Location of snorkel survey sites for juvenile rockfish, Barkley Sound area, August, 2006. The Howell label is shown to the left of the marker. Sites in red are where bocaccios were either caught or seen.



[2] Splash-Cam™ underwater video camera linked to a Canon digital video camera (Canon NTSC ZR40)

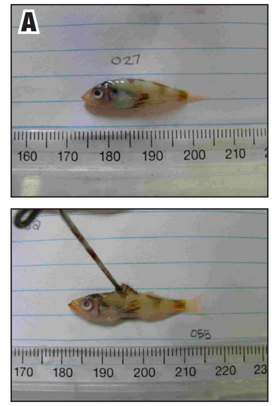
2.6 Incidental observations

Bocaccio juveniles and adults use the Barkley Sound area and have been observed in many instances. What follows is a non encompassive record of various observations made in 2006 and not categorized in the previous sections:

- Two recently settled bocaccios (TL = 30.5 and 33.4 mm) were captured on May 23, 2006, in SMURFs near the north end of Fleming Is and in Dodger Channel (*Figure 8A* and *8B*; Sharon Jeffery, UBC Dept of Botany, pers. comm.
- One adult bocaccio may have been caught near Sechart in June, 2006 , but positive identification is not certain.
- A large school of bocaccios (>250 individuals) was observed by Chrow Is on September 16, 2006. The fish were estimated to be around 150 mm TL (RM, pers. obs.; *Figure 9*)
- One adult bocaccio was observed underwater (in 10 m depth) near Rainy Bay, September 2006 (Jennifer Yakimishyn, pers. comm.; *Figure 10*)
- 16 bocaccios, ranging from 140 to 172 mm TL, were caught in an eelgrass bed in Bamfield Inlet in September, 2006 (Alana Jung and Michelle Paleczny, Bamfield Marine Science Center, pers. comm.)

FIGURE 8. Bocaccio juvenile sampled in SMURF, Fleming Is.

Bocaccio juvenile sampled in SMURF, Dodger Channel.



Photos: Sharon Jeffrey / UBC

TABLE 4. Number of juvenile rockfishes seen or measured in Barkley Sound sites, Aug 20-23, 2006. BOCC = bocaccio, BLRO = black rockfish, CORO = copper rockfish, YERO = yellowtail rockfish. Refer to Figure 7 for locations of sites.

Date sampled	Site	Surface water temperature (°C)	Salinity (ppt)	BOCCO caught	BOCCO seen	BLRO	CORO	YERO	Total measured
Aug 20	Page Is.	16.7	30.6	1	x	4			**5**
Aug 20	Food Is.	15.3	30.8			1	1		**2**
Aug 21	Chrow Is.	14.1	30.9			2	3		**5**
Aug 21	George Fraser Is.	13.6	31.0			12			**12**
Aug 22	Wouwer Is.	12.5	N/A		x	6	5		**11**
Aug 22	Clarke Is.	13.5	N/A		x	6	1		**7**
Aug 23	Howell Is.	12.9	31.0		x	14	2	1	**17**
Aug 23	Lovett Is.	15.1	30.9			6			**6**
TOTAL				**1**	**4**	**51**	**12**	**1**	**65**

FIGURE 9. Juvenile bocaccios in kelp bed, Barkley Sound, September 2006.

Photo: Russell Markel/ UBC

FIGURE 10. Adult bocaccio observed in Rainy Bay, Barkley Sound.

Photo: J. Yakimishyn/ Parks Canada

2.7 Discussion

2.7.1 Length-Weight relationship

Overall, 25 juvenile bocaccios were caught in eelgrass beds, SMURFs and near kelp beds with BINCKE nets in Barkley Sound, Clayoquot Sound and Gwaii Haanas in 2005 and 2006. Even though these fish were sampled in different years and in different sites, the theoretical Length-Weight relationship for males (Love et al. 2002) was a good predictor of the observed data (*Figure 11*). Although growth is sexually dimorphic in bocaccios (Love et al. 2005), the relationship is almost identical for males and females smaller than 300 mm.

The theoretical Length-Weight relationships were also very good predictors for juvenile copper (*S. caurinus*) and black rockfish (*S. melanops*) sampled in Barkley Sound eelgrass beds in July, 2005 (*Figures 12A* and *12B*).

Overall, juvenile bocaccios were lighter than either copper or black for the same size (*Figure 13*; all slopes significantly different, ANCOVA on log transformed variables).

FIGURE 11. Length-Weight relationship of bocaccios caught by different methods in Gwaii Haanas, Barkley Sound and Clayoquot Sound. The fitted line is the predicted relationship from Love et al. (1990) for males: Wt = 0.0081 $L^{3.061}$; nN = 25

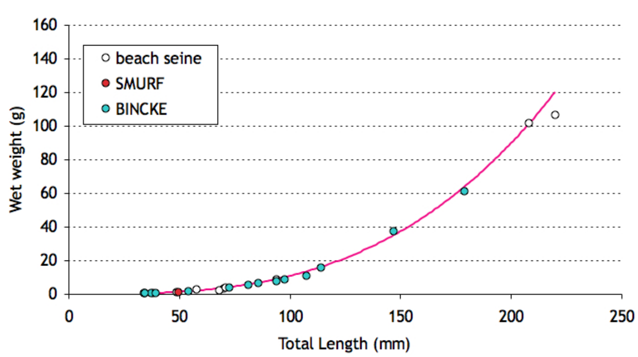


FIGURE 12. Observed and predicted (line) Length-Weight relationships for A) juvenile copper rockfish and B) black rockfish in Barkley Sound, May-September, 2006. Orange and grey lines are from Love et al (2002) for males and the black line the fitted line from the data. Predicted relationships: Wt = 0.0172 $L^{3.018}$ for copper and Wt = 0.000002 $L^{3.442}$ for black (fitted line). N = 252 for copper and N = 152 for black

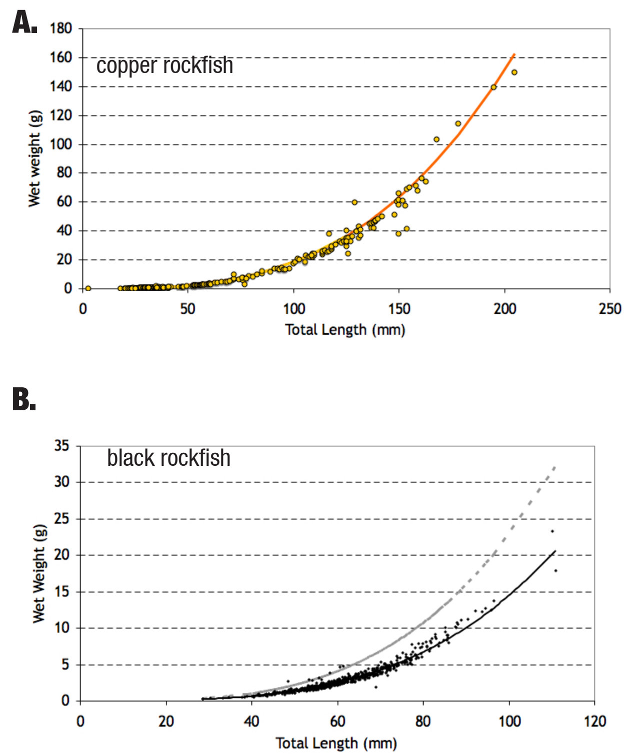
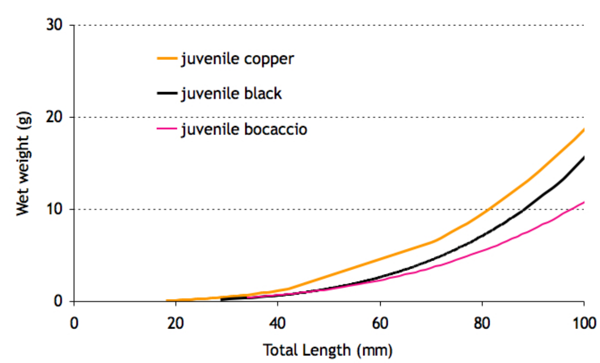


FIGURE 13. Predicted Length-Weight relationships for juvenile copper, black and bocaccio rockfish. Fitted line is used for black rockfish. Refer to Figures 11 and 12 for equations.



2.7.2 Growth rates

Bocaccios are reported to exhibit fast growth rates among rockfish juveniles (Woodbury and Ralston, 1991; Reilly et al. 1992). To test that this is the case in Barkley Sound, bocaccios caught in 2006 with either SMURFs or BINCKE nets were compared to copper and black rockfish juveniles caught at the same time and locations with the same methods (refer to *Figure 5* for location of SMURFs).

The first step to compare growth rates is to ensure that all fishes are from the same year class (0+), as older year 1+ fish may have different growth rates. The size distribution of juvenile bocaccios sampled in Barkley Sound appeared roughly unimodal, with a mode around 60-70 mm and possibly some older fish near 160 mm *(Figure 14)*. The two larger individuals may have belonged to a different age class, although bocaccios have been reported to reach up to 250 mm by end of their first year (Phillips 1964; MacCall et al 1999).

The size distribution of black rockfish caught during the same time interval was strongly unimodal while that of juvenile copper appeared bimodal *(Figure 15)*. This latter assertion was supported by plotting total lengths of copper rockfish in function of time *(Figure 16)*: a second group of larger individuals with a mode around 100 mm was present in early August (day 95). Copper juveniles have been reported to grow to approximately 90 mm in their first year in central California (Lea 1991), which does point to this group being older than other copper rockfish. Thus comparisons of growth rate were based on bocaccios smaller than 140 mm TL, on all black rockfish sampled and on copper juveniles smaller than 80 mm TL.

FIGURE 14. Size distribution of juvenile bocaccio sampled in Barkley Sound from May to September, 2006. N=17

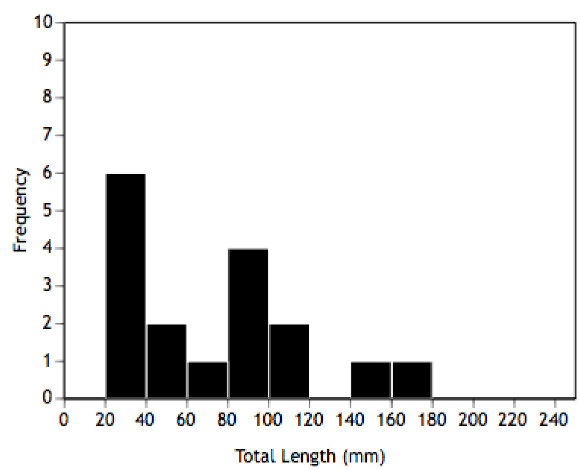
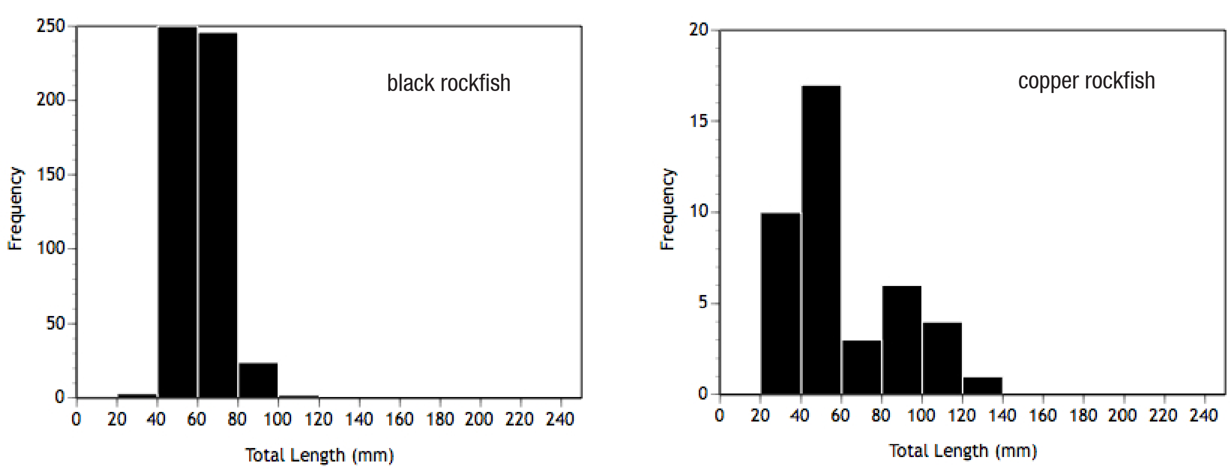


FIGURE 15. Size distributions of juvenile black and copper rockfish sampled in SMURFs or with BINCKE nets in Barkley Sound, May-September 2006. N= 554 and 41, respectively.



Juvenile bocaccios caught in Barkley Sound grew faster than either copper or black rockfish juveniles caught at the same time (*Figures 17 and 18*; slopes significantly different, ANCOVA on log-transformed values). Bocaccios have been reported to consume proportionally more fish larvae than their congeners (Reilly et al. 1992), which may explain this higher growth rate. Their estimated growth rate from the data was 1.01 mm/day, which is at the higher end of reported growth rates for this species (from 0.56 to 0.97 mm/day; Woodbury and Ralston, 1991).

From this obtained growth rate, one can back calculate probable dates of extrusion into plankton (parturition) and of settlement from plankton. Bocaccios are reported to be from 15 to 30 mm when first settling and to be approximately 5 mm long at extrusion (3 to 9 mm, mode between 3.5 and 5.5 mm – MacGregor 1986).

The smallest bocaccio caught in a SMURF was 34 mm long on May 12, 2006. For comparison, the smallest bocaccio caught in an eelgrass bed was 49 mm, in Clayoquot Sound, June 26, 2006 (Robinson et al. in prep). Ammann (2004) collected juveniles 26 mm long in SMURFs in May, 2000, in Monterey Bay.

FIGURE 16. Size distribution of juvenile copper rockfish sampled in Barkley Sound, May to September, 2006. Dashed circle encloses a probably older age group.

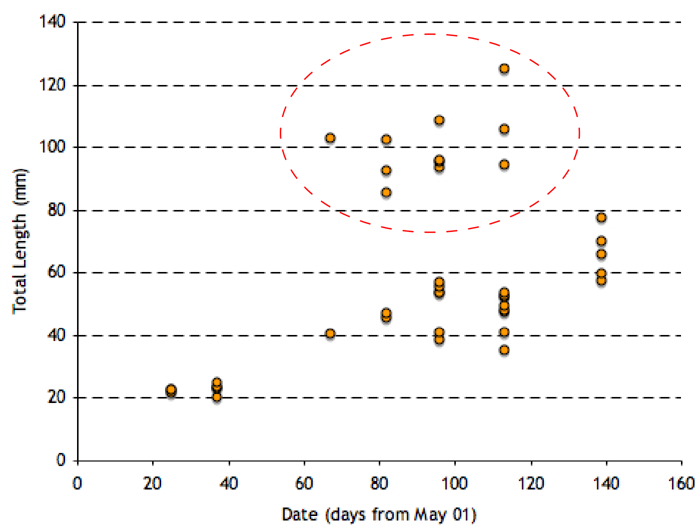
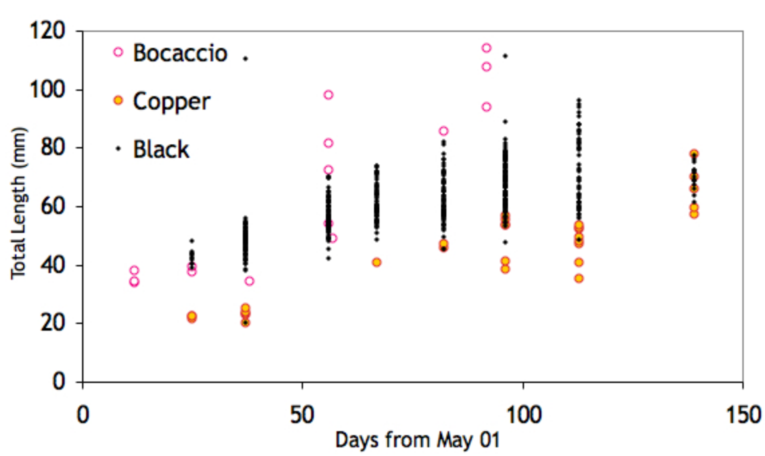


FIGURE 17. Size of juvenile bocaccio, copper and black rockfish sampled in Barkley Sound, May-September, 2006 in function of time (days).



Extrapolating from May 12 would put the onset on settlement from plankton during the first week of May (metamorphosis occurs near 30 mm – Hart 1973) and the extrusion (5 mm – MacGregor 1986) in the first two weeks of April *(Table 5)*. Assuming constant growth rates, bocaccios caught in Barkley Sound may thus have spent four to six weeks in the plankton before settling onto the substrate. This may be a short period when compared to the values cited in the literature (up to 150 days – Sakuma and Ralston 1995). However most reported values are based on growth rates for fish caught in California or more southern areas whereas growth rates are typically slower in more northerly latitudes – latitudinal differences in length and maturation have been reported for splitnose, widow, yellowtail, black and bocaccio rockfishes (Wyllie Echeverria 1987; Love et al. 1990; Field 1984, all cited in Love and Johnson 1998). The growth rates for Barkley Sound bocaccio juveniles are based on an admittedly small sample size (17 fish) and should be viewed with caution until larger samples are collected.

FIGURE 18. Growth rates of juvenile bocaccio, copper and black rockfish sampled in Barkley Sound, May-September, 2006. Fitted equations based on data shown in Figure 16. The variation explained by the fitted lines was 0.50, 0.82 and 0.85 for black, bocaccio and copper respectively.

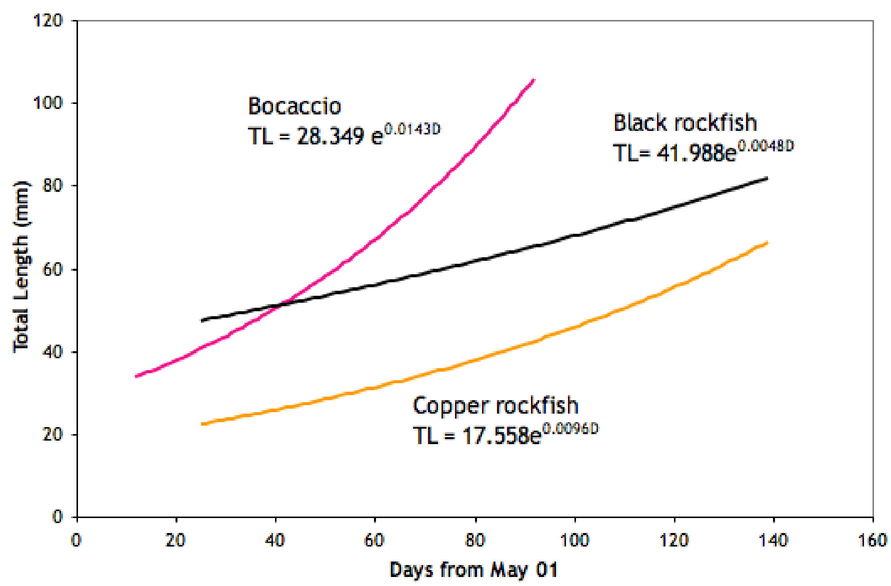


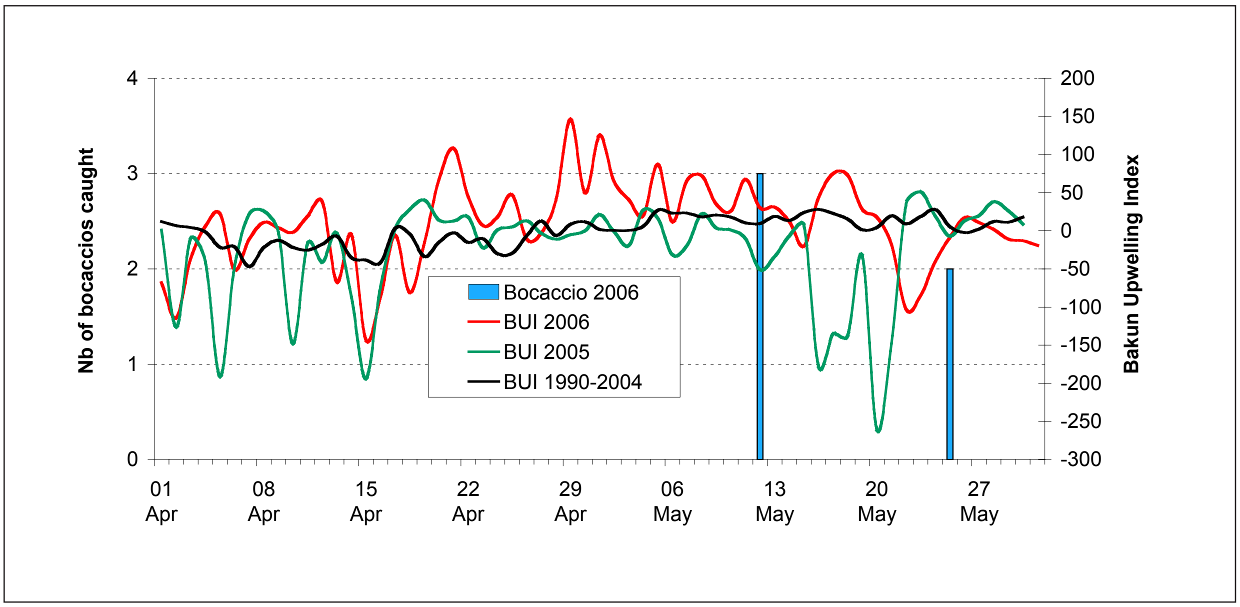
TABLE 5. Back calculation of dates of onset of juvenile bocaccio life history stages in Barkley Sound, based on different growth rates.

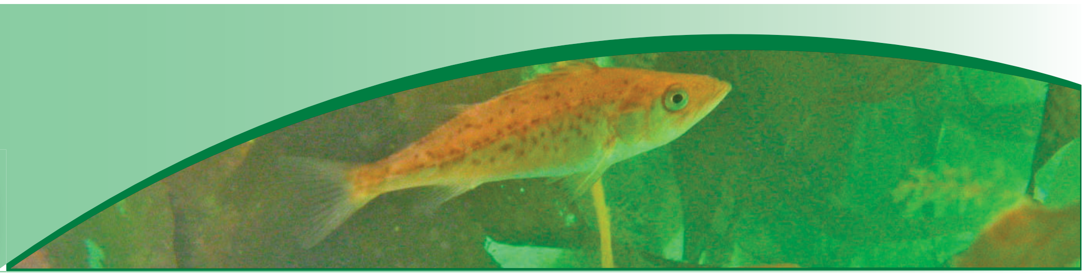
Date	Size (mm)	Stage	Growth rate (mm/day)
12 May	34	Settled on substrate	
5 May 8 May 8 May	30	Settlement from plankton	0.56 0.97 1.01
09 Apr 23 Apr 24 Apr	15	Earliest onset of settlement from plankton	0.56 0.97 1.01
01 Apr 13 Apr 13 Apr	5	Extrusion into plankton	0.56 0.97 1.01

Peak settlements of rockfish often follow ocean upwelling (Johnson et al. 2001) and small pelagic juvenile rockfish often appear offshore in the region of upwelling fronts (Larson et al. 1994). Our data indicate that bocaccio larvae should be transported into Barkley Sound in late April-early May. Their presence was related to the Bakun Upwelling Index (BUI) as measured off Amphitrite Point *(Figure 19)*. The BUI measures relative coastal upwelling in terms of metric tons/sec per 100 m of coastline (McGowan et al. 1996).

It appears that 2006 juvenile bocaccios experienced a relative peak in settlement following an upsurge in upwelling. The latter was the strongest in recent years. While these results are tantalizing and concur with other studies, they are based on few data points (only 3 bocaccios) and more data should be collected before bocaccio settlement patterns are related to oceanographic processes.

FIGURE 19. Number of juvenile bocaccios caught in SMURFs in Barkley Sound from April to May, 2006 and variations in Bakun Upwelling Index (BUI) at Amphitrite Point.





3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

The historical range of bocaccio encompasses the west coast of Vancouver Island and Barkley Sound in particular, and there is strong evidence of significant decline in bocaccio relative abundance in southwestern BC from the early '80s (Stanley et al. 2004). Our recent data concur with this latter statement as very few bocaccios (two dozens in total) were found during the two years of our extensive sampling using various methods in different habitats. In comparison, more than 500 black rockfish were sampled in three months in Barkley Sound SMURFs alone in 2006[3]. Overall, bocaccios, although they undoubtedly use some habitats in Barkley Sound (eelgrass, kelp beds) were extremely rare as compared to other rockfishes. Their small numbers make any conclusion about their ecology problematic, other than their deserving of special conservation status. Incidental observations suggest that bocaccio juveniles actively recruit in the western part of Barkley Sound.

Eelgrass beds sampling, while an invaluable tool to examine the relative health of fish assemblages among areas, did not provide enough data to warrant any conclusion about bocaccio use of this habitat. Bocaccio juveniles undoubtedly use eelgrass but it is not presently possible to assess the extent of their use of this habitat. The school of bocaccios caught in an eelgrass bed in Bamfield Inlet in September certainly points to their use of this habitat later in the year. Whether this is an ontogenetic habitat shift, related to oceanographical parameters or opportunistic sampling of a school that was foraging cannot be determined at the present time. Juveniles observed in September measured on average 170 mm TL or larger, schooled, and were very mobile, which explains their wide-ranging distribution in the area (*Figure 20*).

Our data suggest that bocaccio spawn in early April and that the larvae remain in the plankton

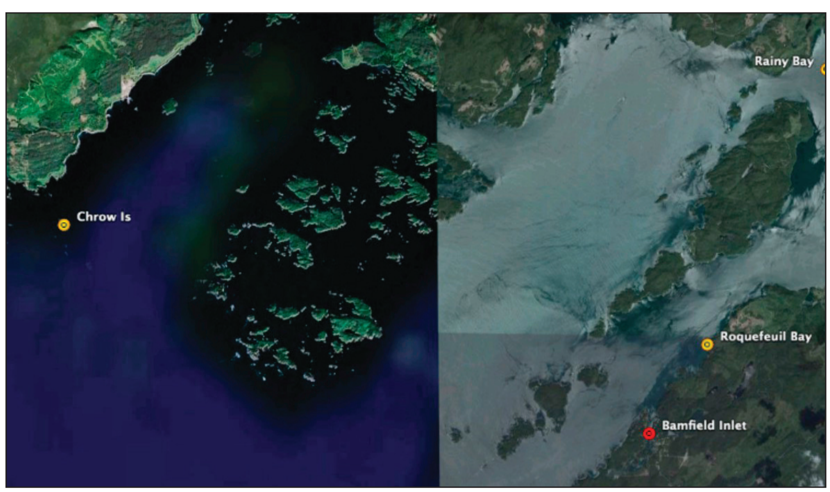


FIGURE 20. Juvenile bocaccios observed in Barkley Sound and surroundings, September, 2006. Red marker is an eelgrass bed.

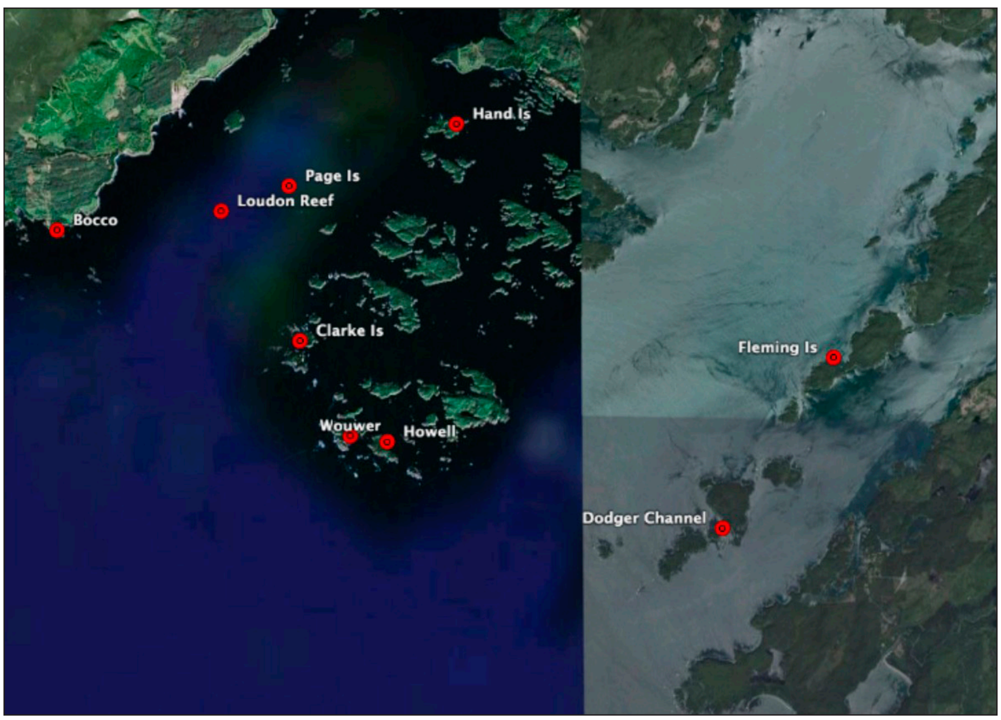
[3] It should be noted that black (and copper) rockfish adults remain and likely spawn inshore (Miller and Shanks 2004) whereas bocaccios are semi-pelagic or remain deeper and more offshore than black rockfish. Their larvae may therefore not be subjected to the same oceanographic processes during settlement.

from April to early May. They are transported into Barkley Sound and may be 'pushed' in by peaks of downwelling water. The locations of the bocaccios caught in SMURFs suggest that they follow tidal flows: most of recently settled fish were caught in the Loudon Channel area, and none were caught in the northern most site in the Pinkerton Islands near Sechart (*Figures 21* and *3D*). However there were no SMURFs installed in the Imperial Eagle Channel, except for two sites monitored by Sharon Jeffery as part of a different study (Sharon Jeffery, pers. comm.). The school of bocaccios caught in eelgrass beds in Bamfield Inlet in September suggests that the fish either move in the area later or settle in it. A sampling program is needed to differentiate between these two hypotheses.

The SMURFs worked well for monitoring patterns of recruitment and year class strength of black and copper rockfish, but not bocaccio. Bocaccios grow very quickly and are very predatory in nature, compared to black and copper rockfish. Therefore they just do not seek shelter in the same way that other rockfish juveniles do.

However the SMURFs results were invaluable for other rockfish species. For example, copper rockfish recruitment was much later and much smaller in 2006 than in 2005 (RM, pers. obs.). They also provide insights about habitat preferences - 2005 copper juveniles were found to perdure during the season only in very protected kelp forests (RM, pers. obs.).

FIGURE 21. Approximate location of recently settled bocaccios in Barkley Sound, 2005-2006.

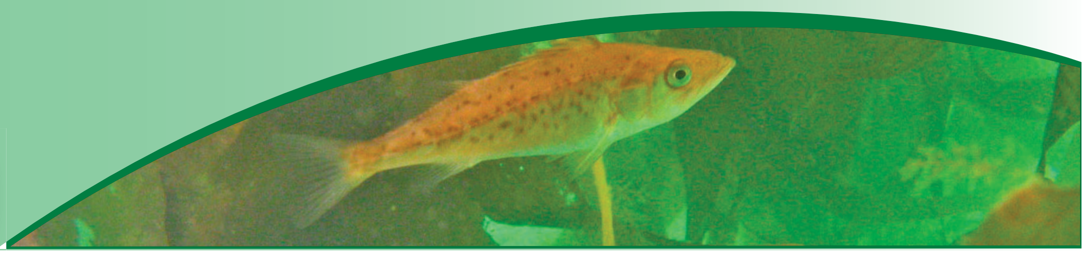


Visual surveys conducted in August near kelp beds provided invaluable data on rockfish and in particular on bocaccio use of these habitats. The Catch per Unit Time was high as compared to sampling eelgrass beds (approximately 0.13 rockfish/unit time as compared to < 0.01 for eelgrass beds).

Most bocaccio juveniles were observed in Barkley Sound near kelp beds (*Macrocystis integrifolia*). This is likely the result of the effectiveness of snorkel surveys, which were not used in other areas nor in other habitats. Thus any conclusion about their preferential use of this area should await further data from similar surveys in other areas and habitats.

3.2 Recommendations

- Snorkel surveys with BINCKE nets proved an efficient and cost-effective method to sample juvenile rockfish and bocaccio in particular. They should be implemented from May onward instead of only in August as fishes are easier to catch early in the year. Such surveys would further provide invaluable data on condition indices of bocaccios at the onset of their settlement.
- Visual underwater surveys provide relatively rapid, cost-effective and large-scale assessments of rockfish recruitment, including bocaccio (more bocaccios were seen than caught). A standard protocol for visual surveys should be designed to assess bocaccio use of various habitats.
- The relationship between abundance and condition index of bocaccio and habitat should be examined to determine which habitat promulgates better growth so that conservation efforts for this species may be better focused and managed. More samples are needed in eelgrass beds and kelp beds, within and outside the PRNPR.
- The influence of oceanographic processes on juvenile rockfish settlement patterns should be examined. Bocaccios in particular appear to settle along tidal currents but more data are needed.
- SMURFs did not collect many bocaccios as compared to other rockfish. However they were installed in only three sites within the PRNPR boundaries. Based on their deployment in neighbouring areas, they work very well for monitoring patterns of recruitment and year class strength of other rockfish species. SMURFs are relatively inexpensive to deploy and their cost/potential benefit ratio is such that they should be considered for further sites within the PRNPR boundaries. A long-term monitoring program involving a small number of SMURFs would be extremely valuable to the PCA.



4.0 LITERATURE CITED

Ammann, A. J. 2004. SMURFs: standard monitoring units for the recruitment of temperate reef fishes. Journal of Experimental Marine Biology and Ecology 299:135-154.

Anderson, T.W. and M.H. Carr. 1998. BINCKE: a highly efficient net for collecting reef fishes. Env. Biol. Fishes 51: 111–115.

Bodkin, J. L. 1988. Effects of kelp forest removal on associated fish assemblages in central California. Journal of Experimental Marine Biology and Ecology 117:227-238.

Carr, M. H. 1991. Habitat selection and recruitment of an assemblage of temperate zone reef fishes. Journal of Experimental Marine Biology and Ecology 146:113-137.

Carr M. H., and D. C. Reed . 1993. Conceptual issues relevant to marine harvest refuges: examples from temperate reef fishes. Can J Fish Aquat Sci 50:2019–2028

Carr, M. H. 1994. Effects of macroalgal dynamics on recruitment of a temperate reef fish. Ecology 75:1320-1333.

COSEWIC 2006. http://www.cosewic.gc.ca. Site accessed October, 2006

Eschmeyer, W.N., Herald, E.S., and Hammannn, H. 1983. A field guide to Pacific Coast fishes. Houghton Mifflin, Boston, Mass.

Harvey, C. J., N. Tolimieri, and P. S. Levin. 2006. Changes in body size, abundance, and energy allocation in rockfish assemblages of the Northeast Pacific. Ecological Applications 16: 1502-1515.

Hart, J. L. 1973. Pacific Fishes of Canada. Fish. Res. Bd. Can. Bull. 180, 730 p.

Johnson, K. A., M. M. Yoklavich, and G. M. Cailliet. 2001. Recruitment of three species of juvenile rockfish *(Sebastes* spp.) on soft benthic habitat in Monterey bay, California. Calif. Coop. Oceanic Fish. Invest. Rep. 42: 153-166.

Larson, R. J., W. H. Lenarz, and S. Ralston. 1994. The distribution of pelagic juvenile rockfish of the genus *Sebastes* in the upwelling region off central California. Calif. Coop. Oceanic Fish. Invest. Rep. 35: 175-221.

Lea, R. N., R. D. McAllister, and D. A. VenTresca. 1999. Biological aspects of nearshore rockfishes of the genus *Sebastes* from central California with notes on ecologically related sport fishes. Fish Bulletin 177:1-112

Lea R. N. 2001. Copper rockfish. pp. 173-174 In: Lee W. S., C. M. Dewees, R. Klingbeil, and E. J. Larson (eds), California's Living Marine Resources: A Status Report. California Department of Fish and Game.

Love, M.S., P. Morris, M. McCrae and R. Collins. 1990. Life history aspects of 19 rockfish species (Scorpaenidae: *Sebastes*) from the Southern California Bight. NOAA Tech. Rep. NMFS 87.

Love, M. S., and K. Johnson. 1998. Aspects of the life histories of grass rockfish, *Sebastes rastrelliger*, and brown rockfish, *S. auriculatus*, from southern California. Fishery Bulletin 87: 100-109.

Love, M. S., J. E. Caselle, and L. Snook. 2000. Fish assemblages around seven oil platforms in the Santa Barbara Channel area. Fishery Bulletin 98: 96-117.

Love, M.S., M. M. Yoklavich, and L. K. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press.

Love, M. S., D. M. Schroeder, and W. H. Lenarz. 2005. Distribution of bocaccio (*Sebastes paucispinis*) and cowcod (*Sebastes levis*) around oil platforms and natural outcrops off California with implications for larval production. Bull Mar Sci 77: 397-408.

MacCall, A.D., S. Ralston, D. Pearson, and E. Williams. 1999. Status of bocaccio off California in 1999 and outlook for the next millennium. Appendix to Status of the Pacific Coast Groundfish fishery through 1999 and recommended acceptable biological catches for 2000. Pacific Fisheries Management Council. Oregon, U.S.A. http://www.pmcc.org.

MacGregor, J.S. 1986. Relative abundance of four species of *Sebastes* off California and Baja California. Calif. Coop. Oceanic Fish. Invest. Rep. 27: 121-135.

McCain B. B., S. D. Miller, and W. W. Wakefield II. 2005. Appendix H. Life history, geographical distribution, and habitat associations of 82 west coast groundfish species: A literature review. In: Pacific Coast Groundfish Fishery Management Plan Essential Fish Habitat Designation and Minimization of Adverse Impacts Draft Environmental Impact Statement. Vol 4 of 4. NOAA report.

McGowan, J. A., D. B. Chelton, and A. Conversi. 1996. Plankton patterns, climate, and change in the California current. Calif. Coop. Oceanic Fish. Invest. Rep. 37: 45-68.

Miller, J. A., and A. L. Shanks. 2004. Evidence for limited larval dispersal in black rockfish (*Sebastes melanops*): implications for population structure and marine-reserve design. Can. J. Fish. Aquat. Sci. 61: 1723-1735.

Phillips, J.B. 1964. Life history studies on ten species of rockfish (genus *Sebastodes*). Fish Bulletin 126: 1-70.

Reilly, C. A., T. W. Echeverria, and S. Ralston. 1992. Interannual variation and overlap in the diets of pelagic juvenile rockfish (genus: *Sebastes*) off Central California. Fishery Bulletin 90: 505-515.

Robinson, C.L.K., G. Martel, and J. Yakimishyn. 2006. Monitoring for the ecological integrity of eelgrass beds (*Zostera marina*) in Canada's coastal national parks of British Columbia. Report prepared for Western and Northern Service Center. Parks Canada, Vancouver.

Sakuma, K. M., and S. Ralston. 1995. Distribution patterns of late larval groundfish off central California in relation to hydrographic features during 1992 and 1993. Calif. Coop. Oceanic Fish. Invest. Rep. 36:179–192.

Shaffer J.A., D.C. Doty., R.M. Buckley and J.E. West. 1995. Crustacean community composition and trophic use of the drift vegetation habitat by juvenile splitnose rockfish *Sebastes diploproa*. Marine Ecology Progress Series 123:13-21

Stanley, R. D., P. Starr, and N. Olsen. 2004. Bocaccio update. Canadian Science Advisory Secretariat Research Document 2004/027

Tolimieri, N., and P. S. Levin. 2005. The roles of fishing and climate in the population dynamics of bocaccio rockfish. Ecological Applications 15:458-468.

Woodbury, D., and S. Ralston. 1991. Interannual variation in growth rates and back-calculated birthdate distributions of pelagic juvenile rockfishes (*Sebastes* spp.) off the central California coast. Fishery Bulletin 89: 523-533.