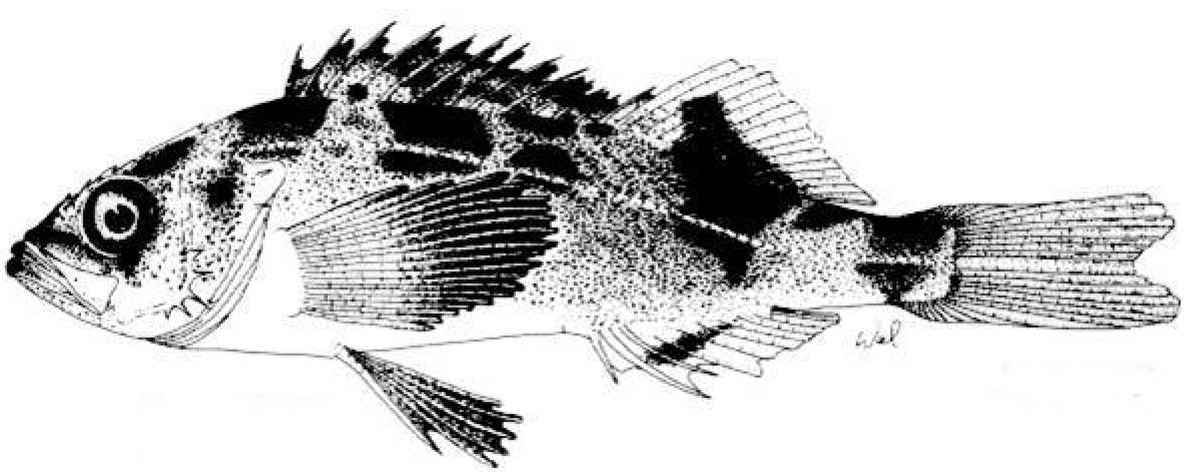
COSEWIC
Assessment and Status Report

on the

Yellowmouth Rockfish
Sebastes reedi

in Canada



THREATENED
2010

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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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le sébaste à bouche jaune (*Sebastes reedi*) au Canada.

Cover illustration/photo:
Yellowmouth Rockfish — Line drawing of adult Yellowmouth Rockfish. Illustrator is Wayne Laroche. Taken from Matarese *et al.* 1989.

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COSEWIC
Assessment Summary

Assessment Summary – April 2010

Common name
Yellowmouth Rockfish

Scientific name
Sebastes reedi

Status
Threatened

Reason for designation
As with other rockfish species, this slow-growing (generation time 30 years), long-lived (maximum age 100 years) species is vulnerable to commercial fishing. Research vessel surveys indicate that abundance has declined considerably over the past 40 years (1.5 generations). While contemporary surveys designed specifically for groundfish species indicate a recent period (5 years) of relative stability, it is not clear that the decline has ceased. The initial period of decline occurred as the commercial fishery for this and other rockfish species developed. Although this is considered normal for a newly exploited population, the total decline in abundance is inferred to be well beyond what is optimal for an exploited population. The absence of any strong recruitment events during the last 20 years is also a concern. The species is an important component of BC’s commercial fisheries. Fishing continues to be a threat and there is no established limit reference point to help manage these fisheries in a precautionary manner.

Occurrence
Pacific Ocean

Status history
Designated Threatened in April 2010.

COSEWIC
Executive Summary

Yellowmouth Rockfish
Sebastes reedi

Species information

The Yellowmouth Rockfish is one of more than 35 rockfish species occurring in marine waters along the British Columbian coast, and one of more than 60 found along the entire Pacific coast of North America. It is similar to the Pacific Ocean Perch, and, prior to the mid-1970s, both species were classified as “red rockfish” or “ocean perch”. Other common names for the Yellowmouth Rockfish include “reedi”, “red eye”, “red snapper” and “rockcod”. The species is distinguished from other rockfish by characteristic yellow, red and black markings in its mouth. Adults are primarily red, with black mottling on their backs. No population genetic studies of Yellowmouth Rockfish have been conducted and this report considers all individuals within BC as part of a single population.

Distribution

The range of Yellowmouth Rockfish extends from the northern Gulf of Alaska to northern California. The species is most abundant between southeastern Alaska and Oregon. Yellowmouth Rockfish are found on the continental slope throughout British Columbia and are caught in high densities in Queen Charlotte Sound, off northwest Vancouver Island and offshore from Rennell Sound. The area of occupancy of Yellowmouth Rockfish in Canadian waters is estimated to be 11 000-34 000 km^2.

Habitat

Yellowmouth Rockfish occur at depths of 100-430 m along the continental slope. Information is lacking on larval and juvenile stages, but like other rockfish, immature Yellowmouth are pelagic. Adults frequently aggregate over rocky substrate. In British Columbia Yellowmouth are most frequently captured by the trawl fishery between 130-357 m. Based on the species’ apparent depth and substrate preferences, approximately 48 000 km^2 of potential habitat is estimated to exist for Yellowmouth Rockfish in Canada, which can be used as a proxy for the extent of occurrence of the species.

The continental slope habitat associated with Yellowmouth Rockfish is subject to fishing activity in BC, most notably commercial bottom trawling. Very little of this offshore area receives habitat protection. Yellowmouth Rockfish associate with several other groundfish species in mid-water assemblages, including Pacific Ocean Perch, Arrowtooth Flounder and Redstripe Rockfish.

Biology

Limited research has been conducted on the Yellowmouth Rockfish. In British Columbia fertilization takes place in February and females give birth to live young from April through June. Immature Yellowmouth are pelagic for up to a year, during which time the larvae metamorphose into juveniles and finally settle on the ocean floor. Inter-annual recruitment is typically highly variable in rockfish species. The last known strong recruitment year for Yellowmouth Rockfish in Canada was in 1982.

Individuals mature at approximately 10 years of age, when females average lengths of 39 cm and males 37 cm. The maximum length recorded for the species is 60 cm. Otolith measurements suggest that individuals live a maximum of 99 years in British Columbia. The average age of fish caught between 1978-1993 was 22 years old. The generation time (average age of parents in the population) is 30 years. Like other rockfish, Yellowmouth have closed swim bladders which make them vulnerable to injury when captured from deep water. Juvenile rockfish may be preyed upon by other fish, such as hake and salmon, as well as seabirds.

Population sizes and trends

Most Yellowmouth Rockfish are captured by the trawl fishery, which has been active since the 1930s. Information on species composition and discarding were not routinely recorded prior to the mid-1970s, which adds uncertainty to historical catch estimates. The total coastwide catch by both domestic and foreign vessels over the lifetime of the fishery is estimated to be at least 60 000 t (41 million fish). Catch by Canadian vessels peaked in 1986 at 2491 t and averaged 1842 t annually between 1997-2007.

Contemporary surveys provide limited information on Yellowmouth abundance patterns because the time-series are too short (less than 5 years in many cases) and the indices are highly variable. Historical surveys dating to 1967 did not provide synoptic spatial coverage of the entire DU, and these survey results were also highly variable for this species. Nonetheless, these historical surveys indicate a substantial decline in Yellowmouth Rockfish abundance between 1967-1999. Catch per unit effort data from 1996-2007 indicate a 2.5% annual decline in the species. This trend may be influenced by changes in fishing behaviour. Furthermore, abundance levels may reflect the low recruitment which has characterized the BC population since the early 1980s.

Information is lacking on the status of neighbouring populations of Yellowmouth in US waters. British Columbia appears to be the population centre for the species, as catch levels are much lower in the US.

Limiting factors and threats

Rockfish life history traits of slow growth, delayed maturity, and longevity potentially make this group of groundfish vulnerable to overfishing, habitat loss from bottom trawling and adverse environmental changes. Recruitment is highly variable and factors controlling this are unknown. Yellowmouth Rockfish typically co-occur with other commercially important groundfish species and are taken as part of a multi-species fishery.

Commercial fishing is the primary threat to Yellowmouth Rockfish. The species is caught mainly by bottom and mid-water trawls in BC. The lack of reliable historical and contemporary records on Yellowmouth abundance poses a challenge for determining the current population status of the species across its range. Additionally, Yellowmouth may be mistakenly identified as Pacific Ocean Perch once captured.

Special significance of the species

Yellowmouth Rockfish is a commercially important species in British Columbia. In the 2007-2008 fishing season, the total Canadian catch of the species had a landed value of approximately $1.5 million.

Existing protection

There is no specific protection for Yellowmouth Rockfish either in Canadian or US waters. The conservation status of the species has not been assessed.

Yellowmouth Rockfish has been managed under a single species quota since 1979, currently set at 2364 t for the 2008-2009 fishing season. In the US, Yellowmouth Rockfish are managed under slope rockfish assemblage quotas. The species likely receives partial protection from rockfish conservation areas and prohibitions on trawling in sections of its US range.

COSEWIC HISTORY

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. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* 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. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

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

COSEWIC Status Report

on the

Yellowmouth Rockfish
Sebastes reedi

in Canada

2010

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SPECIES INFORMATION

Name and classification

The Yellowmouth Rockfish, *Sebastes reedi*, (Westrheim and Tsuyuki 1967) is a member of the order Scorpaeniformes and family Sebastidae. It was originally classified as *Sebastodes reedi* (Westrheim and Tsuyuki 1967) but reassigned to the genus *Sebastes* following taxonomic revisions to Pacific rockfish in the 1970s (Bailey *et al.* 1970). A recent taxonomic study has produced a well-supported phylogeny of the *Sebastes* genus, indicating that it is monophyletic, and that the Yellowmouth Rockfish is most closely related to the Darkblotched Rockfish (*S. crameri*; Hyde and Vetter 2007). Yellowmouth Rockfish are morphologically similar to Pacific Ocean Perch (*S. alutus*) and both species were often identified as “red rockfish” or “ocean perch” in catch records prior to the mid-1970s (DFO 1999a). Other common names for the species include “red snapper”, “redeye”, “reedi” and “rockcod” (Love *et al.* 2002; Oregon Dept. Fish and Wildlife 2007).

Morphological description

Adult Yellowmouth Rockfish resemble several other rockfish species (e.g., Pacific Ocean Perch, Chilipepper *S. goodei*, Redstripe Rockfish *S. proriger*, Sharpchin Rockfish *S. zacentrus*) but are distinguished by the yellow, red and black blotches in their pinkish white mouth (Westrheim and Tsuyuki 1967). Adults are predominantly red, intermixed with yellow to orange (or mixed with black for individuals < 40 cm), with diffuse olivaceous mottling on their backs (Fig. 1) (Orr *et al.* 2000). Three indistinct dark bands are present on the head and a pinkish lateral line extends down the body (Kramer and O’Connell 1995). Yellowmouth Rockfish have an elongated lower jaw with a moderately wide symphyseal knob and a moderately indented caudal fin (Hart 1973; Kramer and O’Connell 1995). Individuals have 13 dorsal and three anal spines (Fig. 2) (Kramer and O’Connell 1995).

Figure 1. Adult Yellowmouth Rockfish (Grant *et al.* 1996).

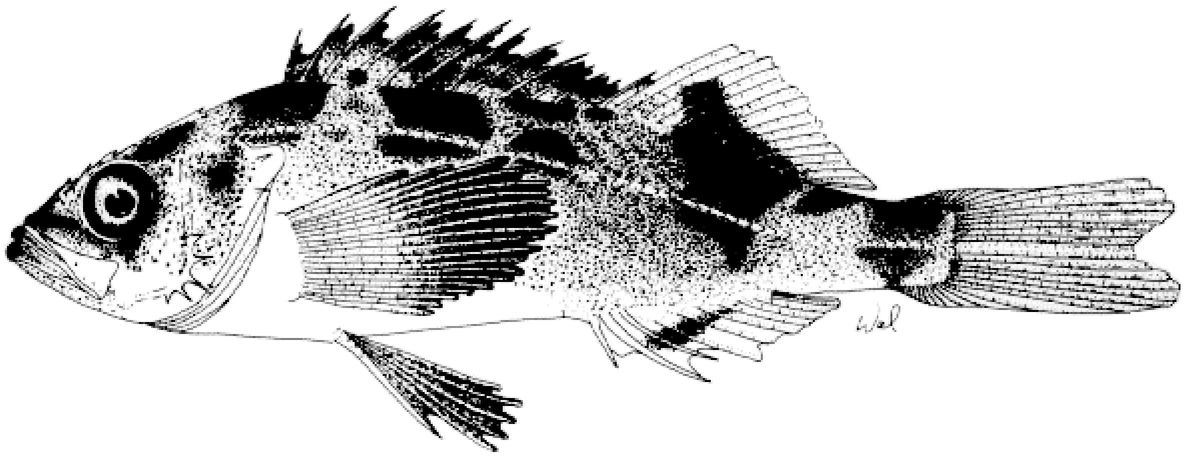

Figure 2. Line drawing of adult Yellowmouth Rockfish (Matarese *et al.* 1989).

Genetic description

No known studies have been conducted on the population genetic structure of the Yellowmouth Rockfish. Westrheim and Tsuyuki (1967) carried out electrophoretic analyses of hemoglobin from Yellowmouth Rockfish collected between Oregon and Alaska and identified two variant protein forms. No corresponding morphological or meristic differences were detected.

DISTRIBUTION

Global range

Yellowmouth Rockfish are found in the northeastern Pacific, from the northern Gulf of Alaska to northern California (Love *et al.* 2002). Specimens have been recorded as far north as $56^{0}\,50^{'}$ N and as far south as $43^{\circ}\,11^{'}$ N (Chen 1971). The species is most abundant between southeastern Alaska and Oregon (Love *et al.* 2002).

Canadian range

Yellowmouth Rockfish are distributed throughout coastal marine waters in British Columbia. Between 1996-2007 the highest concentrations of the species were targeted by the groundfish trawl fishery in the gullies of Queen Charlotte Sound (especially Goose Island), off northwest Vancouver Island, and offshore from Rennell Sound (Haigh and Starr 2008). Yellowmouth Rockfish also are caught in high numbers in shallow waters north of Barkley Sound (Haigh and Starr 2008).

The area of occupancy for Yellowmouth Rockfish (AO) is calculated to be 33 092 km^2, using CPUE data from observed commercial trawl tows collected between 1996-2007, and a grid cell of 0.1° longitude x 0.075° latitude (Fig. 3)[1] (Haigh and Starr 2008). Grid cell area varies latitudinally with this method but covers approximately 59 km^2 (7.7 km x 7.7 km). Using the same CPUE data with a Universal Transverse Mercator (UTM) grid cell size of 2 km x 2 km yields an AO of 11 332 km^2. The discrepancy between methods arises from the fact that, while a trawl tow covers tens of kilometres, it is represented in the data by only one or two points (i.e., at the start and possibly end of the tow) (Table 1). The smaller grid cell size may not coincide with either of these sampling points (Haigh and Starr 2008).

Table 1. Estimates of area of occurrence (km^2) of Yellowmouth Rockfish using two different grid scales: DFO geographic grid cell (0.10 longitude x 0.0750 latitude) and COSEWIC UTM grid cell (2 km x 2 km) (from Haigh and Starr 2008). Annual values are shown along with the overall IAO estimated after aggregating all data from 1996-2006.

Fishing Year	DFO	COSEWIC
1996	16 673	3796
1997	15 226	3712
1998	15 863	3696
1999	16 043	3784
2000	16 195	3836
2001	14 405	3436
2002	15 029	3440
2003	12 452	2788
2004	13 611	3112
2005	13 390	2960
2006	12 675	3088
1996-2006	33 092	11 332

[1] Note that in Fig. 3 all AO grid cells with fewer than three fishing vessels have been excluded due to privacy concerns. These grids are, however, included in all AO calculations.

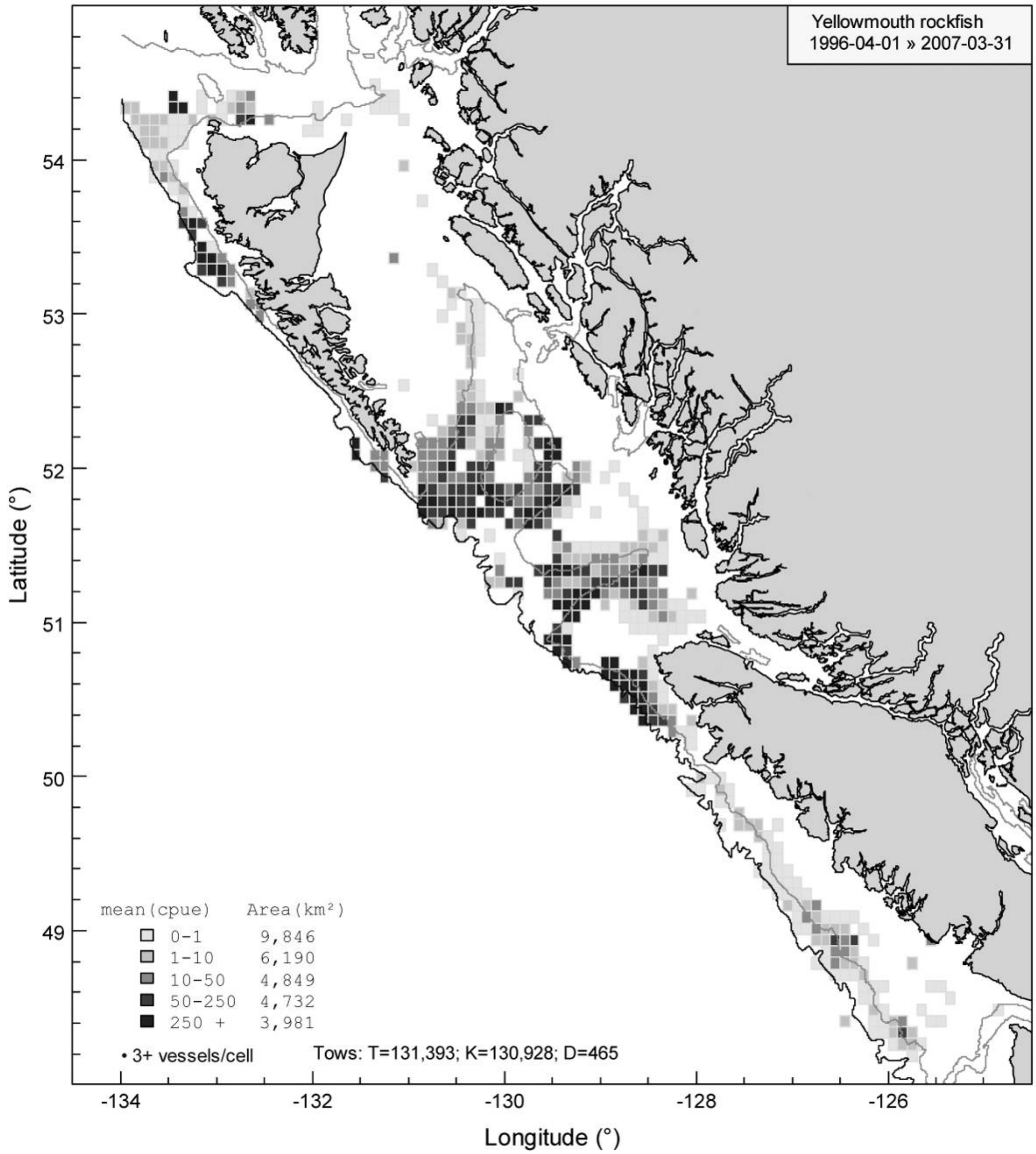

Figure 3. Mean CPUE (kg/h) of Yellowmouth Rockfish caught by the trawl fishery in 0.10 x 0.0750 grid cells along the BC coast. Isobaths displayed are 200 m and 1000 m (from Haigh and Starr 2008).

HABITAT

Habitat requirements

Yellowmouth Rockfish are most common between 180-275 m (Kramer and O'Connell 1988; Love *et al.* 2002). In BC 95% of all trawl fishing events (1996-2007) that captured Yellowmouth Rockfish occurred between 130-357 m (Fig. 4). Little is known about their larval and juvenile stages; however, like other *Sebastes* rockfish species, immature Yellowmouth are pelagic (Moser and Goehlert 1991). Adults frequently aggregate in mid-water over high-relief rocks (Love *et al.* 2002).

By identifying bottom bathymetry lying within the apparent preferred depth range of Yellowmouth Rockfish (130 to 375 m), a rough estimation of potential habitat for the species in British Columbia can be obtained (Fig. 5). Not all bathymetry within this depth range is actual Yellowmouth habitat (e.g., Masset Inlet on Graham Island), and depths outside the 95% quantile range at which the species has been recorded are overlooked with this method. Nevertheless, the highlighted bathymetry (48 368 km^2) provides a general approximation of potential Yellowmouth habitat available in the province and can serve as a proxy for the extent of occurrence of the species in Canada.

The surficial geology of the Queen Charlotte basin and Hecate Strait has been described by Barrie *et al.* (1991). Yellowmouth fishing events (weighted by catch and standardized to a 1 km^2 grid) were overlayed on the surficial geology of these areas to determine frequency of occurrence of the species over different bottom substrates (Haigh and Starr 2008). Yellowmouth Rockfish were primarily found over hard surfaces, such as bedrock and gravel in the Queen Charlotte basin (Table 2). Aggregations of the species identified by Westrheim and Tsuyuki (1967 cited in Haigh and Starr 2008) off La Pérouse bank, west of Triangle Island and west of Rennell Sound were also in similar habitat.

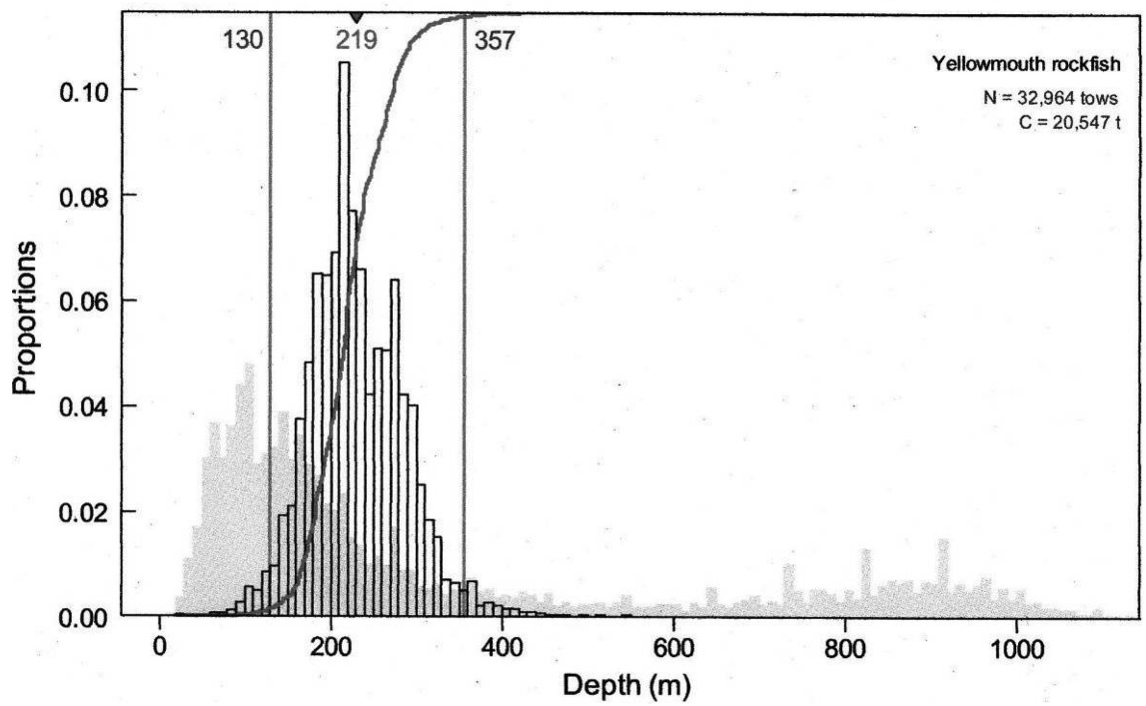

Figure 4. Depth frequency of tows that captured Yellowmouth Rockfish from commercial trawl logs (1996-2007). The vertical solid lines denote the 2.5% and 97.5% quantiles. The shaded histogram in the background indicates the relative trawl effort on all species. The cumulative catch of Yellowmouth Rockfish, superimposed on the histogram in relative space (0 to 1), provides confirmation that most of the Yellowmouth catch comes from these depths. The depth of median cumulative catch is represented by an inverted triangle at the top. 'N' = total number of tows; 'C' = total catch (t) (from Haigh and Starr 2008).

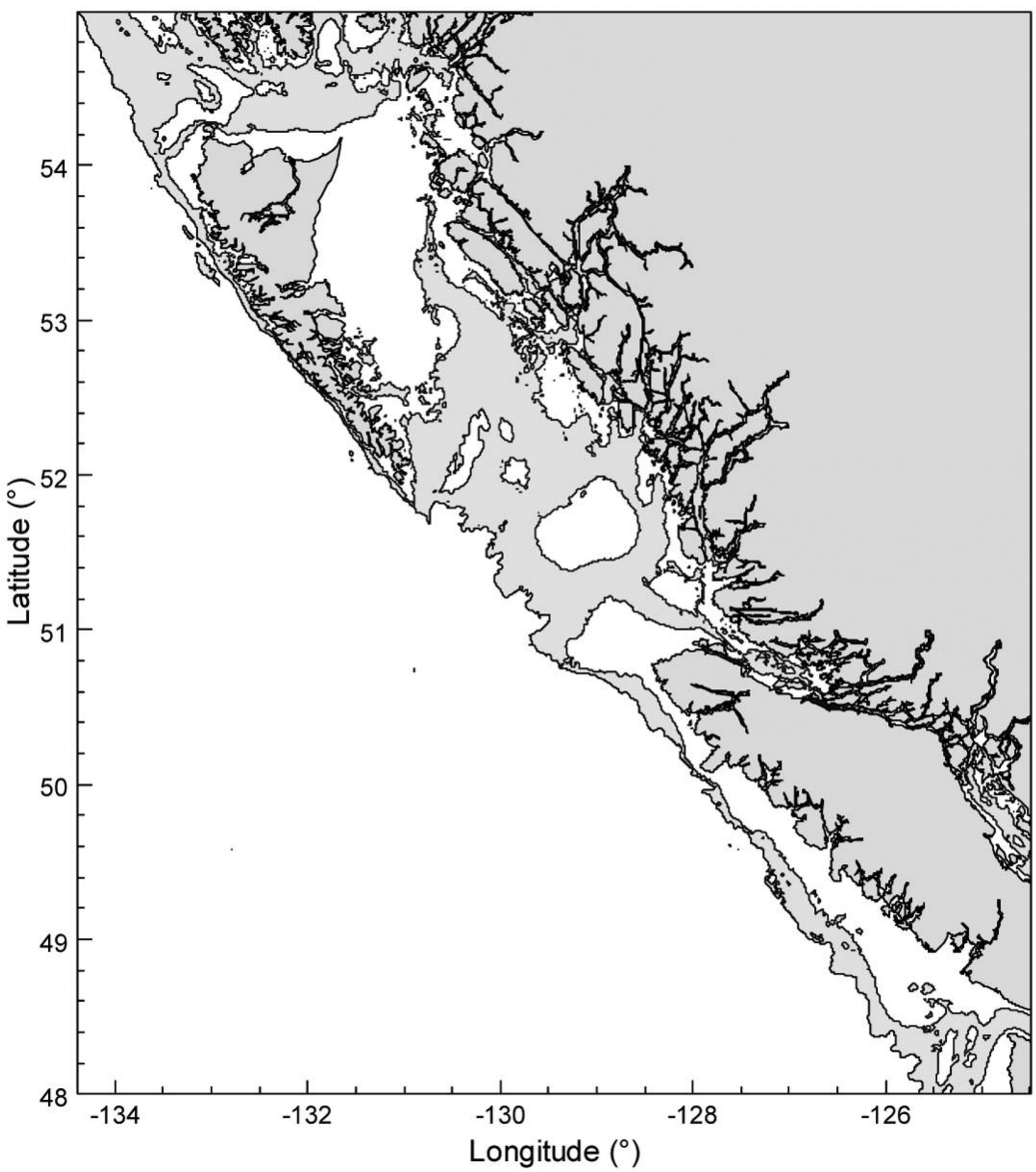

Figure 5. Potential Yellowmouth Rockfish habitat along the BC coast (represented by shaded bathymetry between 130 and 357 m) (from Haigh and Starr 2008).

Table 2. Yellowmouth Rockfish catch frequency in different surficial geology categories within the Queen Charlotte basin (from Haigh and Starr 2008).

Surficial geology category	% Frequency
Outwash sand & gravel	30.4
Sand & gravel/bedrock	21.6
Bedrock	18.3
Glaciomarine mud	11.0
Holocene sand & gravel	9.9
Holocene mud	5.6
Till	1.6
Sand & gravel/glaciomarine mud	1.5
Sand & gravel	0.1

Habitat trends

No specific information on trends in habitat availability currently exists for Yellowmouth Rockfish. However, marine waters within its Canadian range are subject to human activity, including industry, shipping, and commercial fishing, all of which can have varying effects on marine habitat. Approximately 83% of British Columbia's continental shelf and slope is affected by human activity, with commercial bottom trawling having the largest impact (Ban and Alder 2008). Relatively little of British Columbia's marine environment is currently protected, with 1.5% of the province's exclusive economic zone and 4.7% of the continental shelf off-limits to commercial activities (Ban and Alder 2008).

Habitat protection/ownership

In Canada, the Department of Fisheries and Oceans (DFO) has established Rockfish Conservation Areas (RCAs) along the BC coast since 2002, primarily to protect inshore rockfish and Lingcod (*Ophiodon elongatus*). A total of 164 RCAs were implemented for the 2007 fishing season, mainly close to shore (e.g., in the Strait of Georgia and Johnstone Strait). Since the depth range distribution of juvenile Yellowmouth Rockfish is not documented, it is unknown whether these areas protect juvenile Yellowmouth habitat. However, the shallow depths of these RCAs mean they are unlikely to affect the habitat of adults.

As part of a conservation strategy for overfished groundfish, the US Pacific Fishery Management Council (PFMC) established RCAs along the US west coast in 2002. RCAs are situated in areas known to contain the highest biomass of overfished species and are off limits to fishing (Roberts and Stevens 2006). Since Yellowmouth Rockfish co-occur with several overfished species in US waters (e.g., Darkblotched Rockfish, Pacific Ocean Perch), their habitat is likely included in these areas. RCAs vary by location throughout the year, and by gear type. For example, approximately 14 000 km^2 is closed to bottom-trawling on the continental shelf from 183-274 m along the entire US west coast (Roberts and Stevens 2006). California and Washington also have prohibited trawling for groundfish in state waters (which extend approximately 4 km out from the coast). Other RCAs extend from shore out to 450 m at different times of year (Roberts and Stevens 2006).

In Alaska, the North Pacific Management Council (NPMC) has restricted or prohibited fishing activity in several areas affecting groundfish habitat. These include the Sitka Pinnacles Marine Reserve (groundfish harvesting prohibited), King Crab closure areas around Kodiak Island (bottom trawling prohibited year-round in some areas and from February to June in others), the Gulf of Alaska Slope Habitat Conservation Areas (non-pelagic trawling prohibited), the Gulf of Alaska Coral Habitat Protection Areas (bottom contact gear prohibited) and Alaska Seamount Habitat Protection Areas (bottom contact gear prohibited) (NPMC 2006).

BIOLOGY

Little information is available on the biology and ecology of the Yellowmouth Rockfish. Much of the following description, therefore, is based on life history characteristics of *Sebastes* rockfish in general.

Life cycle and reproduction

Like other rockfish species, the Yellowmouth Rockfish is viviparous, meaning that it has internal fertilization of eggs, maternal nourishment of developing embryos and release of live young (Wourms 1991). Fertilization occurs in February in BC, followed by larval release from April to June (Hart 1973; Haigh and Starr 2008). Westrheim (1975) indicates that parturition peaks in May in BC. Fecundity of the species is unknown but ranges from approximately 1700 to 412 000 eggs in other rockfish (Wourms 1991). In general, fecundity increases with age in rockfish species (Roberts and Stevens 2006).

Rockfish larvae are 4-9 mm in length at parturition and are relatively well developed (Wourms 1991). However, they are weak swimmers and their survival is strongly influenced by environmental factors, such as ocean currents and upwelling events (Shanks and Eckert 2005). Larval release rarely coincides with peak oceanic conditions (e.g., in water temperature, upwelling intensity and food supply) and mortality is high during the pelagic phase (Enticknap and Sheard 2005). This developmental stage varies from several months to a year in different rockfish species, during which time the larvae metamorphize into juveniles, and then settle on the ocean floor (Wourms 1991). In Yellowmouth Rockfish, individuals make the transition from immature to mature throughout the entire year, although the timing appears to vary by sex (i.e., males make the transition from June through November and females from August through November; Fig. 6).

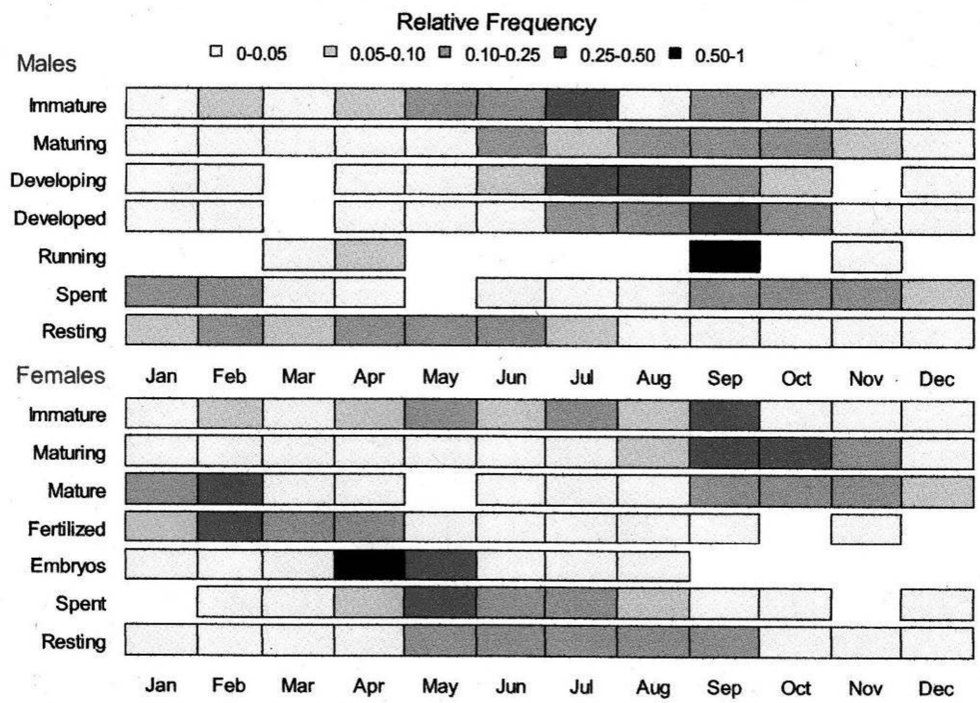

Figure 6. Relative frequency of maturity stages of Yellowmouth Rockfish, expressed by month (from Haigh and Starr 2008).

Rockfish species typically exhibit highly variable inter-annual recruitment (i.e., settlement) success as a result of environmental conditions. In BC exceptional recruitment episodes are estimated to occur every 15 to 20 years for inshore rockfish (Yamanaka and Lacko 2001). DFO research and fishery data suggest that 1982 was a particularly strong recruitment year for Yellowmouth Rockfish in BC (Haigh and Starr 2008).

Yellowmouth Rockfish reach 50% maturity in BC at approximately ten years of age, when males are typically 37 cm in length and females are 39 cm in length (Fig. 7; Haigh and Starr 2008). Individuals reach a maximum length of approximately 60 cm (DFO 1999a). Fish from northern BC grow more slowly than those from the southern part of the province (Love *et al.* 2002). The von Bertalanffy growth coefficient (k) for Yellowmouth Rockfish has been estimated to range from 0.22 to 0.25 (Schnute *et al.* 1999; Roberts and Stevens 2006). Using 6860 specimens caught in BC commercial, charter and research trips from 1978-2003, Haigh and Starr (2008) calculate values for k ranging from 0.09 to 0.29 for males, 0.09 to 0.13 for females, and 0.09 to 0.17 for males and females combined (Appendix 1). However, because a significant portion of specimens come from the commercial fishery (i.e., 80%), these k estimates are likely biased against younger age classes, because fishing practices (e.g., net mesh size) tend to exclude smaller fish.

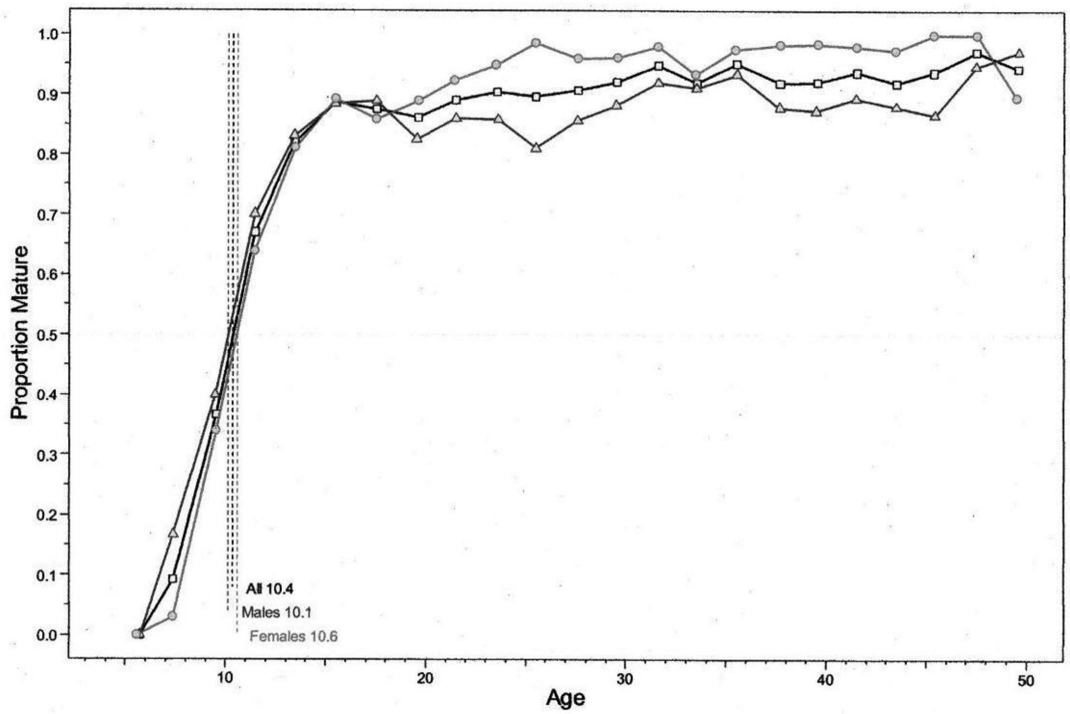

Figure 7. Maturity ogives for Yellowmouth Rockfish using ages grouped at 2-year intervals. The age of each group is expressed as the mean of the observed ages in each group. Vertical dashed lines indicate ages at 50% maturity for males, females, and all available specimens, including those lacking a sex determination. Females are represented by circles, males by triangles and both sexes combined by squares (from Haigh and Starr 2008).

Based on otolith measurements, a maximum age of 71 years in the Gulf of Alaska (DiCosimo and Kimball 2001) and 99 years in BC (Munk 2001) has been calculated for the species. The average age of fish caught in BC was 22 years between 1978-1993 (DFO 1999a). The instantaneous natural mortality rate (M) for Yellowmouth Rockfish in BC is estimated to range from 0.05 to 0.06 (Archibald *et al.* 1981; Haigh and Starr 2008).

Taking an approximate age at 50% maturity (A) of 10 years and a natural mortality rate (M) of 0.05 yields a generation time (G) of 30 years (G = A + 1/M) for Yellowmouth Rockfish.

Information on the feeding ecology of Yellowmouth Rockfish is lacking. However, like other rockfish species, Yellowmouth larvae likely feed on copepods, euphausiids and other invertebrates (Enticknap and Sheard 2005). As rockfish mature they typically switch to a variety of fish and crustacean prey, including Herring, Sandlance, crabs, shrimps, as well as euphausiids (Fort *et al.* 2006).

Predation

No information on predation of Yellowmouth Rockfish is currently available. Juvenile rockfish species (including Darkblotched Rockfish) are preyed upon by Pacific Hake (*Merluccius productus*) in US waters (Harvey *et al.* 2008) and comprise a significant portion of seabird and Chinook Salmon (*Oncorhynchus tshawystscha*) diets in the California Current System (Mills *et al.* 2007).

Physiology

All *Sebastes* rockfish have physoclistic or closed swim bladders that are unable to adjust to rapid changes in pressure. Consequently, rockfish are extremely susceptible to barotrauma when captured from deep water, including swim bladder rupture and arterial embolisms (Jarvis 2007). Bycatch mortality is considered to be close to 100% for most rockfish species (Fort *et al.* 2006).

Dispersal/migration

No information is available on the movement of Yellowmouth Rockfish. In general, rockfish larvae are pelagic from two to seven months, while many rockfish adults are sedentary and exhibit site fidelity (Roberts and Stevens 2006). Rockfish species commonly associated with Yellowmouth (see following section) display a range of movement behaviours. Immature Darkblotched Rockfish have low dispersal ability (<100 km; Gomez-Uchida and Banks 2005). Adult Yellowtail Rockfish (*S. flavidus*) demonstrate site fidelity and homing behaviour and may persist in the same site-specific aggregations for years (Pearcy 1992). Nonetheless, some Yellowtail individuals have been tracked travelling between southeast Alaska and central BC and from central BC to central Washington (DFO 1999b). Adult Silvergrey Rockfish (*S. brevispinis*) seem to exhibit seasonal variation in their vertical distribution, migrating from deeper to shallower water from winter to summer (Stanley and Kronlund 2005). Adult Redstripe Rockfish, and possibly Darkblotched Rockfish, exhibit vertical migration, rising off the bottom at night (Leaman *et al.* 1990; Hannah *et al.* 2005).

Interspecific interactions

Yellowmouth Rockfish are typically found in multispecies complexes. In BC the depth range at which Yellowmouth Rockfish are most frequently captured (130-357 m, 18.4% of total catch weight in trawl tows) is dominated by Pacific Ocean Perch (35.6% of total weight in trawl tows), with significant abundances of Arrowtooth Flounder (*Atheresthes stomias*; 18.4%), Redstripe Rockfish (8.5%), Silvergrey Rockfish (4.6%), Yellowtail Rockfish (4.3%) and Pacific Hake (4.1%) (Haigh and Starr 2008). Along the US west coast (i.e., from Washington to California) and Gulf of Alaska, Yellowmouth Rockfish occur in deepwater assemblages consisting of a variety of rockfish species including Chilipepper, Darkblotched Rockfish, Pacific Ocean Perch, Splitnose Rockfish (*S. diploproa*) and Shortspine Thornyhead (*Sebastolobus alascanus*) (Rogers and Pikitch 1992; Enticknap and Sheard 2005).

Yellowmouth Rockfish collected off the Oregon coast show evidence of infection by common pathogens of marine fish. Ten percent of surveyed fish were infected with *Ichthyophonus* sp. while 2% were infected with *Mycobacterium*-like lesions (Kent *et al.* 2001).

Adaptability

Over evolutionary time, Yellowmouth Rockfish may have been well adapted to extended periods of environmental stress because of their longevity, viviparity and increased fecundity with age. However, these life history traits now make the species vulnerable to recruitment overfishing (excessive removal of fish from the population reduces population capacity and thus probability of successful recruitment) (Roberts and Stevens 2006). Viviparity improves the survival of developing embryos and larvae, and in highly fecund species such as rockfish, may promote the colonization of new habitats (Wourms 1991).

POPULATION SIZES AND TRENDS

Search effort

Yellowmouth Rockfish catch records only extend back to 1971. To reconstruct historical removals of the species prior to 1971,1996-2006 trawl fishery data on the proportion of Yellowmouth Rockfish caught to other rockfish (YMR/ORF) and the proportion of Yellowmouth Rockfish discarded to retained (YMRd/YMR) were applied to historical catch records (Haigh and Starr 2008). While these ratios have remained relatively constant over the ten-year period it is probably unrealistic to assume that modern ratios, taken from a fishery using an Individual Vessel Quota (IVQ) system, resemble past fishery patterns. Historical abundance estimates were made for both US vessels fishing in BC waters from 1930 to 1975 and Canadian vessels from 1945 to 1982. Catch estimates are more difficult to calculate for the large Soviet and Japanese trawling fleets, which operated along the BC coast from 1965 to 1976, because information on species composition and locality of catches are unavailable (Haigh and Starr 2008). However, employing the above YMR/ORF ratio used for domestic fisheries to the largest year of the Soviet fishery (1966) provides a rough estimate of this fishery’s impact on the Yellowmouth population.

Contemporary abundance estimates for Yellowmouth Rockfish are obtained from a variety of research surveys (e.g., bottom trawl, mid-water shrimp tows) and commercial catch-per-unit-effort (CPUE) from the trawl fishery.

Synoptic bottom trawl surveys operate biennially within Queen Charlotte Sound (QCS synoptic bottom trawl survey; north Vancouver Island to southern Hecate Strait), along the west coast of Vancouver Island (WCVI synoptic bottom trawl survey), and west of the Queen Charlotte Islands (WQCI synoptic bottom trawl survey). These surveys target all groundfish species using random tow allocations per stratum and cover depths of 50 to 1300 m. The surveys were only initiated within the last five years and thus do not yet provide sufficient data to detect trends. Based on bootstrapped biomass indices from these surveys, precision of the biomass estimates is considered to be adequate to poor (Haigh and Starr 2008). The biomass indices assume a catchability quotient of q = 1 which is probably too high for Yellowmouth Rockfish, although catchability is unknown for the species. Over time these time series may provide more useful data on abundance trends.

Tow-by-tow data are available from the *G.B. Reed* historical Queen Charlotte Sound surveys for nine years between 1965 and 1984. Although these surveys cover various geographic areas both within and outside British Columbia, to ensure consistency between surveys, only tows from Goose Island Gully (i.e, tows between 50.9^0 N and 51.6° N; Fig. 8) were used for abundance estimates. Estimates are based on tows conducted between 147-428 m. These data are available for seven years between 1967 and 1984, for a total of 254 tows. The precision for these indices is considered low (Haigh and Starr 2008).

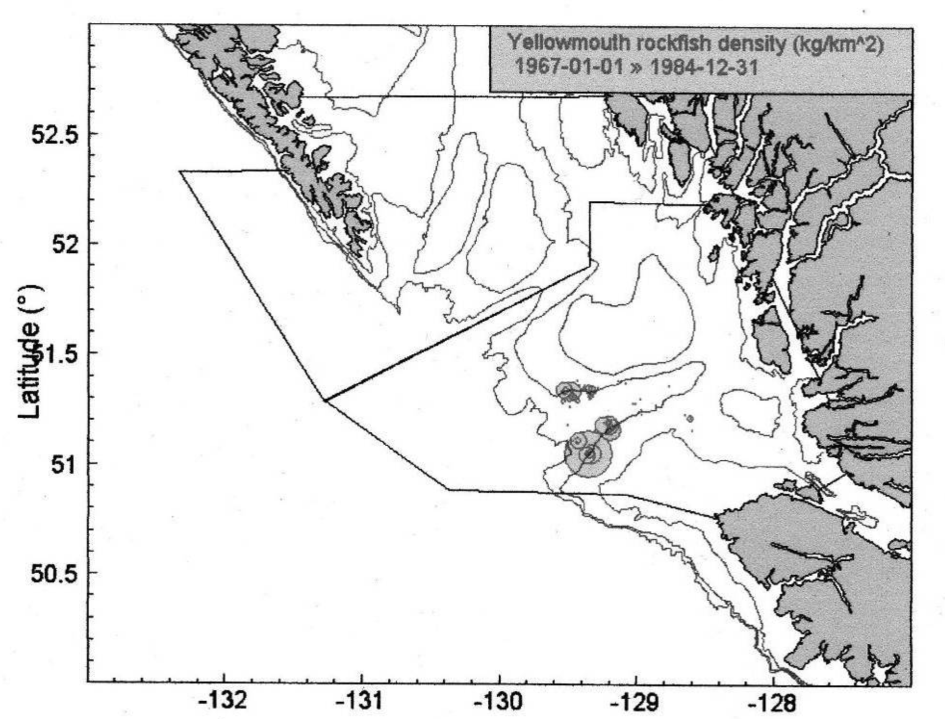

Figure 8. Locations of all trawls from the *G.B. Reed* trawl survey (1967-1984) which caught Yellowmouth Rockfish. Only tows in Goose Island Gully which were used in the biomass index calculation are shown. Circles are proportional to catch density (largest circle = 8.11 kg/km^2). Also shown are the 100, 200 and 300 m isobaths (from Haigh and Starr 2008).

Two shrimp trawl surveys provide additional incidental abundance trend information for slope rockfish in British Columbia. The WCVI shrimp trawl survey covers the west coast of Vancouver Island, and, while it has generated useful indices for other rockfish species (e.g., Bocaccio *S. paucispinus* and Canary Rockfish *S. pinniger*), only two observations of Yellowmouth Rockfish were made in the survey over a 33-year period from 1972 to 2007. In contrast, the QCS shrimp trawl survey, covering southern Queen Charlotte Sound, has had a more reliable catch of Yellowmouth Rockfish. This survey has operated since 1999, consistently sampling depths up to 220 m. The survey is divided into three aerial strata: stratum 109 (west of the outside islands and extending into Goose Island Gully), stratum 110 (south of Calvert Island and the mainland) and stratum 111 (between Calvert Island and the mainland). Stratum 111 was omitted from the abundance analysis because no Yellowmouth Rockfish have been caught in this inshore area (Fig. 9) (Haigh and Starr 2008). The majority of remaining tows have occurred in stratum 109 and over 600 usable tows are available during the nine survey years.

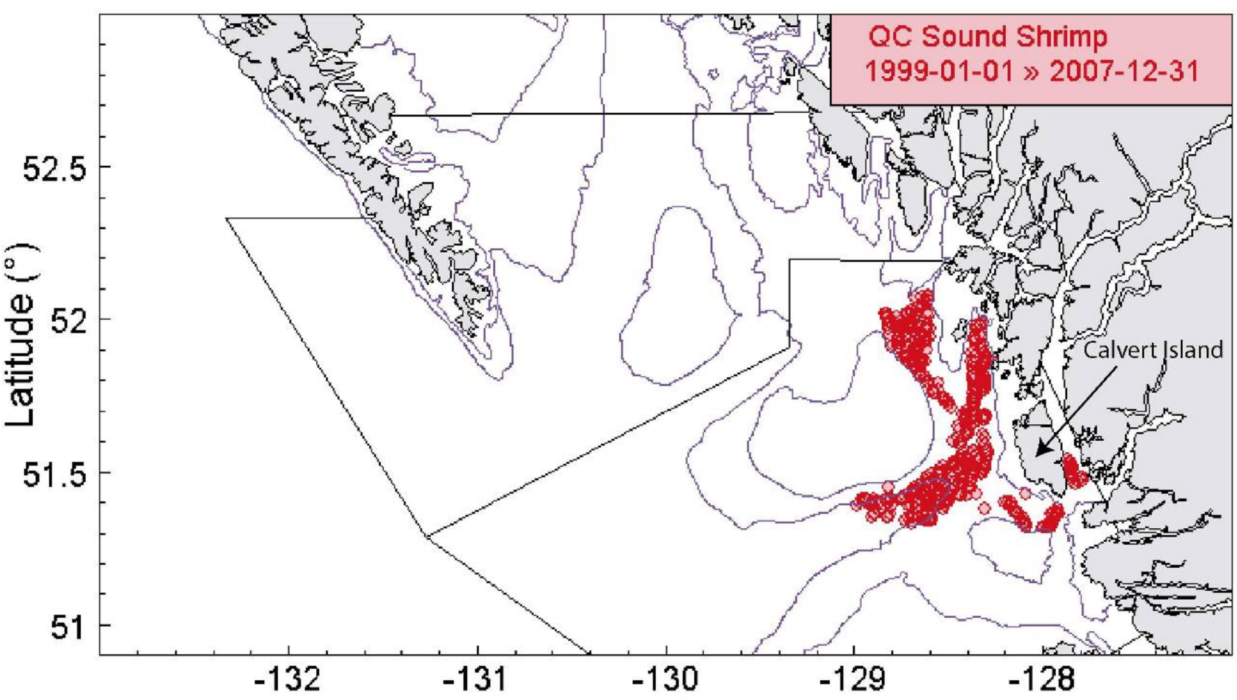

Figure 9. Locations of tows conducted by the Queen Charlotte Sound shrimp survey from 1999 to 2007. The tows to the east of Calvert Island represent Stratum 111 which was not used in the analysis (from Haigh and Starr 2008). Tows to the south of Calvert Island are in stratum 110, and the remaining tows west of the coastal islands are in stratum 109.

NMFS triennial bottom trawl surveys along the US west coast extended into Canadian waters in seven years between 1980-2001. The surveys cover the Vancouver International North Pacific Fisheries Commission (INPFC) region (Fig. 10), which is divided by NMFS into strata. The size and definition of these strata has varied over time. To standardize survey data, strata not surveyed consistently from year to year were subsequently omitted, and indices from two years (1980 and 1983) were scaled up so that their area coverage was comparable to later years (Haigh and Starr 2008). All abundance indices for Yellowmouth Rockfish derived from this dataset were highly variable. Furthermore, the bootstrapped coefficient of variation (CV) estimates do not account for the expanded ratios applied to 1980 and 1983 surveys and the uncertainty in these estimates is likely greater than what is indicated.

A general linear model (GLM) analysis of commercial trawl CPUE was conducted for April 1996 through March 2007, using only bottom trawl data. The start date of the analysis coincides with the initiation of the At-Sea Observer Program, which means that identification to species was accurate. Much of the previous catch rate data is considered unreliable due to mis-reporting and variation in trip limits over time.

Because commercial fisheries aim to maximize harvesting rates of target species, and are governed by existing fishery regulations, their CPUE indices may not necessarily accurately reflect fish abundance. A number of factors may account for the observed variability in CPUE values, including date of capture, capturing vessel, depth and location of capture and fishing behaviour (e.g., avoidance fishing) (Schnute *et al.* 1999). However, large-scale changes in Yellowmouth abundance should be reflected in the CPUE signal, especially if the stock is declining, because vessels will no longer be able to achieve their target catches (Haigh and Starr 2008).

Only bottom tows were used in the CPUE analysis because mid-water trawls were unreliable at catching Yellowmouth Rockfish. All observations in which Yellowmouth Rockfish were absent were removed. While these zero-tows may provide important information, the lognormal model used for the analysis required positive values for the dependent observations (Haigh and Starr 2008).

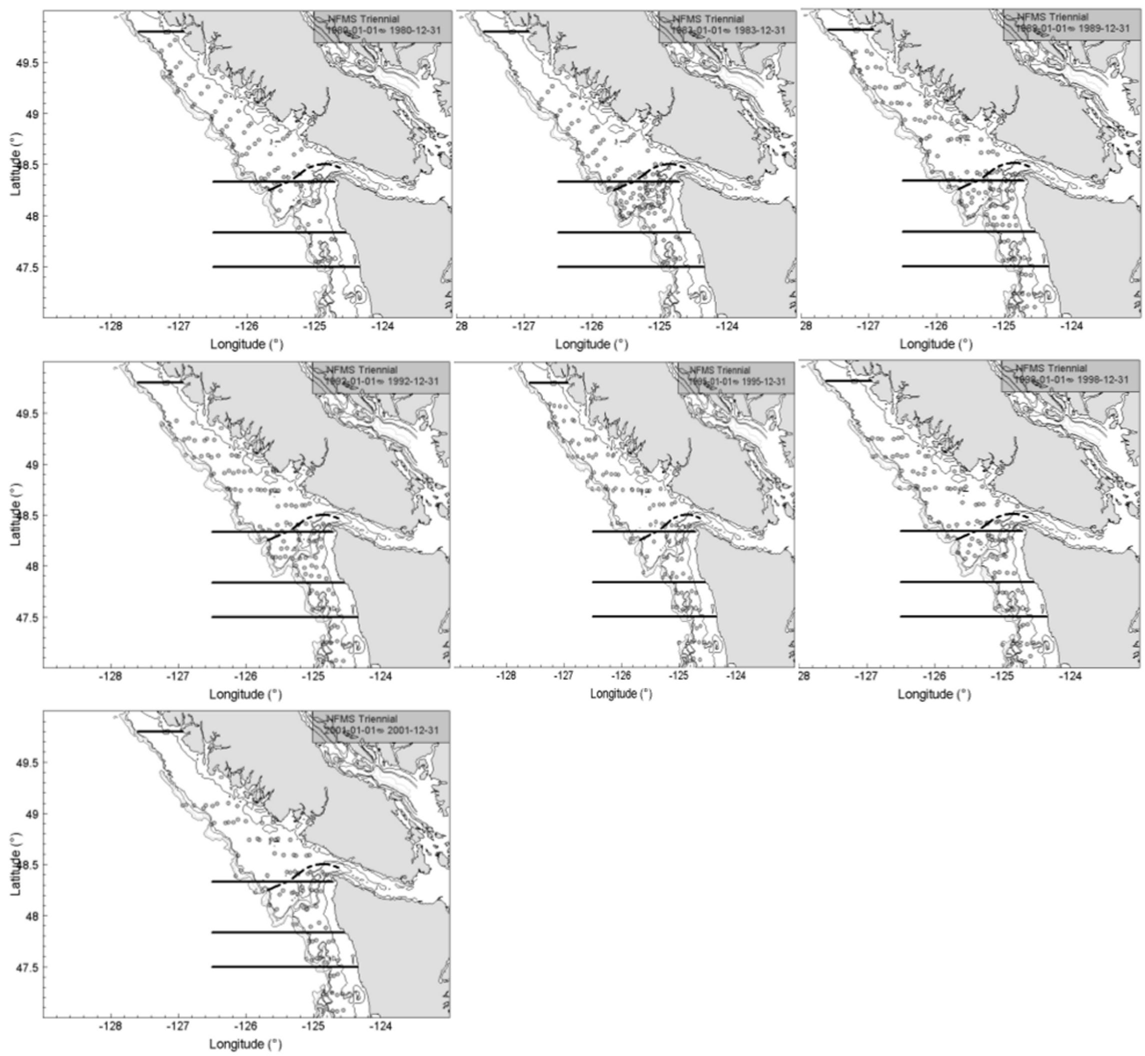

Figure 10. Tow locations in the Vancouver INPFC region for each of the seven triennial surveys that included Canadian waters. The approximate position of the US/Canada marine boundary is shown (dashed line). The horizontal lines are the stratum boundaries: $47^{0}30'$, $47^{0}50'$, $48^{0}20'$, and $49^{0}50'$. Tows south of the $47^{0}30'$ line were excluded from the analysis. Isobaths are the stratum depth boundaries at 55, 183, 220, 366, and 500 m (from Haigh and Starr 2008).

Abundance

The estimated total coastwide catch of Yellowmouth Rockfish since the 1930s in Canada (including all Canadian and US fisheries) is at least 60 000 t (Appendix 2) or 41 million fish (using the mean weight $\hat{w}$ =1.47 kg, σ = 0.33, n = 1678; Haigh and Starr 2008).

Yellowmouth Rockfish are caught in much lower numbers along the US west coast and in Alaska, and British Columbia appears to be the population centre for this species.

Fluctuations and trends

Yellowmouth Rockfish is an important component of the BC groundfish fishery. The mean annual catch by decade remained fairly constant until the mid-1970s but increased sharply once a Yellowmouth quota was introduced in 1979 (Fig. 11). Catch by Canadian vessels peaked in 1986 (2491 t or 1.6 million fish) and has averaged 1842 t (or 1.2 million fish) annually between 1997-2007. In comparison, the Soviet 1966 trawl fishery caught between 29 000-63 000 tonnes of groundfish in BC. Assuming the Yellowmouth to other rockfish ratio calculated for contemporary domestic trawls, this translates to approximately 1300-3000 tonnes of Yellowmouth caught in the 1966 fishery, an amount comparable to levels harvested annually by Canadian vessels since 1979 (Haigh and Starr 2008).

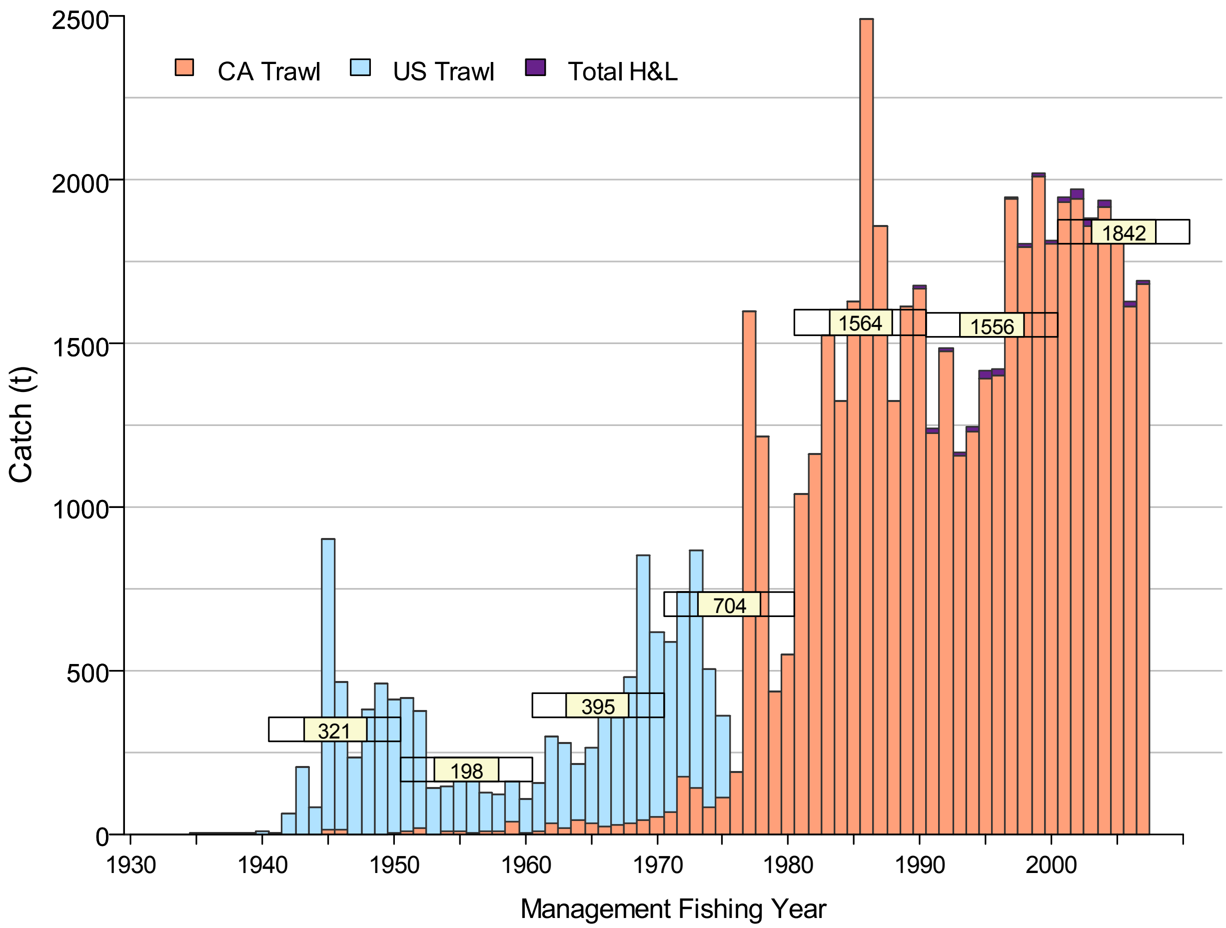

Figure 11. Catch history of Yellowmouth Rockfish by US and Canadian fleets along the BC coast. Mean annual catches by decade are displayed in horizontal boxes.

Based on the most recent stock assessment in 1999, recruitment has been low in BC Yellowmouth Rockfish since the early 1980s (DFO 1999a, Haigh and Starr 2008 Figure 9). As a result, abundance levels are expected to decline steadily until the next major recruitment episode. Successful recruitment likely will not be evident in the age structure data until cohorts reach seven years of age (DFO 1999a).

Two experimental programs were conducted in the 1980s to assess adaptive management strategies for Pacific ocean perch stocks; these are not directly relevant to Yellowmouth Rockfish assessment although the first showed that this species can be depleted by intensive fishing. The first experiment focused on PMFC Area 3C (southwest Vancouver Island) and consisted of overharvesting the area (by ~160 t of the estimated sustainable yield, or 500 t/yr) for five years (1980-1984), followed by a return to sustainable harvests (300 t/yr) in 1985. Surveys carried out before (1979) and after (1985) the experimental period indicate that the relative abundance of Yellowmouth Rockfish declined by 17.1% (compared with a decline of 55.8% for Pacific Ocean Perch). The total annual catch of Yellowmouth Rockfish decreased from 2077 to 668 kg, and the CPUE declined from 22.1 kg/h to 6.68 kg/h (Leaman and Stanley 1993). The second experiment was originally intended to allow unlimited harvesting for three to five years within PMFC Area 5E (Langara Spit, northwest of Queen Charlotte Islands), followed by no harvesting for an equivalent period. However, the harvesting period was extended to nine years (1984-1992), followed by area closure in 1993. Surveys in 1979 and 1983 in the area reported unreliable biomass indices for Yellowmouth Rockfish (Leaman and Stanley 1993). The area was re-opened to fishing in 1997.

The three synoptic bottom trawl surveys have generated only a few years of data to date and thus are not yet useful for detecting abundance trends (Figs. 12 and 13, Table 3). Nevertheless, over time these surveys may provide valuable information on Yellowmouth population parameters. In particular, the QCS and WCVI surveys generated coefficient of variation values (CVs) under 0.50, suggesting that their precision may be fairly reliable in future (Appendices 3 and 4).

Biomass estimates from the *G.B. Reed* seven year surveys in Goose Island Gully were relatively uniform for the first five years, but dropped markedly in the last two surveys. Most surveys (except for 1977) had wide error bars and all had high CVs, ranging from 49-84% (Fig. 14, Table 3, Appendix 5). The proportion of tows containing Yellowmouth Rockfish varied from less than 20% to over 50%. The species was mainly captured along the 200 m depth contour around the entrance to Goose Island Gully (Fig. 8). A log-linear regression of the time series provided a non-significant slope estimate of -0.12 yr-1 (p=0.15, Table 3).

Biomass estimates from the QCS shrimp trawl survey have been relatively low and highly variable, with no obvious trend emerging in the time series (Fig. 15, Table 3, Appendix 6). Most catches of Yellowmouth Rockfish were made in the 170-210 m depth range along the upper section of Goose Island Gully. No Yellowmouth were captured at any depth in stratum 110. The proportion of tows capturing Yellowmouth in stratum 109 varied from less than 5% to more than 20% (Fig. 16). A log-linear regression of the time series provided a non-significant slope estimate of 0.059 yr-1 (p=0.52, Table 3).

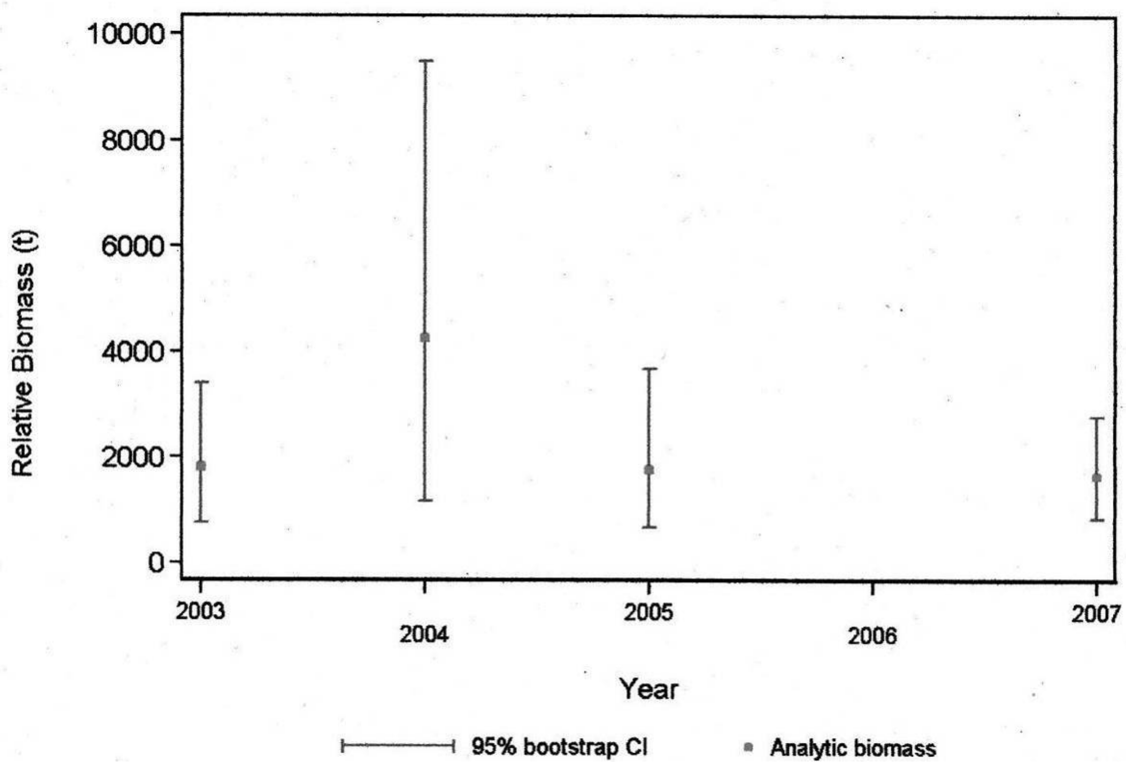

Figure 12. Relative index for Yellowmouth Rockfish in Queen Charlotte Sound from the QCS synoptic bottom trawl survey. Vertical bars indicate 90% confidence intervals from 1000 bootstrapped biomass index estimates (from Haigh and Starr 2008).

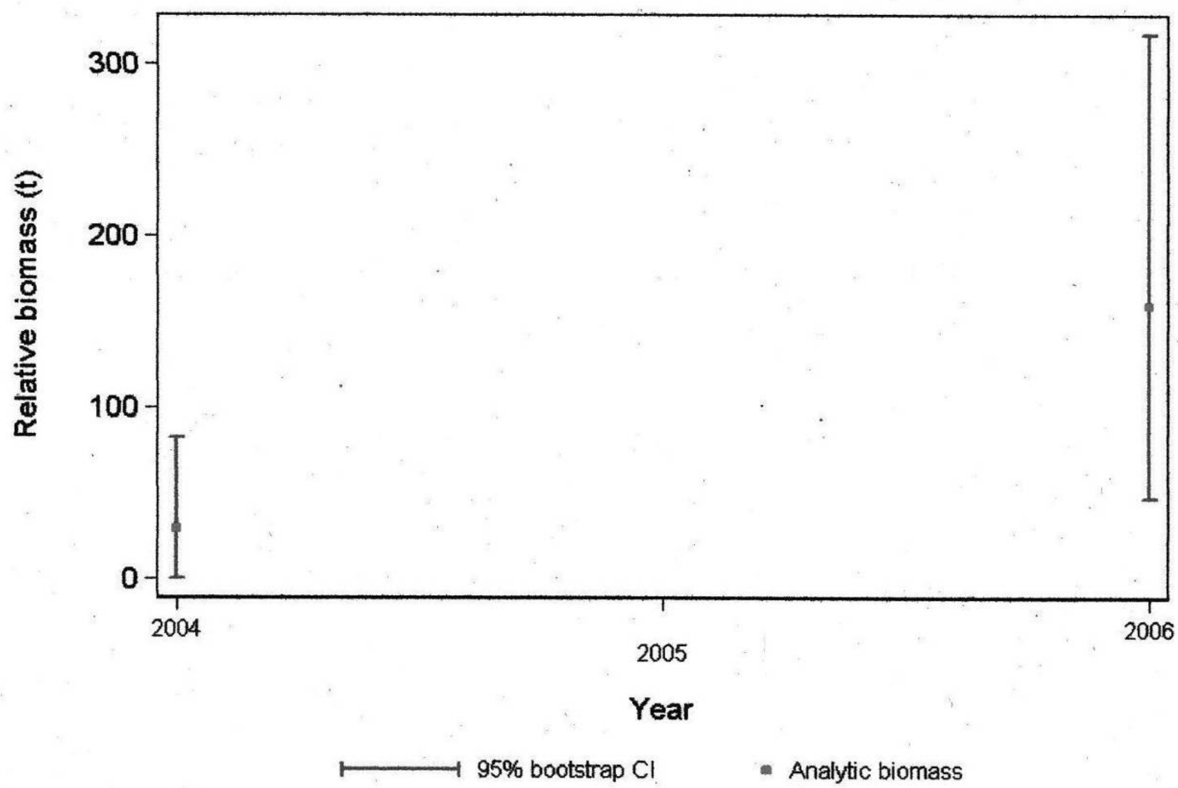

Figure 13. Relative index for Yellowmouth Rockfish on the west coast of Vancouver Island from the WCVI synoptic bottom trawl survey. Vertical bars indicate 90% confidence intervals from 1000 bootstrapped index estimates (from Haigh and Starr 2008).

Table 3. Summary of existing biomass indices for Yellowmouth Rockfish in British Columbia. The rate of change was estimated with a log-linear regression, and the probability level of the slope estimate is shown (p-value) along with the number of survey estimates used (n points). The final column provides comments on the reliability of the different indices and analyses.

Index name	Years	Rate of change yr-1	p-value	n points	Reliability
QCS synoptic bottom trawl survey	2003-2007	-0.097	0.62	4	Low due to short time series but may be useful in the future
WCVI synoptic bottom trawl survey	2004-2006			2	Low due to short time series, but may be useful in the future
G.B. Reed historical QCS survey	1967-1984	-0.12	0.15	7	Highly variable index, proportion of tows with Yellowmouth ranged from <20%->50%
WCVI shrimp trawl survey	1975-2007				Insufficient data (only two observations of Yellowmouth)
QCS shrimp trawl survey	1999-2007	0.059	0.52	9	Low reliability due to highly variable proportion of tows with Yellowmouth (0->20%)
NMFS triennial bottom trawl survey	1980-2001	-0.21	0.058	6	Low reliability, relatively few tows (3%) captured Yellowmouth
Combined regression: *G.B. Reed*, NMFS triennial, QCS groundfish, WCVI groundfish, QCS shrimp	1967-2007	-0.14	0.0001	28	Questionable due to low temporal and spatial overlap
Combined regression: *G.B. Reed*, NMFS triennial	1967-1998	-0.17	0.009	13	As above
Commercial trawl CPUE	1996-2007	-0.025		11	Catch and effort rates may be influenced by changes in fishing practices over survey period

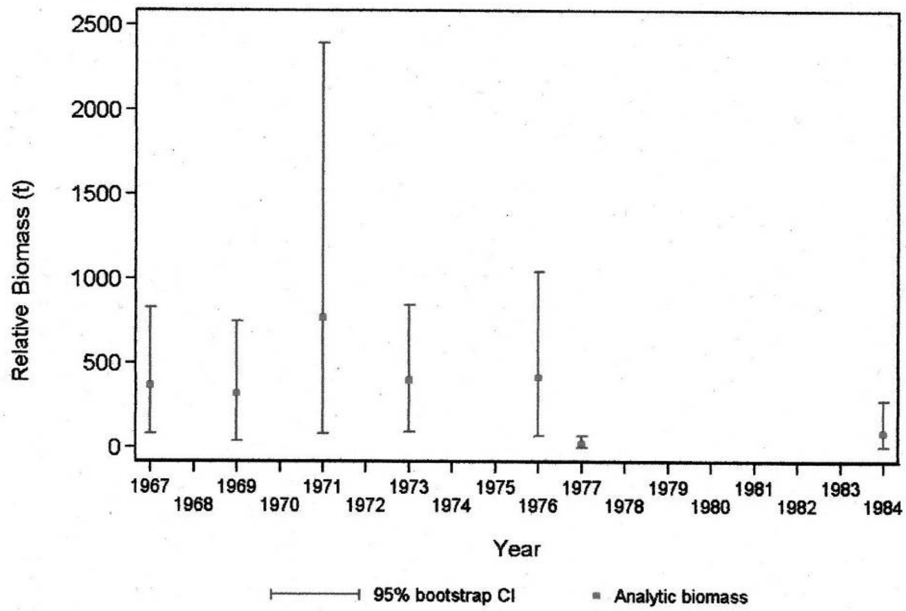

Figure 14. Relative biomass estimates for Yellowmouth Rockfish from the Goose Island Gully *G.B. Reed* trawl surveys from 1967-1984, with bias corrected 95% confidence intervals from 1000 replicates (from Haigh and Starr 2008).

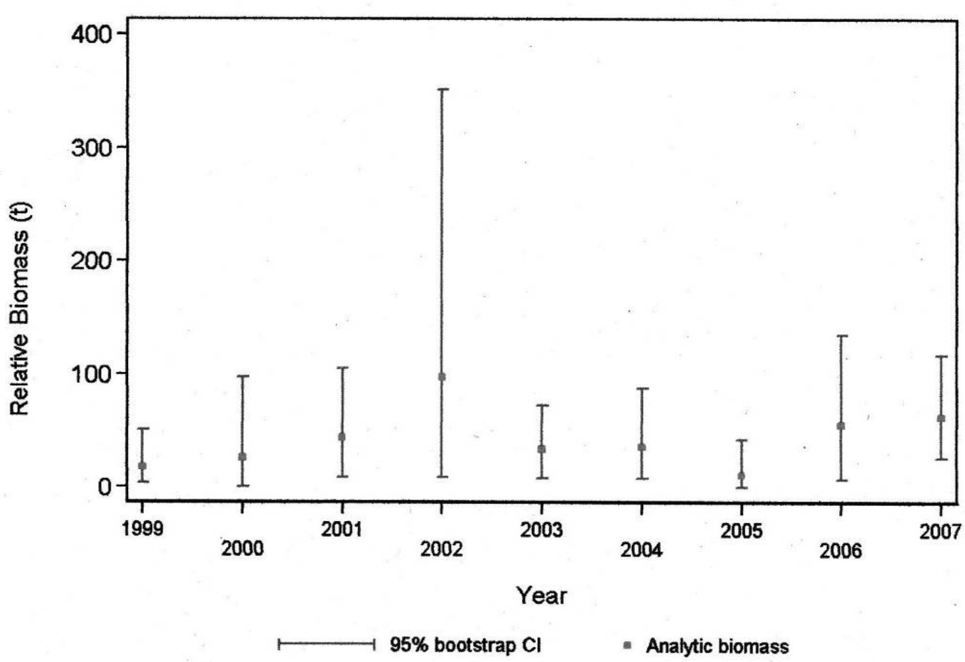

Figure 15. Relative biomass estimates for Yellowmouth Rockfish from the QC Sound shrimp trawl survey for 1999-2007, with bias corrected 95% confidence intervals from 1000 bootstrap replicates (from Haigh and Starr 2008).

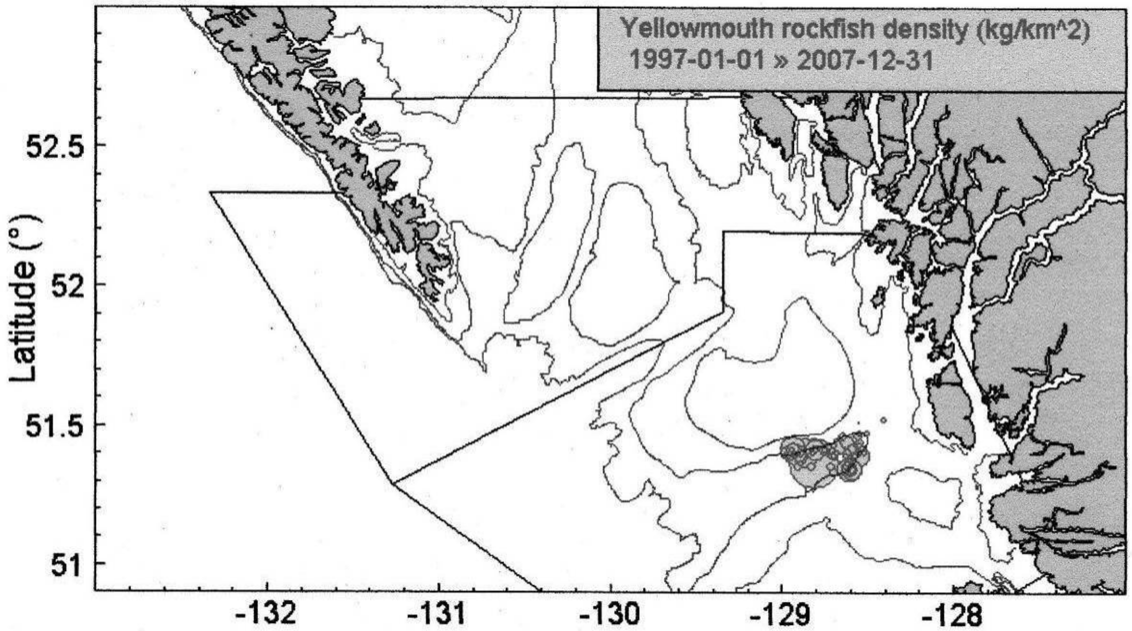

Figure 16. Locations of all trawls from the Queen Charlotte Sound shrimp trawl survey (1999-2007) which caught Yellowmouth Rockfish. Circles are proportional to catch density (largest circle = 2.47 kg/km^2). The 100, 200 and 300 m isobaths and the area stratum boundaries for the QCS synoptic bottom trawl survey are also displayed (from Haigh and Starr 2008).

The NMFS triennial bottom trawl survey generated highly variable biomass estimates. Estimates were generally higher in the early years of the survey but error bars and CVs were large for most estimates, making it difficult to detect an overall trend (Fig. 17, Table 3, Appendix 7). The largest Yellowmouth Rockfish catch occurred in 1983 in both Canadian and US waters. Overall, Yellowmouth seems more abundant in the Canadian portion of the survey (Fig. 17). Approximately 3% of all tows (23 of 697) caught Yellowmouth Rockfish over the seven-year survey. No Yellowmouth were caught in the Canadian portion of the survey in 2001, and Yellowmouth were absent from the US portion of the survey in 1980 (Appendix 7). The highest proportion of tows with Yellowmouth in Canada occurred in 1989 (0.092) and in 1983 (0.06) in the US. Yellowmouth was caught in highest frequency between 100-300 m (Haigh and Starr 2008). A log-linear regression of the Canada Vancouver time series provided a non-significant slope estimate of -0.21 yr-1 (p=0.058). It should be noted that the 2001 observation of “0” catch was not included in this analysis.

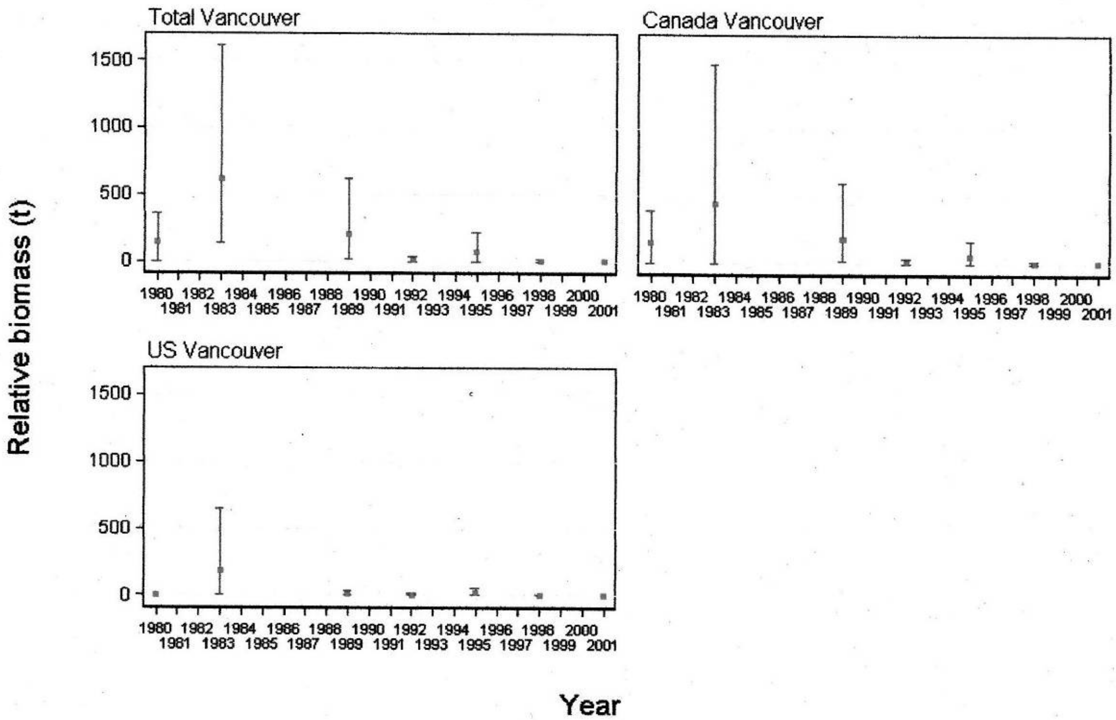

Figure 17. Relative biomass estimates for Yellowmouth Rockfish from NMFS triennial surveys in the INPFC Vancouver region (total region, Canadian portion, and US portion) with 95% bias corrected error bars estimated from 5000 bootstrap replicates (from Haigh and Starr 2008).

A combined log-linear regression of the different survey time series was conducted using the *G.B Reed*, NMFS triennial survey, Queen Charlotte Sound and West Coast Vancouver Island groundfish surveys, and the Queen Charlotte Sound shrimp survey. An analysis of covariance was used with separate intercepts for the survey series and a common slope. The slope estimate was statistically significant (-0.13 +- 0.089, $p<0.001$, Table 3, Fig. 18). Over the 40-year time period covered by the surveys, this would indicate a decline of 99.6%.

A second combined analysis including only the *G.B. Reed* and NMFS triennial surveys (which have relatively long time series and overlap temporally) shows a significant declining trend between 1967 and 1998, giving an overall decline in the indices to 2% of the original (Table 3).

The results from both of these combined analyses should be treated with caution. A key assumption of the analysis is that the individual surveys are measuring a common process that is the temporal trend in abundance of the Yellowmouth Rockfish DU. It should be noted that there is little spatial and temporal overlap among these surveys and it is virtually impossible to verify this assumption. Furthermore, Yellowmouth Rockfish catches have been relatively stable over the past 20 years (Fig. 11) and it is difficult to reconcile this with such a large estimated decline in abundance.

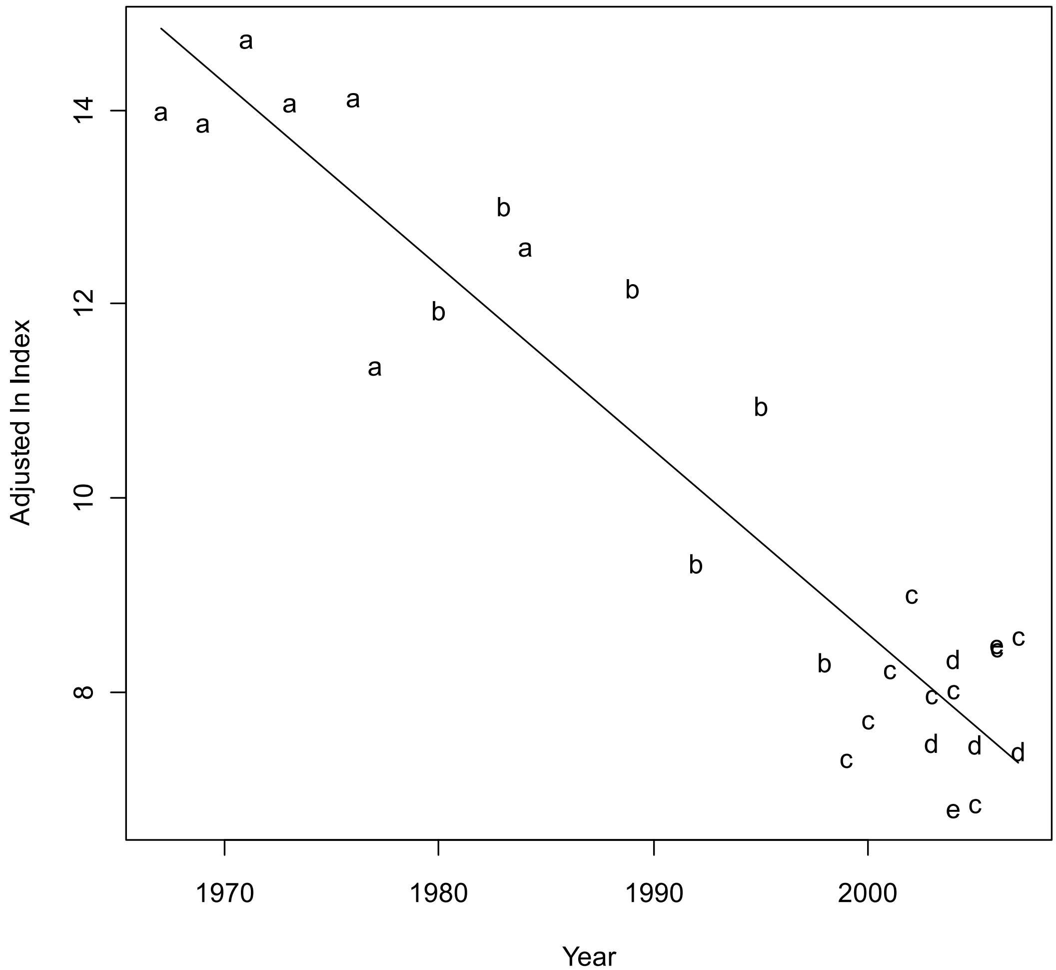

Figure 18. Time series on research survey indices (ln scale) of Yellowmouth Rockfish adjusted for their respective intercepts in a combined analysis of covariance. The letters indicate a) *G.B. Reed*, b) NMFS triennial, c) Queen Charlotte Sound shrimp survey, d) Queen Charlotte Sound synoptic groundfish survey, and e) west coast Vancouver Island synoptic groundfish survey. The fitted line shows the annual rate of change estimated in the combined GLM analysis (slope = -0.14 yr-1).

CPUE indices are relatively high for Yellowmouth Rockfish, averaging over 500 kg/h coastwide. The highest CPUE values were found along the west coast of Moresby Island, an area of relatively low total rockfish catch (Haigh and Starr 2008). An annual decline of 2.5% in Yellowmouth Rockfish CPUE has occurred between 1996-2006, although the trend has levelled out somewhat since 2001 (Fig. 19). As mentioned before, caution should be exercised when interpreting CPUE indices, because they may be affected by a variety of factors unrelated to actual abundance. For example, under the IVQ system, fishers may alternate between targeting and avoiding Yellowmouth Rockfish depending on such conditions as local abundance, market requirements, and quota availability (Haigh and Starr 2008). Additional factors affecting the CPUE indices include time of year (Yellowmouth CPUE peaks in August and dips in December; Fig. 20b), depth (CPUE is highest between 150-300 m; Fig. 20c), and latitude (CPUE is highest between 50.2^0 N- 51^0 N and lowest between 51^0 N and 51.6^0 N; Fig. 20d). Furthermore, the choice of which vessels to include in the analysis can have a dramatic effect on CPUE trends. For example, the annual rate of decline mentioned above was calculated using all vessels contributing 3% or more of the Yellowmouth catch over the period of the analysis. However, if this threshold is increased to 3.5% the index changes from a declining to an increasing trend (Haigh and Starr 2008).

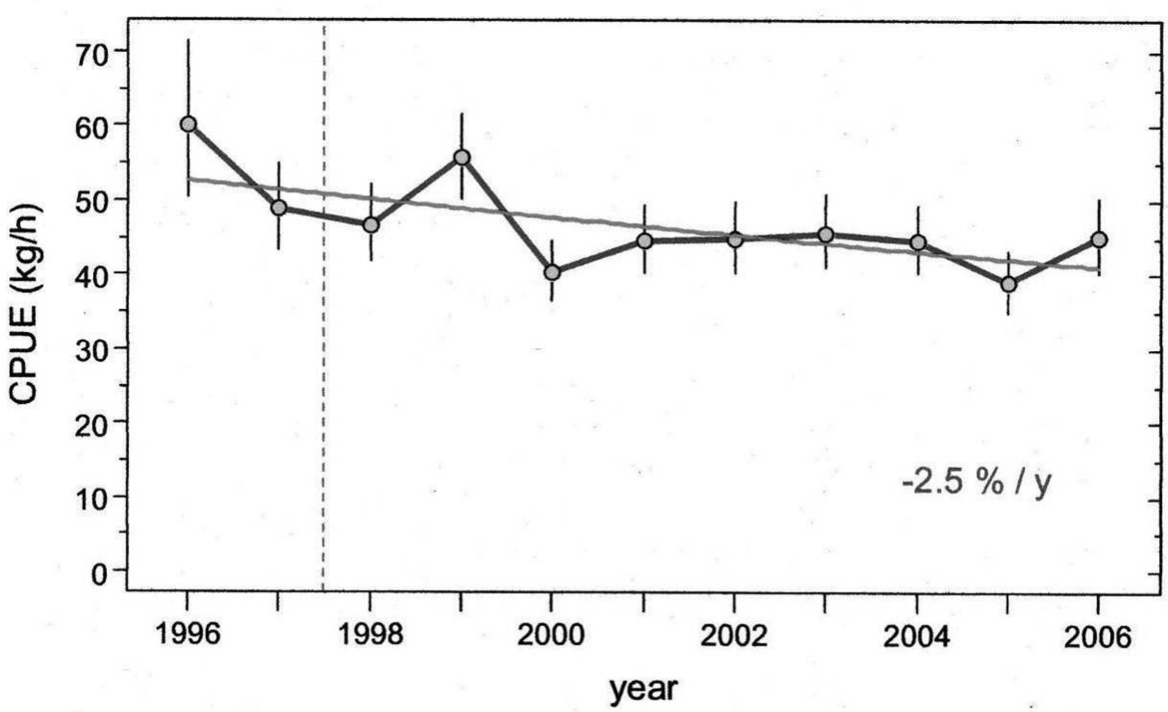

Figure 19. Annual index trend in Yellowmouth Rockfish commercial trawl CPUE data (1996-2006) based on a general linear model (GLM) analysis with five factors: year, month, depth, latitude, and vessel. The error bars show 95% confidence intervals. The vertical dashed line indicates an adjustment phase during which vessels chose two out of three trimesters to maximize catch within the bounds of quotas and catch limits. Following this period, an individual vessel quota (IVQ) program was introduced, with transferable IVQs managed under a market-based trading system (from Haigh and Starr 2008).

Information on trends in Yellowmouth Rockfish length over time is available from research, charter and commercial trawl surveys since 1967 (Figs. 21-23). In general, most individuals captured are between 40-50 cm in all years, although the 2004-2007 charter data indicate an increase in juveniles (~10 cm) caught during this period.

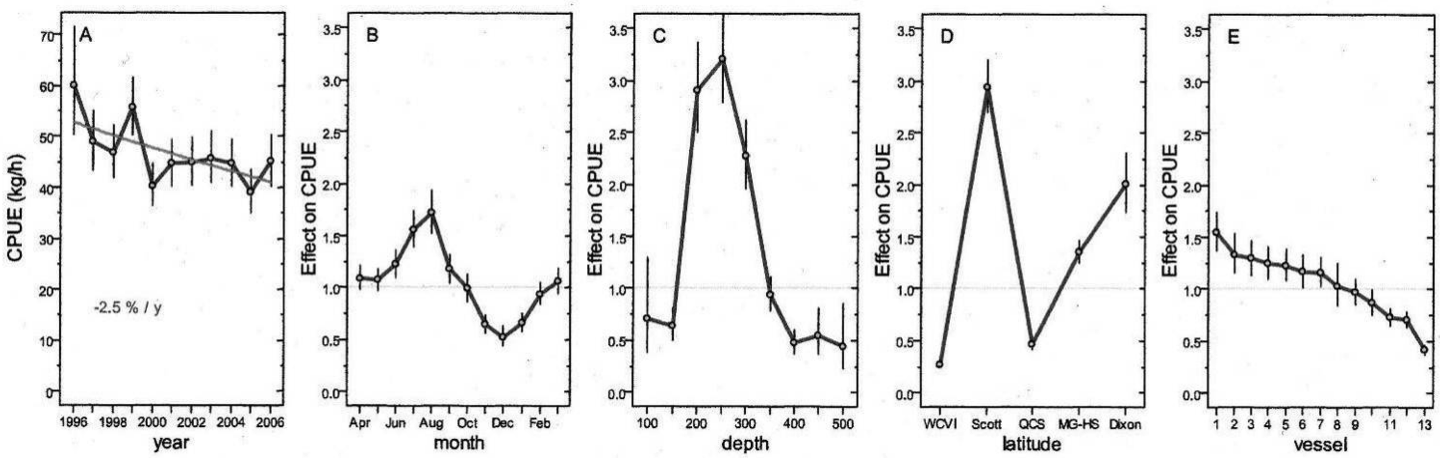

Figure 20. Annual index trend and factor coefficients for the GLM analysis of Yellowmouth Rockfish commercial trawl CPUE data (April 1996 to March 2007). (A) annual CPUE indices (by fishing year) with fitted curve indicating instantaneous decline; (B) month effect on CPUE; (C) depth effect on CPUE where depth is partitioned into 50-m depth zones between 50-500 m; (D) latitude effect on CPUE where WCVI = 48^0 N to 50.2^0 N, Scott = 50.2^0 N to 51^0 N, QCS = 51^0 N to 51.6^0 N, MG-HS = 51.6^0 N to 52.8^0 N, and Dixon = 52.8^0 N to 54.8^0 N; (E) vessel effect on CPUE where vessels accounted for $\geq$ 3% of the Yellowmouth catch over the period of the analysis. Error bars show 95% confidence intervals (from Haigh and Starr 2008).

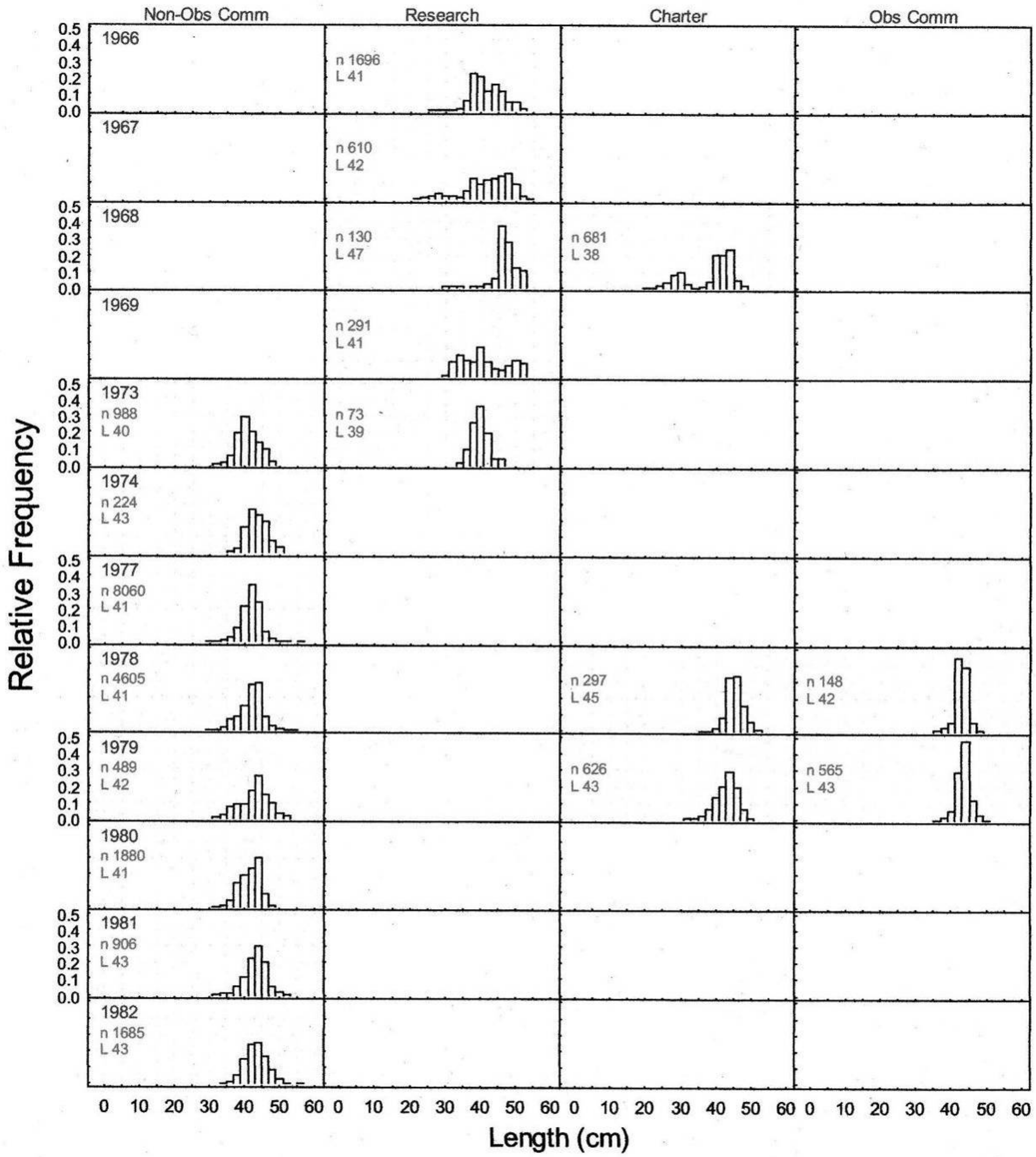

Figure 21. Relative frequency of Yellowmouth Rockfish lengths by calendar year (1966-1982) and trip type. Lengths are binned using 2-cm intervals; n = number of fish, L = mean length (cm) (from Haigh and Starr 2008).

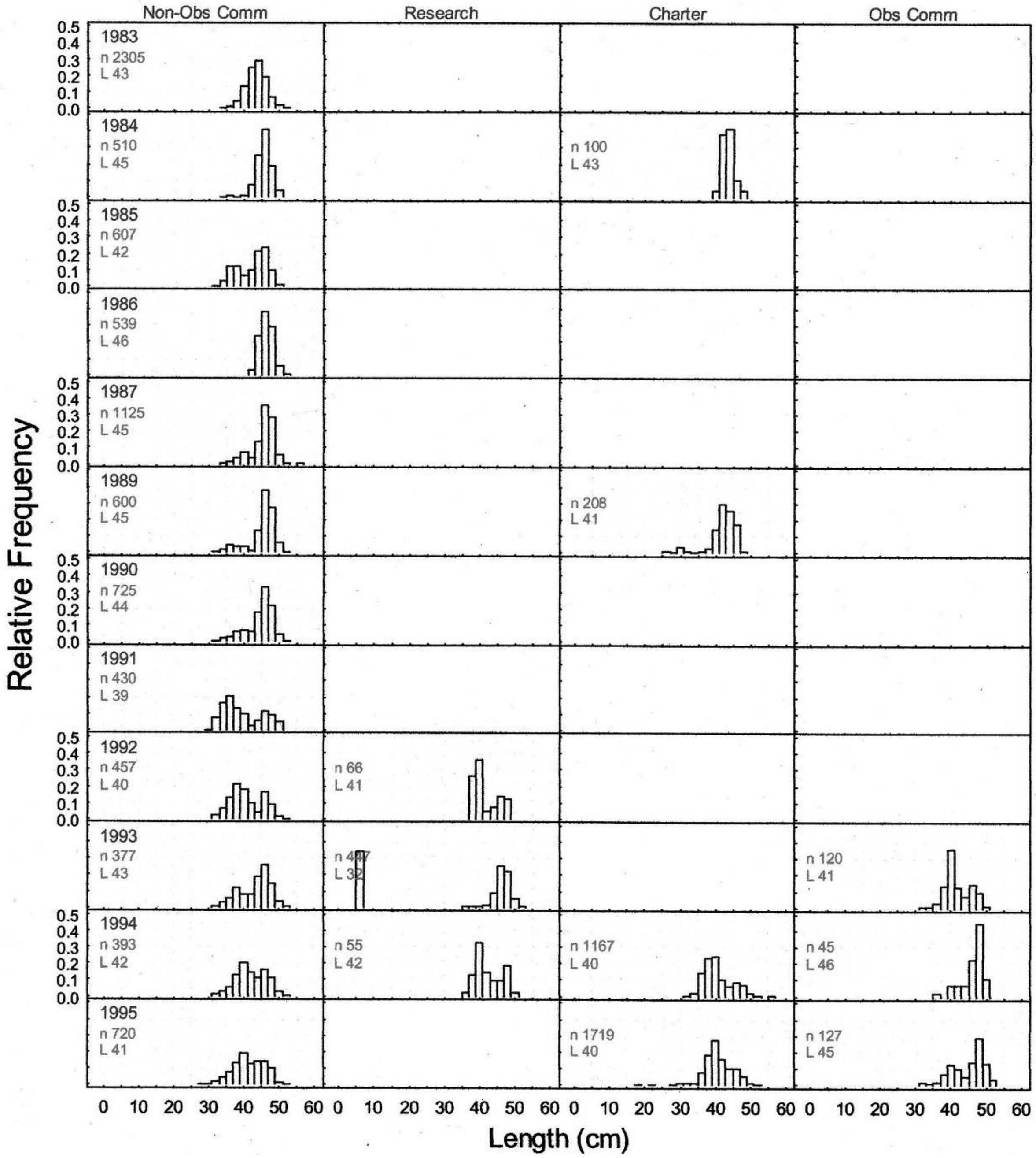

Figure 22. Relative frequency of Yellowmouth Rockfish lengths by calendar year (1983-1995) and trip type. Lengths are binned using 2-cm intervals; n = number of fish, L = mean length (cm) (from Haigh and Starr 2008).

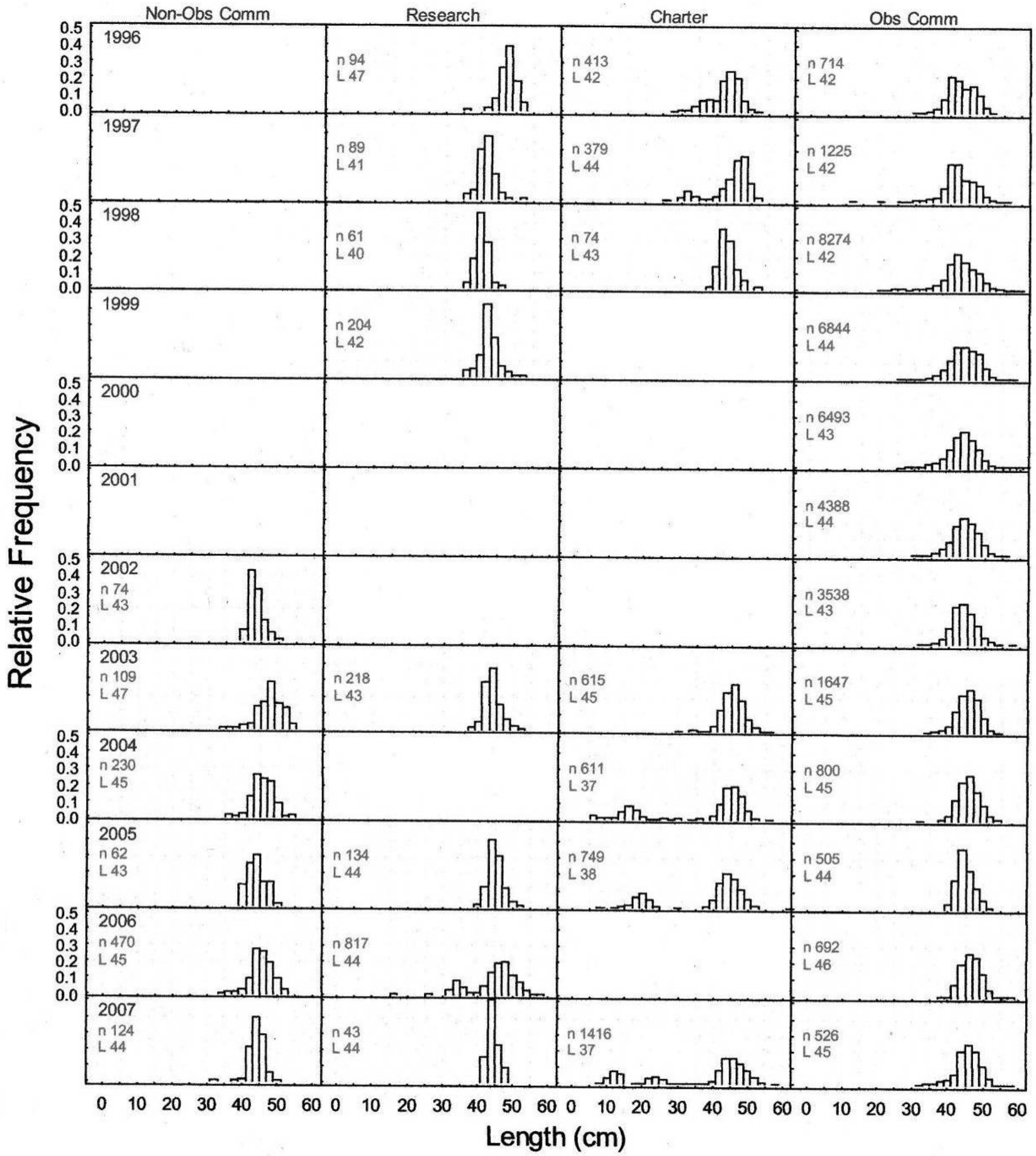

Figure 23. Relative frequency of Yellowmouth Rockfish lengths by calendar year (1996-2007) and trip type. Lengths are binned using 2-cm intervals; n = number of fish, L = mean length (cm) (from Haigh and Starr 2008).

Rescue effect

Information on the current status and long-term productivity of Yellowmouth Rockfish populations in neighbouring waters to B.C. is extremely limited, as the species is typically grouped together with other slope rockfish. The population centre for the species appears to occur within its Canadian range. Data from triennial trawl suveys conducted in the Gulf of Alaska indicate that Yellowmouth Rockfish biomass was highly variable in the 1990s (e.g., ranging from 923 tonnes taken in 1996 to 5570 tonnes taken in 1999) (Heifetz *et al.* 2000). Results from the NMFS US triennial bottom trawl survey indicate that Yellowmouth biomass estimates for the US portion of the Vancouver INPFC region were much lower than for the Canadian portion (Fig 17). In 2004 Yellowmouth Rockfish represented one of the top eight slope rockfish species harvested in Oregon (10 tonnes caught in bottom hauls) but did not figure in the top eight species for California or Washington (Roberts and Stevens 2006). Since the dispersal capability of the species is presently unknown it is difficult to determine the likelihood of recolonization of Canadian habitat following local extirpation.

LIMITING FACTORS AND THREATS

Several characteristics of rockfish species make them particularly susceptible to disturbance. In particular, rockfish have relatively low intrinsic rates of increase due to their slow growth, delayed maturity and extreme longevity (Adams 1980; Roberts and Stevens 2006). Recruitment is highly variable and little is known about controlling factors. Many rockfish species exhibit site fidelity once maturity is reached, potentially resulting in small isolated populations vulnerable to localized depletion (Roberts and Stevens 2006). Co-occurrence with a number of other groundfish species makes fishery management at the species level challenging, although recent improvements to management of the groundfish species complex have been made to deal with this issue. Rockfish physiology makes these species prone to complete mortality when brought to the surface from depth (Fort *et al.* 2006; Haigh and Starr 2008). Taken together, these traits have led to declines in many slope rockfish as a result of overfishing, habitat loss from bottom trawling and adverse environmental changes (Roberts and Stevens 2006).

Commercial fishing is currently the main threat to Yellowmouth Rockfish. As for other rockfish, intensive fishing practices may disproportionately target the largest, oldest and most fecund Yellowmouth individuals, potentially leading to a truncated age distribution, loss of spawning biomass and diminished recruitment success (Berkeley and Markle 1999).

Yellowmouth Rockfish is captured mainly by bottom and mid-water trawls in BC, although a limited hook-and-line fishery also exists. The species is also taken in small numbers by the halibut fishery (Appendices 2-4). The trawl fishery for slope rockfish has been active since the 1930s but early catch statistics for Yellowmouth Rockfish are unreliable because several species were grouped together for catch reports.

Furthermore, no data exist on historical discard levels in groundfish fisheries prior to 1995. Since the late 1970s reporting has improved significantly (DFO 1999a). Today the fishery has 100% observer coverage for bottom trawls and most mid-water trawls, in addition to 100% dockside monitoring, ensuring that all catches (including landings and discards) are enumerated (Roberts and Stevens 2006). In 2006 a three-year pilot plan was implemented to have 100% at-sea electronic and video monitoring for the hook-and-line fishery as well (DFO 2007).

Uncertainties

The current standing stock of Yellowmouth Rockfish is unknown. The paucity of historical records on species composition in the commercial fishery makes it difficult to determine the current population status of the species along the BC coast. Data from more recent research surveys are also problematic as they tend to span too short a time period, target other species (e.g., shrimp) and/or do not adequately cover the preferred mid-water habitat of this species. In addition, Yellowmouth Rockfish may be mistakenly identified as Pacific Ocean Perch after capture, which could lead to underestimates of actual harvest or bycatch rates (Love *et al.* 2002).

SPECIAL SIGNIFICANCE OF THE SPECIES

Yellowmouth Rockfish is a commercially important species in BC (DFO 1999a). In the 2007-2008 fishing season, the total Canadian catch of Yellowmouth Rockfish had a landed value of approximately $1.5 million, based on a $0.50/lbs price (DFO 2008a).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Monterey Bay Aquarium’s Seafood Watch Program has classified all slope rockfish as high conservation concern and inherently vulnerable (Roberts and Stevens 2006). The status of the Yellowmouth Rockfish has not been assessed by NatureServe (NatureServe 2007) nor by the BC Conservation Data Centre (Prescott pers. comm. 2007).

Yellowmouth Rockfish are currently managed by catch quotas, which were introduced in 1979. Yellowmouth catch within Area 5E (Langara Spit, northwest of the Queen Charlotte Islands) was managed under a slope rockfish aggregate (Yellowmouth, Pacific Ocean Perch and Rougheye Rockfish *S. aleutianus*) quota between 1983-1988 and in 1986 coastwide aggregate quotas were in place for these three slope rockfish species. In the past, quotas were based on observed relative abundance of Yellowmouth collected from biomass surveys. However, these surveys were directed at Pacific Ocean Perch, were limited to the Queen Charlotte Sound area (area 5AB) and relied solely on bottom trawl surveys (DFO 1999a; Schnute *et al.* 1999). Since 1997, quota determinations have also incorporated information from observer data onboard trawl vessels. In addition, the IVQ system was introduced for the BC trawl fishery in 1997, setting area-specific annual catch (retained and discarded) limits on quota species for each vessel.

The Canadian Yellowmouth Rockfish fishery is regulated by an individual quota set each fishing season. For the 2008-2009 fishing season 96.77% (2364 t) of the Yellowmouth total allowable catch (TAC) has been allocated to the trawl fishery, 2.49% (60 t) to the hook and line and 0.74% (18 t) to the halibut fishery. An additional three tonnes have been designated for research purposes (DFO 2008a). In the last two fishing seasons (2006-2007 and 2007-2008) Pacific groundfish trawl fleets have landed less than 60% of the Yellowmouth TAC (Table 4).

Table 4. Proportion of the total allowable catch (TAC) of Yellowmouth Rockfish caught in the groundfish trawl fishery during 2006-2007 and 2007-2008 fishing seasons (DFO 2008b).

Fishing season	Total quota (tonnes)	Total catch (tonnes)	% of TAC harvested
2006-2007	2822.32	1665.02	59
2007-2008	2911.27	1397.86	48

In the US, Yellowmouth Rockfish are managed as part of slope rockfish assemblages to which a total allowable catch is assigned. Yellowmouth Rockfish likely receive partial protection from fishing in RCAs (from Washington to California) and in the eastern Gulf of Alaska where trawling is currently banned (Enticknap and Sheard 2005; Roberts and Stevens 2006).

TECHNICAL SUMMARY

Sebastes reedi
Yellowmouth Rockfish sébaste à bouche jaune
Range of Occurrence in Canada: Pacific Ocean (Marine waters along BC's continental slope)

Demographic Information

Generation time (average age of parents in the population) • (assuming 50% maturity reached at 10 years and a natural mortality rate of 0.05)	30 yrs
Observed percent reduction in total number of mature individuals over the last 10 years or three generations: • see table summarizing indices (Table 3) • no stastically significant trends in individual research vessel surveys over varying periods. However, three of the four slope estimates were negative. • 99% decline over 40 years in index combining four RV surveys. However, these surveys had little spatial and temporal overlap • annual decline of 2.5% over 10 years in commercial CPUE index • reliability of all indices considered relatively low for this species	Indications of decline in surveys with longest time series and in commercial CPUE, possibly substantial
Projected or suspected percent reduction or increase in total number of mature individuals over the next 10 or 5 years, or 3 or 2 generations	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Unknown
Are the causes of the decline understood? • decline probably due to fishing potentially compounded by variable recruitment	Causes of variable recruitment not well known; fishing could be involved
Have the causes of the decline ceased? • fishing continues; recruitment remains variable	No
[Observed, inferred, or projected] trend number of populations	N/A (single population)
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	N/A

Extent and Area Information

Estimated extent of occurrence	48 000 km²
[Observed, inferred, or projected] trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Probably not
Index of area of occupancy (IAO)	11 000-34 000 km²
[Observed, inferred, or projected] trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	Probably not
Is the total population severely fragmented?	No
Number of current locations	N/A
Trend in number of locations	N/A
Are there extreme fluctuations in number of locations?	N/A
Trend in area and/or quality of habitat	Unknown

Number of mature individuals in each population

Population	N Mature Individuals
Total	Unknown
Number of populations (locations)	N/A

Quantitative Analysis

Not carried out	N/A

Threats (actual or imminent, to populations or habitats)

Commercial harvest may pose direct threats to populations through overfishing and indirect threats through habitat destruction caused by bottom trawling.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Information limited on current status in US waters. BC is probably the population centre of the species.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Probably
Is rescue from outside populations likely?	Unknown

Current Status

COSEWIC: Threatened (April 2010)

Status and Reasons for Designation

Status: **Threatened**	Alpha-numeric code: **A2b**

Reasons for designation:
As with other rockfish species, this slow-growing (generation time 30 years), long-lived (maximum age 100 years) species is vulnerable to commercial fishing. Research vessel surveys indicate that abundance has declined considerably over the past 40 years (1.5 generations). While contemporary surveys designed specifically for groundfish species indicate a recent period (5 years) of relative stability, it is not clear that the decline has ceased. The initial period of decline occurred as the commercial fishery for this and other rockfish species developed. Although this is considered normal for a newly exploited population, the total decline in abundance is inferred to be well beyond what is optimal for an exploited population. The absence of any strong recruitment events during the last 20 years is also a concern. The species is an important component of BC's commercial fisheries. Fishing continues to be a threat and there is no established limit reference point to help manage these fisheries in a precautionary manner.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A2b based on a suspected continuous long-term decline from an unfished condition to a level inferred to between 30 and 50% of the optimal level for an exploited population.

Criterion B (Small Distribution Range and Decline or Fluctuation): Not met as extent of occurrence and index of area of occupancy exceed thresholds.

Criterion C (Small and Declining Number of Mature Individuals): Not met as population size estimate not available, and certainly larger than threshold.

Criterion D (Very Small Population or Restricted Distribution): Not met.

Criterion E (Quantitative Analysis): Not undertaken.

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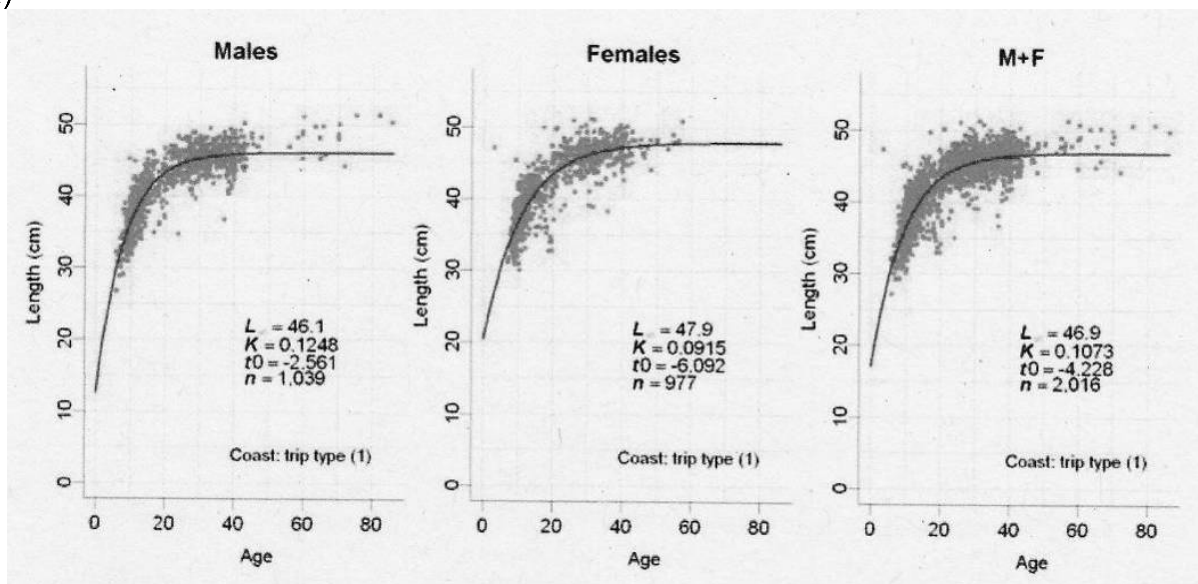
Andrea L. Smith obtained her M.Sc. in conservation biology and her Ph.D. in evolutionary ecology, both at Queen's University. She has worked on a variety of research projects, including studying seabird ecology in British Columbia, the Canadian arctic and the Galapagos, endangered species in Hawaii and the Mojave desert, and forest bird communities in Mexico. Andrea has written several articles on environmental issues for the magazine *ON Nature* and conducted a gap analysis on provincial natural heritage policy for Ontario Nature. She now works as a researcher at York University's Institute for Research and Innovation in Sustainability (IRIS), examining the interdisciplinary challenges of preventing and controlling invasive species.

COLLECTIONS EXAMINED

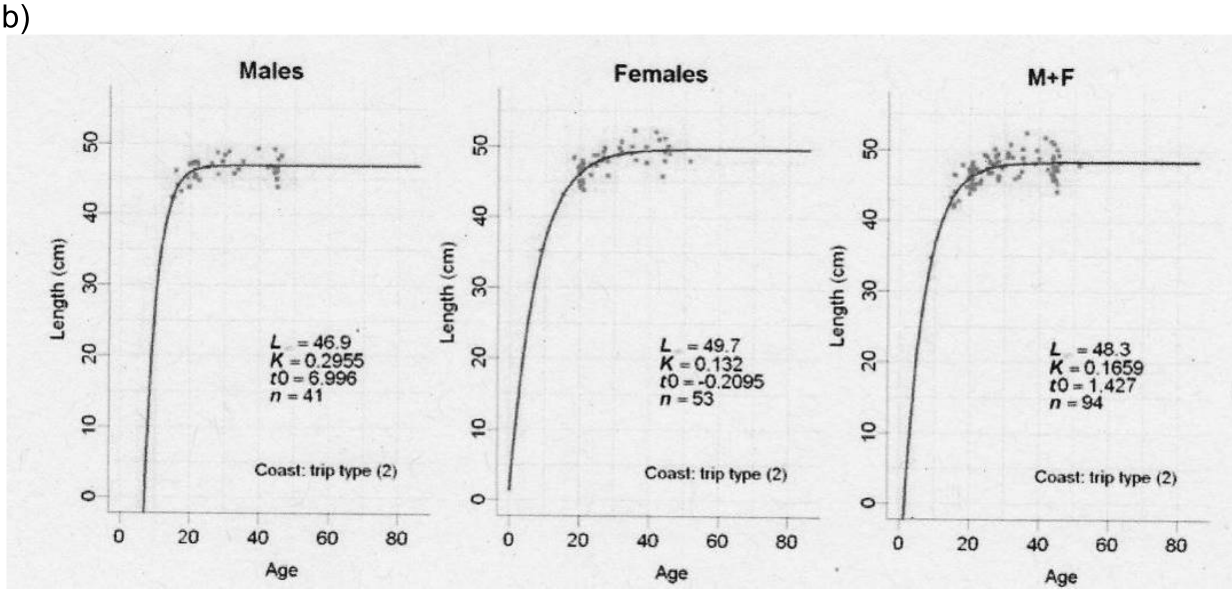
No collections were examined for this report.

Appendix 1. Length-at-age relationships for specimens collected on a) non-observed domestic commercial trips, b) research surveys, c) charter surveys, d) domestic commercial trips, e) research and charter surveys combined, and f) all domestic commercial trips, using the von Bertalanffy growth equation. M+F = male and female specimens combined; *n* = number of specimens (from Haigh and Starr 2008).

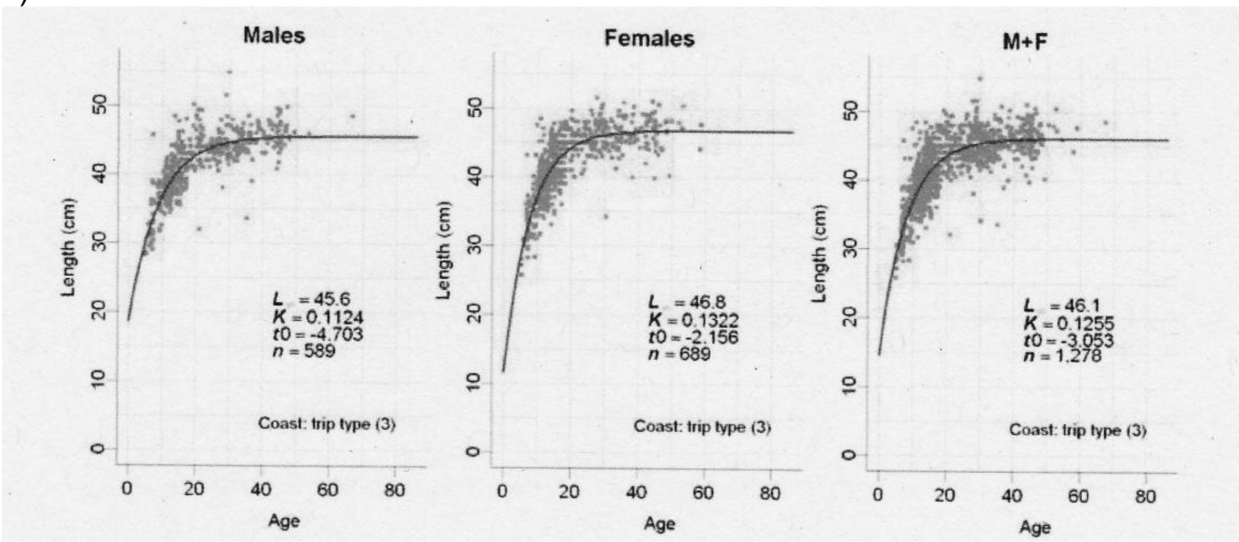
a)



b)

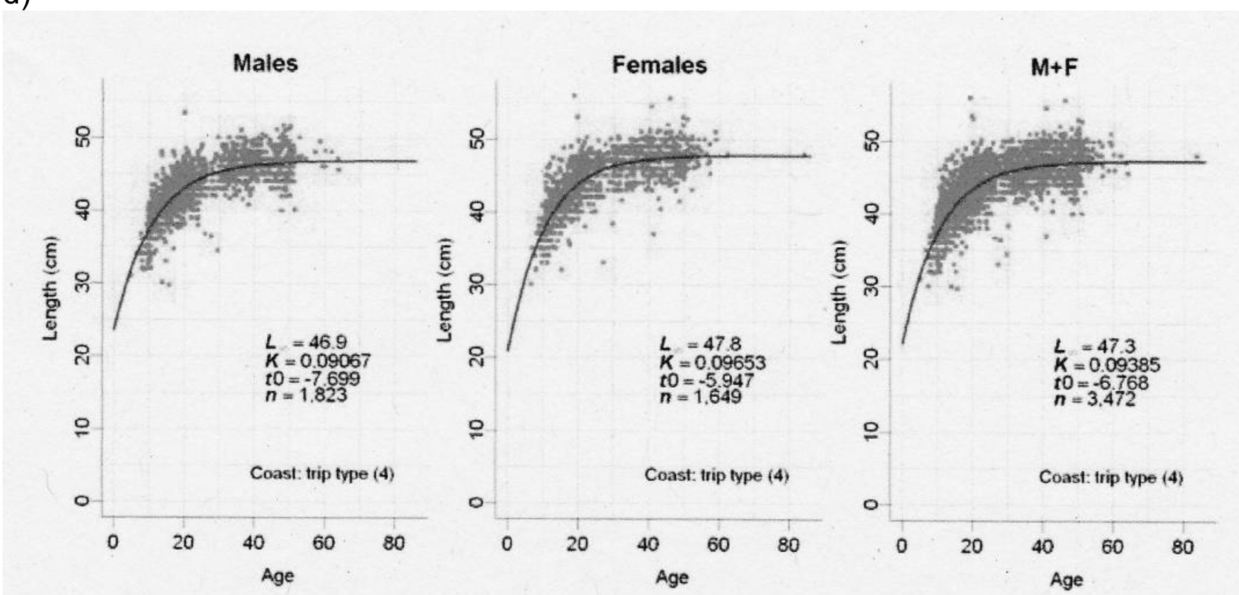


c)



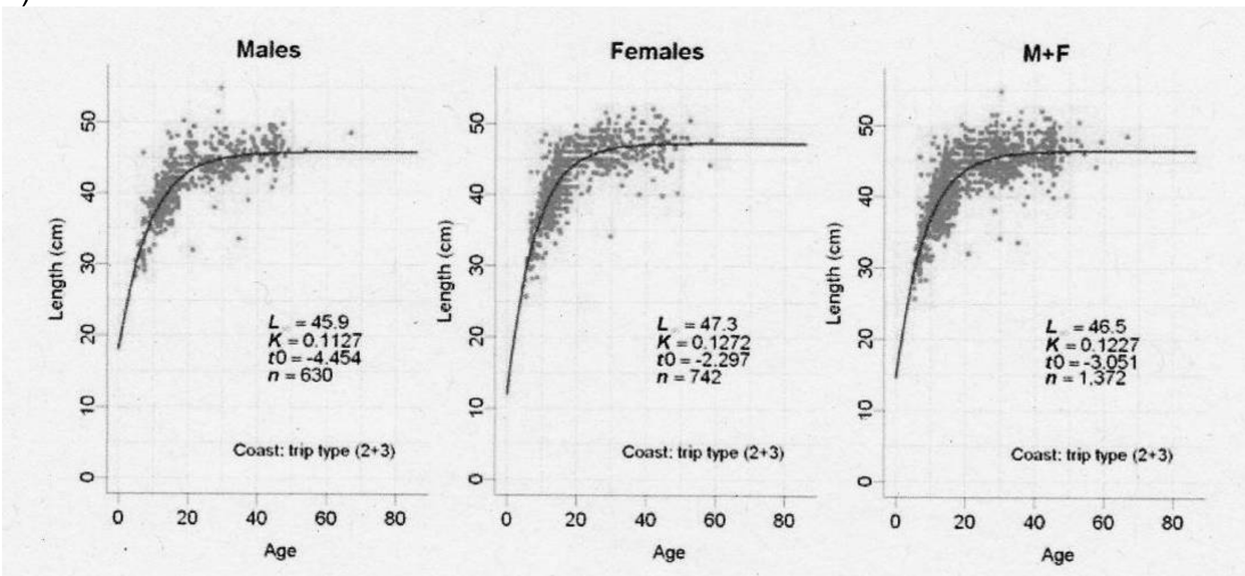
Males
Females
M+F
Length (cm)
Age
L_∞ = 45.6
K = 0.1124
$t0$ = -4.703
n = 589
Coast: trip type (3)
L_∞ = 46.8
K = 0.1322
$t0$ = -2.156
n = 689
Coast: trip type (3)
L_∞ = 46.1
K = 0.1255
$t0$ = -3.053
n = 1,278
Coast: trip type (3)

d)

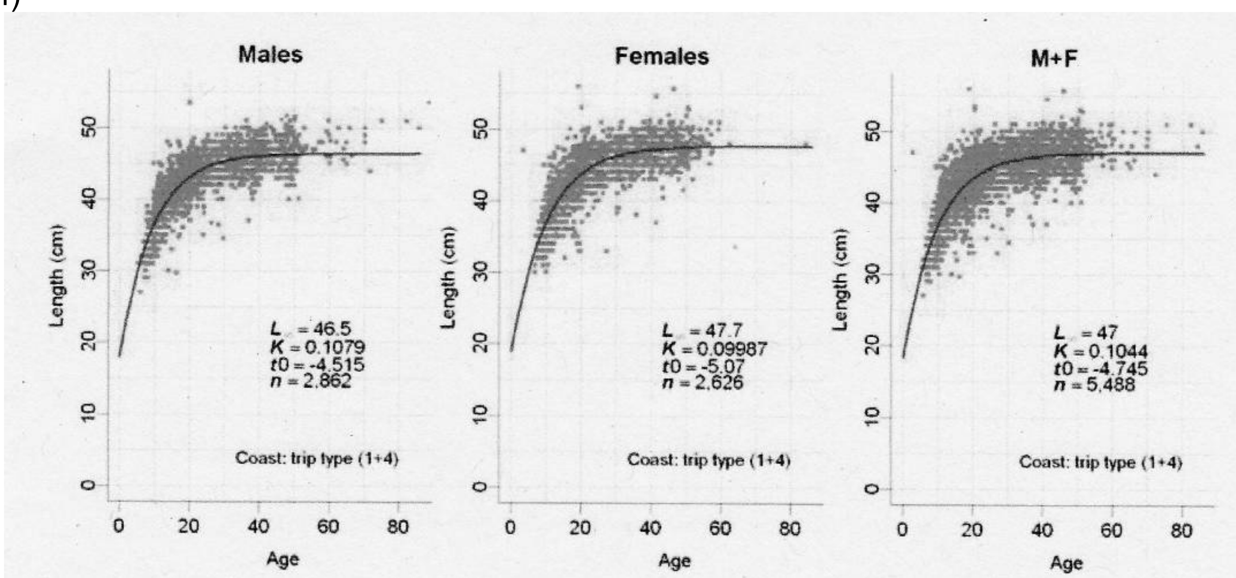


Males
Females
M+F
Length (cm)
Age
L_∞ = 46.9
K = 0.09067
$t0$ = -7.699
n = 1,823
Coast: trip type (4)
L_∞ = 47.8
K = 0.09653
$t0$ = -5.947
n = 1,649
Coast: trip type (4)
L_∞ = 47.3
K = 0.09385
$t0$ = -6.768
n = 3,472
Coast: trip type (4)

e)


Males
Females
M+F
Length (cm)
Age
L∞ = 45.9
K = 0.1127
t0 = -4.454
n = 630
L∞ = 47.3
K = 0.1272
t0 = -2.297
n = 742
L∞ = 46.5
K = 0.1227
t0 = -3.051
n = 1,372
Coast: trip type (2+3)

f)


Males
Females
M+F
Length (cm)
Age
L∞ = 46.5
K = 0.1079
t0 = -4.515
n = 2,862
L∞ = 47.7
K = 0.09987
t0 = -5.07
n = 2,626
L∞ = 47
K = 0.1044
t0 = -4.745
n = 5,488
Coast: trip type (1+4)

Appendix 2. Annual catch (tonnes) of Yellowmouth Rockfish coastwide by various fisheries in B.C. Catches are rounded to the nearest tonne (from Haigh and Starr 2008).

Year	CA Trawl	US Trawl	Zn HL	Shed II	Halibut	Total HL	Total
1930	---	---	---	---	---	---	---
1931	---	---	---	---	---	---	---
1932	---	---	---	---	---	---	---
1933	---	---	---	---	---	---	---
1934	---	0	---	---	---	---	0
1935	---	2	---	---	---	---	2
1936	---	3	---	---	---	---	3
1937	---	3	---	---	---	---	3
1938	---	4	---	---	---	---	4
1939	---	4	---	---	---	---	4
1940	---	9	---	---	---	---	9
1941	---	3	---	---	---	---	3
1942	---	63	---	---	---	---	63
1943	---	204	---	---	---	---	204
1944	---	85	---	---	---	---	85
1945	14	887	---	---	---	---	901
1946	16	447	---	---	---	---	463
1947	0	234	---	---	---	---	234
1948	1	379	---	---	---	---	380
1949	1	461	---	---	---	---	463
1950	3	410	---	---	---	---	413
1951	7	410	---	---	---	---	417
1952	18	361	---	---	---	---	379
1953	2	142	---	---	---	---	144
1954	10	137	---	---	---	---	147
1955	12	179	---	---	---	---	191
1956	7	178	---	---	---	---	185
1957	10	118	---	---	---	---	128
1958	11	113	---	---	---	---	124
1959	38	124	---	---	---	---	162
1960	6	101	---	---	---	---	107
1961	9	146	---	---	---	---	155
1962	36	265	---	---	---	---	301
1963	17	261	---	---	---	---	278
1964	42	172	---	---	---	---	215
1965	34	229	---	---	---	---	263
1966	22	406	---	---	---	---	428
1967	27	333	---	---	---	---	360
1968	36	446	---	---	---	---	482
1969	45	809	---	---	---	---	854
1970	55	564	---	---	---	---	619
1971	66	520	---	---	---	---	587
1972	174	564	---	---	---	---	738
1973	142	727	---	---	---	---	868
1974	83	423	---	---	---	---	506
1975	110	250	---	---	---	---	360
1976[L]	189	---	---	---	---	---	189
1977	1,596	---	---	---	---	---	1,596

Year	CA Trawl	US Trawl	Zn HL	Shed II	Halibut	Total HL	Total
1978	1,214	---	---	---	---	---	1,214
1979[L]	438	---	---	---	---	---	438
1980	548	---	---	---	---	---	548
1981	1,039	---	---	---	---	---	1,039
1982	1,160	---	---	---	---	---	1,160
1983	1,524	---	---	---	---	---	1,524
1984	1,324	---	---	---	---	---	1,324
1985	1,628	---	---	---	---	---	1,628
1986	2,491	---	---	---	---	---	2,491
1987	1,857	---	---	---	---	---	1,857
1988	1,322	---	---	---	---	---	1,322
1989	1,611	---	0	---	---	0	1,611
1990	1,666	---	12	---	---	12	1,678
1991[D]	1,225	---	13	---	---	13	1,238
1992[L]	1,475	---	13	---	---	13	1,487
1993	1,157	---	10	---	---	10	1,167
1994[D]	1,231	---	12	---	---	12	1,243
1995[T]	1,391	---	24	---	2	26	1,417
1996[D,O]	1,402	---	12	---	6	19	1,421
1997[Q,T]	1,939	---	7	---	2	9	1,948
1998	1,795	---	9	---	2	11	1,806
1999	2,008	---	9	---	2	11	2,020
2000[T]	1,803	---	9	---	3	12	1,815
2001	1,930	---	10	---	4	15	1,945
2002	1,941	---	25	---	7	32	1,973
2003	1,860	---	14	0	8	22	1,883
2004	1,917	---	12	0	9	21	1,938
2005	1,816	---	15	---	5	20	1,835
2006	1,613	---	---	---	---	---	1,613
2007	1,680	---	0	---	11	11	1,691
Total	48,848	11,175	204	0	77	282	60,305

[D] Dockside monitoring program (DMP) started: 1991 – halibut; 1994 – trawl; 1996 – ZN H&L
[O] Observer program started: 1996 – trawl
[L] Limited vessel entry: 1976 – trawl; 1979 – halibut; 1992 ZN H&L
[Q] Individual vessel quota (IVQ) system started for TAC species: 1997 – trawl
[T] Trip limits implemented: 1995 – ZN monthly limit on rockfish aggregate; 1997 – trawl trip limit of 15,000 lbs for combined non-TAC rockfish; 2000 – halibut option D with annual limit of 20,000 lbs of rockfish aggregate.

Appendix 3. Biomass estimates of Yellowmouth Rockfish derived from the Queen Charlotte Sound (QCS) synoptic bottom trawl survey. Estimates are based on 1000 bootstraps; *n* = number of tows, *n*+ = number of tows catching Yellowmouth Rockfish, E [*B*] = expected biomass (t), $\underline{B}$ = mean bootstrapped biomass (BB), *B*0.05 = 5% quantile of BB, *B*0.95 = 95% quantile of BB, CV = coefficient of variation (from Haigh and Starr 2008).

Year	*n*	*n*+	E [*B*]	$\underline{B}$	$B_{0.05}$	$B_{0.95}$	CV
2003	236	38	1814	1800	761	3399	0.364
2004	234	48	4256	4251	1165	9493	0.477
2005	224	44	1770	1782	667	3673	0.430
2007	257	75	1656	1625	838	2788	0.302

Appendix 4. Biomass estimates of Yellowmouth Rockfish derived from the west coast Vancouver Island (WCVI) synoptic bottom trawl survey. Estimates are based on 1000 bootstraps; *n* = number of tows, *n*+ = number of tows catching Yellowmouth Rockfish, E [*B*] = expected biomass (t), $\underline{B}$ = mean bootstrapped biomass (BB), $B_{0.05}$ = 5% quantile of BB, $B_{0.95}$ = 95% quantile of BB, CV = coefficient of variation (from Haigh and Starr 2008).

Year	*n*	*n*+	E [*B*]	$\underline{B}$	$B_{0.05}$	$B_{0.95}$	CV
2004	98	2	29.3	28.9	0.0	82.0	0.736
2006	166	9	159.0	161.8	46.8	317.3	0.435

Appendix 5. Relative biomass estimates for Yellowmouth Rockfish derived from the Goose Island Gully *G.B. Reed* trawl surveys. Estimates are based on 1000 bootstraps (from Haigh and Starr 2008).

Survey year	Relative biomass (t)	Mean bootstrap biomass (t)	Lower 95% bound biomass (t)	Upper 95% bound biomass (t)	Bootstrap CV	Analytic CV
1967	366.5	357.5	82.9	830.0	0.501	0.509
1969	321.8	325.5	38.1	749.2	0.581	0.570
1971	770.2	799.3	81.7	2393.3	0.795	0.836
1973	398.9	404.6	95.2	845.7	0.468	0.492
1976	418.9	418.4	73.6	1045.4	0.569	0.569
1977	26.3	26.0	4.3	72.7	0.658	0.645
1984	89.8	86.2	5.9	280.5	0.802	0.799

Appendix 6. Relative biomass estimates for Yellowmouth Rockfish derived from the Queen Charlotte Sound shrimp trawl survey. Estimates are based on bootstraps (from Haigh and Starr 2008).

Survey year	Relative biomass (t)	Mean bootstrap biomass (t)	Lower 95% bound biomass (t)	Upper 95% bound biomass (t)	Bootstrap CV	Analytic CV
1999	17.8	17.9	3.9	51.0	0.604	0.609
2000	26.3	26.3	0.0	97.8	0.911	0.937
2001	44.3	44.4	8.9	105.4	0.526	0.538
2002	97.3	96.5	9.3	351.2	0.871	0.835
2003	34.0	34.5	8.5	72.7	0.459	0.456
2004	36.0	35.1	7.8	87.7	0.567	0.584
2005	11.2	11.0	0.0	42.5	0.884	0.887
2006	55.8	56.7	7.0	135.1	0.533	0.539
2007	62.9	63.9	26.3	116.9	0.366	0.371

Appendix 7. Relative biomass estimates for Yellowmouth Rockfish in the Vancouver INPFC region (total region, Canadian portion and U.S. portion), with 95% confidence intervals based on the bootstrap distribution of biomass. Bootstrap estimates based on 5000 random draws with replacement (from Haigh and Starr 2008).

Estimate type	Survey year	Relative biomass (t)	Mean bootstrap biomass	Lower bound biomass	Upper bound biomass	Bootstrap CV	Analytic CV
Total	1980	139	141	0	361	0.609	0.661
Vancouver	1983	613	627	138	1608	0.575	0.585
	1989	202	203	16	622	0.735	0.753
	1992	15	14	2	43	0.713	0.726
	1995	72	69	1	222	0.778	0.791
	1998	6	6	0	20	0.925	1.000
	2001	0	0	N/A	N/A	N/A	N/A
Canada	1980	151	153	0	391	0.609	0.661
Vancouver	1983	442	461	0	1478	0.746	0.739
	1989	187	189	18	594	0.752	0.771
	1992	11	10	0	41	0.898	0.917
	1995	56	55	1	172	0.780	0.791
	1998	4	5	0	17	0.931	1.000
	2001	0	0	N/A	N/A	N/A	N/A
U.S.	1980	0	0	N/A	N/A	N/A	N/A
Vancouver	1983	180	177	3	650	0.943	0.946
	1989	14	14	1	36	0.624	0.616
	1992	4	4	0	10	0.606	0.631
	1995	16	15	0	51	0.825	0.791
	1998	1	1	0	5	0.972	1.000
	2001	0	0	N/A	N/A	N/A	N/A

Appendix 8. Annual catch (tonnes) of Yellowmouth Rockfish by the trawl fishery in PFMC areas along the B.C. coast (3CD: west coast Vancouver Island, 4B: Strait of Georgia, 5AB: Queen Charlotte Sound, 5CD: Hecate Strait, 5E: west coast Queen Charlotte Islands, UNK: Unknown, CST: coastwide). Entries marked '—' indicate no recorded catch (from Haigh and Starr 2008).

Year	3C	3D	4B	5A	5B	5C	5D	5E	UNK	CST
1971	---	---	---	5	---	---	---	---	---	5
1972	---	---	---	---	---	---	---	---	---	---
1973	---	---	---	177	---	---	---	---	---	177
1974	---	---	---	79	---	---	---	---	---	79
1975	0	---	---	1	---	---	---	---	---	2
1976	---	---	---	12	---	---	---	---	---	12
1977	---	---	---	333	3	---	4	1,257	---	1,596
1978	0	---	---	11	98	---	---	1,105	---	1,214
1979	2	0	---	6	25	---	---	405	---	438
1980	---	---	---	25	23	---	---	500	---	548
1981	0	0	---	---	46	69	---	925	---	1,039
1982	6	1	1	179	322	169	---	482	---	1,160
1983	33	40	---	411	342	58	---	640	0	1,524
1984	6	120	---	28	591	64	---	514	---	1,324
1985	4	412	---	128	371	37	0	676	---	1,628
1986	1	982	---	227	91	10	---	1,179	---	2,491
1987	7	703	---	439	82	67	0	559	---	1,857
1988	7	169	---	364	359	17	1	407	---	1,322
1989	43	315	---	599	245	24	---	386	---	1,611
1990	40	280	---	437	382	50	0	478	---	1,666
1991	37	217	---	490	339	20	1	121	---	1,225
1992	60	273	---	526	443	47	3	124	---	1,475
1993	48	301	---	383	247	19	2	157	---	1,157
1994	70	383	0	578	140	15	0	44	---	1,231
1995	65	275	---	672	290	16	1	72	---	1,391
1996[O]	112	242	0	487	418	26	0	116	---	1,402
97[I]	7	148	---	380	39	3	0	18	---	594
1997	24	326	---	882	642	20	7	38	---	1,939
1998	55	163	---	722	612	70	0	173	---	1,795
1999	66	97	---	802	758	66	1	220	---	2,008
2000	23	92	---	554	603	88	0	442	---	1,803
2001	42	82	---	809	521	43	1	432	---	1,930
2002	54	83	---	702	706	20	1	376	---	1,941
2003	22	30	0	820	617	31	0	340	---	1,860
2004	53	28	---	846	781	30	0	179	---	1,917
2005	24	22	---	596	971	40	2	161	---	1,816
2006	18	35	---	541	837	13	0	169	---	1,613
2007	21	44	0	370	992	8	12	233	---	1,680
Total	950	5,862	1	14,622	12,935	1,137	35	12,930	0	48,471

[I] Interim period (Jan-Mar) before implementation of IVQ in 1997 for offshore trawl. Fishing years prior to this period are calendar years; fishing years after this period run from April to March.
[O] Observer program started in 1996

Appendix 9. Annual catch (tonnes) of Yellowmouth Rockfish in the hook and line fishery along the B.C. coast (PFMC areas as in Appendix 1). Catches from 1989 to 1994 are taken from fisher log records; catches since 1995 are taken either from validated dockside records or fisher logs, whichever is highest (from Haigh and Starr 2008).

Year	3C	3D	4B	5A	5B	5C	5D	5E	UNK	CST
1989	---	---	---	0.3	---	---	---	---	---	0
1990	0.5	2.2	0.1	0.3	0.5	0.7	0.5	6.9	---	12
1991	0.2	0.2	0.3	1.8	0.5	3.8	1.9	4.2	---	13
1992	0.0	---	---	1.0	5.6	0.0	0.4	5.5	---	13
1993	1.4	0.8	0.9	0.4	---	---	---	6.5	---	10
1994	---	0.0	---	9.6	0.1	---	---	1.7	---	12
1995	---	0.1	---	9.9	1.2	0.0	---	6.8	5.7	24
1996	0.0	0.7	---	7.8	---	0.0	0.2	3.0	0.6	12
97[I]	---	---	---	---	---	---	---	0.0	---	0
1997	---	0.2	---	1.9	0.1	0.0	---	1.3	3.2	7
1998	0.0	0.0	0.0	4.0	0.0	0.0	---	4.5	0.4	9
1999	0.1	0.2	---	4.5	0.0	0.0	0.0	3.4	0.4	9
2000	---	0.1	0.0	4.2	2.3	0.0	0.0	1.9	0.1	9
2001	0.0	0.0	---	6.5	1.8	0.0	0.0	1.7	0.1	10
2002	---	0.1	---	14.9	3.2	0.2	0.0	3.7	2.8	25
2003	---	0.1	---	6.3	7.0	---	---	0.2	0.7	14
2004	---	0.1	---	7.8	3.7	---	---	0.1	---	12
2005	---	0.1	0.0	12.8	1.9	---	---	0.0	---	15
2006	---	---	---	---	---	---	---	0.0	---	0
2007	---	0.0	0.0	0.2	0.1	---	---	0.0	---	0
Total	2	5	1	94	28	5	3	52	14	204

[I] Interim period (Jan-Mar) before implementation of IVQ in 1997 for offshore trawl. Fishing years prior to this period are calendar years; fishing years after this period run from April to March.

Appendix 10. Annual bycatch (tonnes) of Yellowmouth Rockfish by the halibut fishery along the B.C. coast (PFMC areas as in Appendix 1) Catches from 1995 onwards are taken from either validated dockside records or fisher logs, whichever is highest (from Haigh and Starr 2008).

Year	3C	3D	4B	5A	5B	5C	5D	5E	UNK	CST
1995	---	---	0.0	0.0	0.0	0.0	---	0.0	2.1	2
1996	---	0.1	0.0	0.1	0.4	1.0	2.0	0.0	2.7	6
97[1]	---	---	---	---	---	---	---	---	0.3	0
1997	---	0.1	0.1	0.6	0.6	0.0	---	0.0	0.9	2
1998	0.0	0.2	0.2	0.5	0.9	0.3	0.0	0.0	---	2
1999	0.0	0.4	0.1	0.3	1.4	0.1	0.0	0.1	---	2
2000	---	1.6	---	---	0.6	---	---	1.1	0.0	3
2001	---	2.1	---	---	0.9	---	---	1.3	0.0	4
2002	---	3.5	---	---	1.2	---	---	2.7	0.0	7
2003	---	5.0	---	---	2.0	---	---	1.0	0.0	8
2004	---	4.7	---	---	1.9	---	---	2.7	0.0	9
2005	---	2.5	---	---	1.1	---	---	1.3	0.0	5
2006	0.1	0.2	---	8.3	5.0	0.0	0.0	0.1	---	14
2007	0.1	0.1	---	6.3	4.1	0.0	0.0	0.2	---	11
Total	0	21	0	16	20	2	2	11	6	78

[1] Interim period (Jan-Mar) before implementation of IVQ in 1997 for offshore trawl. Fishing years prior to this period are calendar years; fishing years after this period run from April to March.

Regional areas used in the halibut fishery are assigned to the following PMFCs: QC=5E, PR=5D, NC=5D, CC=5B, WC=2D, SG=4D. PFMA areas are assigned to PMFC areas using PFMA centroids in PMFC polygons.