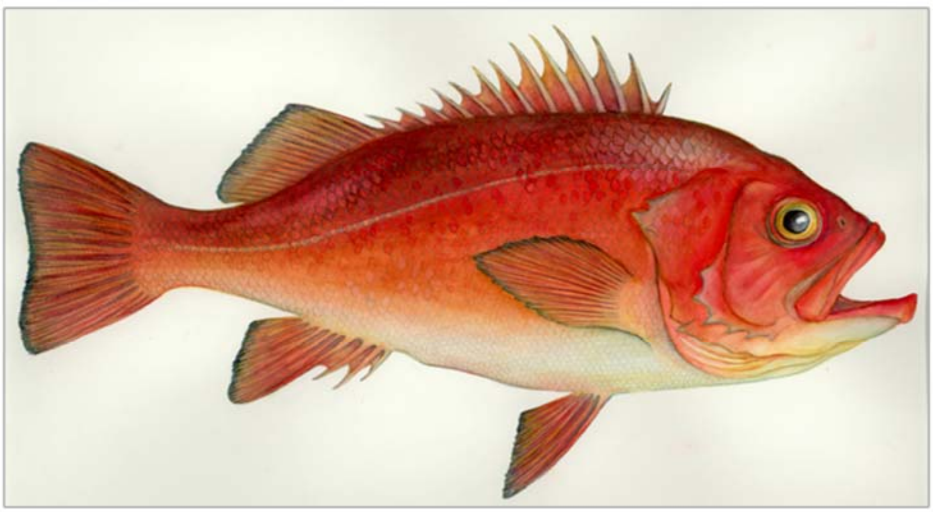
COSEWIC
Assessment and Status Report

on the

Yelloweye Rockfish
Sebastes ruberrimus

Pacific Ocean inside waters population
Pacific Ocean outside waters population

in Canada



SPECIAL CONCERN
2008

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:

COSEWIC. 2008. COSEWIC assessment and status report on the Yelloweye Rockfish *Sebastes ruberrimus*, Pacific Ocean inside waters population and Pacific Ocean outside waters population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 75 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:
This report was developed under the supervision of Howard Powles, COSEWIC (Marine fishes) Specialist Subcommittee Co-chair, with the support of Howie Wright from the Marine Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le sébaste aux yeux jaunes (*Sebastes ruberrimus*), population des eaux intérieures de l'océan Pacifique et population des eaux extérieures de l'océan Pacifique, au Canada.

Cover illustration:
Yelloweye rockfish — Drawing by Brenda G. Gillespie, courtesy of the Department of Fisheries and Oceans Canada.

Catalogue No. CW69-14/571-2009E-PDF
ISBN 978-1-100-12744-6

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – November 2008

Common name
Yelloweye Rockfish - Pacific Ocean inside waters population

Scientific name
Sebastes ruberrimus

Status
Special Concern

Reason for designation
This species is one of an inshore rockfish complex which is exploited by commercial, recreational and Aboriginal fisheries. Life history characteristics make the species particularly susceptible to human-caused mortality, with a maximum recorded age of 120 yr and generation time estimated at 66 yr. Fishery-independent surveys over the past 20 yr do not show significant declines, while declines over 19 yr in commercial catch per unit effort are not believed to represent abundance accurately. Commercial catch quotas have been reduced and restrictions on harvesting are expected to keep catches low in future; in addition, areas have been closed to commercial and recreational fishing. A designation of Special Concern is consistent with the life history characteristics and probable continued removals in fisheries.

Occurrence
Pacific Ocean

Status history
Designated Special Concern in November 2008. Assessment based on a new status report.

Assessment Summary – November 2008

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This species is one of an inshore rockfish complex which is exploited by commercial, recreational and Aboriginal fisheries. Life history characteristics make the species particularly susceptible to human-caused mortality, with a maximum recorded age of 120 yr and generation time estimated at 70 yr. Fishery-independent surveys over the past 10 yr do not show significant declines, while declines over 19 yr in commercial catch per unit effort are not believed to represent abundance accurately. Fishery quotas have been substantially reduced from the early 1990s to recent years, closed areas are in place, and restrictions on harvesting are expected to keep catches low in the future. A designation of Special Concern is consistent with the life history characteristics and probable continued removals in fisheries.

Occurrence
Pacific Ocean

Status history
Designated Special Concern in November 2008. Assessment based on a new status report.

COSEWIC
Executive Summary

Yelloweye Rockfish
Sebastes ruberrimus

Pacific Ocean inside waters population
Pacific Ocean outside waters population

Species information

The Yelloweye Rockfish *Sebastes ruberrimus* is one of 102 species of rockfish belonging to the genus *Sebastes*, 96 of which are found in the North Pacific and about 36 of which occur in Canada's Pacific waters. In Canada Yelloweye Rockfish are managed as part of an "inshore" rockfish complex which includes quillback rockfish, copper rockfish, China rockfish, black rockfish and tiger rockfish.

Two designatable units (DUs) of Yelloweye Rockfish in Canada are recognized in this report. The Pacific Ocean inside waters DU includes the Strait of Georgia, Johnstone Strait and Queen Charlotte Strait. The Pacific Ocean outside waters DU extends from at least southeast Alaska through to northern Oregon and includes the whole of the B.C. offshore, north and central coast waters. The two DUs are distinguished on the basis of genetic information indicating restricted gene flow, and age at maturity.

Distribution

Yelloweye Rockfish are found only in the northeast Pacific and have been observed from Ensenada, Baja California to Umnak Island, in the Aleutian Islands. They are present throughout the coastal waters of B.C.

Habitat

Fisheries primarily take Yelloweye Rockfish between 19 and 251 m depth (95% of observations). Yelloweye Rockfish have been observed from submersibles in depths from 30 to 232 m over substrates that are hard, complex and with some vertical relief, such as broken rock, rock reefs, ridges, overhangs, crevices, caves, cobble and boulder fields.

Biology

Female yelloweye produce between 1.2 and 2.7 million eggs annually and like all rockfishes are matrotrophically viviparous, supplying nutrients to the developing embryos. Mating takes place in November, females may store the sperm for weeks prior to fertilization, and parturition occurs in May and June. A prolonged pelagic larval phase may last for up to two months, after which settlement occurs to benthic habitats. Juveniles usually occur in shallower waters than their conspecific adults. Yelloweye Rockfish are solitary benthic dwellers with small home ranges.

Yelloweye Rockfish have been aged to 115 years in B.C. and females reach 50% maturity at about 16 and 20 years of age for the outside waters and inside waters DUs, respectively. Generation time (G = A + 1/M, where M or natural mortality is 0.02 and A is age at 50% maturity) is estimated at 66 and 70 years for the outside and the inside areas, respectively. Mean age of reproductive females is estimated at 32.5 years for the outside population and 37.5 years for the inside population. On average, females tend to be larger and older than the males and can reach a maximum size of 88 cm in B.C. Total mortality estimates range from 0.03 to 0.06, suggesting fishing mortality of 0.01 to 0.03.

Population and trends

Both survey and commercial catch per unit effort (CPUE) information is available to assess population trends in inside and outside DUs, although reliability of the various indices is variable. For the outside DU, a longline survey conducted for halibut with broad coverage of the continental shelf shows a CPUE decline of 40% from 1995 to 2004 but the slope is not significant; a hook and line survey in limited areas shows an insignificant increase. Commercial handline and longline CPUE declined 85% and 59% respectively between 1986 and 2004 but CPUE was probably affected by fishery changes as well as by abundance. For the inside DU, submersible surveys in 1984 and 2003 showed declines in mean, median and maximum sightings per transect but these were not significant. Commercial handline and longline CPUEs declined 59% and 49% respectively. Age and length information indicates that the proportion of old individuals declined into the early 1990s and that a recruitment event occurred in the mid-1990s. Overall, abundance has probably declined in about 20 years, when data are available, but it is not possible to quantify the decline.

Limiting factors and threats

Fishing is the principal identified threat, with both commercial and recreational sectors exploiting this species. These fisheries have exploited the species at least since the early years of the 20th century and landings were probably substantial prior to the 1950s when catch statistics first became available. Total landings in the outside increased to a maximum of 1200 t/yr in the early 1990s, declining thereafter with reduced abundance and imposition of management controls, to around 200 t/yr recently. A similar pattern occurred in the inside with a maximum of around 160 t/yr in the late 1980s and a subsequent decline to around 20 t/yr in recent years. Commercial catches have been well monitored since the mid 1990s. Recreational catches are not well monitored and information on removals is imprecise. Fishery management measures have recently been strengthened and this threat is better controlled than in the past. Inside areas have been exploited more intensively and for a longer period than outside areas.

Particularly slow growth, late maturation, and low natural mortality make Yelloweye Rockfish particularly susceptible to mortality from human activities.

Special significance

Yelloweye are among the largest (90 cm maximum) rockfish and are very slow growing and late maturing, even among rockfishes. Given their longevity, large size, and piscivorous diet, they are likely important in structuring nearshore rocky reef ecosystems. They are a targeted species in Aboriginal, recreational and commercial fishing sectors. “Red cod” or Yelloweye Rockfish are culturally significant to First Nations.

Existing protection or other status designations

Yelloweye Rockfish do not have any international status designations. In U.S. waters to the south of B.C. Yelloweye Rockfish were designated “overfished” in 2002 and the species is under a rebuilding plan in the Washington-California area.

In Canada total allowable catch (TAC) of Yelloweye Rockfish in commercial fisheries was reduced by 50% outside and 75% inside between 2001 and 2002 in response to concerns about population status. The coastwide overall total allowable catch has remained at 300 t since 2002. Rockfish Conservation Areas (areas closed to all commercial and recreational fishing) protect rockfish habitat with a goal of 20% protection outside and 30% inside; currently 164 such RCAs are in place. All commercial fisheries taking this species are 100% monitored at sea: trawl fisheries by observers since 1996, hook and line fisheries by video since 2006. Recreational bag limits have been reduced but the recreational fishery is not well monitored.

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
(2008)

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.

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SPECIES INFORMATION

Name and classification

The Yelloweye Rockfish *Sebastes ruberrimus* is one of 102 species of rockfish in the genus *Sebastes* worldwide and one of 96 species of rockfish found in the North Pacific. The genus and species names are from the Greek *sebastos* (magnificent) and the Latin *ruberrimus* (very red) (Hart 1973). In Canada's Pacific waters 36 species of rockfish have been found (Peden and Gillespie unpublished manuscript). Yelloweye Rockfish are referred to by many names including red snapper, red rock cod, rasphead rockfish, red rockfish, red cod, goldeneye rockfish, and turkey red rockfish (Lamb and Edgell 1986). Yelloweye Rockfish are managed in B.C. as part of the "inshore" rockfish complex which includes quillback rockfish (*S. maliger*), copper rockfish (*S. caurinus*), China rockfish (*S. nebulosus*), black rockfish (*S. melanops*) and tiger rockfish (*S. nigrocinctus*).

Morphological description

Yelloweye Rockfish are one of the largest rockfish, reaching a maximum recorded length of 91 cm and 11.3 kg (Love *et al*. 2002). They are easily identified by their bright orange to red colouration and bright yellow eyes. Adults usually have a light to white stripe on their lateral line (Figure 1). Juveniles are more dark red in colouration than the adults and have two light stripes, one on the lateral line and a shorter one below the lateral line (Mecklenburg *et al*. 2002) (Figure 1). Yelloweye Rockfish have 13 dorsal spines and the fins may have black tips (Kramer and O'Connell 1995).

Figure 1. Photographs of Yelloweye Rockfish taken from a submersible, adult (left panel) and juvenile (right panel). Photo credit K. L. Yamanaka.

Genetic description

Geographic variation accounted for less than 1% of the observed genetic variation in a microsatellite survey of 2500 Yelloweye Rockfish captured in coastal waters of British Columbia (B.C.) and southeast (SE) Alaska between 1998 and 2000 (Yamanaka *et al*. 2000). The genetic data did not refute the null hypothesis that all samples were drawn from a single population. The level of polymorphism was moderate, for a marine fish, with an average of 13 alleles observed at the 13 microsatellite loci. Moderate to high levels of expected heterozygosity in all samples (range 71.1% to 74.0%) also indicated that the effective population size for yelloweye in B.C. was large. Sample sites included in the study ranged from southeast Alaska to Vancouver Island, but all samples in B.C. were collected off the west coasts of the Queen Charlotte or Vancouver islands. Thus, no samples from coastal mainland sites, the straits of Georgia, Juan de Fuca or Queen Charlotte, or southern U.S. waters were analyzed.

Yamanaka *et al*. (2006) identified a Pacific Ocean inside waters population of Yelloweye Rockfish from the Strait of Georgia that was genetically distinct from a Pacific Ocean outside waters population including all Yelloweye Rockfish samples collected in waters outside of the Strait of Georgia from Sitka, Alaska to Oregon. For all samples from outside waters (which excluded 'inside' samples from the Georgia and Queen Charlotte straits) the level of genetic diversity (expected heterozygosity) at the nine loci ranged from 70.7% to 74.2% (average = 72.5%) and standardized allelic richness (for a sample size of 46 fish) ranged from 10.7 to 11.7. In contrast, the three samples from the inside waters of Georgia Strait and Queen Charlotte Strait showed significantly lower levels of heterozygosity (P=0.004) and allelic diversity (P=0.002). For all three samples combined, the expected heterozygosity was 62.7% and allelic diversity was 8.0.

The inside samples contained no unique microsatellite alleles not also found in outside samples (Yamanaka *et al*. 2006).

The reduced heterozygosity and number of alleles observed in the "inside" yelloweye samples indicated that they were drawn from a population with a smaller effective population size than all other samples (Yamanaka *et al*. 2006). For neutral loci following an infinite alleles mode of mutation, the relationship between effective population size (N_e) and heterozygosity is expected to be: $H = 4N_e\mu/(1+ N_e\mu)$ (Kimura and Crow 1964) where μ is the mutation rate. This indicates that the effective population size of Yelloweye Rockfish in the waters inside Vancouver Island is about two thirds that of Yelloweye Rockfish in outside waters. Actual values of N_e depend on the mutation mode and rate of microsatellite loci in yelloweye.

Genetic analysis of additional samples of Yelloweye Rockfish from the Strait of Georgia and from Johnstone, Queen Charlotte and Juan de Fuca Straits has recently been conducted to provide additional information on the distinctiveness and geographic extent of the Inside Yelloweye Rockfish population. These analyses are summarized in paragraphs which follow.

Samples in addition to those of Yamanaka *et al.* (2006) were obtained through sampling commercial catches in 2000 and 2005 and through onboard sampling of research survey catches from 2005 to 2007 (Table 1; Figs. 2, 3). The new samples consist of a single fish sampled in the Strait of Juan de Fuca and two fish sampled near Saltspring Island in 2000, and a series of samples collected throughout the inside waters between Gordon Channel at the northern end of Queen Charlotte Strait and

Saltspring Island at the southern end of Georgia Strait between 2005 and 2007. Additionally, a total of 7 Yelloweye Rockfish were sampled off the lower west coast of Vancouver Island in 2005 and in 2006 (Table 1, Figure 2).

The three samples of Inside fish identified in Yamanaka *et al*. (2006) are included (Table 1) for completeness but given more exact capture locations as follows:

Georgia Strait 2000 has been re-labelled Gabriola Island 2000
Georgia Strait 2005 has been re-labelled Gabriola Island 2005
Queen Charlotte Strait 2004 has been re-labelled Lower Bute Inlet 2004

DNA was extracted from the Yelloweye Rockfish samples and nine microsatellite loci were amplified for each fish as described in Yamanaka *et al.* (2006). These new data together with some Outside samples were used to construct a neighbour-joining dendrogram of samples based on F_{ST} values with the program GDA (Lewis and Zaykin 2001).

Individual Yelloweye Rockfish collected from Juan de Fuca Strait, the Strait of Georgia and the lower west coast of Vancouver Island were classified as belonging to the Inside or Outside populations of Yelloweye Rockfish as follows. The 2000 and 2005 Gabriola samples and 2005 West Texada samples were combined to form a baseline sample of the Inside population. All samples from outside waters, previously shown to exhibit no consistent geographic population structure at these nine loci, were combined to form a baseline population of the Outside population. A Bayesian analysis based on Monte Carlo Markov chains was conducted to determine relationships of individuals to inside or outside populations (methodological details are available on request).

Levels of expected and observed heterozygosity tended to be low in the new samples (Table 1), consistent with earlier results from inside waters (Yamanaka *et al.* 2006) showing a level of allelic richness lower than in outside waters. However, several samples had values of expected or observed heterozygosity, or both, that exceeded 0.70. These samples included the small samples from Saltspring Island (7 fish collected between 2000 and 2007) and the lower west coast of Vancouver Island (7 fish collected in 2005 and 2006). The two larger samples from Gordon Channel also had higher heterozygosity levels.

Relationships among the samples based on F_{ST} values indicate that most of the new samples collected from inside waters are most closely related to the original three samples of the Inside population described by Yamanaka *et al*. (2006) (Figure 4). Exceptions are the 2006 and 2007 samples collected from Gordon Channel, the most northerly sampling site in Queen Charlotte Strait, and the 2005 – 2006 sample from the lower west coast of Vancouver Island, all of which clustered with samples of the Outside population. Bootstrap support for the separation of the samples into the Inside and Outside sample clusters apparent in the dendrogram was 65.1%.

In accordance with the genetic relationships depicted in the neighbour-joining dendrogram, most of the new Yelloweye Rockfish samples were individually classified as belonging to the Inside population by the Bayesian analysis (Figure 5). Again, the 2006 and 2007 samples from Gordon Channel and the lower west coast of Vancouver Island sample were exceptions, as was the single fish sampled from the Strait of Juan de Fuca in 2000. All 73 fish sampled over two years from Gordon Channel, six of the seven fish sampled from Vancouver Island and the Juan de Fuca fish were classified as Outside Yelloweye Rockfish. All other rockfish except for a single fish from each of the 2006 George Passage, 2007 Thurlow Island, 2005 Mitlenatch Island and 2007 Saltspring Island samples were classified as Inside fish. Thus, of 295 rockfish sampled from 2005 to 2007 in inside waters between George Passage and Saltspring Island, all but four were classified as belonging to the Inside population. Similarly, in waters beyond these sampling sites Yelloweye Rockfish were almost uniformly classified as belonging to the Outside population, with only the occasional exceptions (3 of 78 fish from the B.C. central coast, 1 of 130 from Topknot, 1 of 7 from lower west coast Vancouver Island and 1 of 95 from Oregon were classified as belonging to the Inside population).

Whether the ‘exceptional’ fish within the samples that are predominantly of Inside or Outside origin are simply misclassified because they carry a rare genotype for the population to which they belong, or they represent true ‘migrants’ originating from the other population, or they are indicative of the presence of hybrid fish of admixed genetic origin is not clear. In any case, the level of mixture or admixture of the two populations seems limited.

The most westerly George Passage sampling location is 50.728^{o} N and 127.033^{o} W, the most easterly Gordon Channel sampling location is 50.869^{o} N and 127.215^{o} W. A western boundary is proposed, between these locations, in a straight line, connecting the western shores of Numas and Malcolm Islands within Queen Charlotte Strait (Figure 6). The southernmost Saltspring Island sampling location is 48.687^{o} N and 123.292^{o} W, and the Juan de Fuca sampling location is 48.300^{o} N and 123.730^{o} W. A southern boundary is proposed coinciding with the Canadian portion of the southern boundary of the Strait of Georgia marine ecozone as defined by the Department of Fisheries and Oceans (Powles *et al*. 2004) (Figure 6).

Designatable units

Two designatable units of Yelloweye Rockfish in B.C. are proposed in this report, consistent with available information on distinctness and significance of the populations described above. Northern and southern boundaries of the inside DU are proposed based on genetic relationships of individual specimens to inside or outside populations. The most westerly George Passage sampling location is 50.728^{o} N and 127.033^{o} W, the most easterly Gordon Channel sampling location is 50.869^{o} N and 127.215^{o} W. A western boundary is proposed, between these locations, in a straight line, connecting the western shores of Numas and Malcolm Islands within Queen Charlotte Strait (Figure 6). The southernmost Saltspring Island sampling location is 48.687^{o} N and 123.292^{o} W, and the Juan de Fuca sampling location is 48.300^{o} N and 123.730^{o} W. A southern boundary is proposed which coincides with the Canadian portion of the southern boundary of the Strait of Georgia marine ecoregion proposed by DFO (Powles *et al.* 2004) (Figure 6).

The two identified populations are considered to meet the COSEWIC distinctness criteria for designatable units for the following reasons:

- The ‘inside’ population samples form a distinct grouping, characterized by a shared pattern of reduced genetic diversity, genetic similarity among samples, and significant genetic differentiation relative to ‘outside’ populations. The observed genetic differentiation between inside and outside population samples is relatively large for a marine fish, particularly one with an extended pelagic larval phase. Although unique microsatellite alleles were not found in the inside population, unique microsatellite alleles are very rarely, if ever, observed in marine fish populations;
- age at 50% maturity is different for the two areas: 16 and 20 years for the outside and inside areas respectively (see subsequent section on biological characteristics);
- the proposed inside DU corresponds closely with the "Strait of Georgia" marine ecozone defined by the Department of Fisheries and Oceans (Powles *et al.* 2004).

The two populations are considered to meet the "significance" criterion for designatable units because because they have persisted in two different marine ecoregions with presumably different selective regimes (i.e. leading to different local adaptation). For instance, the difference in age at maturity may reflect differences in regimes. Loss of either population (notably the inside population) would result in an extensive gap in the historical range of the species in Canada.

In this report biological data and population indices are summarized separately for “inside” and “outside” areas. The “inside” area is defined by DFO as Pacific Fishery Management Areas 12 to 20, 28 and 29 (Yamanaka and Lacko 2001). The “outside” area is defined by DFO as all B.C. waters other than those defined as “inside”.

Table 1. Expected (HE) and observed (HO) heterozygosity values for new Yelloweye Rockfish samples. N is sample size.

Location	Date	N	H_E	H_O
Gordon Channel	2006	26	0.75	0.72
Gordon Channel	2007	37	0.71	0.68
George Passage	2006	6	0.58	0.60
George Passage	2007	14	0.68	0.68
U. Johnstone St	2007	19	0.62	0.62
L. Johnstone St	2006	27	0.63	0.62
Thurlow Islands	2007	11	0.63	0.65
L. Bute Inlet*	2004	35	0.67	0.66
L. Bute Inlet	2006	29	0.62	0.57
L. Bute Inlet	2007	19	0.63	0.62
Desolation Sound	2005	89	0.62	0.63
Mitlenatch Island	2005	9	0.62	0.63
Mitlenatch Island	2006	28	0.68	0.65
Malaspina Strait	2005	24	0.64	0.67
Howe Sound	2005	3	0.65	0.52
W. Texada Island	2005	66	0.62	0.60
Gabriola Island*	2000	57	0.63	0.60
Gabriola Island*	2005	90	0.64	0.65
Saltspring Island	2000 - 2007	7	0.67	0.73
Juan de Fuca Strait	2000	1	-	-
L. W. Vancouver Island	2005 - 2006	7	0.74	0.72

* denotes renamed populations from Yamanaka *et al*. (2006) to reflect the finer geographic scale of this analysis

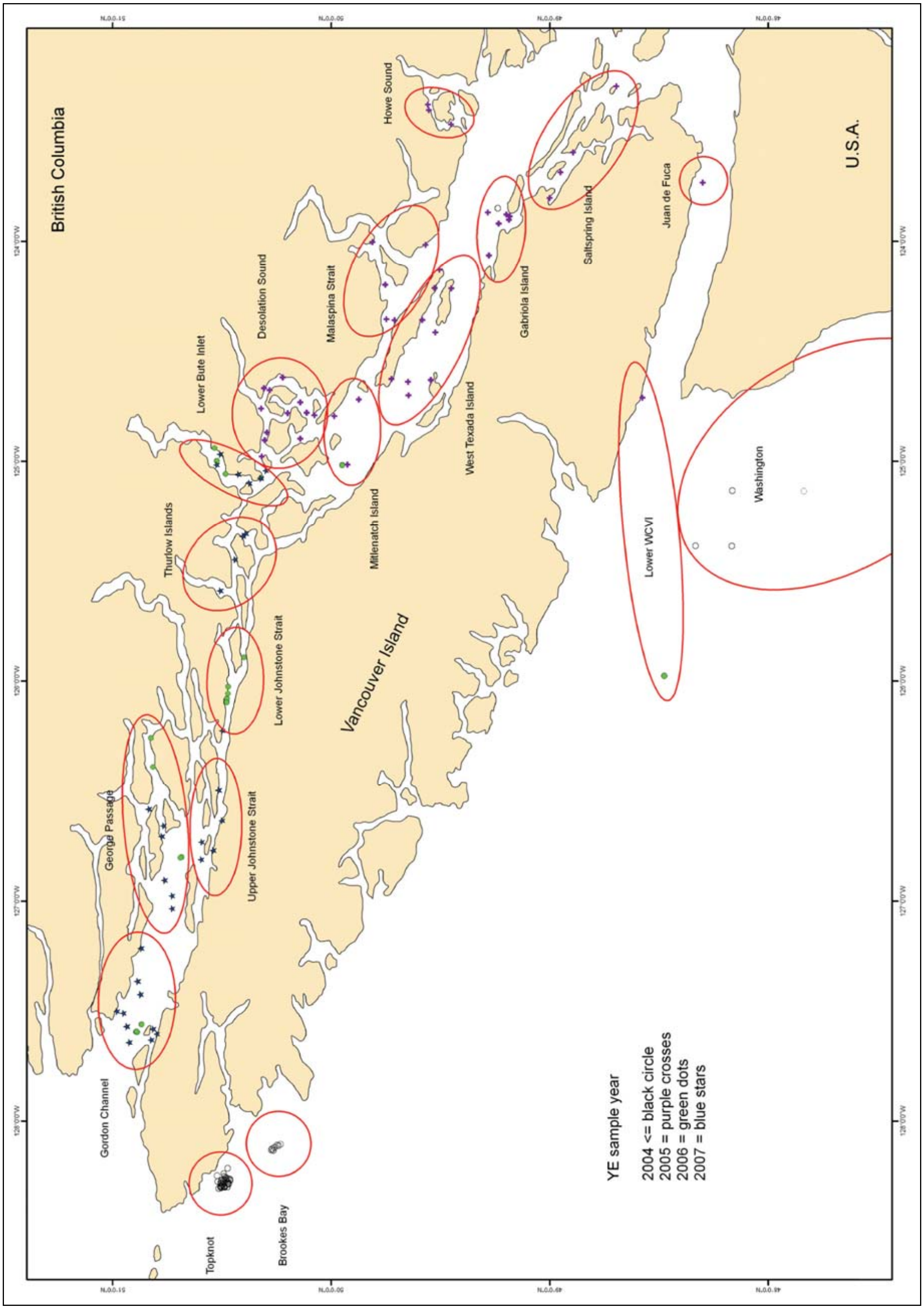

Figure 2. Yelloweye Rockfish sampling locations from the southern British Columbia region. Only the most recent samples available, additional to those of Yamanaka *et al.* (2006) are included here.

Figure 3. Yelloweye Rockfish sampling locations from Alaska, British Columbia, Washington and Oregon, used by Yamanaka *et al.* (2006).

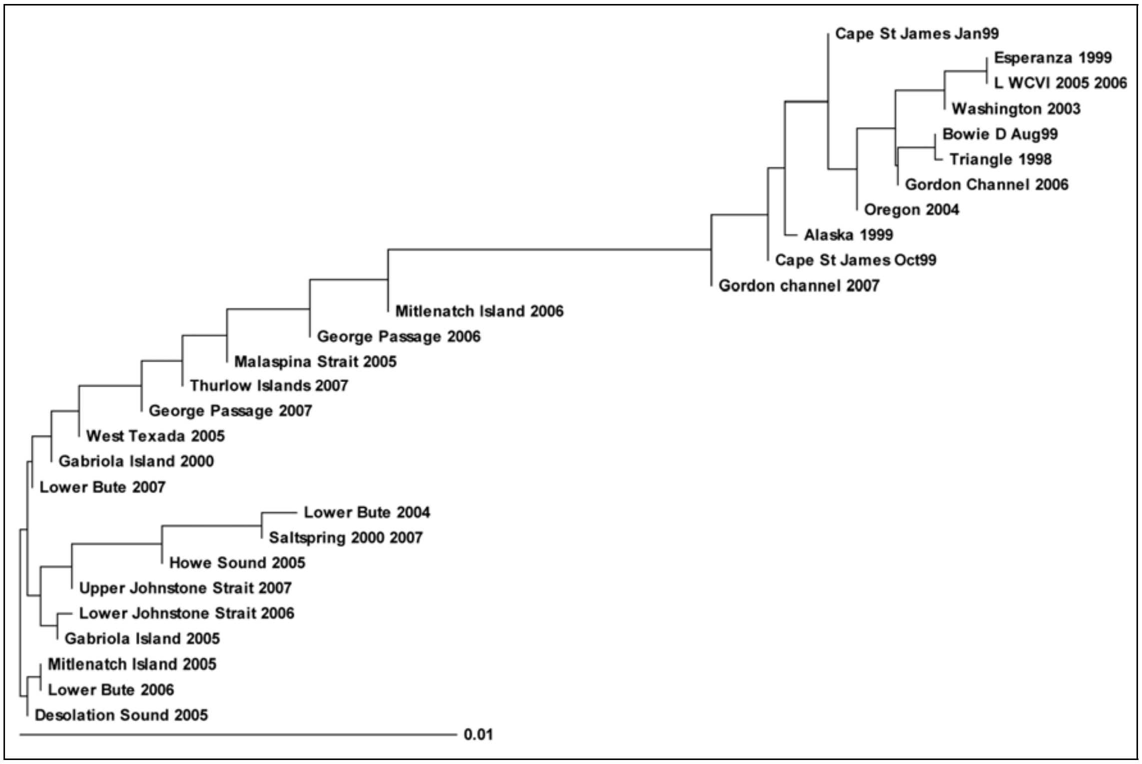

Figure 4. Neighbour-joining dendrogram of genetic relationships among Yelloweye Rockfish samples collected in waters between Vancouver Island and mainland B.C./Washington State and samples from the Outside yelloweye population which extends from Alaska to Oregon.

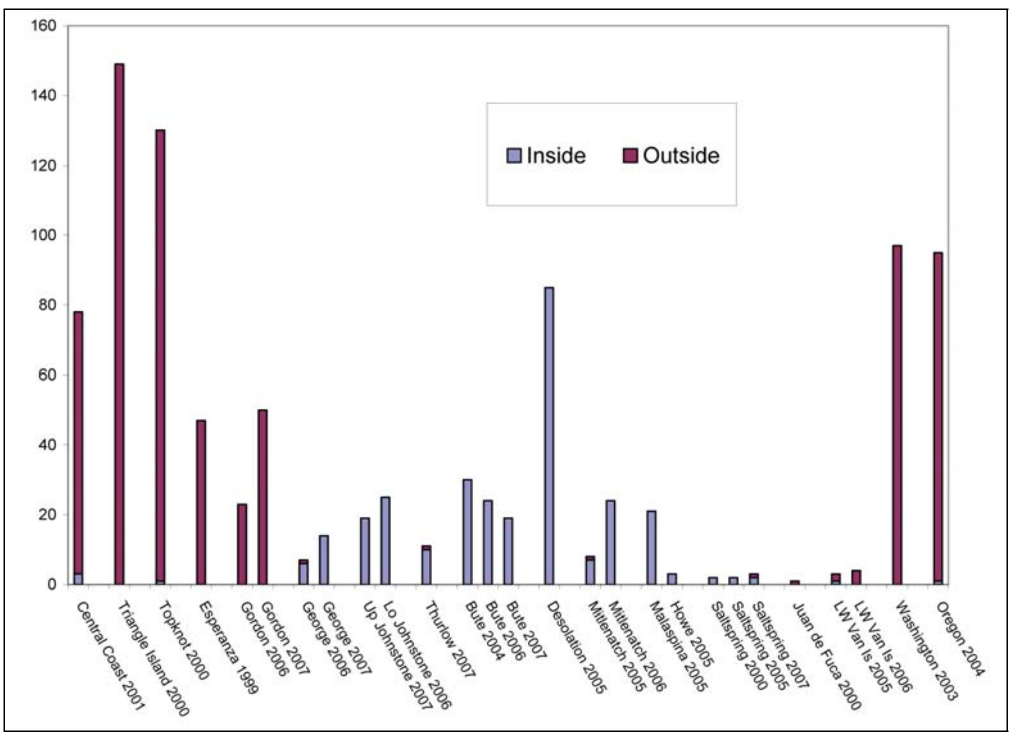

Figure 5. Yelloweye Rockfish classified as belonging to the Outside or Inside populations in coastal samples to the north (B.C. central coast), west (Triangle Island, Topknot, Esperanza Inlet, lower west coast of Vancouver Island) and south (Washington, Oregon) of samples collected in the waters between Vancouver Island and mainland B.C./Washington State (Gordon Channel to Juan de Fuca Strait).

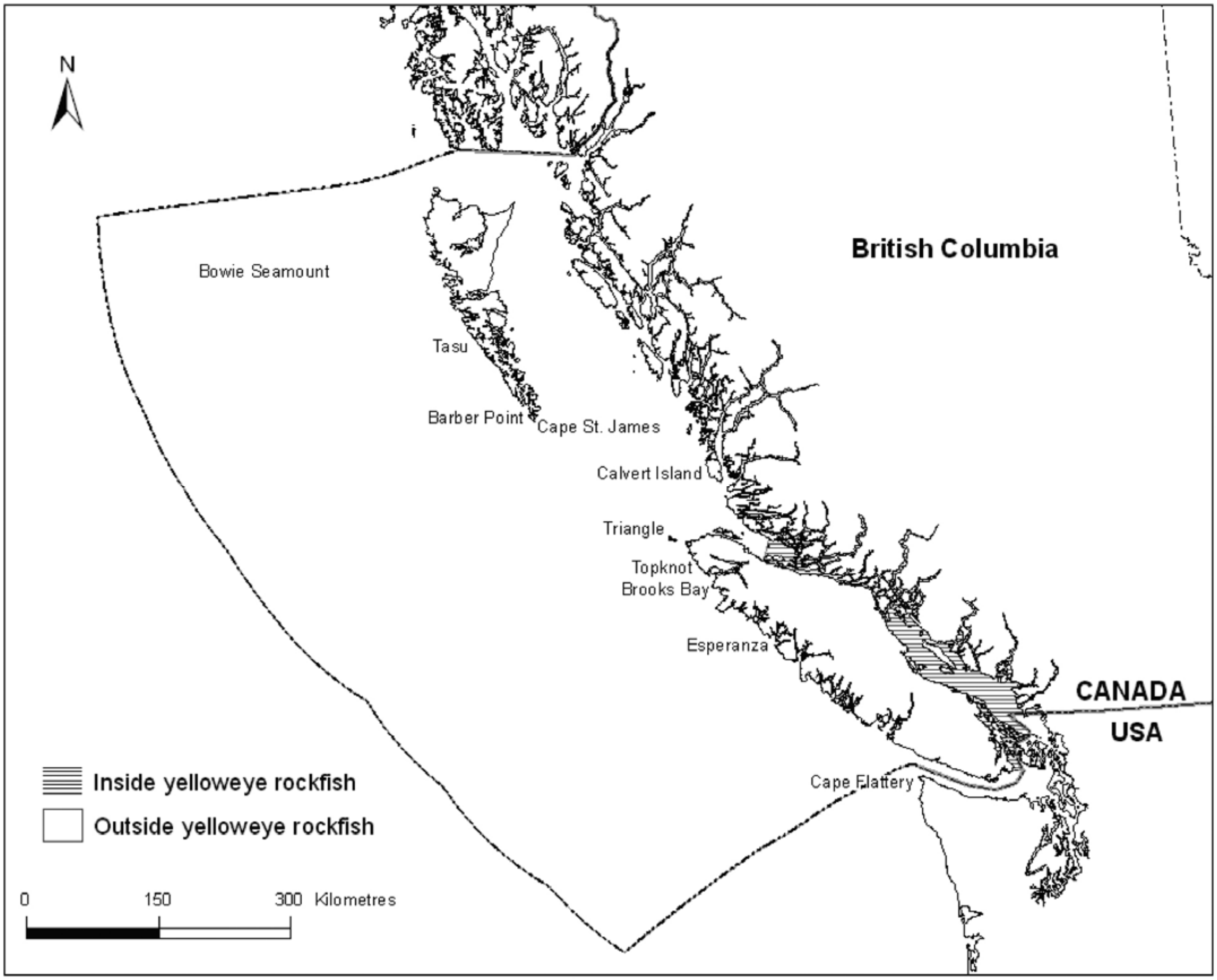

Figure 6. Proposed boundaries between Inside and Outside DUs.

DISTRIBUTION

Global range

Yelloweye Rockfish are found only in the northeast Pacific and have been observed from as far south as Ensenada, northern Baja California to south of Umnak Island, in the Aleutian Islands (Phillips 1957) (Figure 7).

Figure 7. Global distribution of Yelloweye Rockfish reprinted with permission from Love *et al*. (2002).

Canadian range

Yelloweye Rockfish range throughout the marine waters of Canada's Pacific Coast, based on records from commercial fisheries and surveys (Figure 8). Canadian distribution of this species is approximately 20% of the global range (Love *et al*. 2002).

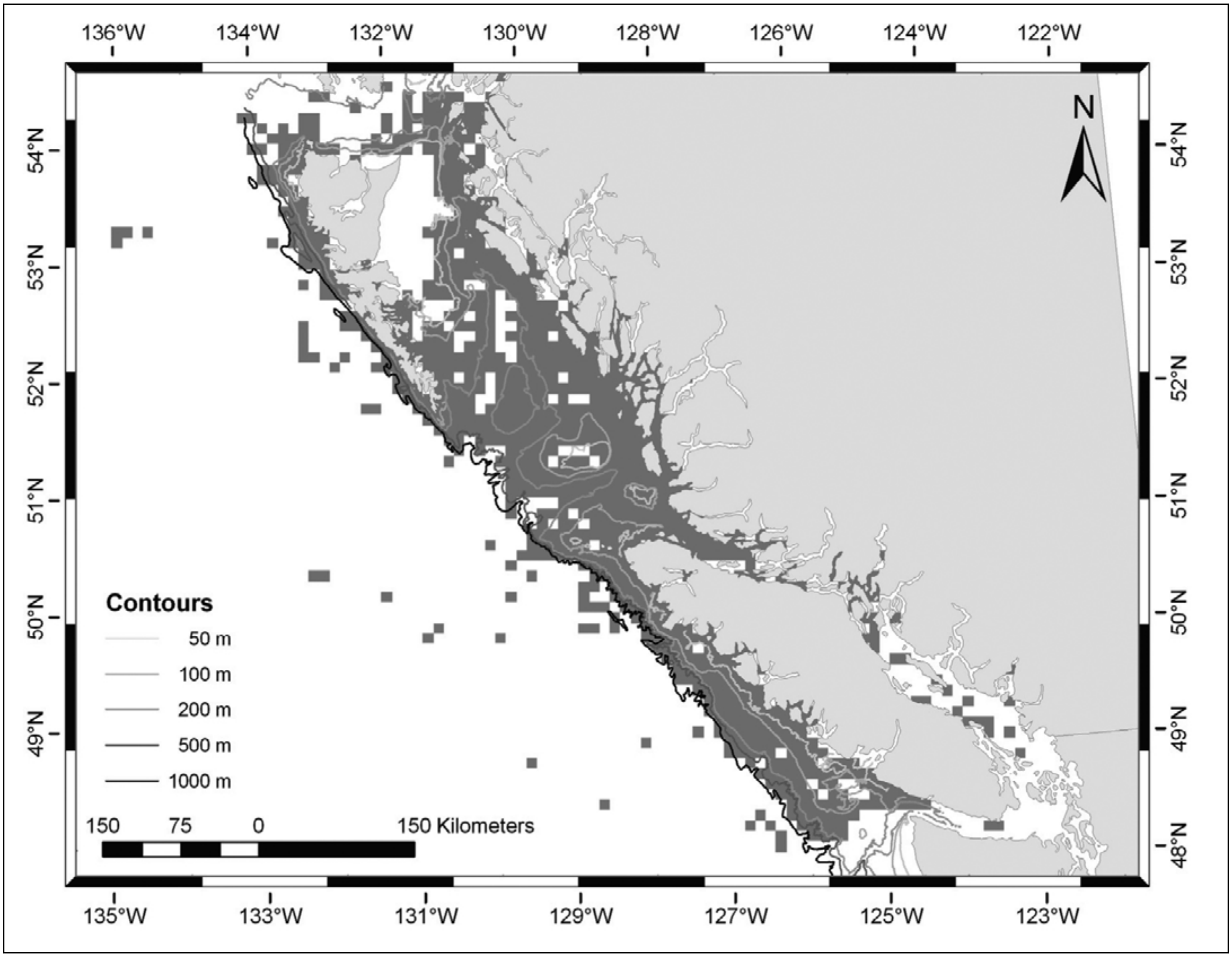

Figure 8. Distribution of Yelloweye Rockfish in B.C. from commercial hook & line and trawl catch records and groundfish research surveys (1996-2004) summarized on a 10 by 10 km coastwide grid (Yamanaka *et al.* 2006).

More detailed information is available on spatial distribution and catch rate of Yelloweye Rockfish on the inside waters from combined longline survey data collected in 2003, 2004 and 2005 (Figure 9). Yelloweye Rockfish occur from Queen Charlotte Strait in the north to D'Arcy Island in the Gulf Islands in the south. The research survey for the inside area covers 2,359 2x2 km blocks of potential Yelloweye Rockfish habitat. Of these blocks, 233 were surveyed and 101 (43%) had a Yelloweye Rockfish catch. Yelloweye Rockfish were not caught in the fishing sets made in Juan de Fuca Strait, supporting the placement of the southern boundary of the inside DU.

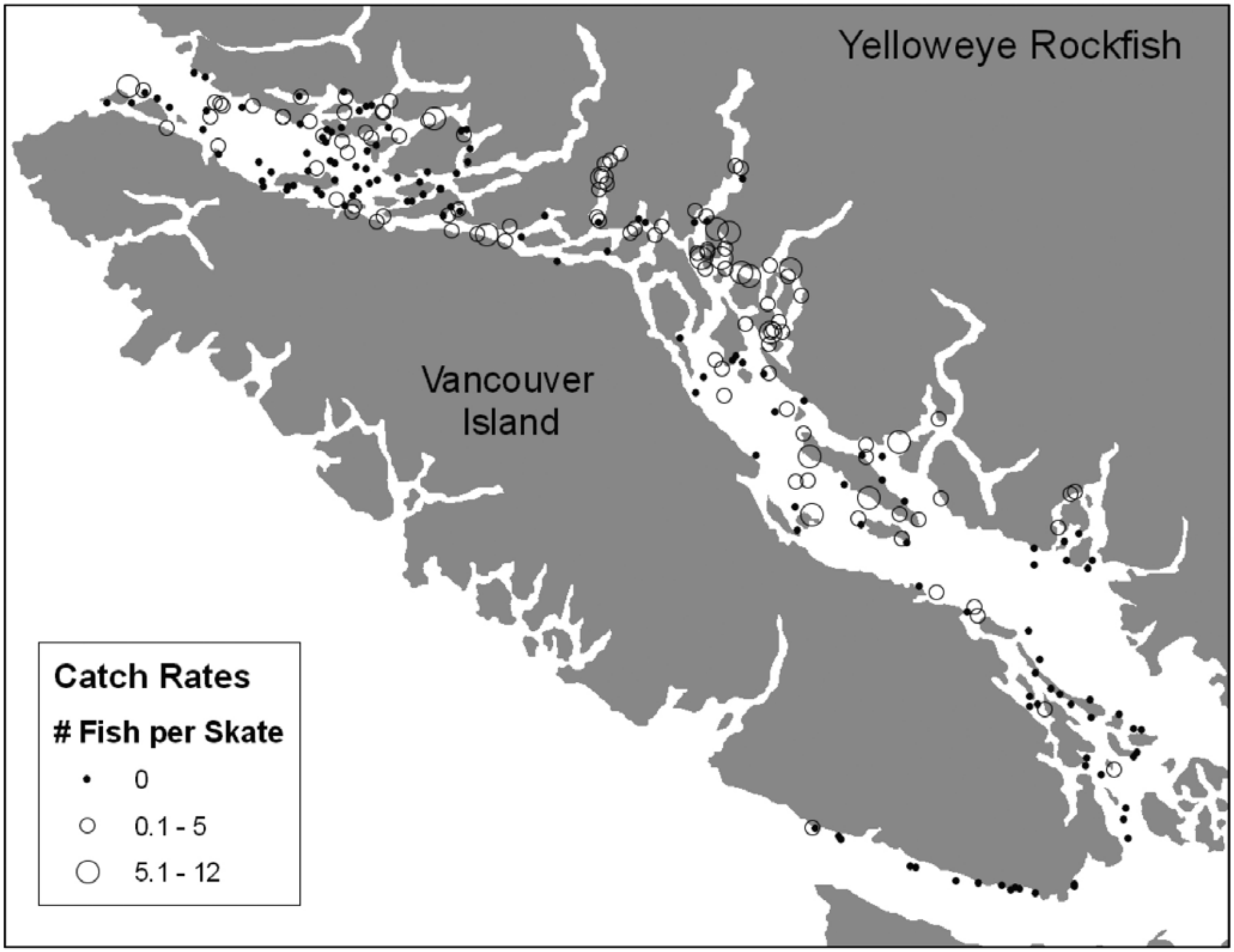

Figure 9. Spatial distribution of catch rate for Yelloweye Rockfish during the research longline surveys conducted in 2003, 2004 and 2005 combined (Yamanaka *et al.* 2006)

Extent of occurrence

A generalized distribution of catch (commercial hook & line and trawl and groundfish research surveys) by depth interval was derived by overlaying bathymetry on the catch records and summarizing data over a 10 X 10 km grid to estimate extent of occurrence (Yamanaka *et al.* 2006) (Tables 2, outside, and 3, inside). Yelloweye Rockfish are most commonly caught in the 51-100 m and 101-200 m depth. They are widely distributed and recorded as caught in all depth intervals and overall occupy 66% and 32% of the total surface area outside and inside, respectively.

Based on these analyses an estimate of extent of occurrence for the outside area is 77, 585 km^2 and for the inside 4,182 km^2.

Table 2. For the outside area, the total surface area (km^2) of marine water by depth interval (m) from 1 to 2000 m (based on map bathymetry), area with Yelloweye Rockfish commercial and research survey catch recorded and the percentage of the total surface area with Yelloweye Rockfish catch recorded for the years 1996 – 2004 combined.

Depth Interval (m)	Total Area (km^2)	Occurrence (km^2)	Percent Occupied
1-50	18,620	9,809	52.7
51-100	18,128	15,468	85.3
101-200	32,399	28,164	86.9
201-500	22,836	15,626	68.4
501-1000	7,277	4,412	60.6
1001-1500	8,475	2,313	27.3
1501-2000	10,631	1,793	16.9
Total:	118,366	77,585	65.5

Table 3. For the inside area, the total surface area (km^2) of marine water by depth interval (m) from 1 to 2000 m (based on map bathymetry), area with Yelloweye Rockfish commercial and research survey catch recorded and the percentage of the total surface area with Yelloweye Rockfish catch recorded for the years 1996 – 2004 combined.

Depth Interval (m)	Total Area (km^2)	Occurrence (km^2)	Percent Occupied
1-50	2,947	720	24.4
51-100	2,003	775	38.7
101-200	3,970	1,703	42.9
201-500	3,629	927	25.5
501-1000	192	57	29.7
Total:	12,741	4,182	32.8

Area of occupancy

Examining the depth of capture for Yelloweye Rockfish recorded on commercial hook and line and trawl fishery logbooks and groundfish research surveys, 95% of all observations lie between 19 and 251 metres in depth (Yamanaka *et al.* 2006) (Figure 10).

An estimate of the maximum potential habitat area for Yelloweye Rockfish was derived by applying this preferred depth range (surrogate for habitat), to bathymetry coastwide. Summarizing over a 5 x 5 km grid, an estimate of maximum potential habitat is 83,596 km^2 coastwide in B.C. The habitat area with Yelloweye Rockfish catch, or occupied habitat area, an estimate of area of occupancy, is 41,775 km^2 or 50 percent of the maximum potential habitat area. The area of occupancy within the outside and inside areas is 40,175 and 1,600 square kilometres, respectively (Figure 11).

This estimate does not differentiate between bottom types (it includes them all), which would lead to this being an overestimate of the true habitat area as Yelloweye Rockfish associate only with hard bottom substrates within their depth range. On the other hand, not all potential habitat areas have been fished, which would lead to this being an underestimate.

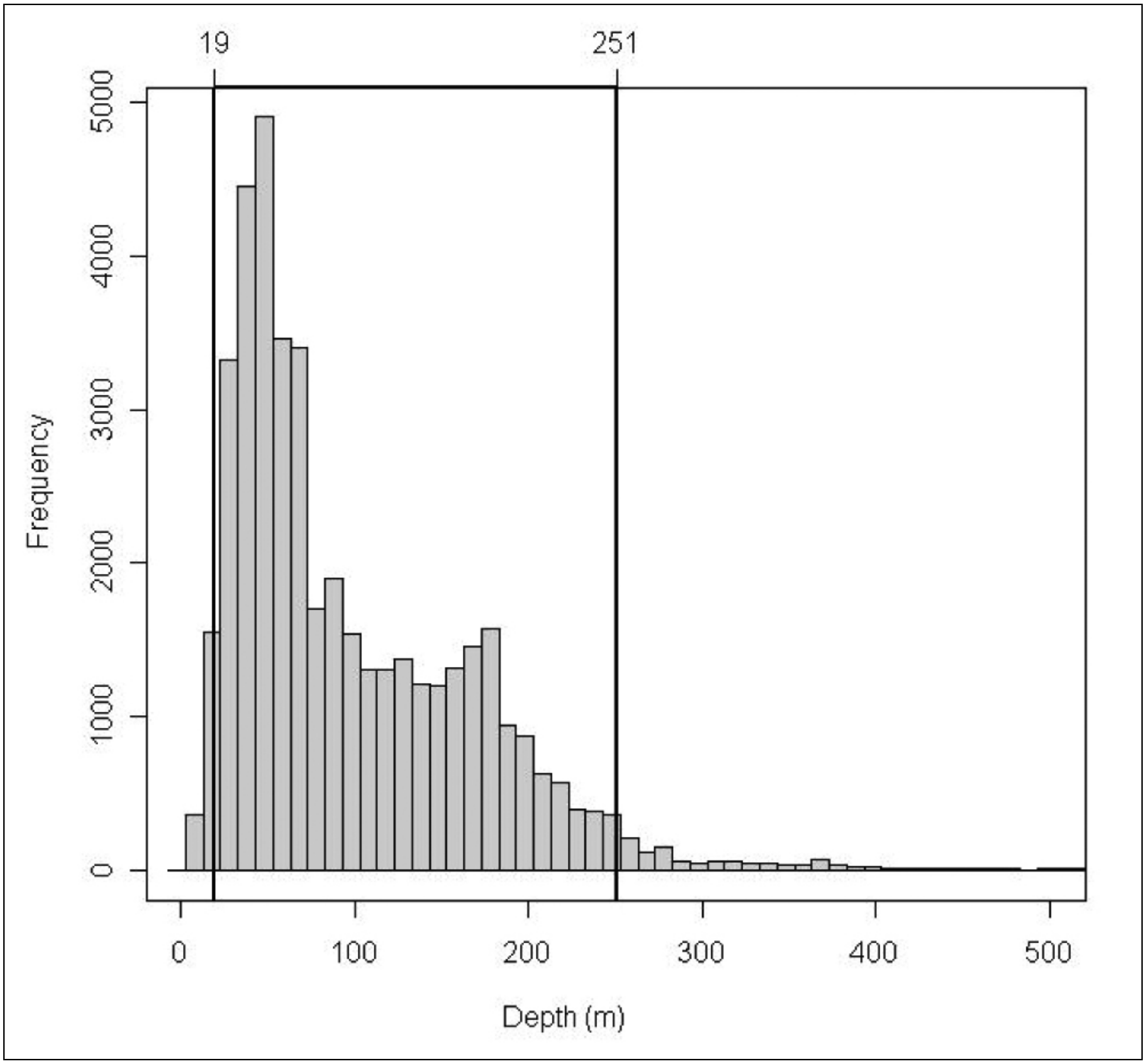

Figure 10. Histogram of the capture depth of Yelloweye Rockfish in the commercial hook & line and trawl fisheries in B.C. between 1996 and 2004. Vertical lines denote the 2.5% and 97.5% quartiles of the data (Yamanaka *et al.* 2006).

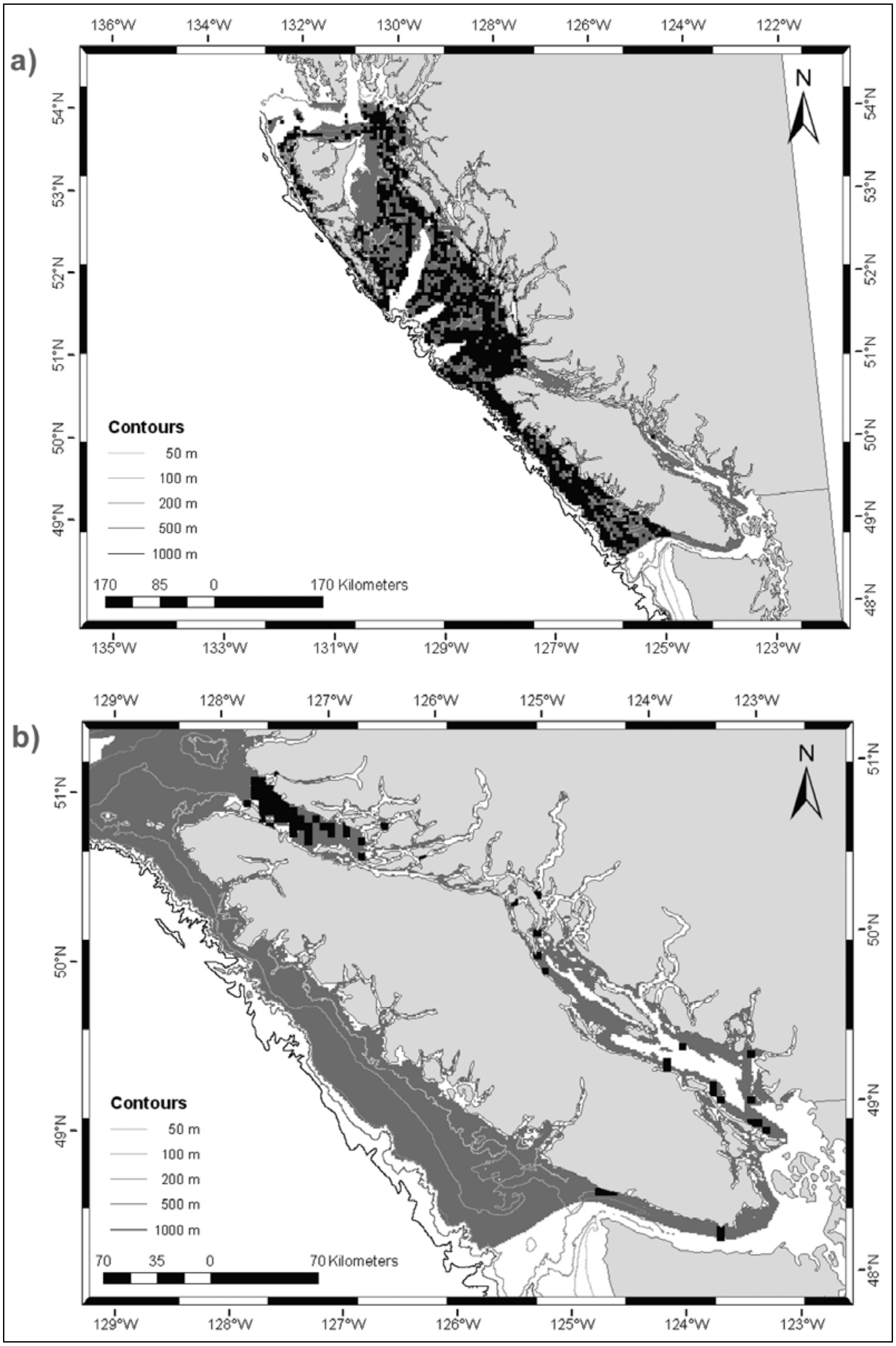

Figure 11. Maximum potential habitat (grey shading) of Yelloweye Rockfish in Canadian waters, based on the depth of capture range of 19 to 251 m, over a 5 x 5 km grid, is 83,596 square kilometres. The occupied habitat (black shading) based on commercial fishing records and research surveys, for the years 1996 – 2004 combined, is 41,775 square kilometres, or 50% of the potential habitat. For the outside (a) and inside (b) areas, there are 40,175 and 1,600 square kilometres of occupied habitat, respectively (Yamanaka *et al.* 2006).

Temporal changes in distribution

The distribution of Yelloweye Rockfish for all depths combined was examined by year to determine whether temporal changes have occurred. The percent of total area with Yelloweye Rockfish commercial catch was determined annually for the outside and inside areas from 1996 to 2004 (Table 4). In the outside area, the percent of occupied blocks was fairly stable between 1996 and 2000 at ~ 56% then decreased to 47% between 2001 and 2004. Similarly for the inside area, occupied blocks were stable between 1997 and 2000 at ~74% and decreased to ~30% between 2001 and 2003.

Table 4. The total number of blocks (10 x 10 km grid) fished, the total number of blocks with a recorded Yelloweye Rockfish catch (commercial fisheries and research surveys) and the percent of blocks with Yelloweye Rockfish catch for the outside and inside areas by year (1996-2004) (Yamanaka *et al.* 2006).

Year	Area	Blocks Fished	Blocks Occupied	Percent
1996	Outside	1129	652	57.8
1997	Outside	991	586	59.1
1998	Outside	959	539	56.2
1999	Outside	1006	585	58.2
2000	Outside	1038	542	52.2
2001[1]	Outside	1330	616	46.3
2002[1]	Outside	1177	559	47.5
2003[1]	Outside	1089	519	47.7
2004[1]	Outside	1017	471	46.3
1996	Inside	185	80	43.2
1997	Inside	79	61	77.2
1998	Inside	80	56	70
1999	Inside	66	50	75.8
2000	Inside	81	63	77.8
2001[1]	Inside	281	101	35.9
2002[1]	Inside	139	35	25.2
2003[1]	Inside	246	76	30.9
2004[1]	Inside	132	75	56.8

[1] new logbooks implemented

It is uncertain whether the declines in the percent distribution of Yelloweye Rockfish represent changes in species distribution or result from management actions applied to the commercial fisheries. In 2001, new logbooks for the Schedule II fisheries (directed lingcod and dogfish by hook & line gear) were implemented and compiled in PacHarvHL for the first time. This effectively increased the number of blocks fished by the commercial fisheries but Yelloweye Rockfish were likely under-reported in the new Schedule II logbook records due to the mandatory non-retention of rockfish in this fishery. Incidental rockfish catches were likely discarded at sea and not reported on logbooks, potentially contributing to the observed decline in 2001.

Catch quotas for Yelloweye Rockfish were lowered substantially between 2001 and 2002, by 50% in the outside area and 75% in the inside area. Lowering of catch quotas would have the effect of lowering fishing activity (blocks fished as well as blocks occupied) and could also have increased the non-reporting of Yelloweye Rockfish catch in logbooks.

HABITAT

Habitat requirements

Yelloweye Rockfish are habitat specialists, exhibiting a solitary, demersal existence over substrates that are hard, complex and have some vertical relief, such as broken rock, rock reefs, ridges, overhangs, crevices, caves, cobble and boulder fields (Yamanaka unpublished data, Richards 1986, O'Connell and Carlile 1993, Murie *et al*. 1994, Yoklavich *et al*. 2000, Love *et al*. 2002). Information on the habitat of Yelloweye Rockfish from California through B.C. and in Alaska has come from direct *in situ* observations from submersibles.

The ambient temperature and salinity were measured during submersible surveys conducted in 2003 and 2005 and are summarized for all observations of Yelloweye Rockfish (Yamanaka *et al.* 2006) (Table 5). The observed temperature ranged from 8.1 to 12.1^{o}C and salinity ranged from 28.2 to 35 parts per thousand. The submersible surveys were conducted over a limited range of habitats in B.C. and likely represent a subset within the overall physiological tolerance of the species.

Table 5. Summary of temperature (^{o}C) and salinity (parts per thousand) measured for all observed Yelloweye Rockfish during submersible surveys in a portion of the Strait of Georgia and Juan Perez Sound in 2003 and 2005.

Yelloweye Rockfish	Temperature	Salinity
Mean	9.21	32.07
Standard Error	0.0407	0.1350
Median	9.19	30.99
Minimum	8.06	28.16
Maximum	12.10	35.04
Count	208	208

Submersible surveys conducted in B.C. have observed Yelloweye Rockfish at various locations coastwide in 1984, 2000, 2003 and 2005 (Richards 1986, Murie *et al*. 1994, Yamanaka 2005, Yamanaka unpublished data). Sub-adult and adult Yelloweye Rockfish (>20 cm fork length) have been observed from submersibles in B.C. hovering near or settled upon rock ridges or outcrops and occupying crevices in rock substrates or boulders patches from 30 to 232 m in depth with a median of all observations of 79 m (Yamanaka *et al.* 2006) (Table 6).

Table 6. Minimum (min), 25th percentile (25%), median, 75th percentile (75%), maximum (max) depth and number (n) of sub-adult and adult Yelloweye Rockfish greater than 20 cm in fork length observed during submersible surveys coastwide and by site (Yamanaka *et al.* 2006).

Yelloweye Rockfish	**Depth in metres**					
(>20cm)	**Min**	**25%**	**median**	**75%**	**Max**	**n**
Coastwide all locations	30	71	79	103	232	1350
Bowie Seamount	49	71	78	102	232	1132
Juan Perez Sound	37	55	69	121	170	32
Desolation Sound	30	70	100	140	207	113
Jervis Inlet and Area	36	60	90	115	197	68
Southern Gulf Islands	159	165	171	179	197	5

Juvenile Yelloweye Rockfish (<20 cm in fork length) have also been observed from submersibles in a shallower depth range than the adults, 30 to 168 m with a median of all observations of 73 m (Table 7). Juveniles occupy similar rock habitats to the adults but are seen in areas with smaller crevice space available for refuge, including cloud sponge formations, crinoid aggregations on top of rocky ridges and over cobble substrates.

Table 7. Minimum (min), 25th percentile (25%), median, 75th percentile (75%), maximum (max) depth and number (n) of juvenile Yelloweye Rockfish less than or equal to 20 cm in fork length observed during submersible surveys coastwide and by site (Yamanaka *et al.* 2006).

Yelloweye Rockfish	**Depth in metres**					
Juveniles (≤20cm)	**Min**	**25%**	**median**	**75%**	**Max**	**n**
Coastwide all locations	30	68	73	87	168	601
Bowie Seamount	54	72	79	92	160	374
Juan Perez Sound	32	43	48	50	81	21
Desolation Sound	30	51	68	80	160	149
Jervis Inlet and Area	35	57	78	90	152	56
Southern Gulf Islands	168	n/a	n/a	n/a	168	1

Habitat trends

There are no data on habitat trends for Yelloweye Rockfish. It is assumed that there have been no net changes to the habitat (19-251 m depth range coastwide) since the last glaciation.

Habitat protection/ownership

Rockfish Conservation Areas (RCAs) are spatially defined areas where fishing is prohibited year round by both commercial and recreational sectors (http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/fisheriesmgmt/rockfish/default_e.htm). RCAs were developed in consultation with stakeholders and are used as a spatial management tool to protect a portion of the rockfish population from harvest. These RCAs are aimed at protecting Yelloweye Rockfish and other inshore rockfish species (Yamanaka and Lacko 2001) by identifying rockfish habitat (rocky reef areas from 0 to 300 m depth) and closing a portion of these habitats to all harvesting activities. RCAs will remain closed into the future to support the rebuilding of inshore rockfish stocks. DFO has closed up to 20% and 30% of rockfish habitat within RCAs for the outside and inside areas, respectively.

BIOLOGY

Yelloweye Rockfish have been sampled for biological data (length, weight, sex, maturity, age) by the Department of Fisheries and Oceans (DFO) intermittently since 1980. These data are archived in the DFO database GFBio. Historically, biological samples were taken opportunistically from commercial landings and in more recent years large samples have been collected during research surveys. Submersible surveys have provided information on depth ranges for adult and juvenile fish. For other information in this section, research largely from the U.S. has been used to characterize aspects of Yelloweye Rockfish biology that have not been directly studied in B.C.

Life cycle and reproduction

Female Yelloweye Rockfish produce between 1.2 and 2.7 million eggs annually (Love *et al*. 2002). Although other rockfishes display courtship behaviors, this is undocumented for Yelloweye Rockfish. In B.C., the mating season for Yelloweye Rockfish is most likely in November when male gonads are known to be in “running ripe” condition and may extend into the winter months. Females can mate with several males and store sperm for several weeks prior to fertilizing the eggs (Wyllie Echeverria 1987). Rockfishes are matrotrophically viviparous, supplying nutrients to the developing embryos late in their development (Boehlert and Yoklavich 1984, Yoklavich and Boehlert 1991). The gestation period is generally between one to two months for rockfishes (Love *et al*. 2002). Parturition for Yelloweye Rockfish in B.C. occurs between April and September with a peak in May and June.

The duration of the pelagic larval phase of Yelloweye Rockfish is unknown but *Sebastes*, in general, have a prolonged pelagic larval period lasting for one to two months. Larvae and juveniles occur in the upper mixed layer (<300 m) and are dispersed by physical transport processes (Loeb *et al*. 1995, Kokita and Omori 1999). In the pelagic environment the small (3-7 mm) larvae develop into pelagic juveniles (20 to 70 mm) prior to settling in benthic habitats (Bjorkstedt *et al*. 2002). *Sebastes* larvae are opportunistic feeders known to feed initially on copepod nauplii and invertebrate eggs, moving onto larger prey such as copepodites, adult copepods, and euphausiids as they grow (Moser and Boehlert 1991). Settlement occurs when the pelagic juveniles reach 3 - 9 cm and 6 - 9 months of age (Love *et al*. 2002). Benthic juveniles continue to feed on crustaceans but shift to larger prey from planktonic to benthic species then on to fish (Love *et al*. 1991). The recruitment of rockfish is influenced to a large extent by their success during these pelagic larval-juvenile and benthic settlement phases.

Typically, rockfish juveniles settle to nearshore hard bottom habitats at shallower depths than their conspecific adults. This appears to hold true for Yelloweye Rockfish observed from submersibles at all coastal B.C. locations surveyed. Rockfish move bathymetrically with age, hence the older (larger) rockfish tend to occupy the deeper depths within their specific depth range (Love *et al*. 1991, Lea *et al*. 1999). Some benthic rockfishes are known to have limited home ranges and may defend some portion of their territories (Love *et al*. 2002). Yelloweye Rockfish are more or less solitary, benthic dwellers and are likely to exhibit these behaviours. There is no direct evidence from tagging to substantiate a home range for Yelloweye Rockfish.

Rockfish populations are characterized by highly variable recruitment. Prolonged periods of poor recruitment result in natural population declines. Recruitment failure has occurred, for Yelloweye Rockfish, in Oregon and California in ten years following 1987 (Wallace 2001). Unfavourable oceanic conditions are a likely cause for recruitment failure but specific environmental factors that lead to Yelloweye Rockfish recruitment failures in B.C. are unknown. In California, links have been made to oceanographic conditions such as upwelling and strong onshore drift (Yoklavich *et al*. 1996).

Age and growth

Biological sample data are summarized for two areas; “outside” waters to the West of Vancouver Island and all waters extending North and South to the U.S. boundaries and “inside” waters to the East of Vancouver Island. These two areas are used to represent probable “outside” and “inside” DUs for Yelloweye Rockfish in B.C.

Yelloweye Rockfish have been aged to 115 years in B.C. and 121 in Alaska (Yamanaka and Lacko 2001, Munk 2001). Half of individuals between 42.1 – 49.1 cm in fork length and 17.2 – 20.3 years of age are sexually mature (Kronlund and Yamanaka 2001). The average age of mature females, assessed through historical biological samples for the outside area, taken between April and June, is 32.5 (std dev = 17.78, n = 1,590) (Yamanaka *et al.* 2006). For the inside, the average age of mature females, taken between April and July, is 37.5 (std dev = 15.74, n = 71). Age at 50% maturity of females estimated from maturity ogives is 16 yr for the outside and 20 yr for the inside.

Estimates of generation time (G) using the formula: G = A + 1/M, where A is the age at 50% maturity and M is the natural mortality rate, are 66 and 70 years for the outside and inside areas, respectively. M for this formula is 0.02 as estimated by Yamanaka and Lacko (2001).

In the Yelloweye Rockfish population, there are equal numbers of males and females, the average age of females is older than that for males and the maximum age of both sexes is 115 years for the outside area and 87 for males and 101 for females for the inside area (Yamanaka *et al.* 2006) (Table 8). Yelloweye Rockfish are one of the largest species within the genus *Sebastes*. The average fork length of males is longer than that for females but the maximum fork length of females is greater than that for males (Table 8). Length – weight relationship is shown in Figure 12 and length – age data fit to the von Bertalanffy growth function are shown in Figure 13. Sexual dimorphism is common among rockfishes with females most commonly larger in size than the males (Wyllie Echeverria 1986).

Table 8. Summary of biological sample data for Yelloweye Rockfish, including descriptive statistics on sex, age and fork length (source: DFO GFBio database 23/09/2005) (Yamanaka *et al.* 2006).

Yelloweye Rockfish	outside area		inside area	
	males	females	males	females
Number sexed	11334	11402	599	584
mean age (yrs)	27	31	27	30
std dev of age	14.1	17.6	14.2	15.3
Number aged	7036	6930	468	467
Maximum age (yrs)	115	115	87	101
mean fork length (mm)	540	534	476	469
std dev of fork length	87.7	93.5	118.0	112.1
Number of lengths	10657	10830	603	593
Maximum fork length (mm)	812	884	785	804

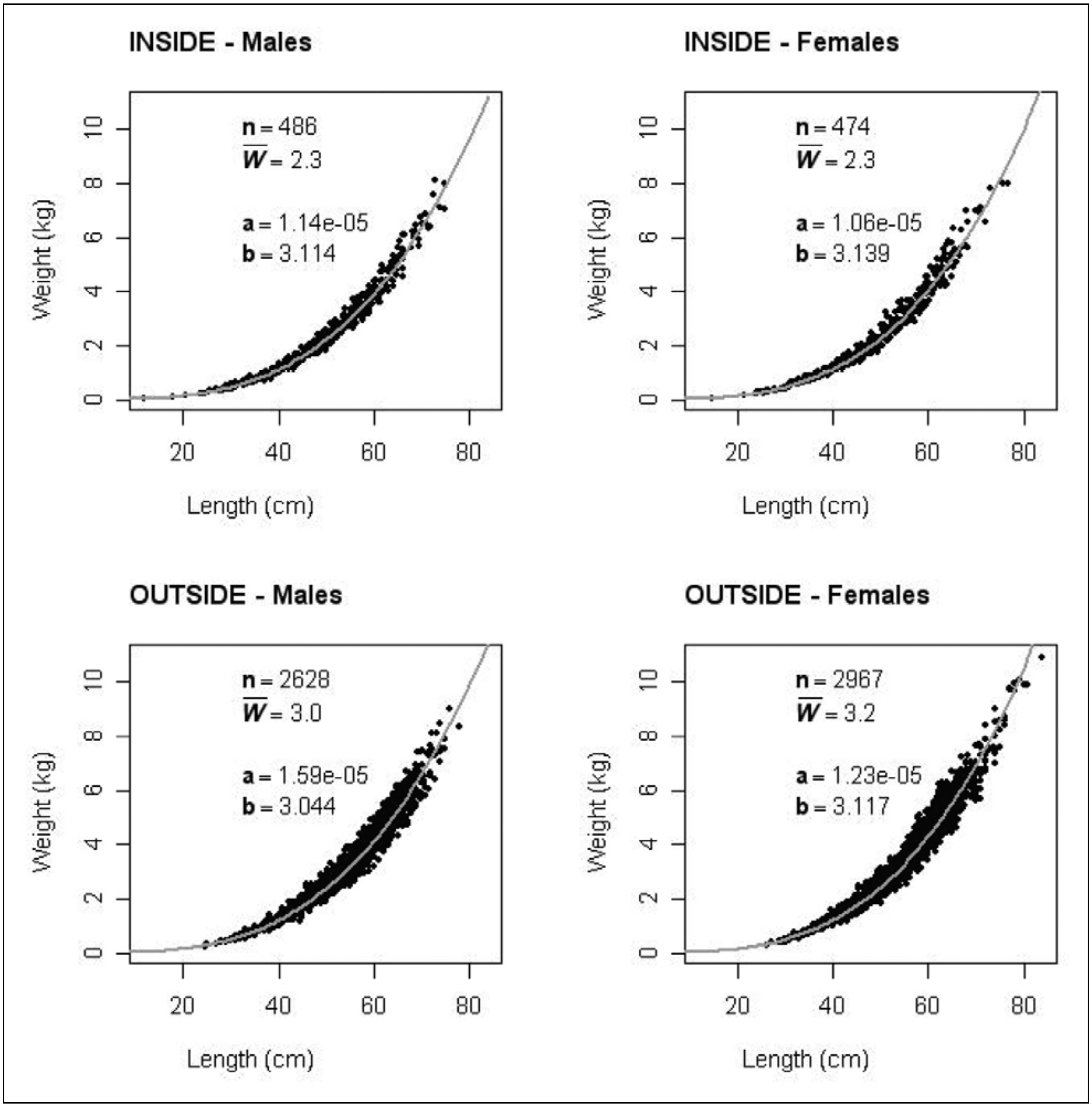

Figure 12. Yelloweye Rockfish fork length (L in cm) vs weight (W in kg) by area and sex $W = aL^b$ (Yamanaka *et al.* 2006)

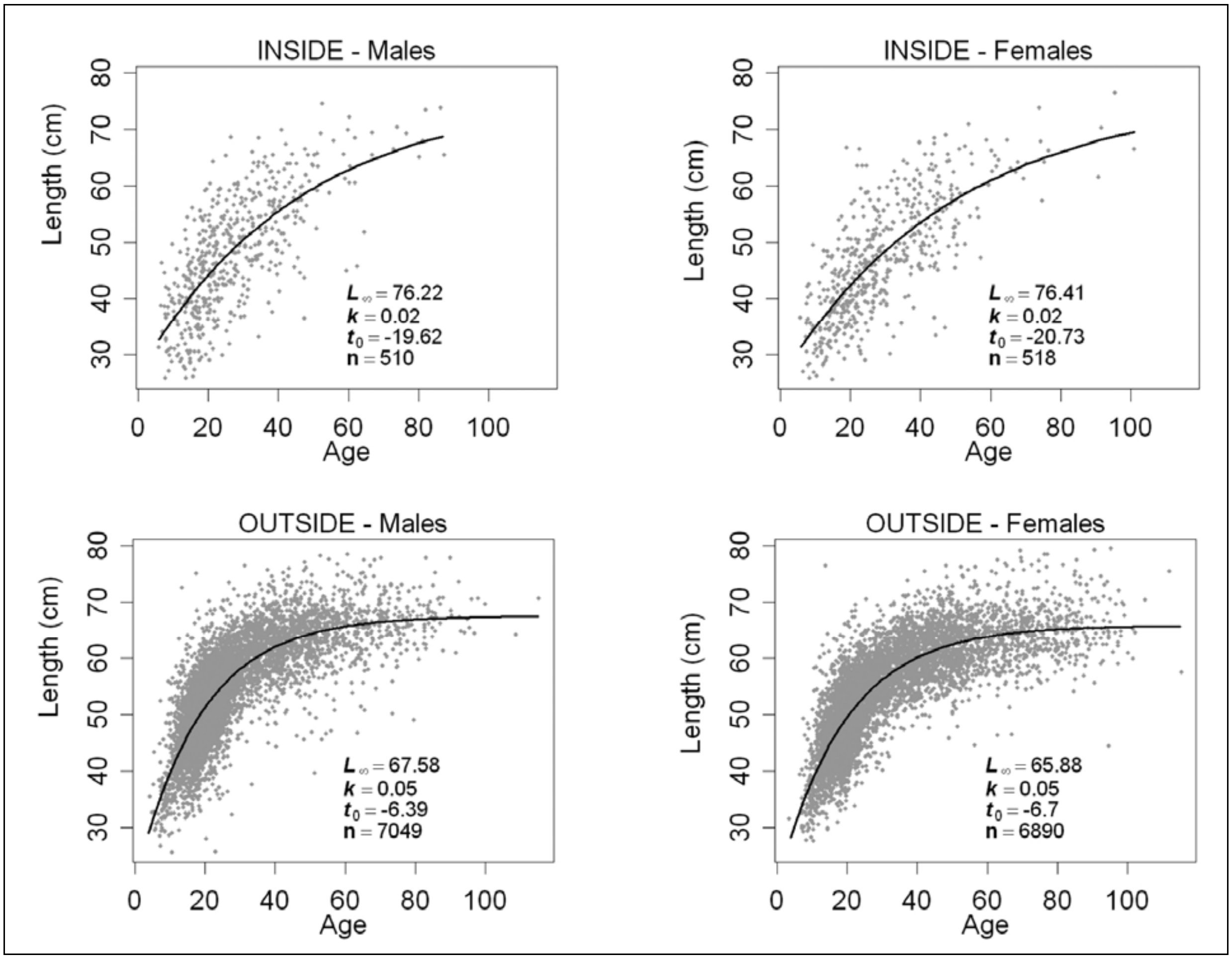

Figure 13. Yelloweye Rockfish fork length (cm) at age (yrs) and the fitted von Bertalanffy growth function by area and sex (Yamanaka *et al.* 2006).

Mortality rates

Simple catch curves were used (Yamanaka and Lacko 2001) to estimate total mortality (Z) from 1997/98 research survey data (Table 9) (Appendix A). Depth of capture for the DFO research charters was filtered to include only the depths between 80 and 225 m.

Table 9. Total mortality estimates (Z) from simple catch curves (Appendix A) by area, year and survey and the r2 statistic for the regression line.

		Total mortality estimate (Ricker 1975)		
Area	**Year**	**Survey**	**Z**	**r^2**
outside	1997/98	DFO research charters	0.051	0.8789
outside	2002/03	DFO research charters	0.055	0.7952
outside	2003	IPHC SSA charters	0.040	0.6915
inside	2003	DFO research longline	0.036	0.5966

Catch curve methods of Schnute and Haigh (2007) incorporate variability in recruitment to estimate total mortality. These methods have been applied to the same age data sets used in the simple catch curve analyses in Table 9 to estimate total mortality for Yelloweye Rockfish from the research survey data (Figures 14 and 15 and Table 10).

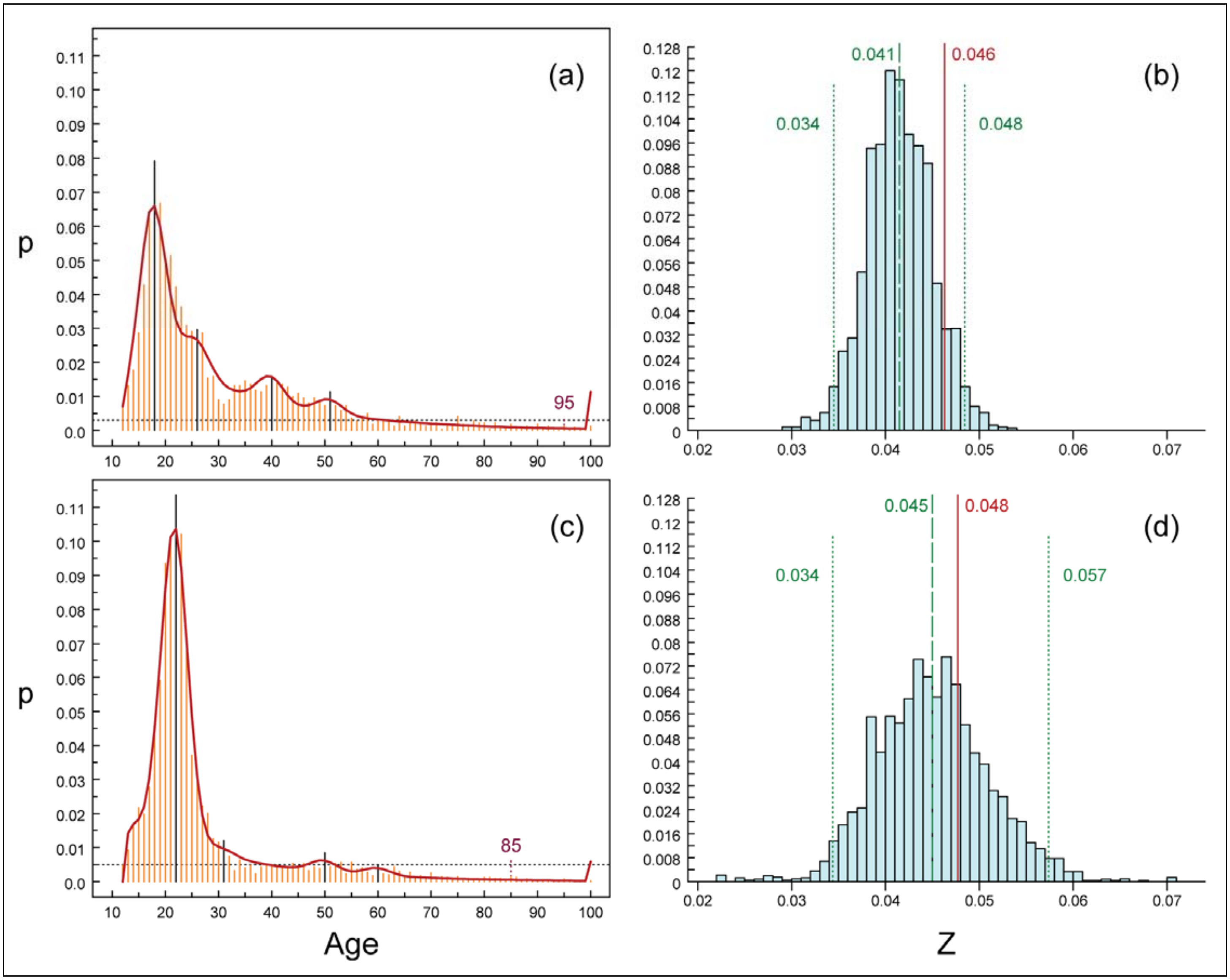

Figure 14. Catch curve analysis for the research charter surveys in 1997/98 (a and b) and in 2002/03 (c and d). Observed proportions-at-age (vertical bars) and predicted (solid curves) using the catch curve model in Schnute and Haigh (2007) (a and c). The recruitment anomalies assumed are highlighted as dark vertical bars. Posterior samples of Z as histograms (b and d). Solid vertical lines indicate the mode from the model fits. Dashed vertical lines indicate the mean values, dotted vertical lines indicate the 2.5% and 97.5% quantiles. (Yamanaka *et al.* 2006)

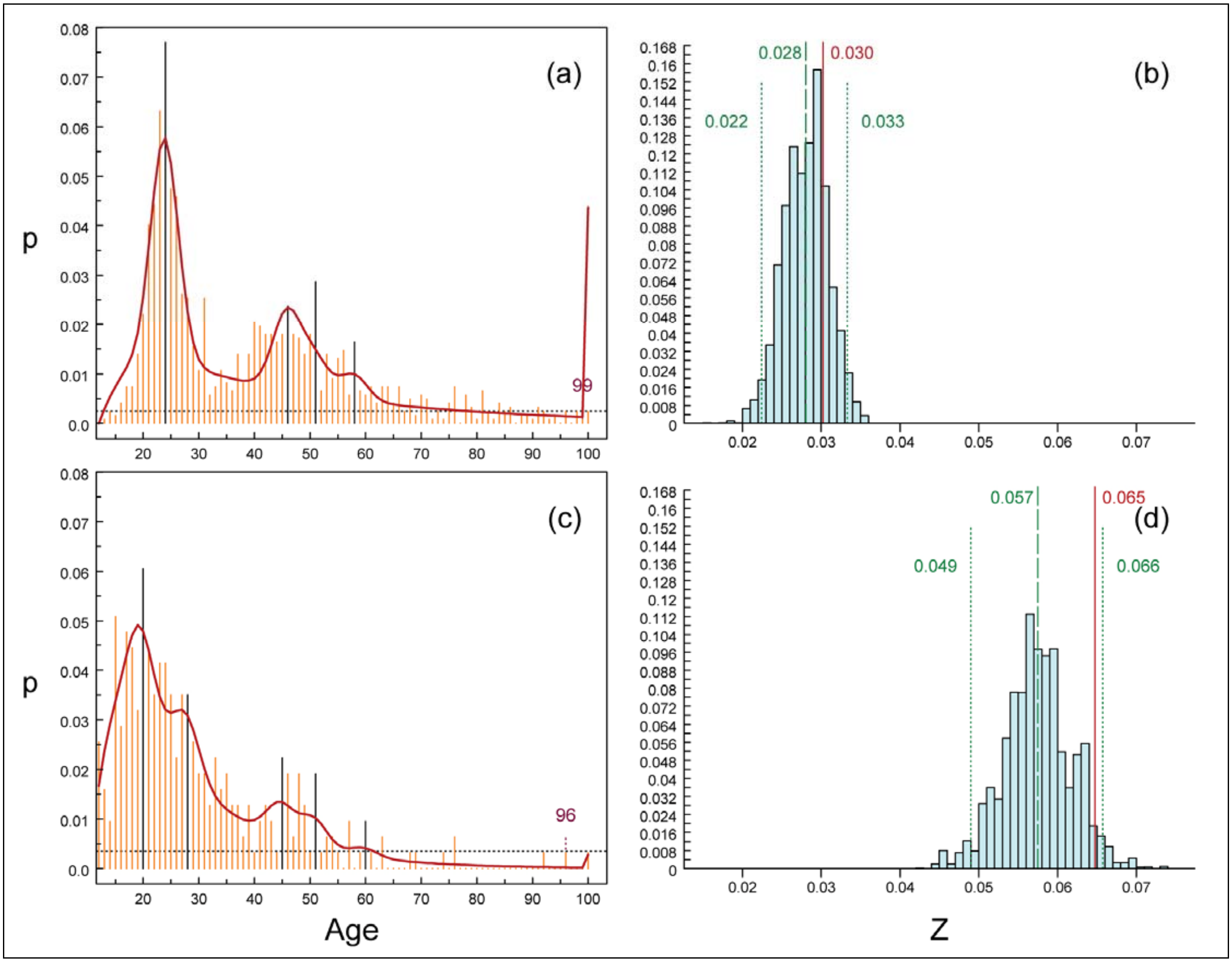

Figure 15. Catch curve analysis for the IPHC SSA survey in 2003 on the outside (a and b) and the DFO longline survey in 2003 on the inside (c and d). Observed proportions-at-age (vertical bars) and predicted (solid curves) using the catch curve model in Schnute and Haigh (2006) (a and c). The recruitment anomalies assumed are highlighted as dark vertical bars. Posterior samples of Z as histograms (b and d). Solid vertical lines indicate the mode from the model fits. Dashed vertical lines indicate the mean values, dotted vertical lines indicate the 2.5% and 97.5% quantiles (Yamanaka *et al.* 2006)

Table 10. Total mortality estimates (Z) using the method of Schnute and Haigh (2007) by area, year and survey showing the mean, mode and 2.5 and 97.5 percentiles of the posterior Z distributions (Yamanaka *et al.* 2006).

			Total mortality estimate (Schnute and Haigh 2006)			
Area	**Year**	**Survey**	**2.5%**	**mean**	**mode**	**97.5%**
outside	1997/98	DFO research charters	0.034	0.041	0.046	0.048
outside	2002/03	DFO research charters	0.034	0.045	0.048	0.057
outside	2003	IPHC SSA charters	0.022	0.028	0.030	0.033
inside	2003	DFO research longline	0.049	0.057	0.065	0.066

Rockfish total mortality rates are difficult to determine using conventional catch curve analysis (Ricker 1975) primarily because of their variable annual recruitment and the effect that trends in recruitment can have on mortality estimates. For example, increasing trends in recruitment cannot be distinguished from the lack of older individuals in the population. This tends to lift the left-hand side of the regression line and increase the slope which can be interpreted as an inflated mortality rate. The new methods developed by Schnute and Haigh (2007) recognize large year classes and account for these in the estimation of a total mortality rate, and thus are considered better estimates that those from simple catch curves.

Using an estimate of the natural mortality rate (M) of 0.02 from Yamanaka and Lacko (2001) and mean Z estimates from Table 10, the fishing mortality rate (F) can be derived from $F = Z – M$. Over the period observed, Yelloweye Rockfish from the outside area have had an estimated F between 0.008 and 0.025 and from the inside area an estimated F of 0.037.

Diet

Most rockfishes are opportunistic feeders that take prey readily available to them, substituting prey items of the same general size and type (Rosenthal *et al*. 1988). Fishes are the major food item for Yelloweye Rockfish, juveniles and adults, in Alaska. Diets include other rockfish (*S. emphaeus, S. maliger, S. helvomaculatus, S. proriger* and juvenile *S. ruberrimus*), juvenile gadids, sand lance (*Ammodytes hexapterus*) and herring (*Clupea pallasi*) (Rosenthal *et al*. 1988). Other prey items consumed are shrimp (*Caridea spp., Pandalus spp.)*, lithodid crab (*Acantholithodes hispidis*, *C. oregonensis),* green sea urchin *(Stongylocentrotus droebachiensis),* and lingcod (*Ophiodon elongates)* eggs. Major food items off Oregon included cancroid crabs, cottids (*Artedius* spp.), righteye flounders, adult rockfish and pandalid shrimps (Steiner 1979).

Predation

Observations of B.C. resident killer whale predatory behaviour has confirmed that adult Yelloweye Rockfish are taken as prey (Ford *et al*. 1998). In the Strait of Georgia, predation by harbour seals has been estimated at 112 t for all rockfish species in 1988 (Olesiuk *et al*. 1990). These rockfish were not identifiable to species but seal predation on Yelloweye Rockfish may be significant relative to the all-fishery harvest of 172 t in the Strait of Georgia in 1988. In Alaska, adults are preyed upon by seals, sharks and dolphins whereas the juveniles are taken by birds, porpoises, and fishes such as rockfish, lingcod, cabezon and salmon (ADFG website).

Physiology

All rockfish have physoclistic swim bladders (lack a pneumatic duct) and must rely on a gas gland to fill the bladder unlike other species such as salmon and lingcod. This gland is a highly vascularized and can push oxygen into the gland even against some very high pressures. To release gas from the swim bladder, the fish opens a set of constrictor muscles that allows the gas to escape the bladder and diffuse into the blood stream. Rockfish cannot rapidly accommodate changes in pressure and gas expansion in the swim bladder when brought to the surface from depth. Yelloweye Rockfish suffer from severe barotrauma that is assumed to be fatal. Rockfish discarded at sea are considered part of the total catch.

Dispersal

Rockfish are known to passively disperse with ocean currents during their extended pelagic larval stage. *Sebastes* larvae were found to concentrate over the continental shelf and slope west of the Queen Charlotte Islands, up to 300 nmi from shore (LeBrasseur 1970). From the composition of otolith microstructure, there is evidence that dispersal may be less than 120 kms for black rockfish (*Sebastes melanops*) (Miller and Shanks 2004). The actual dispersal distance for Yelloweye Rockfish is unknown.

Repopulation of Yelloweye Rockfish through the dispersal of larvae from adults living outside of Canada is likely as there are no physical barriers to dispersal in the marine environment. Yelloweye Rockfish exist both to the north and south of B.C.

Interspecific interactions

There are no known interspecific interactions that limit the survival of Yelloweye Rockfish in Canada.

FISHERIES

Overview

Yelloweye Rockfish are caught primarily by demersal hook and line gear in Aboriginal, recreational and commercial fisheries coastwide (Yamanaka and Lacko 2001). Common gear types used are rod and reel rigged with single or multiple hooks operated manually by the fisher (“handline”) or longline systems with multiple hooks that are operated hydraulically. Rod and reel gear is jigged just off the bottom and longline gear is set directly on the bottom. The largest commercial landings of Yelloweye Rockfish are taken in the directed commercial halibut and rockfish fisheries. Incidental catch occurs in other directed commercial fisheries, such as those for dogfish, lingcod and salmon and to a lesser extent in groundfish and shrimp trawl fisheries and prawn and sablefish trap fisheries. Trawl gear types, because of their use either off the substrate (mid-water) or over smooth substrates (bottom trawl) do not typically intercept Yelloweye Rockfish.

Fisheries management

Recreational harvests are managed by bag limits. In 1986 an eight rockfish daily bag limit was implemented coastwide for the recreational fishery. In 1992 the daily bag limit for the Strait of Georgia recreational fishery was reduced from eight to five rockfish. Further reductions, in 2002, included five rockfish per day of which no more than 2 Yelloweye Rockfish were permitted for the outside and one rockfish of any species per day for the inside.

The directed commercial hook and line fishery for rockfish was licensed in 1986 (Yamanaka and Lacko 2001, Kronlund and Yamanaka 1997, Yamanaka and Kronlund 1997). Area licensing (restricting licence-holders to waters inside or outside the Strait of Georgia Management Region) and catch quotas for each of five management regions were introduced in 1991. Limited entry licensing was implemented for the inside (Strait of Georgia) management region in 1992 and for the remainder of the coast (outside) in 1993. Limited entry licensing reduced the number of licences to 74 in the Strait of Georgia and to 183 licences outside from over 2400 licenses coastwide in 1986.

Within the quotas in place since 1991, allocations have been made to the various commercial fisheries; trawl, directed hook and line rockfish, and hook and line halibut (Table 11).

Table 11. Yelloweye Rockfish catch quotas (t) by management year, gear type, management area and total allowable catch (TAC) (Yamanaka *et al.* 2006).

Management	Trawl	Hook and Line						Yelloweye
Year	Coastwide	Inside[3]	cc[4]	pr[5]	qci[6]	wcvi[7]	Coastwide[8]	tac
1991[1]		50	100	80	200	250		680
1992[1]		59	100	80	200	250		689
1993[1]		70	138	94	308	313		923
1994[1]		70	113	60	302	236		781
1995[1]		62	118	60	291	231		762
1996[1]		31	139	48	242	187		647
1997[1]		24	112	36	123	146		441
1998/99[2]		23	99	32	117	133		404
1999/00[2]	0	23	86	27	91	111		338
2000/01[2]	14	23	73	27	58	95	175	465
2001/02[2]	13	23	71	27	46	97	169	446
2002/03[2]	7	6	40	13	42	52	90	250
2003/04[2]	7	6	38	12	40	50	76	229

[1] January 1 to December 31
[2] April 1 to March 31
[3] inside area, Pacific Fishery Management Area (PFMA) 12 to 20, 28 and 29 (see DFO management plans)
[4] Central Coast, PFMA 6 to 10 and 106 to 110
[5] Prince Rupert, PFMA 3 to 5 and 103 to 105
[6] Queen Charlotte Islands, PFMA 1, 2, 101 and 102
[7] West Coast Vancouver Island, PFMA 21 to 27, 11, 121 to 127 and 111
[8] allocation to the halibut fishery

In 1995, dockside monitoring of all commercial groundfish landings was initiated together with 100% at-sea observer monitoring for the commercial groundfish trawl fishery. Partial at-sea observer coverage for the commercial hook and line groundfish fleet was initiated in 1999. Incidental catch was not well known for unobserved commercial fisheries, especially where the landing of rockfish was either limited or prohibited by licence conditions.

A Rockfish Conservation Strategy (RCS) was developed in 1998 due to the concerns over the:

- continued lack of data for stock assessment and the inability to generate species-specific rockfish catch quotas by fishery management region
- catch curve analyses suggesting significant negative fishery effects on Yelloweye Rockfish and quillback rockfish stocks
- risk of overexploitation due to life history traits of Yelloweye Rockfish and quillback rockfish:
    - o low productivity (extreme longevity, variable recruitment) and possibly very long time frames for recovery,
    - o unique physiology (physoclistic) where barotrauma causes mortality and hence unreported released rockfish need to be accounted for in the catch
    - o behaviour and habitat specificity (sedentary over rocky reef habitats) and ease of exploitation given modern fishing aids
- little effect that reducing quotas had on the fishing rate and landings of yelloweye and quillback rockfish stocks
- continued anecdotal information on Yelloweye Rockfish and quillback rockfish
    - o large unreported non-retention in all fisheries and
    - o spatial depletion

The RCS (http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations /fisheriesmgmt/rockfish/default_e.htm) was announced by the Minister of Fisheries and Oceans in 2001 and focused on four principles:

1. account for all catch (landed and discarded)
2. reduce fishing mortality across all fisheries
3. implement areas closed to all fishing (Rockfish Conservation Areas (RCAs)
4. improve stock assessment

Additional management measures were implemented in 2002, including increased at-sea observer coverage on commercial hook and line fleets, reductions in commercial TAC and recreational daily bag limits by 50% for areas outside and 75% inside to meet a target of a 1.5% harvest rate, together with the implementation of 28 Rockfish Conservation Areas (RCAs) (closed areas) coastwide. Consultations in 2003/04 resulted in the closure of 20% of the “rockfish habitat” on the outside and a goal of 30% “rockfish habitat” closed is set for the inside with consultations completed in 2006. Currently (2007) 164 RCAs are closed to all rockfish fishing. Reductions on commercial and recreational catch limits described above also came into effect in 2002.

In response to DFO’s Rockfish Conservation Strategy, Pacific Fisheries Monitoring and Reporting Framework and Selective Fishing Policy as well as the *Oceans Act* and *Species at Risk Act*, the commercial groundfish industry formed a committee, the Commercial Industry Caucus (CIC), to develop a pilot groundfish integration proposal that addresses these and related issues, to ensure a unified and sustainable groundfish fishery into the future (Diamond Management Consulting Inc. 2005). The CIC is committed to ecologically and economically sound practices.

The CIC is guided by the following five principles:

1. All rockfish catch must be accounted for
2. Rockfish catches will be managed according to established rockfish management areas
3. Fishermen will be individually accountable for their catch
4. New monitoring standards will be established and implemented to meet the above 3 objectives, and
5. Species of concern will be closely examined and actions such as reduction of total allowable catch (TACs) and other catch limits will be considered and implemented to be consistent with the precautionary approach for management.

The Groundfish Integration pilot has been implemented since 2006. A level of 100% at-sea monitoring is in place for the entire groundfish fishery, eliminating unreported catch of rockfish throughout the commercial groundfish fishery, allowing all rockfish to be accounted for within their TACs, and providing the catch data required for stock assessment. To complement 100% observer coverage earlier introduced on trawl vessels, 100% video monitoring is now in place for the commercial groundfish hook and line fisheries, which include the directed halibut, dogfish and rockfish fisheries.

Catch history

Commercial

Commercial Yelloweye Rockfish catch statistics were summarized under various species categories by the Dominion Bureau of Statistics (Canada 1818-1946) and DFO: “various kinds of fish” (1877-1881), “assorted fish” (1882-1889), “rock cod” (1890-1894), “mixed fish” (1895-1917), “red cod, etc.” (1918-1922), “red cod” (1923-1931), “red and rock cod” (1932-1974), “rockfish” (1975-1981), “red snapper” (1982-1994). From 1995 the species was specifically recorded as Yelloweye Rockfish. The “official” DFO catch record starts in 1951 with the initiation of the sale slip system designed to track commercial catch by area and gear type.

Commercial hook & line landings data were extracted from DFO sale slip records under the category of “red and rock cod” (1951-1974) and “rockfish” (1975-1981) and subset by gear type for only the hook and line gears, “red snapper” (1982-1995) by hook and line gear and from the integrated dockside monitoring and logbook DFO databases PacHarvTrawl and PacHarvHL for Yelloweye Rockfish. (1996-2004) (Table 12, Figure 16).

There are many anecdotal records of the early catch of Yelloweye Rockfish in B.C. In an 1886 expedition exploring fisheries resources in the North Arm of Burrard Inlet (Indian Arm, Strait of Georgia), the inspector of fisheries described the "large red rock cod" as being "plentiful” (Canada 1886). In 1888, the inspector of fisheries explained that of the 28 varieties of rockfish known at the time, “the most abundant and highly prized is what is known as the red cod or snapper” (Canada, 1888). These accounts verify that red cod or snapper were abundant in the Strait of Georgia in the late 1800s but are not sufficiently detailed to derive catch statistics for Yelloweye Rockfish from historic “assorted fish” categories.

Table 12. Coastwide catch (tons) of Yelloweye Rockfish by year (1951 to 2004) from the commercial hook and line (H&L) landings and trawl (T) catch (landings and discards), halibut (H) landings and recreational catch (kept and discarded) for the inside (I) and outside (O) areas. Commercial catch between 1951 and 1995 are from sales slip records and between 1996 and 2004 are from PacHarvHL and PacHarvTrawl. Recreational catch data are converted (using 0.7 kg) from numbers of fish recorded in the Strait of Georgia Creel Survey for the years 1981 to 2004 (Yamanaka *et al.* 2006).

Year	H&L I	T I	H I	REC I	H&L O	T O	H O	Total
1951	47.6	0.0	0.0	N/A	165.5	0.0	0.0	213
1952	14.2	0.0	0.0	N/A	112.9	0.0	0.0	127
1953	29.4	0.0	0.0	N/A	42.7	0.0	0.0	72
1954	10.8	0.0	0.0	N/A	44.6	0.0	0.0	55
1955	17.3	0.0	0.0	N/A	34.5	0.0	0.0	52
1956	11.8	0.0	0.0	N/A	30.9	0.0	0.0	43
1957	11.2	0.0	0.0	N/A	58.4	0.0	0.0	70
1958	9.7	0.0	0.0	N/A	35.3	0.0	0.0	45
1959	22.7	0.0	0.0	N/A	40.0	0.0	0.0	63
1960	17.5	0.0	0.0	N/A	56.7	0.0	0.0	74
1961	16.0	0.0	0.0	N/A	58.1	0.0	0.0	74
1962	11.0	0.0	0.0	N/A	73.8	0.0	0.0	85
1963	17.5	0.0	0.0	N/A	65.6	0.0	0.0	83
1964	17.2	0.0	0.0	N/A	38.6	0.0	0.0	56
1965	19.6	0.0	0.0	N/A	37.9	0.0	0.0	58
1966	9.2	0.0	0.0	N/A	40.6	0.0	0.0	50
1967	15.4	0.0	0.0	N/A	54.5	0.0	0.0	70
1968	13.7	0.0	0.0	N/A	34.1	0.0	0.0	48
1969	13.8	0.1	0.0	N/A	62.6	0.2	0.0	77
1970	26.5	0.0	0.0	N/A	84.8	0.0	0.0	111
1971	25.7	0.0	0.0	N/A	69.5	0.0	0.0	95
1972	23.1	0.0	0.0	N/A	69.7	0.1	0.0	93
1973	66.2	0.0	0.0	N/A	64.9	0.0	0.0	131
1974	12.9	0.0	0.0	N/A	89.1	0.0	0.0	102
1975	10.4	0.0	0.0	N/A	132.0	0.0	0.0	142
1976	8.2	0.0	0.0	N/A	83.9	0.0	0.0	92
1977	46.3	0.1	0.0	N/A	112.3	0.6	0.0	159
1978	47.5	0.2	0.0	N/A	133.0	4.4	0.0	185
1979	90.5	26.0	0.0	N/A	190.0	14.5	0.0	321
1980	59.0	11.3	0.0	N/A	168.5	9.2	0.0	248
1981	49.1	5.0	0.0	N/A	122.3	5.9	0.0	182
1982	22.2	13.0	0.0	N/A	48.7	2.0	0.0	86
1983	26.8	0.9	0.0	N/A	67.3	1.9	0.0	97
1984	46.4	1.2	0.0	N/A	124.8	37.4	0.0	210
1985	82.0	4.0	0.0	N/A	235.5	8.9	0.0	330
1986	93.9	0.2	0.0	26.3	592.6	13.4	0.0	726
1987	100.6	0.4	0.0	46.8	578.7	31.6	0.0	758
1988	130.8	0.0	0.0	40.8	620.4	15.8	0.0	808
1989	125.5	0.0	0.0	35.7	838.0	36.2	0.0	1035
1990	135.2	0.0	0.0	14.4	1033.7	48.2	0.0	1231
1991	114.9	0.0	0.0	9.0	1041.4	32.2	0.0	1197
1992	30.1	0.1	0.0	12.8	925.9	38.5	0.0	1007
1993	41.6	0.0	0.0	17.0	1040.7	45.3	0.0	1145
1994	86.4	0.4	0.0	21.1	660.8	81.6	0.0	850
1995	38.0	0.1	0.7	13.2	643.9	46.5	44.2	786
1996	24.5	0.0	1.0	47.6	357.1	20.0	70.5	521
1997	25.7	0.0	1.9	24.7	357.2	19.4	52.2	481
1998	24.2	0.0	5.8	13.7	309.5	15.8	220.4	589
1999	22.8	0.0	1.1	30.0	267.4	14.8	102.2	438
2000	23.8	0.0	0.4	20.2	228.5	16.9	214.8	505
2001	24.9	0.0	0.8	28.4	206.5	13.3	240.6	515
2002	0.6	0.0	0.0	10.8	135.1	12.6	165.7	325
2003	5.1	0.0	0.0	12.2	74.7	13.4	141.5	247
2004	3.2	0.0	0.2	9.9	63.3	9.6	127.3	214

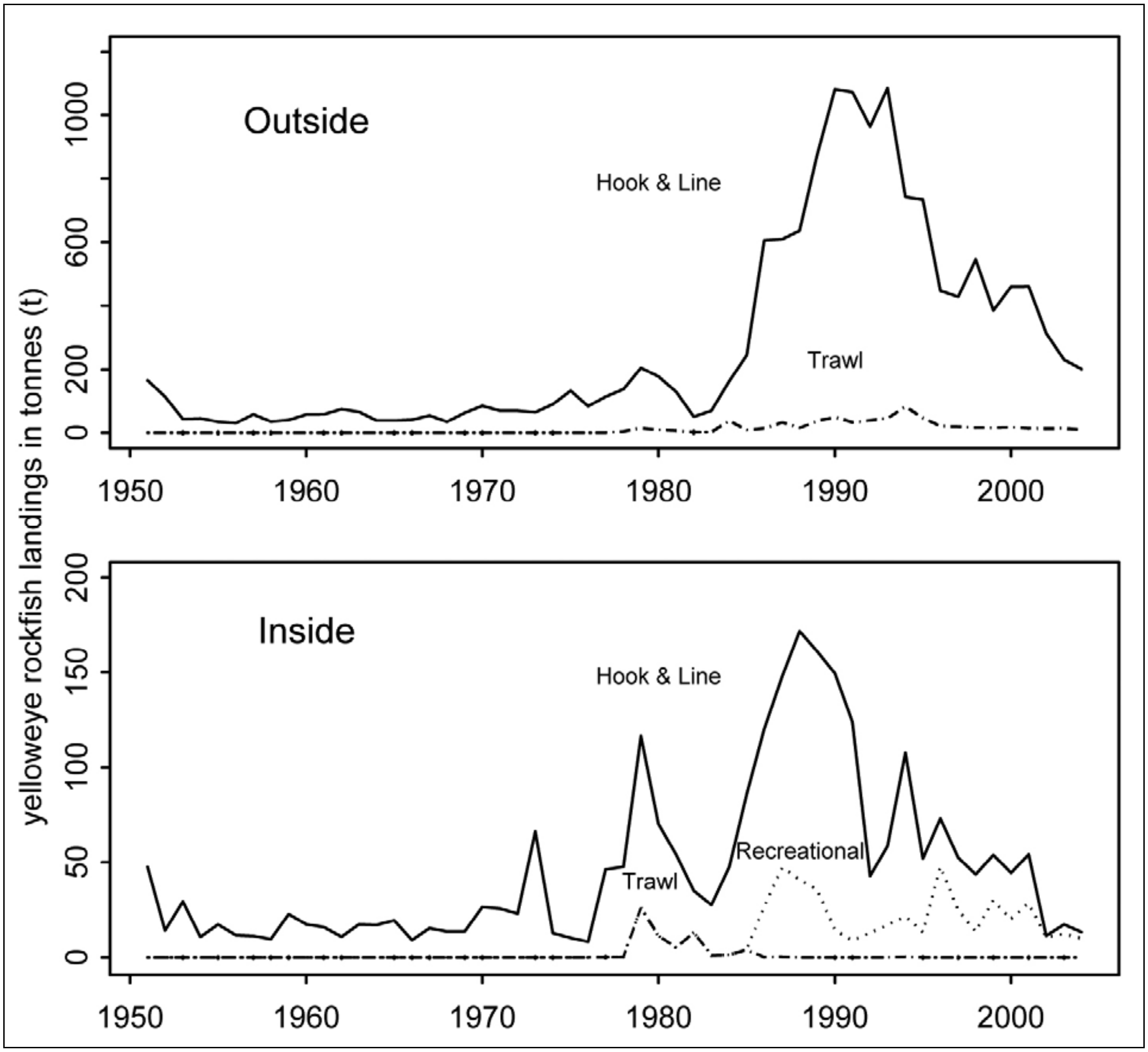

Figure 16. Total landings of Yelloweye Rockfish, by gear for the outside (top panel) and inside (bottom panel) areas, from 1951 to 2004. The solid line represents landings by hook and line gears, dash-dot line represents catch by trawl gear, light dots represents catch by recreational gear.

Commercial landings increased substantially through the 1980s reaching a peak of around 170 t/yr in the inside and 1200 t/yr in the outside. Catches declined substantially thereafter with declining abundance and imposition of stronger management measures from the mid-1990s (Table 12, Fig. 16).

Recreational

Their large size and relatively shallow preferred depths (less than 100 m) make Yelloweye Rockfish an important species to the recreational fishery. While often targeted by individual anglers, the species is also taken as incidental catch in the pursuit of lingcod and halibut in the North coast and West coast Vancouver Island recreational fisheries (Maynard pers. comm. 2005). In the Strait of Georgia, the fishing effort directed towards Yelloweye Rockfish has declined due to both the low abundance as well as an overall reduction in fishing effort (Maynard pers. comm. 2005).

Recreational catch is assessed annually in the Pacific region through a creel survey in portions of the Strait of Georgia and assessed coastwide every five years nationally through a mail-in survey of recreational fishing in Canada (http://www.dfo-mpo.gc.ca/communic/statistics/recreational/canada/2000/index_e.htm). The National survey of recreational fishing reported the catch (in numbers of fish) of rockfish (all species combined) by management region in 2000 and 2005 (Table 13), which indicates a substantial decline over this 5 year period. The figures include fish kept and fish released, but in the case of rockfish it can be assumed that a high proportion of those released will die. Proportion of this total harvest represented by Yelloweye Rockfish is not known and probably varied by areas.

Table 13. Reported catch of rockfish (all species), from national recreational fishery survey (number of fish). (Source: Department of Fisheries and Oceans.)

		2000	2005
Outside	**Total, all rockfish species**	**346,022**	**242,719**
	Queen Charlotte Is.	30,421	41,737
	North Coast	51,060	42,740
	Central Coast	68,582	32,161
	Barkley Sound	80,899	63,115
	Western Vancouver Island		62,967
Inside	**Total, all rockfish species**	**530,630**	**199,007**
	Johnstone Strait	84,099	45,181
	Strait of Georgia	446,531	153,826

The Strait of Georgia creel survey (basis for recreational catch figures in Table 12) has provided an annual estimate of recreational catches (in numbers of fish), primarily for salmon but secondarily for groundfish and other species, since 1986. The number of months and landing sites surveyed over the years has varied but as many as 50 landing sites are monitored throughout the Strait of Georgia from Sooke in the south to Brown’s Bay in the North. Yelloweye Rockfish are estimated from this survey by applying a 5% proportion to the overall rockfish catch (Collicutt and Shardlow 1990, 1992); although a numbers to weight conversion of 0.7 kg per fish is used for inshore rockfish generally, a conversion factor of 3.2 kg per fish is used for yelloweye because of their larger size.

Estimated recreational catch in the inside area increased in the 1980s and fluctuated without trend into the late 1990s, subsequently declining to relatively low levels with imposition of new management measures. Estimated recreational catch has recently been higher than commercial catch in the inside area.

An estimate of recreational catch from the National Survey for the outside area is 56 t based on the same extrapolation as the inside in 2000.

Information from recreational fishing lodges in Haida Gwaii (Queen Charlotte Islands) (Table 14) provides an additional source of information on harvest levels. Recreational harvests of rockfishes have been increasing in this area over the past decade. The proportion of this harvest which is Yelloweye Rockfish, and the conversion to weight, are unknown.

Table 14. Recreational rockfish harvest data (numbers of fish) from creel estimates and lodge log books reported for all species. QCI* data includes management areas 1 and 2w (only logbook data from fishing lodges available). WCVI data includes management areas 23-27 and 121 to 127 (logbook data from fishing lodges and creel estimates available).**

	QCI Lodge Data	WCVI Lodge - all Rockfish	WCVI Creel - all Rockfish	Total Outside Rockfish
1999	7492	n/a	n/a	7492
2000	6974	n/a	14100	21074
2001	4757	n/a	21048	25805
2002	6716	19780	21800	48296
2003	8776	7841	21476	38093
2004	11040	14070	22487	47597
2005	13537	16357	33972	63866
2006	12725	12442	30621	55788
2007	17273	14491	22506	54270

* data provided by Haida Fisheries
** data provided by Fisheries and Oceans

<u>Aboriginal</u>

There is little information on present or historical traditional use of Yelloweye Rockfish by the several coastal First Nation bands along B.C.'s coast. Yelloweye Rockfish has likely always been an important species to coastal First Nations. Early ethnographers all recognized the importance of the "various specimens of cod" as important to a variety of coastal First Nations (Boas 1895). Explicit reference to rockfishes as a subgroup is absent in the early ethnographies (Stewart 1975). Archaeological records of *Sebastes sp.* based on the presence of otoliths, skulls, and pelvic girdle bones are typically only classified to the genus (i.e., *Sebastes*).

The *Nisga'a Joint Fisheries Management Committee* was contacted for information on their knowledge of this species. “No additions or comments to their [Yelloweye Rockfish] status” was reported (Nyce pers. comm. 2005).

Catch summary

Total removals of Yelloweye Rockfish over the years cannot be determined precisely, although information improved substantially with improvements to catch reporting since the 1980s, and to discard reporting in the mid-1990s.

Anecdotal evidence and early catch statistics confirm that Yelloweye Rockfish harvests did occur in the Strait of Georgia, West coast of Vancouver Island and the North coast prior to “official” DFO sale slip records beginning in 1951. Prior to 1982, catch records for Yelloweye Rockfish were not species-specific and typically lumped with other rockfish, groundfish and other fish.

The quantities of rockfishes discarded and unreported, including Yelloweye Rockfish, is unknown prior to 100% observer programs for commercial trawl fisheries in 1995 and partial observer coverage for commercial hook and line fisheries in 1999. Because Yelloweye Rockfish is a highly prized food fish, discarding of this species was probably less than other rockfishes but the economics of fishing varied between fisheries and over time and discarding levels are difficult to assess retrospectively. The mortality associated with discarding is unknown but is considered 100%.

Information from commercial fisheries is considered to be accurate since the mid-1990s when the improvements to reporting were made.

Information from recreational fisheries, which are important for rockfishes and particularly for yelloweye (a prized species), is very incomplete and imprecise. Information is based on sampling surveys for large parts of the range, and is generally for “rockfish” rather than by species. Recreational harvest for inside waters was estimated by applying a 5% factor to total rockfish and a mean weight per individual, so there is uncertainty about the figures. In other areas the proportion of yelloweye in total rockfish catches is unknown.

Despite these caveats, it is clear that there were substantial harvests in the 1980s and 1990s, which declined in the late 1990s with declining abundance and imposition of new management measures. It is probable that harvests of this species were significant prior to the 1980s, because of its accessibility and value (commercial and recreational). Harvesting in the more accessible inside waters probably began long before that in outside waters.

POPULATION SIZES AND TRENDS

Information in this section is drawn from Yamanaka *et al.* (2006).

Search effort

Information from research surveys and from commercial fisheries is available to explore population trends for Yelloweye Rockfish in outside and inside DUs. For the outside area, research charter surveys using hook and line gear at 4 sites in two time periods (1997/8, 2002/3) were conducted and information from the International Pacific Halibut Commission (IPHC) longline survey of continental shelf waters was analyzed. Commercial handline, longline and trawl catch and effort was available. For the inside area, longline and submersible surveys are available, as are commercial handline and longline catch and effort information.

Commercial catch and effort data recorded on logbooks from the directed rockfish hook and line fishery (ZN) are stored in the DFO database PacHarvHL. Research fishing survey data are stored in the DFO database GFBio. Submersible survey visual observations are stored in the DFO database PacGFVideo.

Population size

Information available does not permit estimating total population size of Yelloweye Rockfish. Research surveys directed for Yelloweye Rockfish provide indices of abundance but additional data needed to convert these to absolute abundance (catchability of the longline gear, area swept calculations in visual surveys or probability of detection functions) are not available.

Trawl surveys can use a swept area expansion to estimate biomass for Yelloweye Rockfish. This is a minimum biomass estimate as the bottom trawl gear is not able to survey rocky reef habitats where Yelloweye Rockfish primarily aggregate (Jagielo *et al*. 2003). Figure 17 illustrates the areas surveyed on the B.C. coast and Table 15 shows the corresponding biomass estimates from the bottom trawl surveys.

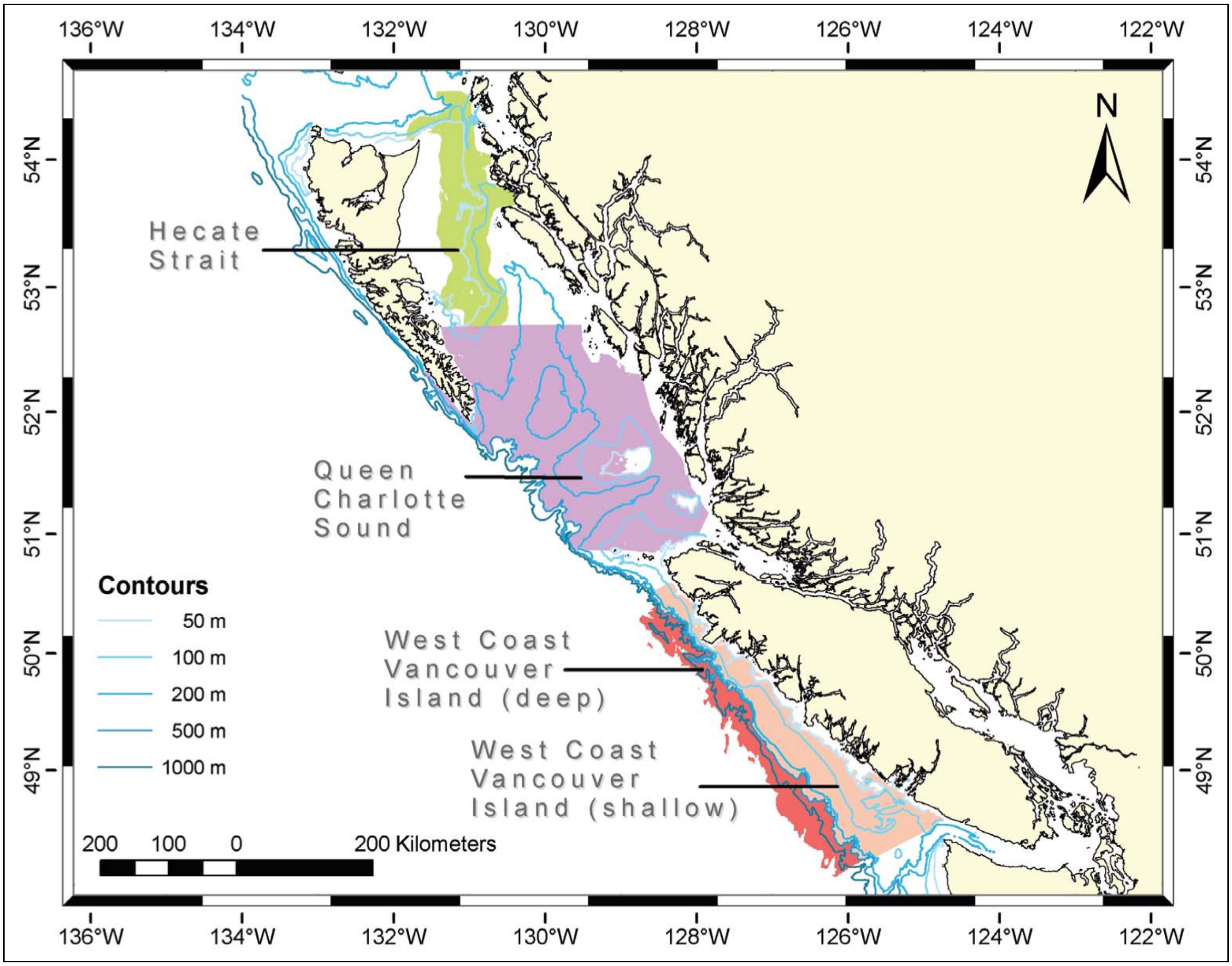

Figure 17. Trawl survey areas for the outside area.

. Table 15. Biomass estimate (area expanded) from bottom trawl surveys. Minimum estimate for Yelloweye Rockfish based on trawlable bottom only. Yelloweye Rockfish occur primarily over hard, untrawlable bottom

Survey	Year	Index (tonnes)	Std. Dev.
West Coast V.I. (shallow)	2004	249	109
West Coast V.I. (deep)	2003	0	0
Queen Charlotte Sound	2004	471	247
Hecate Strait	2003	0	0

The total minimum biomass estimate at this time, for the outside area, is thus 720 t, the equivalent of several hundred thousand individuals. However, this estimate is extremely imprecise and certainly an underestimate. At an average individual weight of 2 kg this would translate into 360,000 individuals, but this is a substantial underestimate.

Population fluctuations and trends

Outside waters population - surveys

Research charter surveys

Chartered commercial fishing vessels conducted research surveys to index Yelloweye Rockfish abundance and collect biological samples for stock assessment purposes (Kronlund and Yamanaka 2001, Yamanaka *et al*. 2004a). The first surveys were conducted in September 1997 and May 1998 in four study areas; two on the west side of the Queen Charlotte Islands and two on the upper west coast of Vancouver Island (Figure 18). These were followed five years later by the same survey conducted in September 2002 and May 2003. CPUE indices are shown in Figure 19 and Table 16.

This information shows an increasing trend between the two periods sampled but the mean values are not significantly different (Fig. 19).

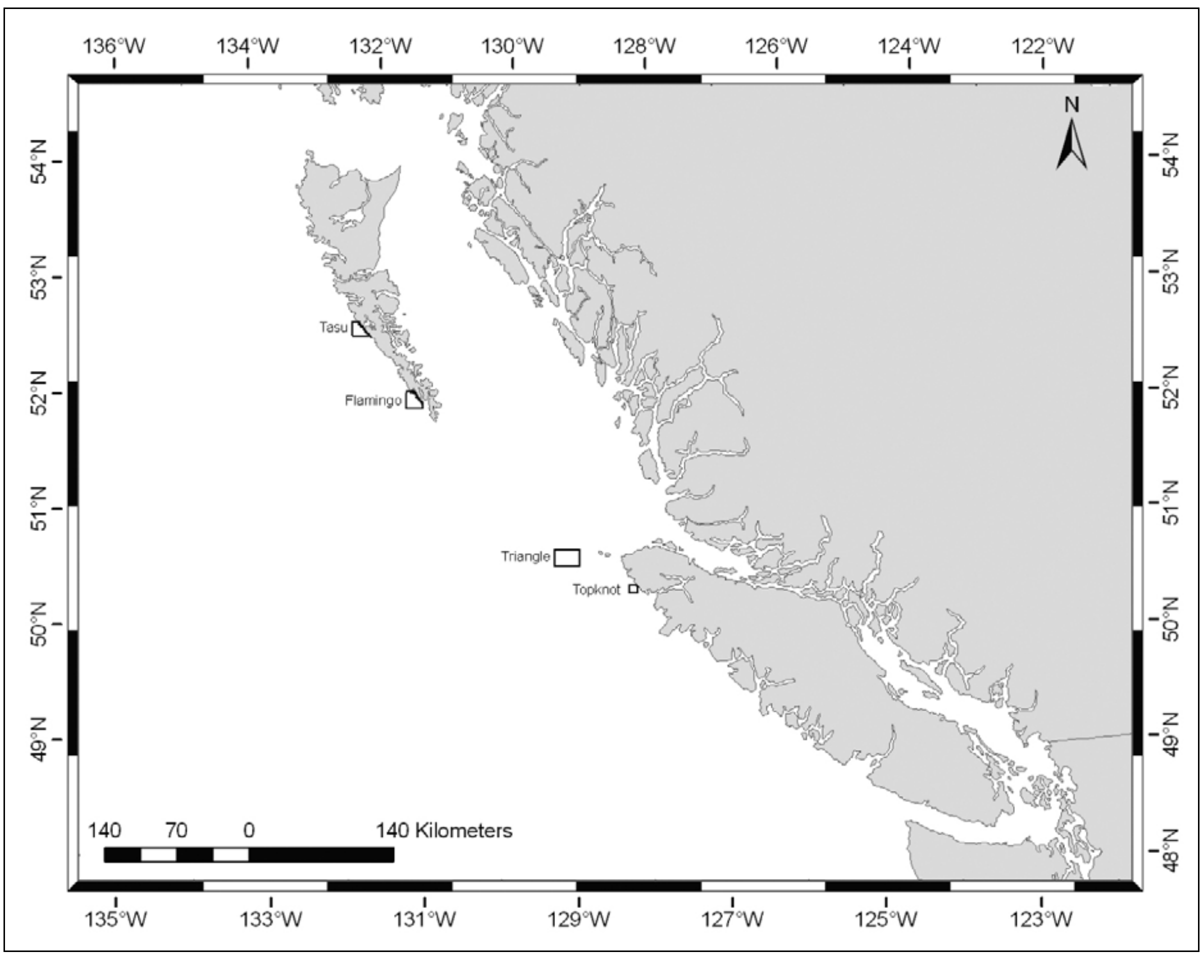

Figure 18. Four study sites surveyed for Yelloweye Rockfish by chartered fishing vessels in 1997/98 and 2002/03. Paired sites, lightly and heavily fished, off the Queen Charlotte Islands (Tasu and Flamingo) and the North West of Vancouver Island (Triangle and Topknot).

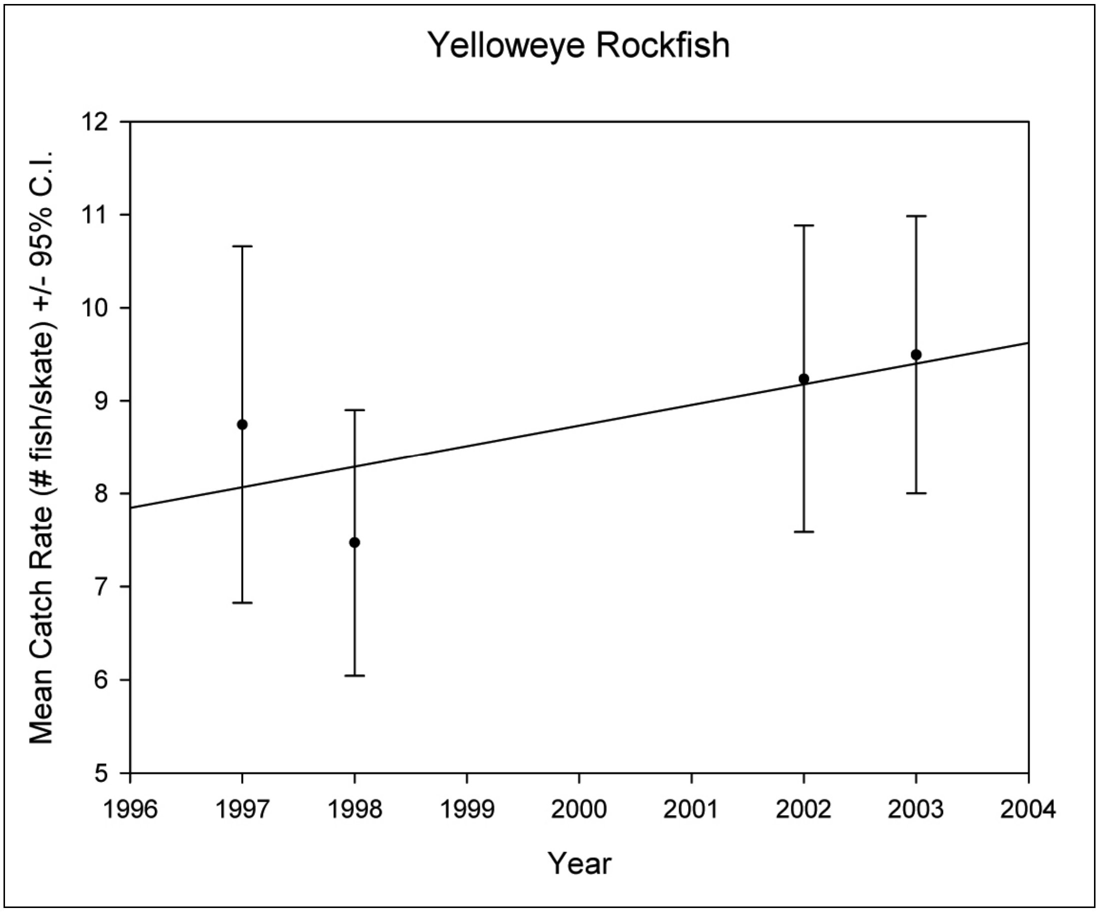

Figure 19. Yelloweye Rockfish mean catch rates and 95% confidence intervals from the charter vessel surveys in the outside area. Slope of the trend line is not significantly different from zero (r^2 = 0.0122, p = 0.1373).

Table 16. Catch per unit of effort statistics by year for Yelloweye Rockfish during the charter vessel research surveys.

Yelloweye Longline survey	Fall 1997	Spring 1998	Fall 2002	Spring 2003
Mean	29.3	26.2	34.8	35.8
Standard Error	2.8	3	3.2	3
1st Quartile	14.8	9.8	20.2	20
Median	28.3	20.8	29.5	32.9
3rd Quartile	42.2	41.2	42.5	41.2
Standard Deviation	15.4	20.4	21.3	19.7
Sample Variance	237.9	417.8	455.6	386.8
Minimum	6.1	2.8	7	9.3
Maximum	55.4	93.5	107.6	99.6
Total Number of Sets	63	80	45	43
Confidence Level (95.0%)	5.8	6.1	6.4	6.1

IPHC SSA

The International Pacific Halibut Commission (IPHC) conducts a Standardized Stock Assessment (SSA) survey annually to assess Pacific halibut stock abundance. In 1995 and annually since 2003, catch data for species other than halibut have been collected (Yamanaka *et al*. 2004b). The survey set locations differed in 1995 from those in 2003/04 (shown in the left panel of Figure 20). Only those sites common in all years (shown in the right panel of Figure 20) were used to calculate a CPUE index.

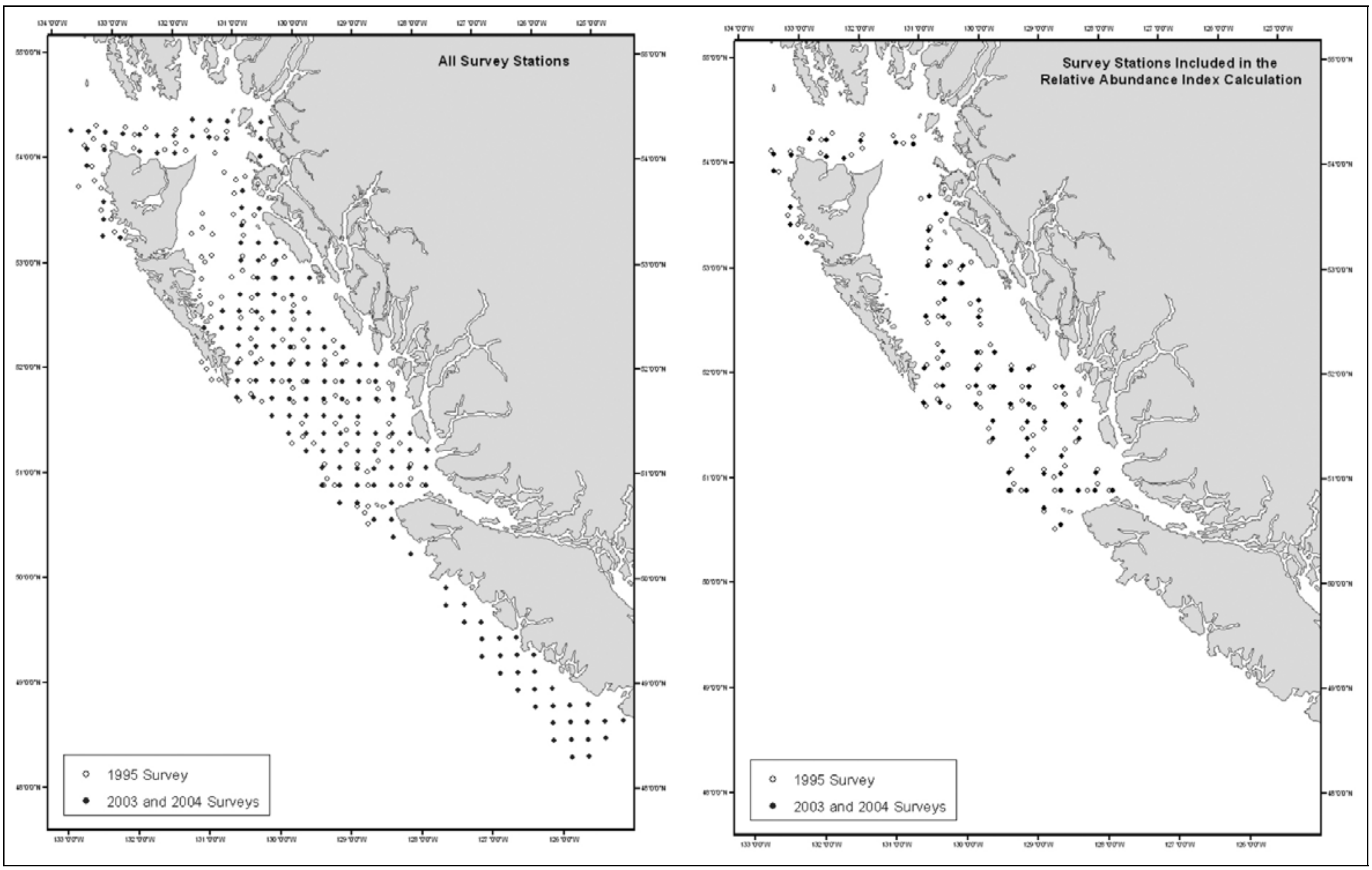

Figure 20. IPHC SSA survey locations for 1995, 2003 and 2004 surveys in B.C. (left panel). Open circles represent survey sites in 1995, filled circles represent survey sites in 2003 and 2004. Overlapping sites surveyed in all years that were included in the CPUE index (right panel).

Yelloweye Rockfish are generally caught throughout the survey area. Catch rates vary widely and range from 0 to 33.8 fish per skate (1800 feet of groundline with 100 hooks) (Figure 21). A catch rate index was constructed from survey sets that overlapped during the 1995, 2003 and 2004 surveys (Figure 22 and Table 17).

Information from this survey showed a decreasing trend between the two periods sampled but mean catch rates were not significantly different (Fig. 22).

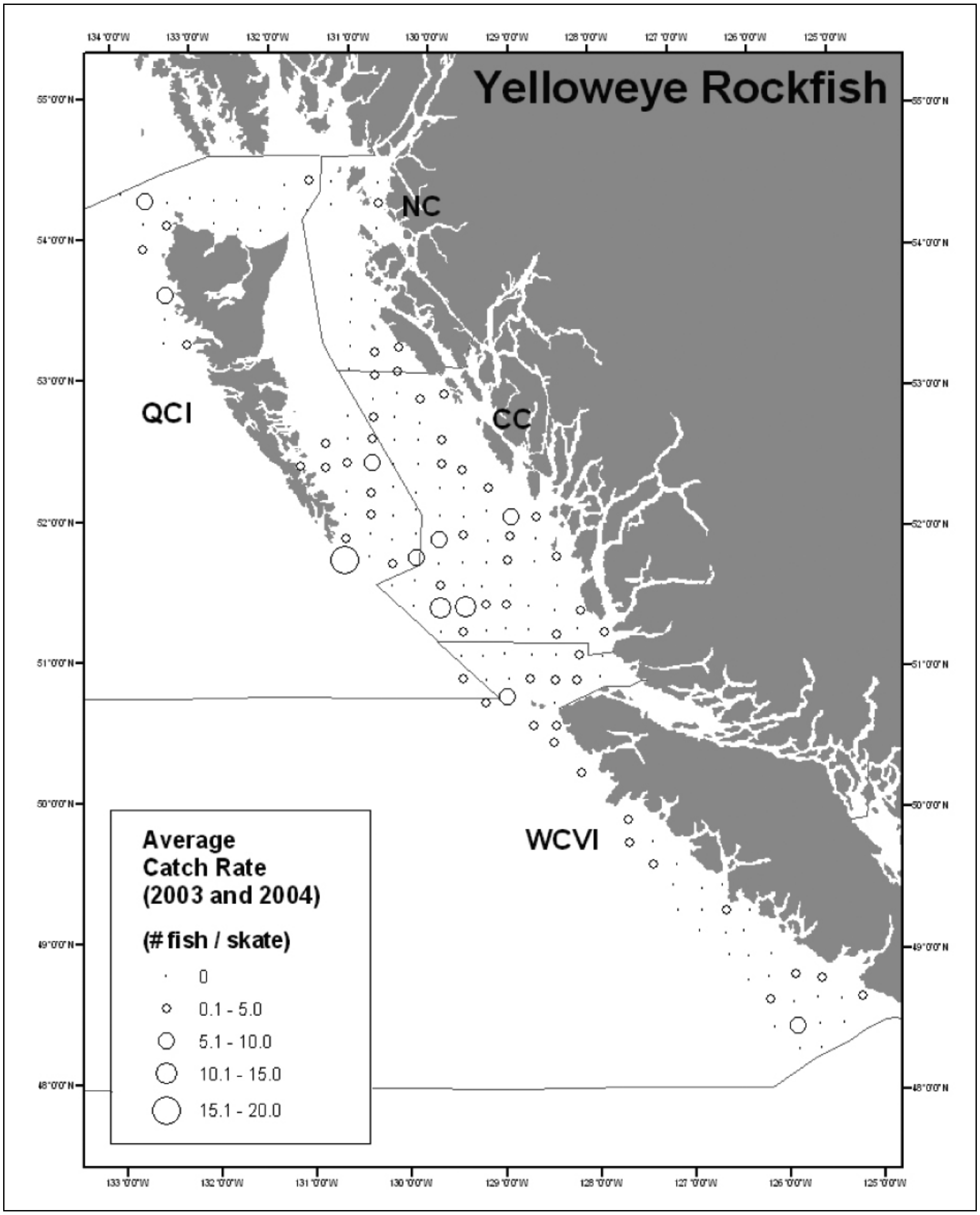

Figure 21. Spatial distribution of Yelloweye Rockfish catch rates from the IPHC SSA survey in B.C. for the years 2003 and 2004 combined.

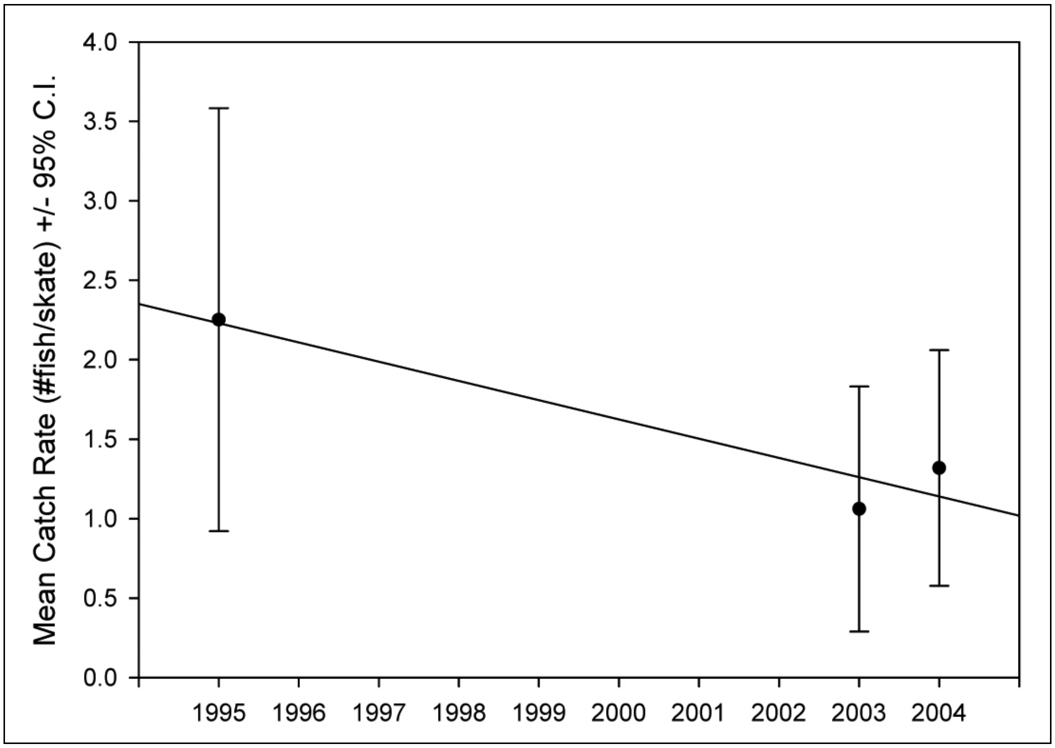

Figure 22. Yelloweye Rockfish mean catch rates and 95% confidence intervals (CI) by year for the IPHC SSA survey. Slope of regression line is not significantly different from zero ($r^2 = 0.013$, $p = 0.098$).

Table 17. Summary statistics for Yelloweye Rockfish catch rate in numbers of fish per skate of fishing gear for the IPHC SSA survey by year in B.C.

Catch Rate (#fish/skate)	1995	2003	2004
Mean	2.25	1.06	1.32
Standard Error	0.67	0.39	0.37
1st Quartile	0	0	0
Median	0	0	0
3rd Quartile	0.40	0.69	0.88
Mode	0	0	0
Standard Deviation	6.02	3.16	3.04
Sample Variance	36.27	10.00	9.27
Minimum	0	0	0
Maximum	33.80	22.88	16.88
Total Number of Sets	81	67	67
Confidence Interval (95.0%)	1.33	0.77	0.74

Inside waters population - surveys

Longline surveys

A new longline survey was initiated to provide an abundance index for inshore rockfish in the inside waters (Lochead and Yamanaka 2004, 2005). This survey has been conducted in 2003 and 2004 in the northern portion of the inside waters, DFO statistical areas (SA) 12 and 13, and in 2005 covered the southern portion of the inside waters, SA 14 through 20, 28 and 29 (Figure 23). No differences in CPUE from the two surveys in areas 12 and 13 were detected (Lochead and Yamanaka 2005). There appears to be no difference in overall catch rate for Yelloweye Rockfish among all the surveys throughout the inside area (Figure 24). Yelloweye Rockfish CPUE indices are no different between the northern and southern portions of the inside area.

Because of the short time period and different areas covered, this survey is considered uninformative about population trends.

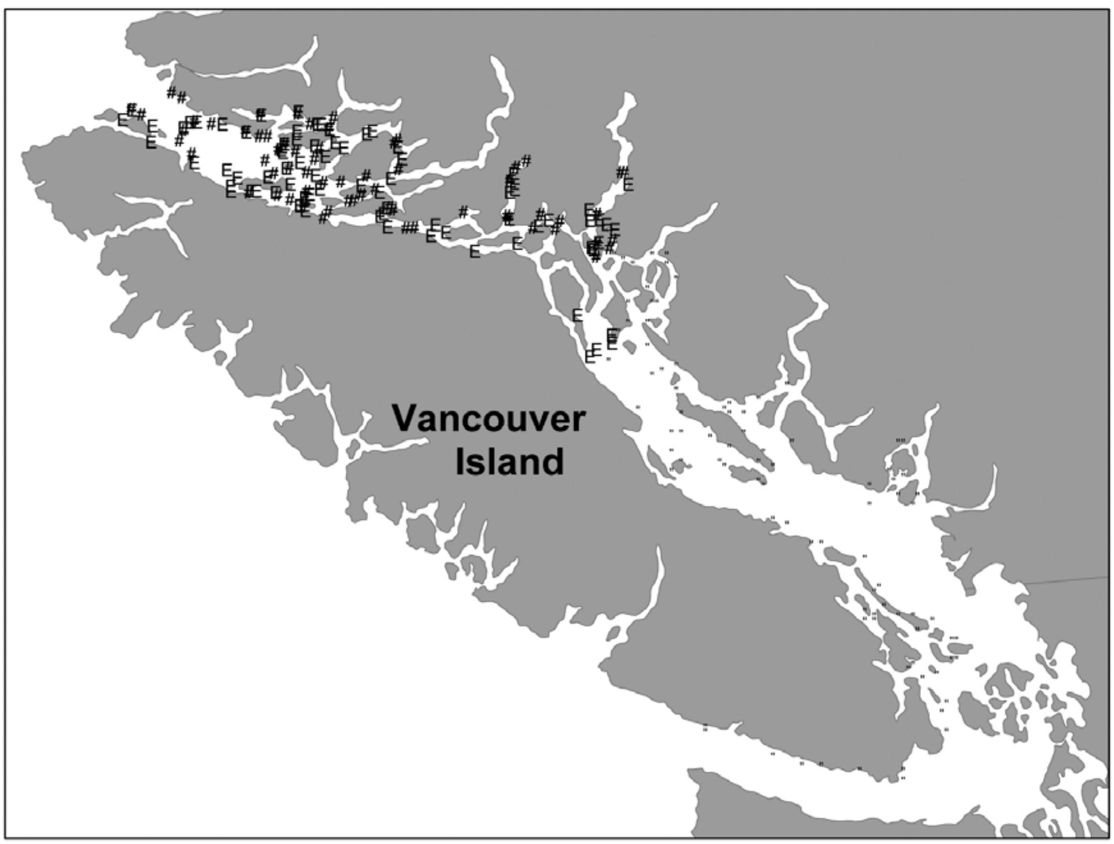

Figure 23. Longline survey set locations fished by year (plus = 2003, triangle = 2004, and square = 2005).

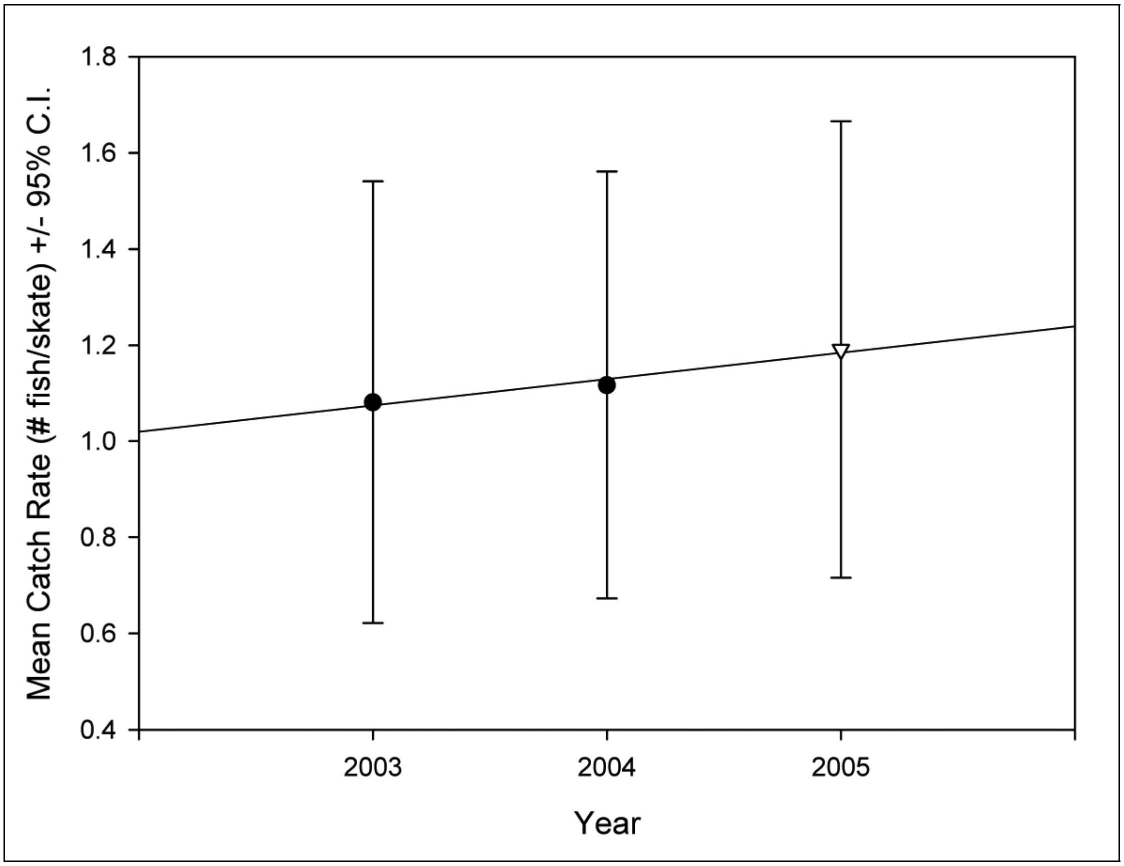

Figure 24. Yelloweye Rockfish mean catch rate and 95% confidence interval (CI) for the inside area longline survey. The survey was conducted in SA 12 and 13 in 2003 and 2004 (filled circles) and in SA 14 through 20, 28 and 29 in 2005 (open triangle) ($r^2 = 0.0005$, $F = 0.12$, $p = 0.7288$).

Submersible surveys

Submersible surveys were conducted in 1984 and 2003 to index abundance of inshore rockfish in the Desolation Sound and Sechelt areas of the Strait of Georgia (Figure 25) (Richards and Cass 1985, Yamanaka *et al*. 2004a). Comparisons of the number of fish observed per transect between common sites and depths surveyed between 1984 and 2003 (Fig. 26, Table 18) show a decline in total individuals observed (180 to 93), maximum number per transect (28 to 11), mean number per transect (8.57 to 4.65) and median number per transect (5 to 4). Differences were not found to be statistically significant.

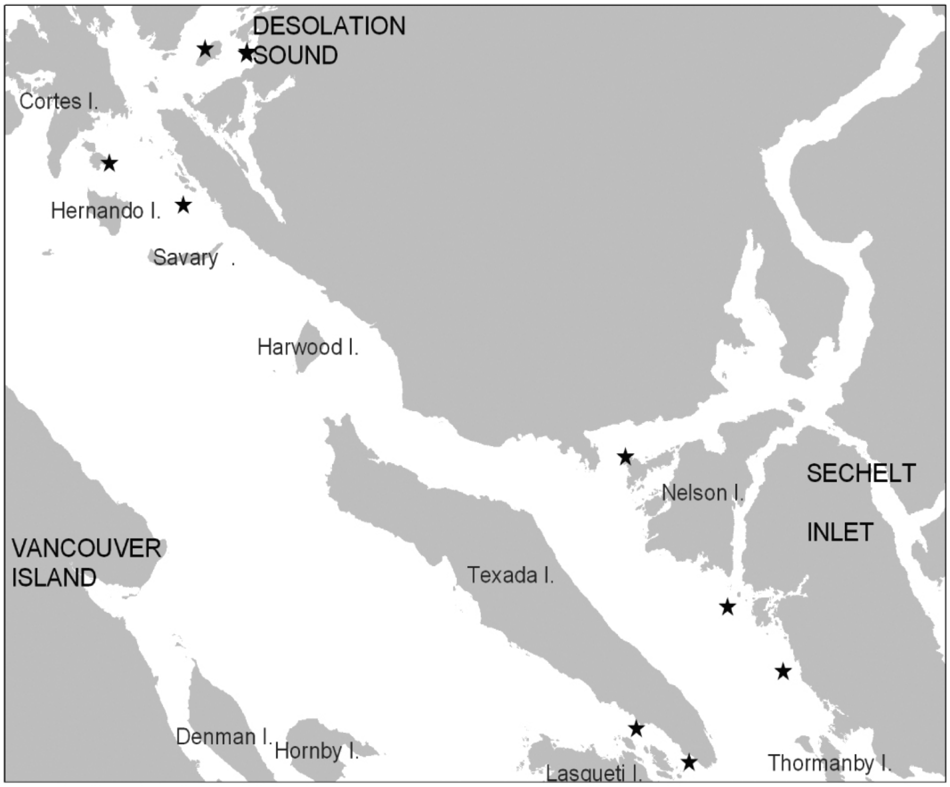

Figure 25. Submersible transect sites surveyed in 1984 and 2003 near Desolation Sound and Sechelt within the Strait of Georgia, inside area.

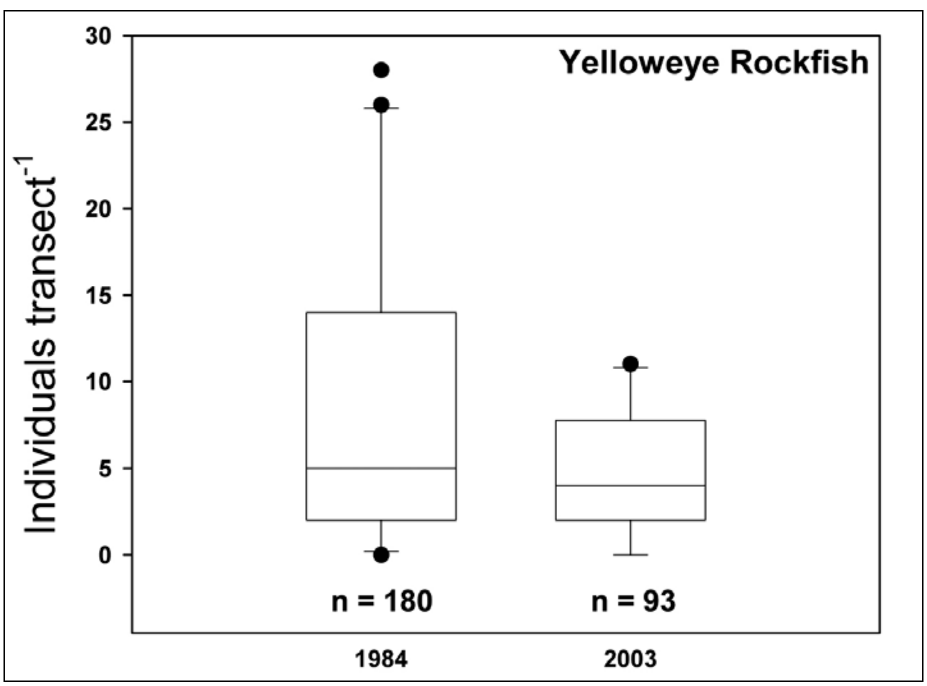

Figure 26. Boxplot of number of Yelloweye Rockfish observed per transect at common sites and depths during submersible surveys conducted in 1984 and 2003. Horizontal midline is median number per transect.

Table 18. Summary statistics of Yelloweye Rockfish observed per transect during submersible dives in 1984 and 2003.

	Numbers of Yelloweye Rockfish per transect	
	1984	**2003**
Number of transects	21	20
Mean	8.57	4.65
Standard Error	1.97	0.80
Median	5	4
Standard Deviation	9.03	3.56
Sample Variance	81.46	12.66
Range	28	11
Minimum	0	0
Maximum	28	11
Confidence Level (95.0%)	4.11	1.67

Inside and outside waters populations - commercial fishery information

Hook and line fisheries

Catch and effort data recorded on logbooks (1986-2004) was used to derive catch per effort indices for the two hook and line fisheries (handline, longline) in inside and outside areas (Fig. 27, Tables 19, 20). Although both gear types operate in both areas, the majority of fishing outside of the Strait of Georgia management region is conducted with longline gear while most fishing inside the Strait of Georgia is with handline gear.

Declining trends in CPUE were observed in all four fishery sectors over this time period: handline inside (59%), longline inside (49%), handline outside (85%) and longline outside (59%). Slopes are significantly different from zero in all cases except longline inside (Fig. 27). Handline and longline fisheries are considered independent indices of abundance as different vessels and gears are used.

Trends in CPUE in this fishery may have been influenced by changes in fishery management and by misreporting as well as by population abundance. High CPUEs prior to 1991 may have been partly due to an increased effort to record landings and become eligible for a licence, pending introduction of limited entry licensing. Landings may have been incorrectly identified to species during this period as no dockside verification was in place. With introduction of limited entry for the inside in 1992 and the outside in 1993, number of licences was reduced (74 and 183 respectively, compared to over 2400 coastwide) and total potential fishing effort decreased substantially. Implementation of 100% dockside monitoring in 1995 provided the ability to check logbook records against dockside observations.

TACs for Yelloweye Rockfish have steadily declined from 1991 to 2002 (~1000 t to 236 t), based on the perception that fishing mortality was too high and CPUE declining. Fishermen state that decreasing TACs result in lowered CPUE as Yelloweye Rockfish is avoided to avoid quota overruns. Between 2001 and 2002, TACs were dramatically reduced, as part of the Rockfish Conservation Strategy, by 50% in the outside area and 75% in the inside area.

Observed CPUEs in the four fishery sectors show wave-like variations which are too rapid to be influenced by abundance fluctuations and which may have been due to changes in fishery practices (Fig. 27, bottom panels). However, a sustained decline in CPUE is shown in all sectors which suggests some factor operating over the almost 20-year period covered. A decline in abundance would be a reasonable explanation for this. However, some uncertainty about the relative contribution of population decline and changes in fishery management and reporting remains.

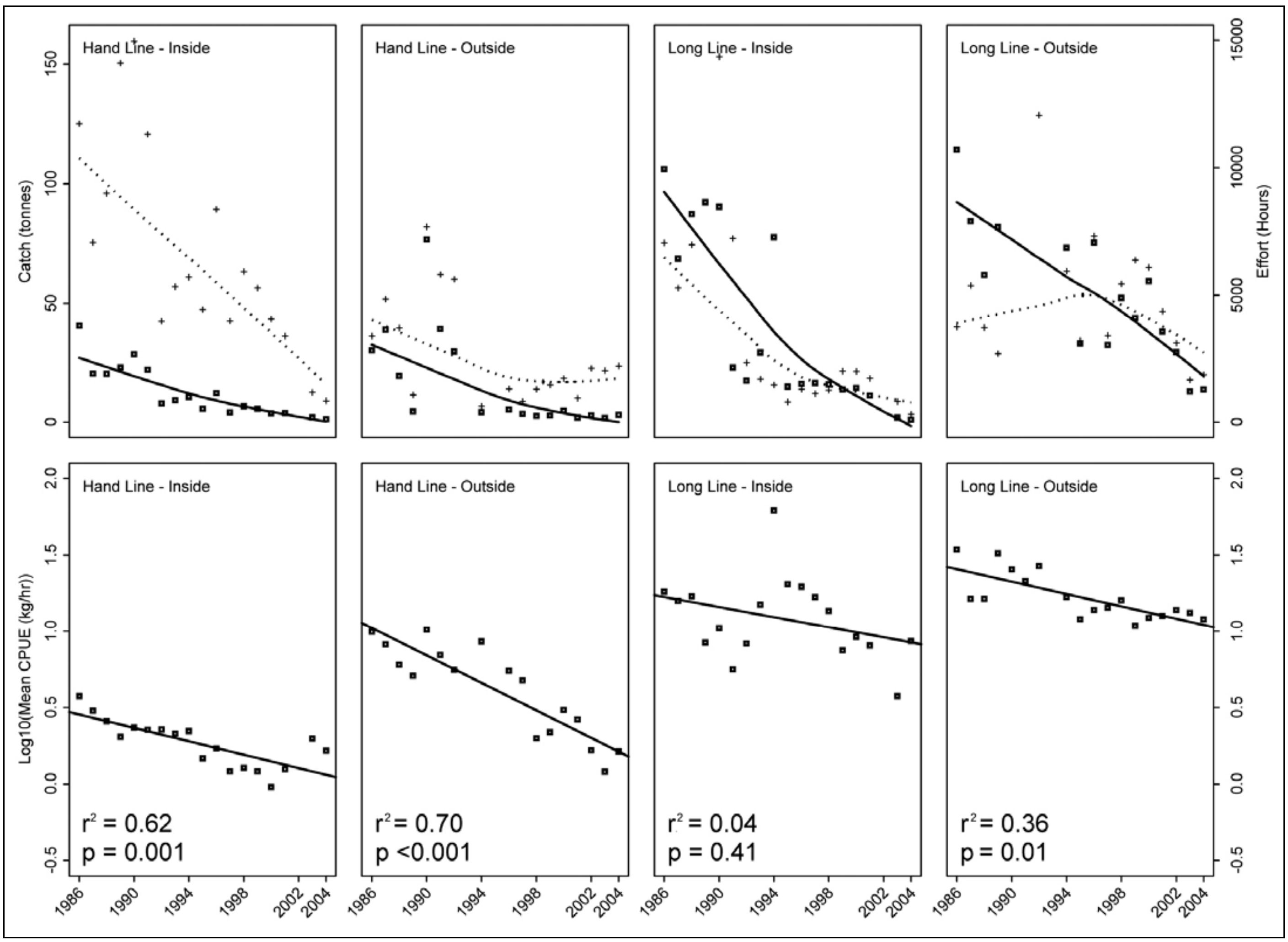

Figure 27. Commercial catch data by gear type (handline and longline) and area (inside and outside) for Yelloweye Rockfish in the commercial directed hook and line rockfish (ZN) fishery. Upper panels display catch (square) and effort (plus). Solid line is a local regression fit of catch, dotted line is a local regression fit of effort. Lower panels display mean log(10) catch per unit of effort (kg/hr) fit with a regression line and regression statistics.

Table 19. Summary statistics for Yelloweye Rockfish commercial catch per unit of effort (kg/hr) for the hook and line rockfish (ZN) fishery by year, handline gear and area.

	Handline - Inside				Handline - Outside			
Year	**Mean**	**S. Dev**	**S. E.**	**n**	**Mean**	**S. Dev**	**S. E.**	**n**
1986	3.76	6.489	0.1590	1666	9.93	13.475	0.6476	433
1987	3.01	6.219	0.1885	1089	8.18	10.898	0.4557	572
1988	2.57	3.455	0.0934	1369	6.03	8.327	0.3833	472
1989	2.03	3.515	0.0815	1861	5.10	6.382	0.5619	129
1990	2.33	3.291	0.0730	2031	10.25	21.517	0.6916	968
1991	2.26	2.939	0.0788	1392	6.99	9.893	0.3828	668
1992	2.27	2.588	0.1093	561	5.57	8.183	0.3378	587
1993	2.14	2.175	0.0823	699				
1994	2.22	3.490	0.1214	826	8.55	12.428	1.5534	64
1995	1.47	2.189	0.0871	631	8.07	24.055	3.4721	48
1996	1.71	2.333	0.0704	1098	5.50	11.447	0.9078	159
1997	1.21	1.848	0.0795	540	4.76	6.316	0.6446	96
1998	1.27	2.373	0.0835	808	1.99	2.413	0.2084	134
1999	1.21	1.382	0.0521	705	2.17	3.809	0.2763	190
2000	0.95	0.828	0.0354	546	3.04	6.316	0.4466	200
2001	1.25	3.346	0.1692	391	2.64	5.009	0.4820	108
2002					1.66	2.468	0.1695	212
2003	1.98	5.103	0.5053	102	1.20	1.618	0.1196	183
2004	1.66	3.629	0.4057	80	1.64	2.289	0.1543	220

Table 20. Summary statistics for Yelloweye Rockfish commercial catch per unit of effort (kg/hr) for the hook and line rockfish (ZN) fishery by year, longline gear and area.

	Longline - Inside				Longline - Outside			
Year	**Mean**	**S. Dev**	**S. E.**	**n**	**Mean**	**S. Dev**	**S. E.**	**n**
1986	18.25	21.694	0.7199	908	34.34	45.301	2.3909	359
1987	15.80	24.480	1.0290	566	16.38	18.205	0.8318	479
1988	16.98	19.685	0.7868	626	16.32	15.795	0.8443	350
1989	8.41	13.425	0.3153	1813	32.40	38.197	2.3553	263
1990	10.49	28.334	0.7706	1352	25.56	36.615	0.6505	3168
1991	5.61	9.930	0.3966	627	21.33	31.667	0.6004	2782
1992	8.32	11.044	0.5116	466	26.74	41.065	1.0424	1552
1993	14.96	30.864	2.0091	236	44.41	40.374	12.1733	11
1994	61.99	99.722	6.9479	206	16.81	33.152	1.2695	682
1995	20.36	22.789	2.2031	107	11.98	17.034	0.8351	416
1996	19.60	25.913	2.0052	167	13.81	21.421	0.6684	1027
1997	16.76	20.669	1.8341	127	14.30	22.784	1.0272	492
1998	13.56	17.374	1.5665	123	16.00	25.261	0.9261	744
1999	7.47	10.041	0.6979	207	10.84	22.324	0.7744	831
2000	9.19	14.562	0.9977	213	12.28	30.292	1.0415	846
2001	8.06	10.136	0.7131	202	12.59	18.896	0.7152	698
2002	10.39	2.093	0.7909	7	13.79	19.986	0.8781	518
2003	3.76	5.099	0.5177	97	13.21	27.231	1.7878	232
2004	8.59	10.131	1.4049	52	11.95	19.813	1.1757	284

Trawl fishery

A catch per unit effort time series was constructed from the commercial groundfish trawl fishery using at-sea observer recorded catch (Figure 28, Table 21). Yelloweye Rockfish are caught incidentally in the trawl fishery and make up less less than 5% of the overall catch (Table 12).

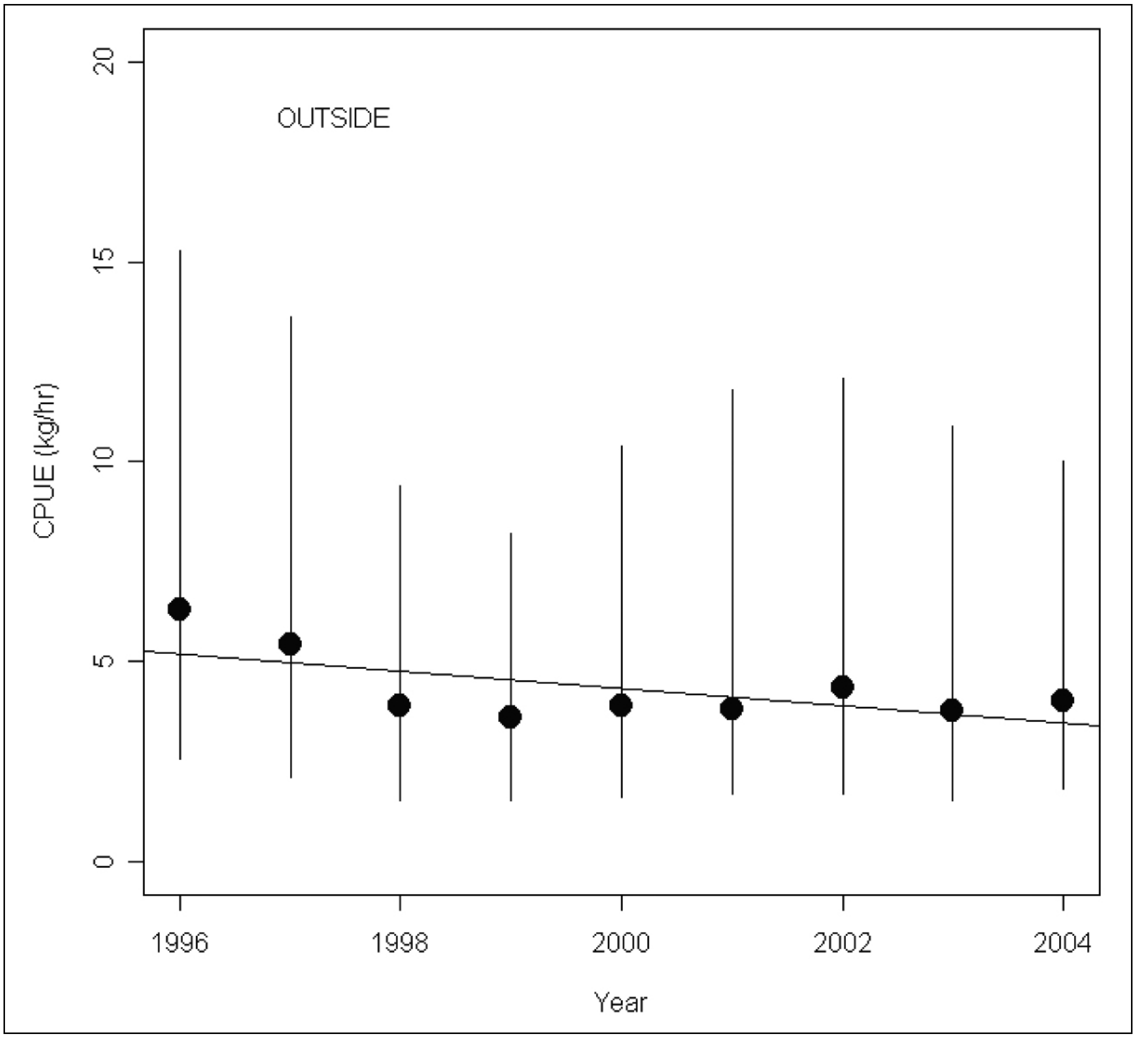

Figure 28. Commercial trawl fishery observed median (1st and 3rd quartiles) Yelloweye Rockfish catch per unit of effort (kg/hr) by year fit with a regression line (r^2=0.42, p=0.06).

Although there is some indication of decline in this information, differences between mean catches in the series are not significantly different.

Table 21. Summary statistics for Yelloweye Rockfish catch per unit of effort (kg/hr) observed in the commercial trawl fishery by year from 1996 to 2004 (source: PacHarvTrawl database).

	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean	14.8	16.1	13.2	10.4	12.1	11.5	13.9	11.3	8.3
Standard Error	1.0	1.8	1.9	1.3	0.9	0.8	1.4	0.8	0.4
1st Quartile	2.6	2.1	1.6	1.5	1.6	1.7	1.7	1.6	1.8
Median	6.3	5.4	3.9	3.6	3.9	3.8	4.3	3.8	4.0
3rd Quartile	15.3	13.6	9.4	8.2	10.4	11.8	12.1	10.9	10.0
Mode	2.9	1.9	3.0	2.3	2.7	5.4	1.7	3.4	5.4
Standard Deviation	27.9	54.3	53.5	40.0	28.1	22.9	37.6	23.7	11.6
Sample Variance	776.9	2953.8	2862.0	1596.6	790.2	526.0	1413.8	559.6	134.5
Minimum	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0
Maximum	355.8	1130.8	1258.5	989.7	455.3	287.4	722.8	354.3	78.9
Count	813	888	821	951	1069	884	692	916	755
Confidence Level (95.0%)	1.9	3.6	3.7	2.5	1.7	1.5	2.8	1.5	0.8

Trends in size and age

Information in this section is drawn from Yamanaka *et al.* (2006).

Trends in fork length and age by sex and area for Yelloweye Rockfish were compiled from samples taken from the commercial fishery and research surveys (Figures 29 and 30). Yelloweye Rockfish from the inside area are generally smaller and younger than those from the outside area (also see Table 8).

For the inside area, after an initial sample of smaller, younger fish in the mid-1980’s, there is little subsequent change in length but a very slight decline in age between 1990 and 2003-2005 (Fig. 29, 30). For the outside area there is a declining trend of size and age from the 1980’s through to 2000, followed by an increase to 2005. The declining trend may be indicative of a period of good recruitment (1980 to 2000) followed by poor recruitment (2000 to 2005).

Proportion-at-age-data from the outside area suggest a strong year class (or several) recruiting to the fishery in the early 1990s and persisting through to the end of the time series in 2005 (Fig. 31). It appears that this (these) year class(es) is(are) fully recruited to the fishery by 2000 with little subsequent recruitment from 2001 to 2005, consistent with the increase in age and length (Figures 29 and 30). Relative proportion of older individuals is substantially lower after the early 1990s than earlier (Fig. 31), which may also have contributed to the decline in mean age and length to 2000. Proportion-at-age data from the inside area are too sparse to interpret trends (Fig. 32).

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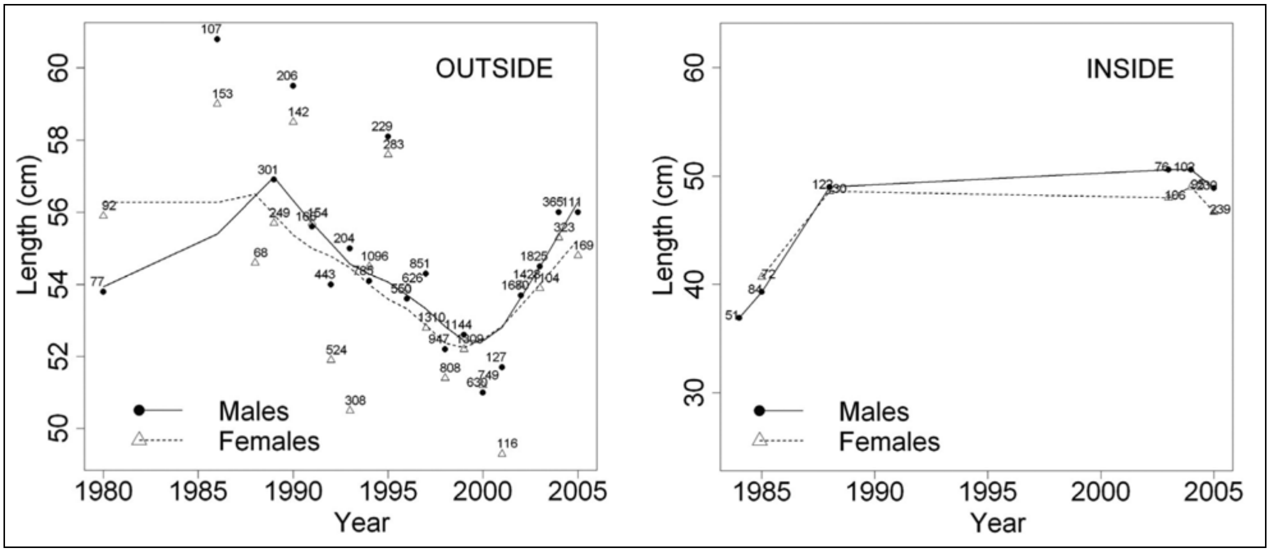

Figure 29. Mean fork lengths by year from samples taken in the commercial fishery and during fishing surveys for Yelloweye Rockfish (males solid line, females dotted line) for the outside (left panel) and inside (right panel) areas. The lines shown are produced from the best-fit locally weighted regression of mean length by year.

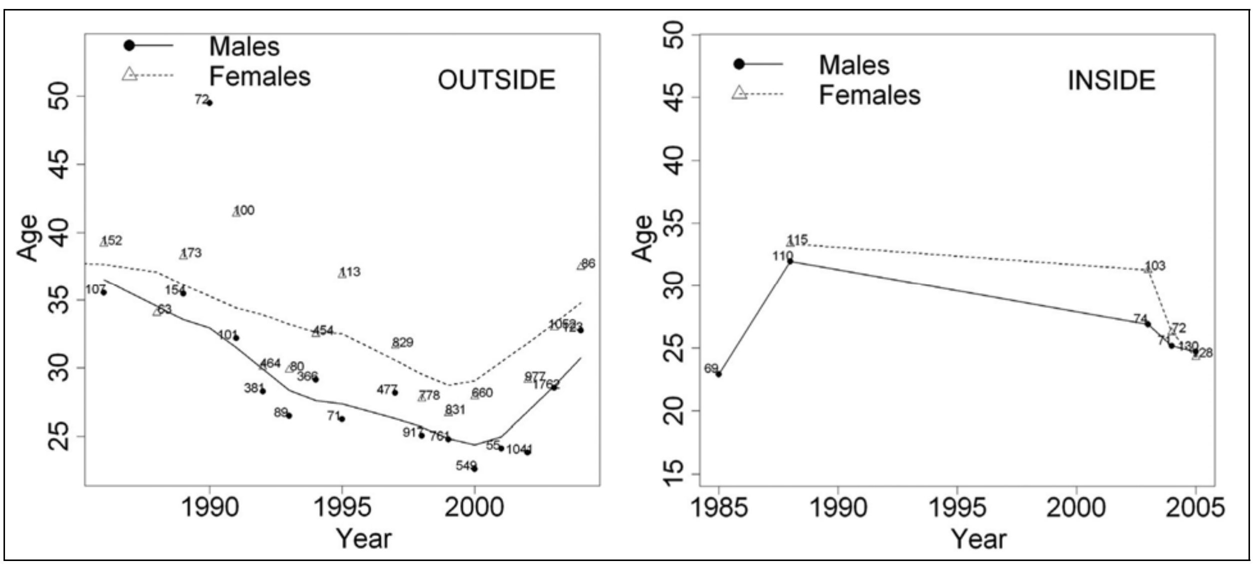

Figure 30. Mean ages from samples taken in the commercial fishery and during fishing surveys by year for Yelloweye Rockfish (males solid line, females dotted line) for the outside (left panel) and inside (right panel) areas. The lines shown are produced from the best-fit locally weighted regression of mean length by year.

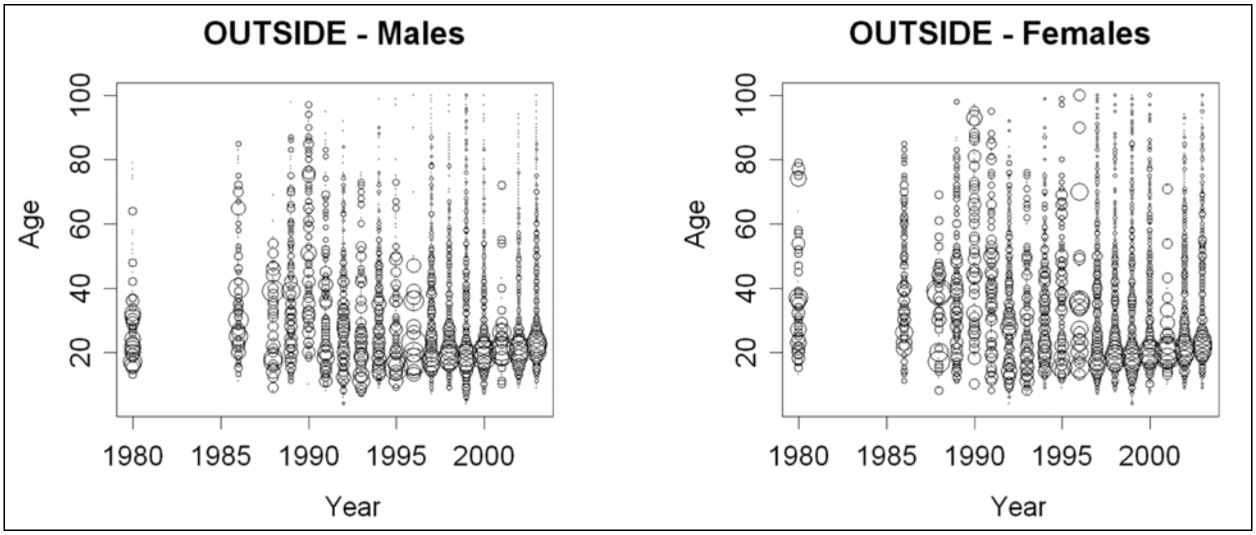

Figure 31. Outside area Yelloweye Rockfish proportions at age from samples taken in the commercial fishery and during fishing surveys by year (males left panel, females right panel).

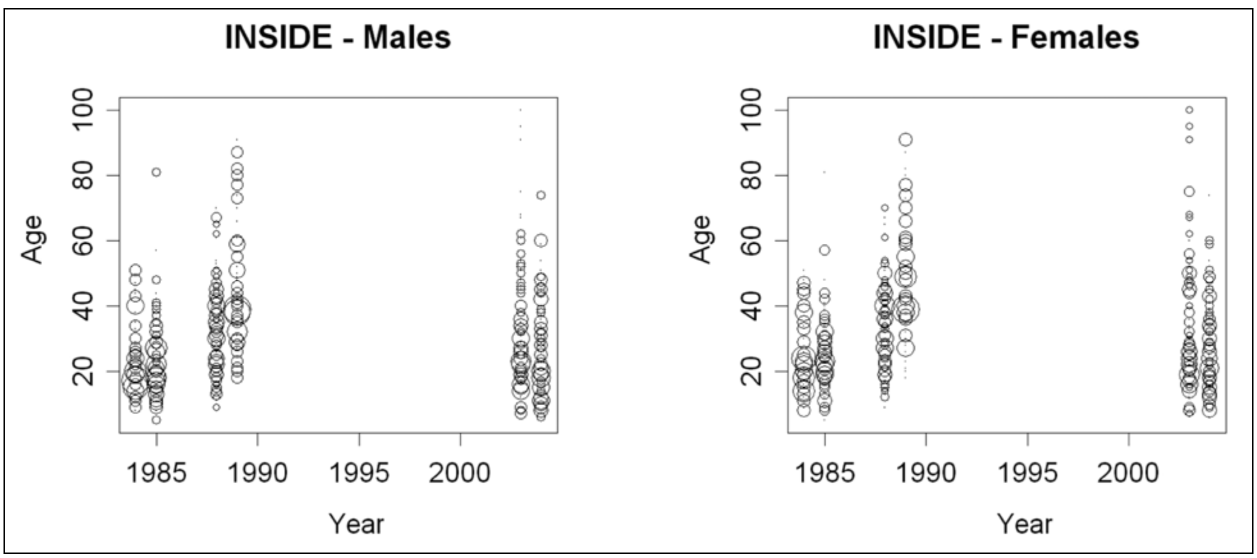

Figure 32. Inside area Yelloweye Rockfish proportions at age from samples taken in the commercial fishery and during fishing surveys by year (males left panel, females right panel).

Summary of trends

Table 22. Summary of available abundance indices.

Index	Name/gear	Area	Period	Trend	Reliability
Outside DU					
Research charters (Fig. 19)	Hook and line	4 sites: 2 QCI, 2 WCVI	Conducted in 1997/8, 2002/3	No trend (increase insignificant)	Medium (designed for species but covers small areas)
IPHC Standardized Stock Assessment (Fig. 22)	Longline	Broad coverage of continental shelf	1995, 2003, 2004	Decreased 40%, statistically insignificant	High (covers species distribution well)
Commercial CPUE (Fig. 27)	Handline	Broad coverage	1986-2004	Decline 85%	Low (fishery changes can affect index values)
Commercial CPUE (Fig. 27)	Longline	Broad coverage	1986-2004	Decline 59%	Low (fishery changes can affect index values)
Commercial CPUE (Fig. 28)	Trawl	Broad coverage	1996-2004	No trend (decline insignificant)	Low (low numbers taken, fishery changes can affect index values)
Inside DU					
Longline (Fig. 24)	Longline	Inside area	2003, 2004, 2005	No trend	High (good coverage, designed for species) but short time span
Submersible (Fig. 26)	Submersible	Inside area	1984, 2003	Declined, statistically insignificant	Medium (covers small areas)
Commercial CPUE (Fig. 27)	Handline	Broad coverage	1986-2004	Decline 59%	Low (fishery changes can affect index values)
Commercial CPUE (Fig. 27)	Longline	Broad coverage	1986-2004	Decline 49% (statistically insignificant)	Low (fishery changes can affect index values)

In outside waters, research hook and line surveys show little trend in abundance indices between 1997 and 2003, while halibut longline surveys (IPHC) show a statistically insignificant decline between 1995 and 2004 (Table 22). Commercial handline and longline CPUE show sustained declines from 1986-2004, while commercial trawl CPUE essentially shows no trend. Commercial CPUE indices were probably influenced by fishery changes as well as by abundance changes; although the relative contribution of each is unknown, the sustained decline suggests a continuous process, which could well be abundance decline.

For the inside area, directed longline surveys have only been conducted for 3 years, 2003 to 2005, so are uninformative about abundance changes. Mean, median, and maximum abundance per transect were lower on submersible surveys in 2003 than in 1984, although the differences were not statistically significant. Longline and handline CPUES showed sustained declines in the inside area as in the outside.

Changes in mean ages and lengths, and in proportions at age, suggest that a recruitment event occurred in the early 1990s, and that proportion of older individuals declined in the 1980s and early 1990s.

Rescue effect

Repopulation of Yelloweye Rockfish through the dispersal of larvae from adults living outside of Canada is posslble as there are no physical barriers to dispersal in the marine environment. Yelloweye Rockfish distribution is continuous to the north and to the south of B.C. Yelloweye Rockfish sampled in outside waters along the coast from SE Alaska to Astoria, Oregon are not genetically distinguishable and their habitats are similar. Based on population status, repopulation of Yelloweye Rockfish from Alaska is more likely than from Washington.

<u>Washington, Oregon and California</u>

The U.S. west coast (Washington, Oregon and California) Yelloweye Rockfish stock declined sharply in the 1980's and early 1990's and the spawning biomass has been below 40% of its original unfished level since 1990 (Wallace *et al*. 2005). Yelloweye Rockfish was declared "overfished" in 2002, and since then has been managed under a rebuilding plan (Methot and Piner, 2002). The recommended harvest level for Yelloweye Rockfish for the U.S. west coast is 26 t. The current spawning biomass (ca 600 t) is around 18% of the historical unfished level, and spawning biomass has been increasing gradually since 2000 (Wallace *et al*. 2006).

<u>Alaska</u>

Yelloweye Rockfish are managed within an aggregate of demersal shelf rockfish (DSR), jointly by the state of Alaska and the National Marine Fisheries Service. The 2004 stock assessment for Yelloweye Rockfish estimated an exploitable biomass of 20,168 t for the federally managed portion (outside waters), with an allowable catch of 450 t (O'Connell *et al*. 2003). Yelloweye Rockfish within State waters is managed to 50 t catch quotas (O'Connell pers comm).

LIMITING FACTORS AND THREATS

Yelloweye Rockfish are among the largest, longest-lived, latest-maturing rockfishes and as such are particularly sensitive to mortality from human activities. Natural mortality is estimated to be extremely low (0.02).

Fishing is the principal known threat to the Yelloweye Rockfish population in B.C. This species is particularly vulnerable to commercial and recreational fishing because of its inshore habitat and high desirability (large size). Aboriginal harvest (current and historical) is not known in detail but the species was probably harvested for subsistence for centuries. The species was certainly harvested in commercial and recreational fisheries during the first half of the 20th century. Fishery removals are essentially unknown prior to the 1950s and are poorly known to the mid-1980s, but could have been substantial, representing a particularly significant impact given the life history parametres. Information on commercial catches has improved since the 1980s, and catches have declined since then because of declining abundance and imposition of stronger management measures. Recreational harvests remain poorly known; there are indications that they have declined in inside waters since the 1980s, but recreational rockfish harvests over the past decade may have increased in Haida Gwaii.

Fishing has had a longer history in the inside waters between Vancouver Island and the mainland, where population has grown rapidly over the past century, than in outside waters. Essentially all of the inside area can be easily reached by recreational fishermen, while large areas of the outside are only accessible to the larger-vessel commercial fishermen.

Since implementation of a rockfish conservation strategy in 2001, commercial yelloweye catches have been substantially reduced to reach targets of a 1.5% harvest rate, 164 areas have been closed to all rockfish fishing (Rockfish Conservation Areas), and catch monitoring programs and stock assessment research have been expanded. These measures have acted to address the principal threat to the species. Control measures are stronger on commercial fisheries (quotas and intensive species-level monitoring) than on recreational fisheries (bag limits and limited monitoring).

SPECIAL SIGNIFICANCE OF THE SPECIES

Yelloweye are one of the largest of the rockfishes. The ecological role of Yelloweye Rockfish is not known but given their longevity, large size, and piscivorous habit, they are likely important in structuring near shore rocky reef ecosystems. Aside from their ecological significance, they are an important component in commercial, Aboriginal, and recreational fishing sectors.

Legends of the Kwicksutaineuk-ah-kwaw-ah-mish First Nation situated on Gilford Island (Broughton Archipelago) involve an “underwater world” comprised of a variety of animals, one of which is “glowuksum” or Yelloweye Rockfish (Figure 30; Sewid pers. comm. 2005).

Figure 33. Photograph of a painting by artist Alan James depicting ‘glowuksum’ or Yelloweye Rockfish as part of the “underwater world” legends of the Kwicksutaineuk-ah-kwaw-ah-mish First Nation. Painting located on Gilford Island, B.C. Photo credit: S. Wallace

Sgan Gwaii on the southwest coast of the Queen Charlotte Islands directly translates as “yelloweye island” from “sgan” the Haida word for Yelloweye Rockfish (Jones 1999). The island is well known by the Haida for the abundance of yelloweye; it was said that yelloweye could be taken in any type of weather. The Ninstints site on the island of *Sgan Gwaii* was the main village of the Kunghit Haida and is now a United Nations World Heritage Site.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Yelloweye Rockfish does not have any international status designations. In U.S. waters south of B.C., Yelloweye Rockfish have been declared “overfished”. In B.C., Yelloweye Rockfish are protected by various catch quota restrictions in both the commercial and recreational fishery. The Rockfish Conservation Strategy has decreased the total allowable catch of Yelloweye Rockfish by 50% outside and 75% inside between 2001 and 2002 to meet a 1.5% target harvest rate. The coastwide overall sector total allowable catches for 2005/06 is 300 t. Rockfish Conservation Areas (areas closed to fishing) protect 20% of rockfish habitats outside and 30% of rockfish habitats on the inside. These closed areas are intended to protect Yelloweye Rockfish and other inshore rockfish species.

TECHNICAL SUMMARY (1) - Pacific Ocean Outside Waters Population

Sebastes ruberrimus

Yelloweye Rockfish (Pacific Ocean outside waters population)

Sébaste aux yeux jaunes (Population des eaux extérieures de l'Océan Pacifique)

Range of Occurrence in Canada: Marine waters of the Pacific Ocean from the Alaska State border in the north to the Washington State border in the south, except for waters in Johnstone Strait/Strait of Georgia/Queen Charlotte Strait

Demographic Information

Generation time (average age of parents in the population)	66 yrs
Population trend and dynamics	
Observed percentage of reduction in total number of mature individuals over the last 10 years.Hook and line survey: insignificant increase 1997-2002 • Longline survey: insignificant decrease (40%) 1995-2004 • Handline CPUE: 85% decline 1986-2004 • Longline CPUE: 59% decline 1986-2004 • Trawl CPUE: no trend 1996-2004	Probably declined but cannot be quantified
Projected percentage of reduction in total number of mature individuals over the next 10 years.	N/A
Observed percentage reduction in total number of mature individuals over any 10-year period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	Yes
Are the causes of the decline clearly understood?	Yes
Are the causes of the decline clearly ceased?	No
Observed trend in number of populations	N/A
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Number of mature individuals in each population

Population	N Mature Individuals
Total	Unknown
Grand Total	

Extent and Area Information

Estimated extent of occurrence (km²)	78,000 km²
Observed trend in extent of occurrence	Probably stable
Are there extreme fluctuations in extent of occurrence?	No
Estimated area of occupancy (km²)	40,000 km²
Observed trend in area of occupancy	Probably stable
Are there extreme fluctuations in area of occupancy?	No
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
Observed trend in area of habitat	Stable

Quantitative Analysis

	Not done

Threats (actual or imminent, to populations or habitats)

Fishing is the principal known past and current threat. Commercial catches are managed to a quota and are well monitored. Recreational catches are managed by bag limit and are not well monitored.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Washington-California: depleted; Alaska: healthy	
Is immigration known or possible?	Possible (larval drift)
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Yes

Current Status

COSEWIC: Special Concern (November 2008)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for Designation: This species is one of an inshore rockfish complex which is exploited by commercial, recreational and Aboriginal fisheries. Life history characteristics make the species particularly susceptible to human-caused mortality, with a maximum recorded age of 120 yr and generation time estimated at 70 yr. Fishery-independent surveys over the past 10 yr do not show significant declines, while declines over 19 yr in commercial catch per unit effort are not believed to represent abundance accurately. Fishery quotas have been substantially reduced from the early 1990s to recent years, closed areas are in place, and restrictions on harvesting are expected to keep catches low in the future. A designation of Special Concern is consistent with the life history characteristics and probable continued removals in fisheries.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not apply because reliable abundance indices do not show declines of more than 30% in three generations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not apply because the range of occurrence exceeds 20,000 km^2 and the area of occupancy is greater than 2,000 km^2.
Criterion C (Small and Declining Number of Mature Individuals): Does not apply because the estimated population size exceeds 10,000 individuals.
Criterion D (Very Small Population or Restricted Distribution): Does not apply because the number of mature individuals exceeds 1,000 and area of occupancy is greater than 20 km^2.
Criterion E (Quantitative Analysis): Not undertaken.

TECHNICAL SUMMARY (2) - Pacific Ocean Inside Waters Population

Sebastes ruberrimus

Yelloweye Rockfish — Sébaste aux yeux jaunes

(Pacific Ocean inside waters population) — (Population des eaux intérieures de l'Océan Pacifique)

Range of Occurrence in Canada : Marine waters of Johnstone Strait/Strait of Georgia/Queen Charlotte Strait

Demographic Information

Generation time (average age of parents in the population)	70 yrs
Population trend and dynamics	
Observed percentage of reduction in total number of mature individuals over the last 10 years • Submersible surveys – decline, 20 years • Handline CPUE – decline 59% in 19 years • Longline CPUE – decline 49% (not significant) in 19 years	Probably declined but cannot be quantified
Projected percentage of reduction in total number of mature individuals over the next 10 years.	Not applicable
Observed percentage reduction in total number of mature individuals over any 10-year period, over a time period including both the past and the future.	Not applicable
Are the causes of the decline clearly reversible?	Yes
Are the causes of the decline clearly understood?	Yes
Are the causes of the decline clearly ceased?	No
Observed trend in number of populations	Not applicable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	Not applicable

Number of mature individuals in each population

Population	N Mature Individuals
	Unknown
Grand Total	

Extent and Area Information

Estimated extent of occurrence (km²)	4,200 km²
Observed trend in extent of occurrence	Probably stable
Are there extreme fluctuations in extent of occurrence?	No
Estimated area of occupancy (km²)	1,600 km²
Observed trend in area of occupancy	Probably stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	Not applicable
Trend in number of locations	Not applicable
Are there extreme fluctuations in number of locations?	Not applicable
Observed trend in area of habitat	Stable

Quantitative Analysis

	Not done

Threats (actual or imminent, to populations or habitats)

Fishing is the principal known past and current threat. Commercial catches are managed to a quota and are well monitored. Recreational catches are managed by bag limit but are not well monitored.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Outside waters population is "Special Concern" but genetically different	
Is immigration known or possible?	Possible (larval drift)
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No – unique DU

Current Status

COSEWIC: Special Concern (November 2008)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for Designation: This species is one of an inshore rockfish complex which is exploited by commercial, recreational and Aboriginal fisheries. Life history characteristics make the species particularly susceptible to human-caused mortality, with a maximum recorded age of 120 yr and generation time estimated at 66 yr. Fishery-independent surveys over the past 20 yr do not show significant declines, while declines over 19 yr in commercial catch per unit effort are not believed to represent abundance accurately. Commercial catch quotas have been reduced and restrictions on harvesting are expected to keep catches low in future; in addition, areas have been closed to commercial and recreational fishing. A designation of Special Concern is consistent with the life history characteristics and probable continued removals in fisheries.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not apply because reliable abundance indices do not show declines of more than 30% in three generations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Extent of occurrence is less than 20,000 km^2 and area of occupancy is less than 2,000 km^2, but there is no indication that population is severely fragmented or undergoes extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not apply because the estimated population size probably exceeds 10,000 individuals.
Criterion D (Very Small Population or Restricted Distribution): Does not apply because the number of mature individuals exceeds 1,000 and area of occupancy is greater than 20 km^2.
Criterion E (Quantitative Analysis): Not undertaken

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Appendix A. Total mortality estimated from Ricker catch curves (1975) for Yelloweye Rockfish age data collected from research surveys.

1. The Surveys

a) Research charters

Research surveys were developed with the directed commercial hook and line rockfish fishing industry in 1997 to determine the fishery's effect on catch rates and population demographics at selected index sites in the outside area. Industry members identified discrete pairs of fishing areas with contrasting fishing histories (lightly and heavily exploited), one pair off the South West Queen Charlotte Islands and the other pair off the North West Coast of Vancouver Island. The Tasu and Triangle sites were deemed lightly exploited and Flamingo and TopKnot sites, heavily exploited (Kronlund and Yamanaka 2001).

Two seasons were sampled, fall and spring, and no differences in catch rate and population demographics were determined so the data were combined to represent annual surveys (Yamanaka *et al*. 2004a). Two depth intervals (37-110 m, 111-201 m) were surveyed at each site with 200 fish targeted at each depth. Data for both annual surveys were depth filtered to include only depths between 80 and 225 m.

b) IPHC SSA

The IPHC conducts their SSA survey annually to assess Pacific halibut from southern Oregon through B.C. to the Aleutian Islands. A fixed station survey design is fished by chartered commercial fishing vessels using standardized conventional gear. Since 2003, data on the total catch by species and biological samples for rockfish have been collected in the B.C. portion (IPHC Area 2B) of the survey (Yamanaka *et al*. 2004b). Age data from the Yelloweye Rockfish collected during the 2003 and 2004 surveys were used for the catch curves. The age data were not depth filtered.

c) DFO longline survey

A longline survey directed for inshore rockfish was initiated in 2003 and surveyed the northern portion of the inside area (statistical areas 12 and 13) from Campbell River in the south to Hope Island in the north (Lochead and Yamanaka 2004). The survey uses a depth stratified (40 to 70 m and 71 to 100 m) random design. Data for the 2003 and 2004 surveys were used in the analysis, and the age data were not depth filtered.

2. Age data

Sagittal otoliths collected from surveys are assigned ages using a burnt section technique (MacLellan 1997) at the Pacific Biological Station Ageing Lab. Age data are stored in the PBS groundfish research database GFBio.

To standardize the ages, in each of the research charter paired surveys, one year was added to the earlier survey data then both year's ages were combined for the analysis. For example, one year was added to the 1997 ages before combining the ages with the 1998 age data.

3. Catch curve methods (Ricker 1975 section 2.2 Simple catch curves p. 33)

Age frequencies are constructed in one year age bins and where the age frequency in an annual bin= 0, this age bin is removed. There is no binning of ages. Frequencies are $-\log_{10}$ transformed and the regression performed on all data after the age at which the maximum age frequency occurs. Total mortality, Z, is calculated from the slope of the regression line multiplied by 2.3026. R^2 values are also presented for the regression line (Figure 1A).

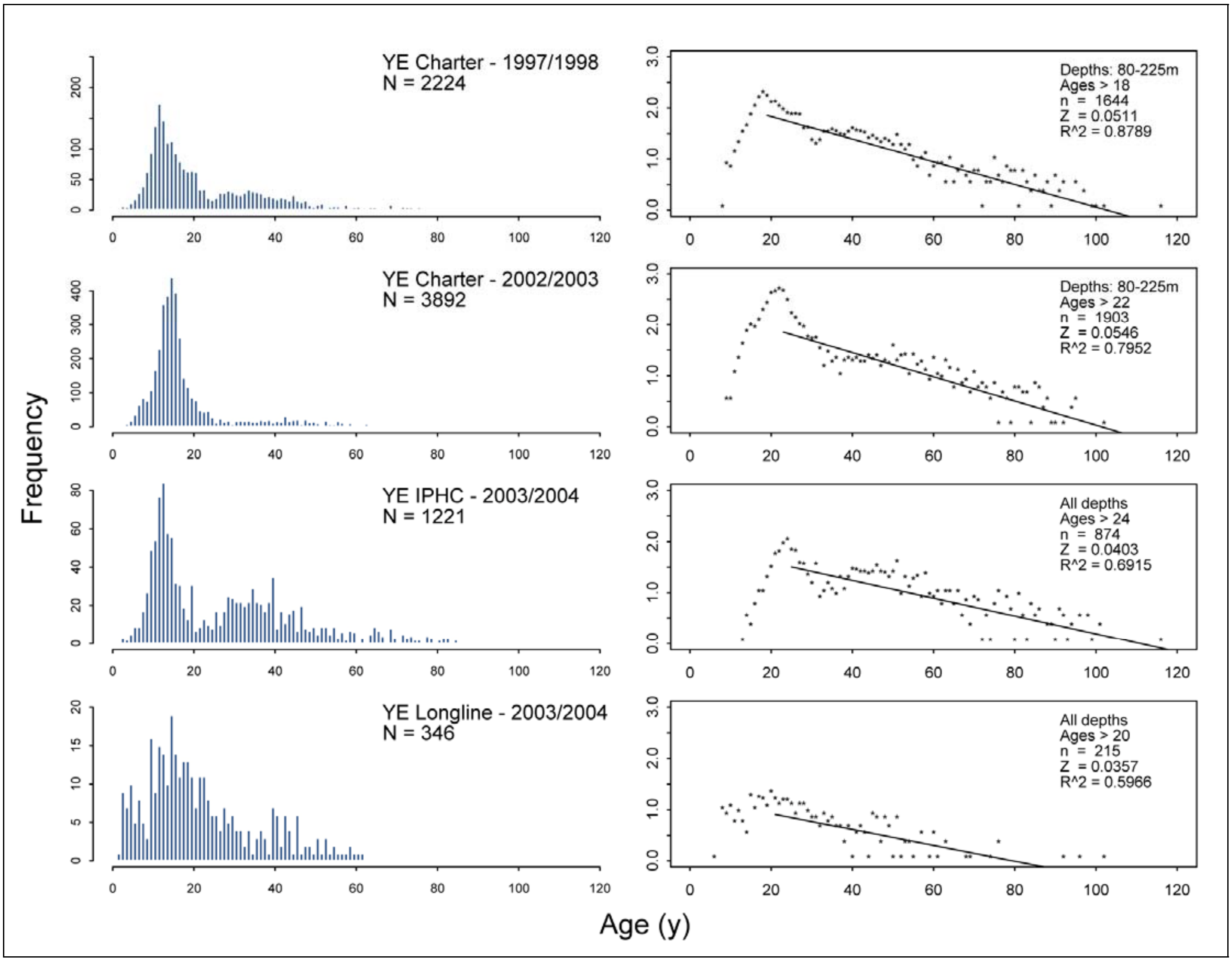

Figure 1A. Age frequencies (left panels), log frequencies with regression line and calculated total mortality, Z and r^2 statistic for the outside research charters in 1997/98 (top), 2002/03 (second from top), outside IPHC SSA survey (second from bottom) and the inside DFO longline survey (bottom).