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Canadian Science Advisory Secretariat
Science Advisory Report 2005/040

SABLEFISH (*Anoplopoma fimbria*) STOCK ASSESSMENT AND ADVICE FOR 2005

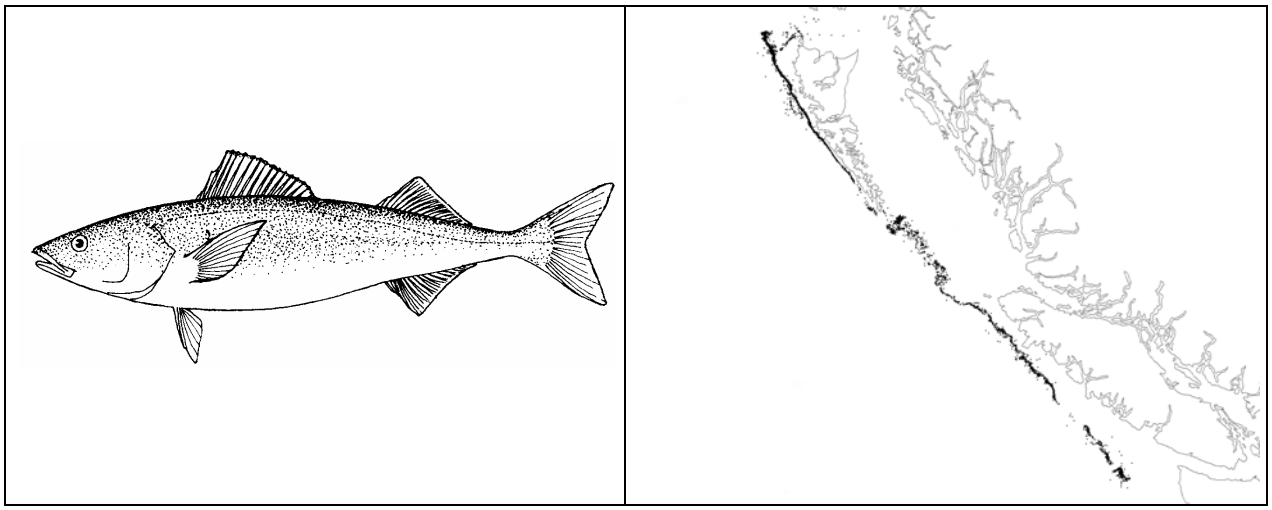

Figure 1: Distribution of directed sablefish fishing activity in the 2003/2004 fishing year.

Context

Sablefish (Anoplopoma fimbria), also referred to as Blackcod, inhabit shelf and slope waters to depths greater than 1500 m, from central Baja California to the Bering Sea and Japan. Spawning occurs from January to March along the continental shelf at depths greater than 300 m. Larval sablefish are found in surface waters over the shelf and slope in April and May. Juveniles migrate inshore over the following six months and rear in near shore and shelf habitats until ages 2 to 5 when they migrate offshore and recruit to deeper waters. Fish become vulnerable to the offshore longline trap and hook fisheries at this time. Juveniles can be highly migratory, with tagged fish traveling from the waters of Hecate Strait and mainland inlets as far north as the Aleutians. Growth is rapid, with mature females reaching an average length of 55 cm, and a maximum of 80 cm, in 3 to 5 years. The oldest fish aged was 113 years. Age, growth and maturity parameters vary among areas and depths. Recruitment rates also vary, with infrequent occurrences of very large year classes interspersed with moderate to low year classes.

The directed sablefish fishery is operated under a transferable quota system limited to 48 license holders. The directed catch is taken primarily by trap gear with about 20 percent of this catch harvested by longline gear. The multi-species trawl sector is allocated 8.75 percent of the total allowable catch. Annual assessments have been conducted since the late 1980s. Fishery management is conducted on stocks defined in the Gulf of Alaska, British Columbia, and the continental United States. Patterns in sablefish recruitment, growth and the movement of tagged fish indicate the presence of northern and southern stocks in B.C. waters that mix off north western Vancouver Island. Large-scale movement occurs with fish tagged in coastal B.C. being recovered from Oregon to the Aleutian Islands. In 2002 the annual quota was reduced from 4,000 t to 2,450 t over two years in response to a marked decline in the 2001 survey index. Positive signals in the survey and commercial catch rate indices since 2001 led to an increase in the TAC to 4,500 t by the 2004/2005 fishing year. A collaborative agreement between Fisheries and Oceans Canada and the Canadian Sablefish Association provides for joint research, stock assessment, management, and enforcement activities.

SUMMARY

- Resource status was evaluated based on coast-wide trends in commercial catch rates (CPUE), research survey catch rates, and tag-recovery estimates of sablefish biomass.

- **Nominal trap catch rates** (1979-2003). Coast-wide nominal CPUE peaked in the early 1990s and declined until 2002. The timing of this peak is consistent with a similar trend observed for the Gulf of Alaska sablefish stock. Coast-wide nominal CPUE (kg/trap) increased substantially in 2003 relative to levels experienced from 1999 to 2002.

- **Standardized commercial trap catch rates** (1990- July 2004). Standardized trap fishery catch rates (kg/trap) declined from 1991 to 1998 prior to the mandatory adoption of escape rings in the trap fishery. Subsequent to 1998 the four-year trend indicated a decline, with a low in 2001, modest improvement in 2002 and substantial improvement in 2003. The northern catch rate for 2004 decreased to a level intermediate between 2002 and 2003. Southern catch rates were relatively stable between 1999 and 2003 but decreased to the lowest index value in the time-series in 2004; however the 2004 index point was based on limited data. The coast-wide trend was intermediate between the north and south trends over the 1999 to July 2004 period.

- **Standardized trap survey** (1990-2004). Survey CPUE (numbers/trap and kg/trap) generally declined from highs in the early 1990s to a low in 2001. A modest increase was observed for northern B.C. in 2002 followed by a substantial increase to near historic high catch rates coast-wide in 2003. The 2004 coast-wide catch rate was similar to the level observed in 2003; the increase was due to positive results observed in three shallow strata.

- **Tagging estimates of trap-vulnerable biomass** (1991-2004). Beginning of year trap-vulnerable biomass declined rapidly from an initial peak in 1992 and 1993 through to 1999. It has remained at low levels since then, with historical lows in 2001 and 2002 followed by a slight increase in 2003. Beginning of year trap-vulnerable 2004 biomass estimated using tag-recovery data only remained at a relatively low level.

- Outputs from a tagging model that integrated commercial and survey catch rate indices suggested that if recruitments to the trap-vulnerable biomass are similar to those realized from 1980 to 2004, the probability is at least 0.69 that annual catches from 0 to 5,500 t should not lead to a short-term conservation concern for $P\left(B_{2010} > B_{2002}\right)$. Over the short-term, the probability $P\left(B_{2007} > B_{2002}\right)$ is at least 0.66 for catches from 0 to 4,500 t.

DESCRIPTION OF THE ISSUE

A meeting of the Regional Advisory Process was held on January 18-20, 2005 at Nanaimo, B.C. to assess the status of sablefish in support of the 2005/2006 fishery. Participants included DFO staff, representatives of the sablefish and trawl industries, and non-DFO scientists.

Sablefish have a long history of exploitation with the first recorded landings in 1913. Foreign fishing was conducted from 1961 to 1981, but was phased out after the declaration of the 200-mile economic exclusion zone in 1977. The directed sablefish fishery is regulated under a “K” tab license that permits longline traps or hooks to be deployed. The fishery has operated under an Individual Transferable Quota (ITQ) system since 1990. The allocation to the trawl fishery is

8.75% of the total allowable catch (TAC). Sablefish are primarily caught using longline traps, with about 20% of the total catch fished using longline hooks during the 1999 to 2003 period. Most trap fishing effort occurs between about 450 m and 825 m. The sablefish fishery continues to be one of the most important in B.C. with an estimated value of CAN $29 million from landings of 3,800 t in 2000. The majority of the product is headed, gutted and frozen at sea for export to Japanese markets. A collaborative agreement between Fisheries and Oceans Canada and the Canadian Sablefish Association provides for joint research, stock assessment, management, and enforcement activities.

Table 1: Annual sablefish landings by gear type.

Year	Longline	Trap	Trawl	Total
1990	1371.8	3072.4	460.7	4904.9
1991	1179.2	3494.4	438.8	5112.4
1992	847.5	3710.2	448.7	5007.5
1993	424.2	4142.4	543.1	5109.8
1994	467.7	4050.7	483.1	5001.5
1995	474.3	3272.2	427.4	4178.7
1996	278.9	2999.4	192.5	3470.8
1997	430.7	3555.1	156.3	4142.1
1998	443.7	3772.0	376.1	4591.7
1999	628.1	3682.9	403.0	4717.6
2000	752.3	2758.1	326.3	3836.7
2001	564.5	2750.1	299.6	3614.2
2002	564.7	2178.9	266.8	3012.7
2003	640.6	1486.6	227.6	2354.8

ASSESSMENT

Four stock abundance indices are incorporated into the sablefish assessment (Figure 1). Coast-wide **nominal commercial trap catch rates** (kg/trap) increased substantially in 2003 relative to levels experienced from 1999 to 2001. Prior to 2003 nominal catch rates remained at, or slightly below, levels experienced in the early 1980s. Data for 2004 were incomplete. **Standardized commercial trap catch rates** (kg/trap) for the north coastal area declined continuously from 1991 to 1998 prior to the mandatory adoption of escape rings in the trap fishery. Subsequent to 1998 the four-year trend indicated a decline, with a low in 2001, modest improvement in 2002 and substantial improvement in 2003 in agreement with the standardized survey trajectory. The northern catch rate for 2004 decreased to a level intermediate between 2002 and 2003. The south area catch rates initially increased and then declined from 1992 through 1998 with a major decline occurring between 1994 and 1995. Subsequent to 1998, southern catch rates were relatively stable between 1999 and 2003 but decreased to the lowest index value in the time-series in 2004. However, the 2004 index point for the south was limited to fishing data obtained from only two trips. The coast-wide standardized catch rates are intermediate between northern and southern values. Coast-wide **standardized trap survey catch rates** (numbers/trap and kg/trap) increased substantially in 2003 and 2004. The trend for both areas shows a general decline in catch rates from highs in the early 1990s. Beginning in the mid-1990s, the rate of decline generally decreased, and there was a period of relative stability through to 2000. The 2001 survey produced the lowest mean and median catch rates observed in the times series, with marked reduction of the variance for the north area in particular. Catch rates for the north area improved in 2002 relative to 2001, and were comparable to those observed in the mid-1990s, but with higher variability. Catch rates in 2003 increased substantially to a historical high and moderated slightly in 2004. Catch rates in the

south area exhibited a continuous decline from the mid-1990s to 2002, but increased significantly in 2003 largely due to improved catches in three shallower depth strata. Catch rates in 2004 were similar in level to those observed in 2003 with similar variability, largely due to high catch rates in three shallower depth strata. **Tagging estimates of trap-vulnerable biomass** declined rapidly from an initial peak in 1992 and 1993 through to 1999. The estimated biomass has remained at low levels since then, with historical lows in 2001 and 2002 followed by a slight increase in 2003. Beginning of year trap-vulnerable 2004 biomass estimated from tag-recovery data only remained at a relatively low level.

A tagging model with monthly time steps was integrated with the catch rate based abundance indices. Model assumptions included constant rates of natural mortality and emigration from the B.C. trap-vulnerable population. Recruitment parameters were estimated for each year and these represented all additions to the trap-vulnerable biomass in B.C. including new year-classes entering the trap-vulnerable population for the first time, fish immigrating to the region and becoming vulnerable to the trap fishery, and fish becoming vulnerable to trap gear through behavioral or other mechanisms. Age-structured data were not available because unresolved problems in ageing methodology have postponed the accumulation of catch at age information since 1996. A Bayesian approach, based on the Markov Chain Monte Carlo (MCMC) algorithm was used to estimate the joint posterior distribution of model parameters. The integrated tagging model was used to conduct 5-year stock projections at constant TAC levels.

As in previous sablefish assessments, a series of performance measures were calculated for each projection to assist in the selection of short-term TACs. The performance measures relate to biomass levels that should be avoided to ensure conservation concerns for sablefish do not arise:

1. The probability that the beginning-year vulnerable stock biomass in 2010 is above the beginning-year 2002 vulnerable stock biomass, $P\left(B_{2010} > B_{2002}\right)$;
2. The probability that the end-year vulnerable stock biomass in 2009 is above the end-year 2001 vulnerable stock biomass, $P\left(B''_{2009} > B''_{2001}\right)$;
3. The probability that the end-year vulnerable stock biomass in 2006 is above the end-year 2001 vulnerable stock biomass, $P\left(B''_{2006} > B''_{2001}\right)$;

Table 2: Performance statistics for 5-year and 2-year catch projections to evaluate the probability of being above B_{2002}. Recruitment values were drawn from the historic 1980 to 2004 time series. The Low, Avg, and High columns indicate the impacts of current 2004 biomass actually being at in the lower, middle, and upper one-third of the marginal distribution of B_{2004}. The Exp column integrates results over the three possible state of B_{2004}.

Total Annual Catch 2005-2009	$P\left(B_{2010} > B_{2002}\right)$				Total Annual Catch 2005-2009	$P\left(B_{2007} > B_{2002}\right)$			
	Low	Avg.	High	Exp		Low	Avg	High	Exp.
0	0.82	0.80	0.82	0.81	0	0.71	0.71	0.73	0.72
3,500	0.73	0.72	0.74	0.73	3,500	0.65	0.68	0.69	0.67
4,500	0.71	0.70	0.71	0.71	4,500	0.64	0.66	0.67	0.66
5,500	0.68	0.68	0.70	0.69	5,500	0.64	0.66	0.65	0.65
7,500	0.63	0.63	0.66	0.64	7,500	0.61	0.62	0.64	0.63
10,000	0.57	0.58	0.60	0.58	10,000	0.58	0.59	0.61	0.59

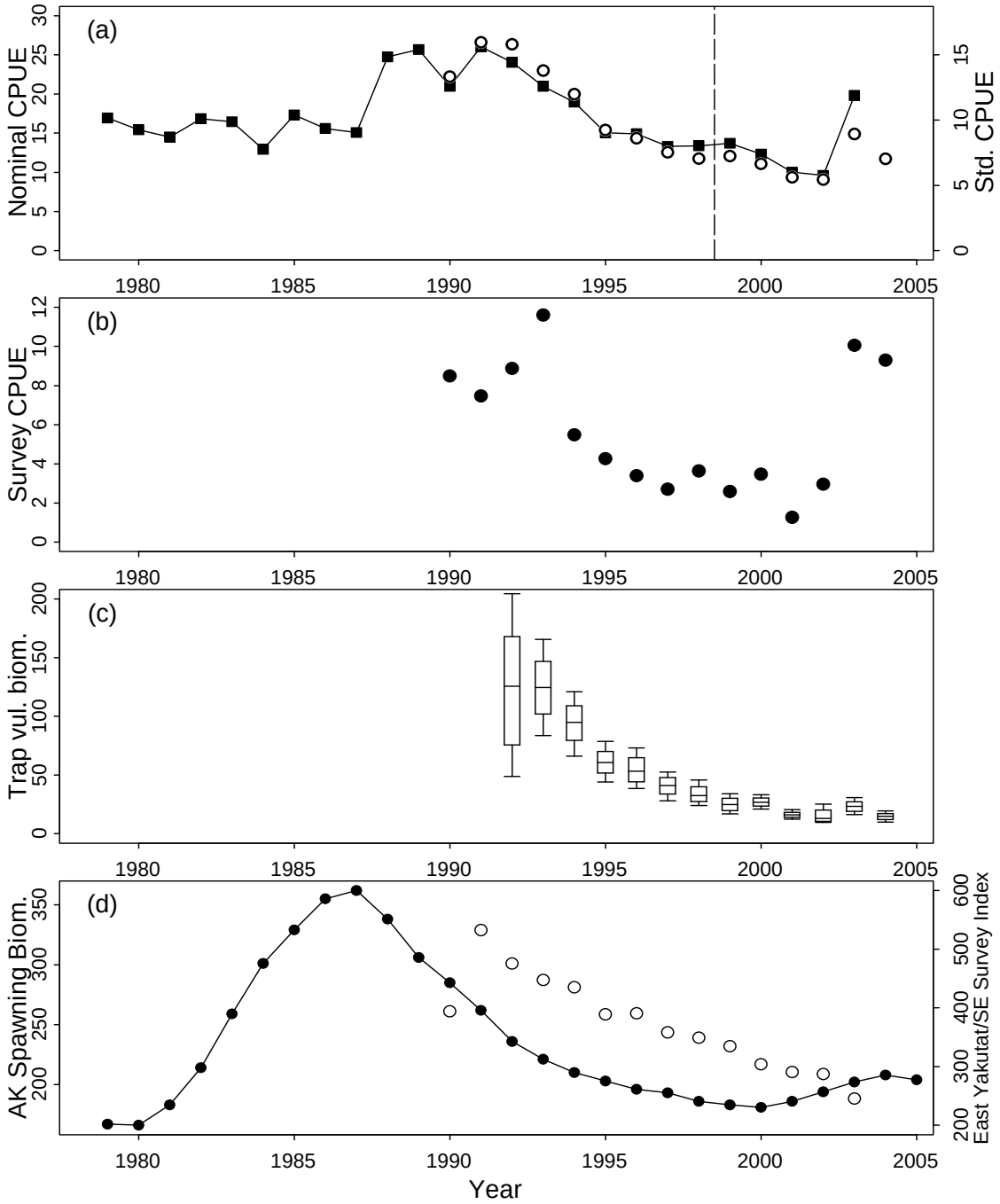

Figure 2: Coast-wide stock indices: (a) B.C. trap fishery nominal index (filled squares) and standardized (open circles) indices (kg/trap), (b) B.C. survey index (numbers/trap), and (c) B.C. trap-vulnerable biomass (1,000 t) posterior distributions for tagging data only, (d) Alaska spawning biomass (1,000 t, filled circles) and East Yakutat/South East survey index (open circles). The dashed vertical line in panel (a) indicates the inception of trap escape rings in the B.C. trap fishery.

ADDITIONAL STAKEHOLDER PERSPECTIVES

Industry representatives from the directed sablefish fishery reported that commercial fishing catch rates had improved over the last three years, in particular for southern B.C. More modest

increases in catch rates were reported from the northern area. Industry commented on very positive results for 2004 based on fishing experience late in the calendar year for which assessment data were not available. Sablefish industry representatives noted an abundance of sub-legal (<55 cm fork length) sablefish from both the trap and longline gear sectors over the last three years. A trawl gear sector representative noted that sablefish had become more abundant in recent years and could become a limiting species for some quota holders in the multi-species trawl fishery.

CONCLUSIONS AND ADVICE

The integrated tagging model synthesizes the trends from commercial and survey catch rates into the dynamics of the tag-recovery model. Model outputs suggested that if the recruitments to the trap-vulnerable biomass are similar to those realized from 1980 to 2004, the probability is at least 0.69 that catches from 0 to 5,500 t should not lead to a short-term conservation concern for $P(B_{2010} > B_{2002})$. Over the short-term, the probability $P(B_{2007} > B_{2002})$ is at least 0.66 for catches from 0 to 4,500 t. Interpretation of the decision tables depends on a number of factors. Although the trends from the stock indices have been in agreement over much of the available time series, the tagging index diverged from the catch rate based indices in 2004. However, the greatest contrast in the results is dependent on whether the future sequence of recruitments to the trap-vulnerable biomass is similar to the longer-term 1980 to 2004 history or more like shorter-term 1994 through 2004 period.

The recent period includes the relatively low recruitments experienced during the mid 1990s through to 2002. Sablefish recruitment during the 1990s was regarded as below average in B.C. and for U.S. stocks in the eastern Gulf of Alaska and off the southern U.S. coast north of Point Conception. Results from indicators such as the west coast Vancouver Island shrimp survey and U.S. triennial shelf and slope surveys suggest production due to the 1999 and 2000 year-class may materialize in the trap-vulnerable biomass in the next few years. Also, analysis of sablefish catch by trawl gear off the west coast Vancouver Island suggests catch rate trends consistent with the shrimp survey results. It is not known whether the stock index results for 2004, and the possibility of an above average 2000 year-class, signal the beginning of a sustained period of recruitments to the trap-vulnerable biomass.

The PSARC Groundfish Subcommittee acknowledged the recent positive indicators, but recommended adoption of the 2-year projections $P(B_{2007} > B_{2002})$ since these results are less dependent on assumptions about future recruitment (Fargo 2005).

OTHER CONSIDERATIONS

Indicators related to stock status of B.C. sablefish but not directly integrated into the assessment model were evaluated. **Gulf of Alaska sablefish stock status abundance** is considered to be at a moderate level with the 1997 year-class projected to comprise 23 percent of the 2005 spawning biomass. Relative abundance in 2004 was 4 percent higher than in 2000. Although the 1998 year-class was initially expected to be above average, it now appears to be weak. The 2000 year-class may be above average but more data are required to confirm its relative contribution to stock abundance. The longline survey index from the East Yakutat/South East region of Alaska adjacent to northern B.C. waters declined from a relatively high level in 1992 to a low in 2003 (Figure 1). The 2004 survey value is comparable to that observed in 2002. However, in contrast to the survey time series for this region, commercial longline catch rates derived from observer data increased substantially from 2001 to 2003. In

contrast, the survey index in B.C. increased sharply in 2003 and a similarly high index value was observed in 2004. **Continental U.S. stock indicators** suggest relatively strong 1999 and 2000 year-classes were observed by the triennial shelf survey, and the 2001 shelf survey results are the highest in the 1980 to 2001 series. These signs that the 1999 and 2000 year-classes may be strong in the waters off the continental U.S. follows poor recruitment through the 1990s and a concurrent decline in sablefish spawning biomass off the continental U.S. over this period.

The **west coast Vancouver Island shrimp survey**, conducted at shallow depths of 50 to 200 m, intercepts juvenile sablefish. Sablefish catch rates increased markedly in 2001 and 2002, and subsequently declined in 2003. These results are in agreement with sablefish catch rates from the continental U.S. shelf and slope surveys and bycatch rates in the U.S. Pacific hake (*Merluccius productus*) fishery, where the 1999 and 2000 year-classes appeared to be above average. Trends in **sablefish catch rates from the B.C. trawl fishery** off the west coast of Vancouver Island are consistent with the occurrence of juvenile sablefish from the 1999 and 2000 year-classes in the WCVI shrimp survey and U.S. shelf and slope surveys, although they provide no basis for determining which year-classes are present to explain changes in abundance due to a lack of biological samples.

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FOR MORE INFORMATION

Contact: A.R. Kronlund (Rob)
Marine Ecosystem and Aquaculture Division
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7
Tel: (250)756-7108
Fax: (250)756-7053
E-Mail: kronlunda@pac.dfo-mpo.gc.ca

This report is available from the:

Pacific Scientific Advice Review Committee
Pacific Region
Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, B.C. V9T 6N7

Telephone: (250)756-7208
Fax: (250) 756-7209
E-Mail: psarc@pac.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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