

APPENDIX A PSARC REQUEST FOR WORKING PAPER

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Individual or group requesting advice: Groundfish Management Unit

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Subject of Paper (title if developed): Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada: Stock Assessment Update for 2004 and Advice to Managers for 2005

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Rational for request: An annual assessment has been conducted for sablefish in the form of a decision table for Canadian harvests (commercial, First Nations, recreational, experimental). It is expected that there will be no major changes from the detailed assessment in 2004 therefore only an update with reference to the previous assessment is necessary for this year.

Question(s) to be addressed in the Working Paper:

1. What is the stock status of B.C. sablefish and are the previous/current harvest levels appropriate?

Objective of Working Paper:

1. To provide an updated assessment of the coast-wide sablefish stock.
2. To provide an updated decision table with appropriate yield options.

Stakeholders Affected: The range of sablefish is coast-wide and the species is found at various depths. The stakeholders affected include such groups as commercial K and T license holders, recreational users, processing plants, buyers, and others.

How Advice May Impact the Development of a Fishing Plan: The advice is critical for the development of fishing plans and management decisions.

Timing Issues Related to When Advice is Necessary: Results from this PSARC paper are required so that a TAC can be identified for the start of the commercial trawl fishery on April 1, 2005 and the sablefish fishery on August 1, 2005. It is anticipated that presentation of the paper at the PSARC Groundfish Subcommittee meeting on January 19-21, 2005 will permit the Department to meet its obligations in providing advice to fishery managers.

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B.1 Landings data

British Columbia

The history of sablefish fishery management is summarized in Table B.1. The table contains a list of the annual total allowable catches (TACs) and quota allocations to the directed sablefish “K” fleet, the non-directed trawl “T” fleet, First Nations, and science projects. Landings by fishing year are also listed though note that the timing and duration of fishing years changed when an August 1 start was instituted in 1999. Details of the 2001/2002 to 2004/2005 fishing year quotas and allocations are provided in Table B.2 to document how the in-season reduction in the TAC during 2001/2002 was implemented over two fishing years with the transition to the 2004/2005 fishing year for completeness. Material in this section was drawn from management plans (see, for example, Fisheries and Oceans Canada 2002, 2003, 2004) and unpublished file material from the Groundfish Management Unit, Pacific Region, Fisheries and Oceans Canada.

Annual trap catches (t) were determined by summing the “official catch” weight of retained sablefish in each calendar year (see description in Appendix E.3 of Haist et al. 2004). Catches from research fishing at offshore locations were included in the landings summary listed in Table B.3 since they are counted against the quota. However, these catches were excluded from the catch rate calculations presented below since they may not be representative of commercial fishing. Landings from seamounts were excluded where they could be identified. Fishery landings and catch and effort data are not complete for 2004; fishery landings data are current to November 30, 2004 unless otherwise noted. Differences between landings reported in 2004 and those contained in this document are summarized in Table B.4.

The commercial fishery for sablefish has been active since the late nineteenth century and was described in detail by McFarlane and Beamish (1983). Total annual landings as high as 5,956 metric tons (t) were realized during the 1910s; however, landings remained modest from 1920 to 1965, ranging between 209 t and 1,895 t (Figure

B.1, panel A, Table B.3). Exploitation increased in the late 1960s with the arrival of foreign longline fleets from Japan, the US, the USSR and the Republic of Korea (McFarlane and Beamish 1983, Figure B.1, panel B). The largest annual landings of sablefish occurred during this period with a peak 7,408 t removed in 1975. Declaration of the Canadian 200 mile Economic Exclusive Zone in 1977 ended unrestricted foreign fishing. However, some foreign fishing was allowed between 1977 and 1980 to utilize yield surplus to Canadian domestic fleet needs. Total landings have ranged from 2,355 t (2003) to 7,408 t (1975) since 1969 and averaged 4,550 t over the 1969 to 2003 period (Figure B.1).

Canadian landings since 1951 have been reported by longline, trawl, and trap gear (Table B.3). The fishery has been managed since 1981 under quotas allocated to the “K” licence (longline and trap gear) and “T” licence (trawl gear) fleets (Table B.1). Sablefish are caught incidentally in the halibut (*Hippoglossus stenolepis*) longline fishery, and there are small allocations to research charters and to First Nations food fisheries (Table B.1, Table B.2). Since 1977, the trawl components of the landings have always been the smallest, ranging from 3 to 16 percent of the total (Figure B.1, panel B, Table B.3). Since 1981, the trawl fishery has been allocated a fixed percentage (8.75) of the total allowable catch based on historic average trawl landings.

Longline was the dominant gear type in the directed sablefish fishery for most years until 1973. At this time, the trap fishery began to develop and the proportion of the catch taken by longline gear declined (Figure B.1, panel B). Since 1978 trap gear clearly dominated domestic landings and the percentage of longline-caught fish in the total landings fluctuated between 6.3 percent (1979) and 28.0 percent (1990). The trap fishery landed an average of 449 t per year over the 1973 to 1978 period. Trap landings increased significantly in 1979, and beginning in 1980 have ranged from 1,486 t in 2003 to 4,142 t in 1993. Longline landings ranged from 249 t in 1980 to 1,372 t in 1990 over the same period.

During the period from 1990 to 1992, the first three years of Individual Vessel Quota (IVQ) management, the proportion of landings attributed to longline was high (17 to 28 percent) but then dropped to below 12 percent over the 1993 to 1998 period. The initial increase was due to larger vessels developing longline operations for groundfish species including sablefish caught under quota. This shift allowed these vessels to fish most of the year. The subsequent decline in sablefish landings by longline is attributed to a move away from the multi-species longline approach in favor of dedicated trap fishing with transferable quota. The adoption of a transferable quota system allowed a move away from derby fishery tactics and vessels could plan to fish sablefish most of the year. Traps were chosen as the most efficient gear. An increase in the proportion of the catch taken by longline from 1999 through 2004 may reflect a move back to a multiple target species approach, i.e. so-called “combination fishing” where halibut “L” or rockfish (*Sebastes*) “ZN” licenses may be fished in conjunction with a sablefish “K” license to avoid discarding imposed by license regulation. The increase in longline landings could also reflect reduced availability of sablefish to trap gear during the 1999 through 2002 period (Kronlund et al. 2002).

Pacific coast

Annual catches from Alaska, British Columbia and the continental United States are plotted in Figure B.2 to show the B.C. contribution to total Pacific coast sablefish catch. Data for Alaska are taken from Table 3.2 of Sigler et al. (2004), Table ES-1 of Schirripa (2002) and Table 8-1a of Pacific Fishery Management Council (2004). Coast-wide catches are dominated by the Alaskan fisheries, which currently take about 20,000 t of sablefish annually. In contrast to Alaska, sablefish catches in B.C. did not increase significantly during the late 1980s and early 1990s in response to increased abundance. By the same token, B.C. catches did not undergo significant reductions during the early 1970s and again in the 1990s when Alaskan catches were reduced well over 50 percent (Figure B.2). Catches in all jurisdictions showed a general decline after 1990; Alaskan catches have increased since 2001.

B.2 Nominal trap fishery catch rates

Sablefish catch and effort data for the “K” licensed fishery are available from logbooks and skipper interviews beginning in 1979. From 1979 to 1991 these data are not available by fishing event (set) but are aggregated such that more than one set is represented by each record. These data are most comprehensive for the trap fishery. Nominal catch per unit effort, U_t , in years $t = 1, \dots, T$ was computed by forming the ratio of the sum of individual catches, C_{ti} , divided by the sum of the associated effort, E_{ti} , for all records $i = 1, \dots, n_t$ that have valid observations for both catch and effort. Thus, the annual catch rate was the so-called ratio of means estimate

$$(1) \quad U_t = \frac{\sum_{i=1}^{n_t} C_{ti}}{\sum_{i=1}^{n_t} E_{ti}} .$$

Total annual effort cannot be computed by direct summation for all trap sets over the 1979 to 2004 period since effort data are sometimes incomplete. The proportion of total landings accounted for by logbook records with both catch and effort data ranged from 62 to 100 percent. Thus, total annual effort, \widehat{E}_t , was estimated by dividing the total annual landings, L_t , by the annual catch per unit effort

$$(2) \quad \widehat{E}_t = \frac{L_t}{U_t} .$$

Figure B.3 shows the trap fishery catch and effort time series by calendar year and area from 1979 to 2003, with partial 2004 data. The panels show a coast-wide summary and north and south stock summaries, where the north-south boundary is at 50.5 degrees latitude (in the vicinity of the northern extent of Vancouver Island). Within each panel of the figure, total annual catch (t) is represented by the open circles joined by a dashed line. Vertical solid bars show the annual effort estimated using equation (2) for all years except the most recent year where the bar is not filled. Annual nominal catch rates (kg/trap) computed using equation (1) are indicated by filled circles joined by a solid line. The dotted vertical reference line indicates the introduction of mandatory escape rings in traps in 1999.

Coast-wide catch rates were relatively stable from 1979 to 1987, but increased substantially in 1988 and remained high for several years. Catch rates from 1991 through 1995 declined to levels similar to, or slightly lower than, those observed prior to 1988. Catch rates declined from 1999 to an historic low in 2001. A substantial improvement in the nominal catch rate occurred in 2002. The coast-wide CPUE trend is largely driven by the catch rates in the north stock area, which has generally accounted for a larger proportion of both trap landings and effort. Nonetheless, the CPUE trajectory is similar in the south stock area with less contrast between high and low levels. Trap fishing was limited in the southern stock area in both 2003 and 2004.

The 1979 to 2001 period witnessed significant changes in the management regime for the sablefish fishery and in fishing practices. The introduction of IVQs in 1990 had a considerable impact on the distribution of trap effort. There was an abrupt shift in trap effort from the south (Major Areas 3 to 5) to the north (Major Areas 6 to 9) in 1991 as fishers under the IVQ program were attracted by higher catch rates and larger fish in the north (Figure B.3). The proportion of total trap catch taken from the north increased from an average of 0.57 from 1979 to 1990 to 0.87 in 1991 and 0.94 in 1992. In the late 1990s there was a shift back to the south and in 1998 landings from the south surpassed those from the north (Figure B.1). The shift can be attributed in part to declining catch rates in the north. However, fishery managers also requested the industry to distribute effort coast-wide to avoid the complexity of implementing area-specific TACs. Trap baiting practices have changed over the same period, with a shift from squid bait to a mixture of squid and Pacific hake (*Merluccius productus*) designed to improve trap efficiency. Escape rings were introduced by regulation in 1999, although some fishers experimented with escape rings in traps in 1998. The impact of this change was investigated in Appendix N of Haist et al. (2004).

Depth and seasonal differences in catch, effort and catch rates are shown in Figure B.4. The sablefish trap fishery extends from approximately 180 to 1,300 m (100 to 700 fm) although approximately three quarters of the fishing effort is expended between 460 to 825 m (250 to 450 fm). The longline fishery generally occurs at shallower depths, with over three quarters of the fishing effort in less than 250 fm (460 m). Each panel of Figure B.4 is identical in construction to those presented in Figure B.3. The data were stratified by stock area, two periods (January to March, and April to December) and three depth ranges (0 to 250 fm, 250 to 450 fm, and 450 fm and deeper). This stratification

was used in previous analyses (eg., Saunders et al. 1996, Haist et al. 1997, 1999) because catch rates observed over the January to March period are generally higher than those during other periods. Also, the January to March period has not been fished consistently over time. Historically, the 250 to 450 fm depth interval has represented the “core” depths fished by the commercial trap fleet. Note that the apparent absence of landings and effort values in some years where CPUE values are displayed is due to relatively small amounts of landings, and hence effort, that do not show on the scale chosen for the plots. Such occurrences represent minimal fishing activity.

Trends evident in the aggregated data of Figure B.3 are reflected in the panels of Figure B.4 that correspond to April to December in the 250 to 450 fm depth stratum. Inspection of the panels confirms that this component of the data has represented the majority of fishing activity over time. However, the early 1990s showed an abrupt increase in trap fishing effort in the northern area in January to March. Since the mid to late 1990s, the proportion of trap effort in shallow depths (0 to 250 fm) has increased markedly, with the exception of the south stock area during the January to March period. Trap fishing in 2003 was limited due to the 2003/2004 quota being nearly caught by March. Effort in 2003 was largely in the north and at depths shallower than 250 fm.

Trap fishery catch rates tend to be higher in the December through March period in the northern waters of British Columbia, a pattern previously described by fishers. This effect is shown in Figure B.5 where catch rates are plotted as a function of latitude and month within each calendar year. Latitude intervals were defined by splitting the coast into 12 nautical mile strips from 48°N to 54.5°N. Within each block defined by latitude and year, the catch rate was computed as the mean of catch rates for individual fishing events observed in the block. In some years, such as 1991 through 1993, the higher winter catch rates began to develop at the end of the calendar year in November and December. There is also a tendency for the higher catch rates to move in a southerly direction through the year. Northern catch rate intensity for December through March decreased in 1997 and 1998, increased in 1999 and declined over the years 2000 through 2001. December 2002 and January and February 2003 showed relatively high catch rates before trap fishing ceased due to the quota being nearly subscribed. Available data for the first three months of 2003 show catch rate intensities similar to those observed in 1991 through 1993. Fishing conducted early in 2004 showed similarly high catch rates for northern B.C.

B.3 Standardized trap fishery catch rates

Catch and effort data selection

Analyses to standardize fishery catch rate (CPUE) data, using generalized linear models (GLMs), were first conducted for the 2002 sablefish stock assessment (section 4 of Kronlund et al. 2003). The annual trap fishery catch rate index from the year effects of the GLM was one of three indices used in a biomass dynamics model in the two most

recent assessments (Kronlund et al. 2003, Haist et al. 2004). Annual indices resulting from a standardization analysis of the longline fishery data were not believed to reflect changes in stock abundance, so the longline catch rate data analysis is not updated here. The trap-fishery GLM analysis was updated using data through July 2004. The methodology used for the 2004 CPUE standardization is the same as that used previously, and only a cursory description of methodology and results is presented here.

Sablefish logbook data, which contain information from individual trap sets, were extracted from the *PacHarvSable* database for 1990 to 2004. Research fishing was excluded from the extraction. Collection of logbook data began earlier than 1990, but these data were aggregated over fishing events. Initially a voluntary program, the completion of logbook records when fishing under a “K” license became mandatory in 1990. A data selection and grooming process was undertaken with two objectives: (1) to limit the data to coastal offshore fishing events by excluding inshore and seamount fishing records, and (2) to remove records that were likely to contain erroneous information. The criteria used in the data grooming process and the number of logbook records that were selected are summarized in Table B.6.

General linear model standardization

For the 2002 CPUE standardization, a core set of fishing masters was selected for inclusion in the analysis. The selection was based on fishing master rather than fishing vessel because experience is more likely to be associated with fishing success in the sablefish trap fishery. A minimum of five years of documented fishing effort was the basis for selecting fishing masters, and the set of individuals selected for the 2002 analysis was used in the current analysis.

The log-normal linear model used for previous CPUE standardizations was used again this year. The stepwise analysis to evaluate alternative covariates in the model fit was not updated; rather, the previously selected set of covariates was used again this year. The dependent variable was the natural logarithm of catch rate, with catch rate measured as kilograms per trap. Independent variables that were treated as factors were *year*, *region* (northern BC, southern BC), *fishing master* and *minor area*. *Day of year* entered the model as a polynomial of degree 3. Note that a *year:region* interaction term was included in the model with the main effects (e.g., *year*region*), independent of statistical significance. An additional model was fit that excluded the *region* covariate for use in the tagging model.

Model results

Model results, in terms of the proportion of the total deviance explained, are shown in Table B.7. The first variable to enter the model was *fishing master* followed by *day of year* and *minor area*. Second order interactions involving *fishing master* were not evaluated because they would greatly increase the number of terms in the model, and

would lead to a sparse design matrix. Inclusion of a *day of year:minor area* interaction did provide a fair improvement in the model fit, although the final model accounted for only 29 percent of the variance in the log CPUE (Table B.7). When the model was fit without the *region* term, the sequence in which the remaining model covariates entered the model was the same as for the model where the *region* term was included. Results for the model without the *region* covariate are presented in Table B.8.

The *year* effects estimated by the standardized CPUE model are shown in Figure B.6 for the northern region, southern region, and the entire coast. Also shown on the figure panels are the corresponding nominal CPUE estimates. There is very close agreement between the standardized and nominal CPUE indices. The vertical grey bars in Figure B.6, drawn between 1998 and 1999, demarcate the introduction of mandatory escape rings in the trap fishery. The use of escape rings is likely to decrease catch rates relative to the period prior to their use, thus creating two time series that are likely not comparable.

For the northern B.C. coast, the CPUE *year* effects show a continuous decline from 1991 through 1998. The magnitude of the southern region *year* effects in the early 1990s were not as large as those for the northern region, and the major decline in CPUE occurred between 1994 and 1995. It is not valid to compare *year* effects across 1998 because of the introduction of escape-rings. For the southern B.C. region, the *year* effects are relatively stable between 1999 and 2003 and decrease in 2004 to the lowest estimate in the time-series. The CPUE index for northern B.C. decreased from 1999 through 2001, increased substantially in 2003, and decreased again in 2004. The CPUE trends estimated for coast-wide data are intermediate between the northern and southern B.C. values.

The annual number of trap vessel trips, fishing masters, fishing events (sets) and months fished utilized for the GLM analysis are listed in Table B.9. For the southern B.C. analysis, logbook data from only one fishing master met the selection criteria in 2004. This fishing master made two trips totaling 80 sets in May and June of 2004. In 2003 two fishing masters made one trip each to the south stock area for a total of 47 sets, largely in December. In contrast, the number of trips, fishing masters and sets is substantially higher in 2003 and 2004 for the north and for both areas in all years prior to 2003 (Table B.9). These sets were not spatially distributed throughout the south stock area but were clustered off Barkley Canyon and the northern end of Vancouver Island. This sparseness of southern trap fishing effort suggests that the year effects may not be representative of fishing performance in 2003 and 2004 and therefore may be biased despite the attempt at standardization.

B.4 Exploratory analysis of fleet dynamics

Figure B.7 shows the cumulative proportion of trap catch by latitude over time. These catches were those reported in fisher logbooks excluding seamounts and research fishing. The dashed vertical line in each figure panel represents the division between

north and south areas. The proportion of trap catch taken in the south has ranged from less than 10 percent in 1991 and 2003 to approximately 50 percent in 1990 and 1998. Data for 2004 are complete to July 31, 2004. Generally more catch is taken in the northern area by trap gear and this tendency was pronounced in the 2002 to 2004 period. The corresponding figure for longline gear is shown as Figure B.8. In general between 60 and 80 percent of fisher logbook catch by longline gear was taken in the south area with the exception of 1991-1992 and 2003-2004 when approximately 45 percent was removed from the south.

Depth fished by trap gear has decreased gradually coast-wide. Figure B.9 shows a plot of the mean depth fished by year, quarter of the year, and offshore region. The 10th and 90th percentiles of the distribution of depth fished on each set are shown in the figure in addition to the mean. A gradual tendency to shallower fishing begins in the mid-1990s in most quarters and regions.

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Table B.1 Summary of sablefish management history. The 2004/2005 fishing year data are current to November 30, 2004.

Year	Fishery	Assessment			First		Total		Date Open	Date Closed	Days Open	FY Days	"K" Vessels	
		Yield Rec.	TAC	K Quota	T Quota	Nations	Science	Landings					Trap	Longline
1981	Derby		3500	3190	310			3830	01-Feb-81	04-Oct-81	245	245	16	
1982	Derby		3500	3190	310			4028	01-Feb-82	22-Aug-82	202	202	15	
1983	Derby		3500	3190	310			4346	01-May-83	26-Sep-83	148	148	14	
1984	Derby		3500	3190	310			3827	01-Mar-84	22-Aug-84	174	174	13	
1985	Derby		4000	3650	350			4193	01-Feb-85	08-Mar-85	35	92	17	
									29-Mar-85	02-May-85	34			
									19-Jul-85	11-Aug-85	23			
1986	Derby		4000	3650	350			4449	17-Mar-86	21-Apr-86	35	63	20	
									12-May-86	09-Jun-86	28			
1987	Derby		4100	3740	360			4630	16-Mar-87	10-Apr-87	25	45	19	
									01-Sep-87	21-Sep-87	20			
1988	Derby		4400	4015	385			5403	06-Mar-88	26-Mar-88	20	140	24	
									05-Apr-88	25-Apr-88	20			
									05-May-88	25-May-88	20			
									05-Jun-88	25-Jun-88	20			
									05-Jul-88	25-Jul-88	20			
									02-Aug-88	22-Aug-88	20			
1989	Derby		4400	4015	385			5324	14-Feb-89	28-Feb-89	14	112	30	
									14-Mar-89	28-Mar-89	14			
									14-Apr-89	28-Apr-89	14			
									10-May-89	24-May-89	14			
									10-Jun-89	24-Jun-89	14			
									06-Jul-89	20-Jul-89	14			
									04-Aug-89	18-Aug-89	14			
									15-Sep-89	29-Sep-89	14			
1990	IVQ		4670	4260	410			4905	21-Apr-90	31-Dec-90	255	255	15	18
1991	IVQ	2,900-5,000	5000	4560	440			5112	01-Jan-91	31-Dec-91	365	365	14	14
1992	IVQ	2,900-5,000	5000	4560	440			5007	01-Jan-92	31-Dec-92	366	366	16	11

Year	Fishery	Assessment		First			Total		Date Open	Date Closed	Days Open	FY Days	"K" Vessels	
		Yield Rec.	TAC	K Quota	T Quota	Nations	Science	Landings					Trap	Longline
1993	IVQ	2,900-5,000	5000	4560	440			5110	01-Jan-93	31-Dec-93	365	365	14	9
1994	IVQ	2,900-5,000	5000	4521	433			5002	01-Jan-94	31-Dec-94	365	365	15	9
1995	IVQ	2,725-5,550	4140	3709	356		29.48	4179	01-Jan-95	31-Dec-95	365	365	15	15
1996	IVQ	690-2,580	3600	3169	304		81.65	3471	01-Jan-96	31-Dec-96	366	366	12	11
1997	IVQ	6,227-16,285	4500	4023	386		45.36	4142	01-Jan-97	31-Dec-97	365	365	13	13
1998	IVQ	3,286-4,761	4500	4023	386		45.36	4592	01-Jan-98	31-Dec-98	365	365	13	12
1999/ 2000	IVQ	2,977-5,052	4500	6395	386		45.36	7012	01-Jan-99	31-Jul-00	578	578	12	19
2000/ 2001	IVQ	3,375-5,625	4000	3555	350		45.36	3884	01-Aug-00	31-Jul-01	365	365	12	23
2001/ 2002	IVQ	4,000	2800	2657	342	45	45.36	3079	01-Aug-01	31-Jul-02	365	365	12	21
2002/ 2003	IVQ	4,000, revised to 2100-2800	2450	1883	206	45	45	2206	01-Aug-02	31-Jul-03	365	365	8	20
2003/ 2004	IVQ	Decision table	3000	2647	254	45	54	2959	01-Aug-03	31-Jul-04	365	365	5	16
2004/ 2005	IVQ	Decision table	4500	3995	384	45	75	845	01-Aug-04	31-Jul-05	365	365	NA	NA

Table B.2 TACs and allocations (metric tonnes) for the 2001/2002 to 2004/2005 fishing years.

Allocation and Landings	2001/2002	2002/2003	2-Year Totals	2003/2004	2004/2005
TAC	2800	2450	5250	3000	4500
Scientific purpose	25	45	70	54	75
First Nation allocation	45	45	91	45	45
Trawl "T" allocation	342	206	548	254	384
Sablefish "K" Allocation	3567	973	4540	2647	4005
Carry Forward	(910)	910	0	0	0
Final "K" Allocation	2657	1883	4540	2647	3995
Total Landings	3079	2206	5285	2959	- na -

Table B.3 Annual sablefish landings (t) in Canadian waters by gear type, excluding sablefish landed from seamounts. Data for 2004 are preliminary and current to November 30, 2004.

Year	Canadian	Foreign	Longline	Other	Trap	Trawl	Total
1913	1988.0						1988.0
1914	3209.0						3209.0
1915	2441.0						2441.0
1916	4312.0						4312.0
1917	5956.0						5956.0
1918	2039.0						2039.0
1919	716.0						716.0
1920	1754.0						1754.0
1921	1383.0						1383.0
1922	1293.0						1293.0
1923	1135.0						1135.0
1924	1238.0						1238.0
1925	1017.0						1017.0
1926	705.0						705.0
1927	1118.0						1118.0
1928	911.0						911.0
1929	1042.0						1042.0
1930	1124.0						1124.0
1931	397.0						397.0
1932	436.0						436.0
1933	413.0						413.0
1934	435.0						435.0
1935	659.0						659.0
1936	490.0						490.0
1937	912.0						912.0
1938	576.0						576.0
1939	617.0						617.0
1940	948.0						948.0
1941	1188.0						1188.0
1942	835.0						835.0
1943	1426.0						1426.0
1944	1519.0						1519.0
1945	1428.0						1428.0
1946	1619.0						1619.0
1947	905.0						905.0
1948	1483.0						1483.0
1949	1895.0						1895.0
1950	648.0						648.0
1951			772.8	0.5		23.1	796.4
1952			453.2	0.6		34.0	487.8
1953			335.6	1.1		8.0	344.7
1954			432.3		0.3	26.4	459.0
1955			359.0			15.2	374.2
1956			172.8			36.5	209.3
1957			465.6		0.3	51.0	516.9

Year	Canadian	Foreign	Longline	Other	Trap	Trawl	Total
1958			167.1		0.6	117.6	285.3
1959			298.3			88.2	386.5
1960			423.3			65.5	488.8
1961			321.3			97.9	419.2
1962			277.7	1.1		113.7	392.5
1963			222.3	0.2		64.8	287.3
1964		83.0	274.5	0.1		125.2	482.8
1965		92.0	193.2	0.3		261.9	547.4
1966		269.0	325.7	0.2		311.9	906.8
1967		1254.0	252.9	0.1		138.6	1645.6
1968		2455.0	292.3	15.1		167.0	2929.4
1969		4763.0	162.3	0.6		148.3	5074.2
1970		5246.0	142.1	0.5		165.9	5554.5
1971		3211.0	123.0			189.3	3523.3
1972		4818.0	399.7			688.3	5906.0
1973		3038.0	119.8		745.8	82.8	3986.4
1974		4287.0	41.3	1.8	327.1	121.8	4779.0
1975		6506.0	152.2	0.9	469.4	279.8	7408.3
1976		6302.0	89.4	0.1	303.4	382.0	7076.9
1977		3718.0	77.1	6.8	214.6	786.5	4803.0
1978		3051.0	57.2	7.8	634.6	130.5	3881.1
1979		2348.0	276.8	6.0	1480.1	276.1	4387.0
1980			248.6		3210.8	335.3	3794.7
1981			326.1		3275.3	228.8	3830.2
1982			343.6	0.3	3437.8	245.9	4027.7
1983			451.4	10.5	3610.5	274.1	4346.5
1984			365.1		3275.4	187.0	3827.4
1985			458.3		3501.3	233.1	4192.7
1986			619.2	0.8	3277.1	551.8	4448.8
1987			1268.6	0.7	2954.3	406.9	4630.5
1988			1273.6	3.2	3488.5	637.3	5402.6
1989			928.6	0.0	3772.0	623.4	5324.0
1990			1371.8		3072.4	460.7	4904.9
1991			1179.2		3494.4	438.8	5112.4
1992			847.5	1.1	3710.2	448.7	5007.5
1993			424.2	0.1	4142.4	543.1	5109.8
1994			467.7		4050.7	483.1	5001.5
1995			474.3	4.8	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	3.6	3682.9	403.0	4717.6
2000			752.3	0.0	2758.1	326.3	3836.7
2001			564.5		2750.1	299.6	3614.2
2002			564.7	2.4	2178.9	266.8	3012.7
2003			640.6		1486.6	227.6	2354.8
2004			475.2		1744.1	270.1	2489.3

Table B.4 Differences in landings history between this document and the summaries presented in 2004. Changes can be attributed to a number of factors including the addition of previously missing data from the 2001/2002 fishing year, removal of duplicated observer data, improved resolution of seamount data, and for 2003 addition of data for the balance of the calendar year.

Year	Gear	Current Landings	Previous Landings	Difference
2000	Longline	752	749	3
2001	Longline	564	484	80
2001	Trap	2750	2431	319
2002	Longline	565	543	22
2002	Trap	2179	1975	204
2003	Longline	641	528	113
2003	Trap	1487	809	678
2003	Trawl	228	112	116
2000	Total	3837	3834	3
2001	Total	3614	3215	399
2002	Total	3013	2787	226
2003	Total	2355	1449	906

Table B.5 Trap fishery landings, nominal catch rates (kg/trap) coast-wide and by north and south stock areas. Trips is the number of trips. P(Effort) is the proportion of landings with effort data while P(North) is the proportion of landings from the north stock area. Data for 2004 are preliminary and current to November 11, 2004.

Year	Coast				North				South				P(North)
	Trips	Landings	Catch rate	P(Effort)	Trips	Landings	Catch rate	P(Effort)	Trips	Landings	Catch rate	P(Effort)	
1979	63	1480.12	16.920	0.81	35	916.31	18.457	0.89	28	563.81	14.38	0.68	0.62
1980	76	3210.77	15.422	0.83	24	1203.29	15.422	0.96	52	2007.48	15.42	0.74	0.37
1981	61	3275.33	14.508	0.90	28	2083.68	17.026	0.91	33	1191.65	11.44	0.88	0.64
1982	33	3437.84	16.845	0.76	13	2071.47	19.039	0.79	20	1366.37	14.08	0.71	0.60
1983	48	3610.52	16.446	0.81	25	2398.11	18.315	0.84	23	1212.41	13.44	0.76	0.66
1984	58	3275.39	12.918	0.82	23	1762.32	13.909	0.89	35	1513.07	11.76	0.75	0.54
1985	34	3501.27	17.327	0.81	14	1625.81	19.630	0.90	20	1875.45	15.40	0.73	0.46
1986	34	3277.08	15.596	0.81	16	1951.10	19.711	0.86	18	1325.98	11.57	0.76	0.60
1987	27	2954.29	15.089	0.62	13	1455.76	17.909	0.69	14	1498.53	12.66	0.55	0.49
1988	29	3488.50	24.736	0.98	14	2181.92	32.670	0.97	15	1306.57	17.77	1.00	0.63
1989	31	3772.04	25.673	0.87	16	2052.65	27.699	0.81	15	1719.39	23.87	0.94	0.54
1990	101	3072.39	20.973	0.99	38	1792.46	25.587	1.00	63	1279.94	16.68	0.98	0.58
1991	104	3494.43	26.043	1.00	76	3025.88	29.104	1.00	28	468.55	15.51	1.00	0.87
1992	88	3710.23	24.058	0.91	78	3500.27	24.424	0.92	10	209.96	18.14	0.70	0.94
1993	106	4142.38	20.980	0.90	72	3012.24	21.019	0.90	34	1130.15	20.88	0.91	0.73
1994	108	4050.72	18.964	0.91	72	2782.82	18.779	0.99	36	1267.90	19.53	0.74	0.69
1995	80	3254.24	15.037	0.72	48	2044.56	15.963	0.81	32	1209.68	13.20	0.57	0.63
1996	83	2984.46	14.928	0.96	45	1992.88	16.728	0.94	38	991.57	12.40	1.00	0.67
1997	99	3553.61	13.317	0.99	55	2187.21	13.647	1.00	44	1366.39	12.81	0.98	0.62
1998	92	3771.98	13.388	0.99	43	1711.13	13.639	1.00	49	2060.85	13.18	0.99	0.45
1999	85	3677.24	13.705	1.00	54	2555.40	16.103	1.00	31	1121.83	10.23	1.00	0.69
2000	65	2745.18	12.326	0.99	47	2120.66	12.767	0.99	16	623.81	11.05	1.00	0.77
2001	78	2750.15	10.020	0.99	55	1662.66	9.831	1.00	23	1087.49	10.33	0.99	0.60
2002	61	2147.00	9.600	0.97	37	1475.62	10.384	0.97	24	671.38	8.23	0.97	0.69
2003	26	1419.12	19.812	1.00	23	1315.91	20.824	1.00	3	103.21	12.23	1.00	0.93
2004	23	1452.96	13.466	0.76	19	1193.17	14.285	0.89	4	259.80	6.05	0.19	0.82

Table B.6 Data selection criteria and the number of records selected for the standardized CPUE analysis.

Reason	Records excluded for the following reasons:	No. of records after selection criteria:
Depth	<ul style="list-style-type: none"> Not recorded 	49101
Traps	<ul style="list-style-type: none"> Null or 0 or greater than 500 	48790
Location information	<ul style="list-style-type: none"> Fishing locations in Hecate Strait, Strait of Georgia, or Johnson Strait Fishing locations at Seamounts 	42672
Core skippers	<ul style="list-style-type: none"> Not one of the 19 core skippers 	35205
Catch	<ul style="list-style-type: none"> Remove records with no sablefish catch reported 	35017

Table B.7 Variables included in the sablefish trap fishery standardized CPUE model, by order of importance (proportion of deviance explained) for the regional CPUE model.

Order	Variable	Cumulative proportion of deviance explained (r^2)	Number of parameters
1	<i>year*region</i>	0.1700	30
2	<i>fishing master</i>	0.2312	48
3	<i>day of year</i>	0.2598	51
4	<i>minor area</i>	0.2708	62
5	<i>day of year:minor area</i>	0.2898	84

Table B.8 Variables included in the sablefish trap fishery standardized CPUE model, by order of importance (proportion of deviance explained) for the coast-wide CPUE model.

Order	Variable	Cumulative proportion of deviance explained (r^2)	Number of parameters
1	<i>year</i>	0.1393	15
2	<i>fishing master</i>	0.2030	33
3	<i>day of year</i>	0.2375	36
4	<i>minor area</i>	0.2538	47
5	<i>day of year:minor area</i>	0.2618	69

Table B.9 Summary of data used to derive the standardized commercial trap fishery catch rate index. The numbers of trips, fishing masters, fishing events (sets), and estimates of the commercial trap fishery catch rate index are listed for north and south areas. The overall catch rate index is provided for the coast. Gray cells indicate catch rates achieved with escape rings.

Year	Trips	Trips	Fishing	Fishing	Fishing	Fishing	Months	Months	Std.	Std.	Std.
	<i>North</i>	<i>South</i>	<i>North</i>	<i>South</i>	<i>North</i>	<i>South</i>	<i>North</i>	<i>South</i>	<i>North</i>	<i>South</i>	<i>Coast</i>
1990	17	30	6	6	546	445	8	7	16.353	8.767	13.330
1991	43	19	11	7	1044	217	11	6	17.314	12.478	15.957
1992	54	10	12	7	1414	114	12	7	16.836	12.019	15.820
1993	70	37	13	8	1843	650	11	9	14.698	11.854	13.794
1994	64	25	13	7	2091	508	12	9	12.332	12.367	11.984
1995	35	22	11	12	1695	669	11	9	10.070	8.551	9.241
1996	31	20	11	8	1393	956	10	10	9.761	7.664	8.596
1997	39	34	11	9	2109	1436	12	12	8.005	7.075	7.529
1998	40	42	13	13	1861	2282	11	10	7.077	6.994	7.048
1999	52	23	14	11	2455	1457	12	12	8.983	5.241	7.238
2000	40	12	11	5	2065	612	12	9	7.233	5.810	6.637
2001	44	18	11	7	2064	1131	11	11	5.969	5.568	5.615
2002	28	20	8	10	1559	896	10	10	6.292	4.449	5.432
2003	18	2	7	2	778	47	6	3	9.975	5.267	8.933
2004	12	2	6	1	600	80	6	2	8.448	2.149	7.035

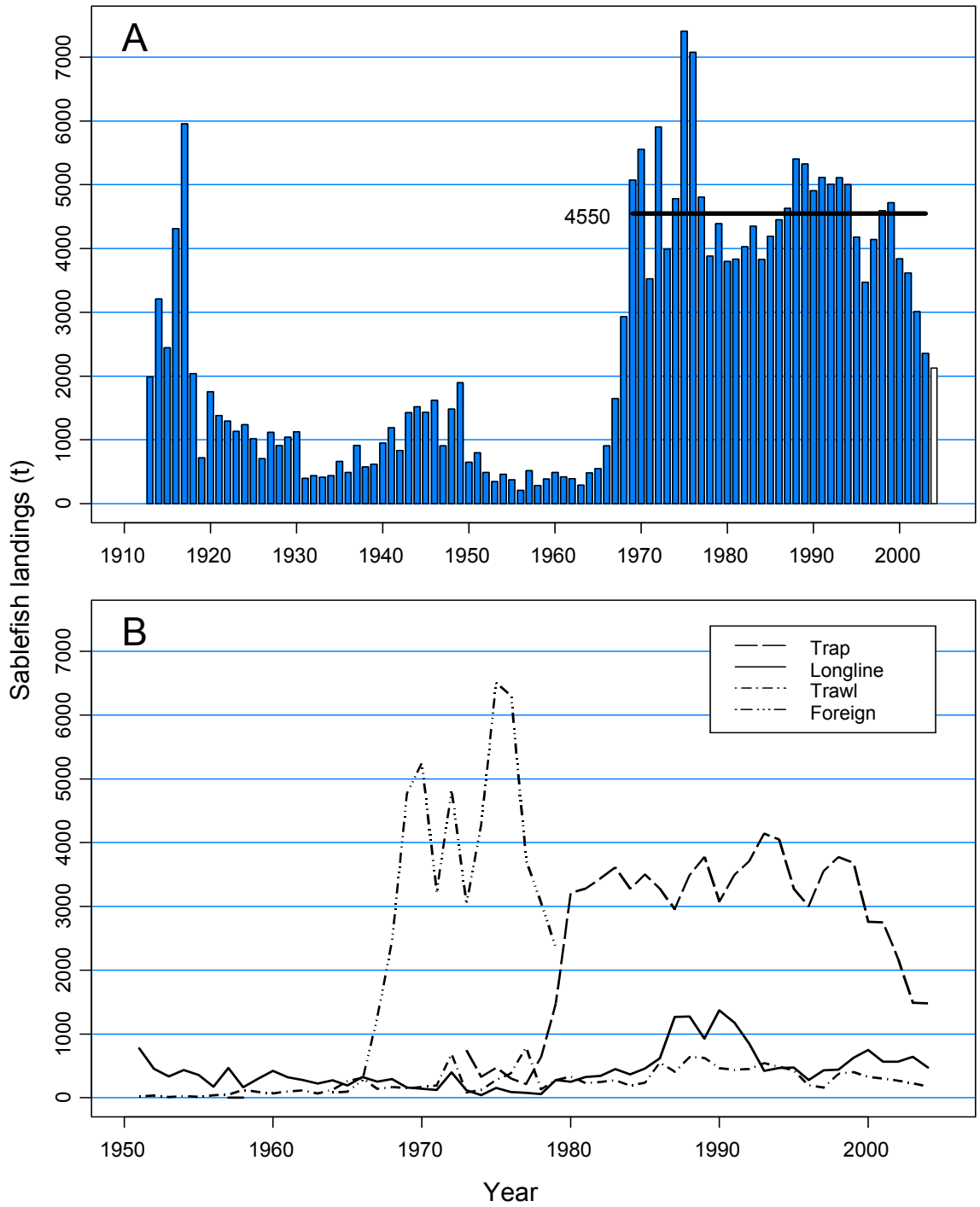


Figure B.1 Annual sablefish landings (t) from 1913 to 2004 from all sources (Panel A). The thick horizontal line shows the mean annual landings (4,550 t) from 1969 to 2003. Panel B shows annual landings by gear type for the period 1951 to 2004. Data for 2004 are incomplete.

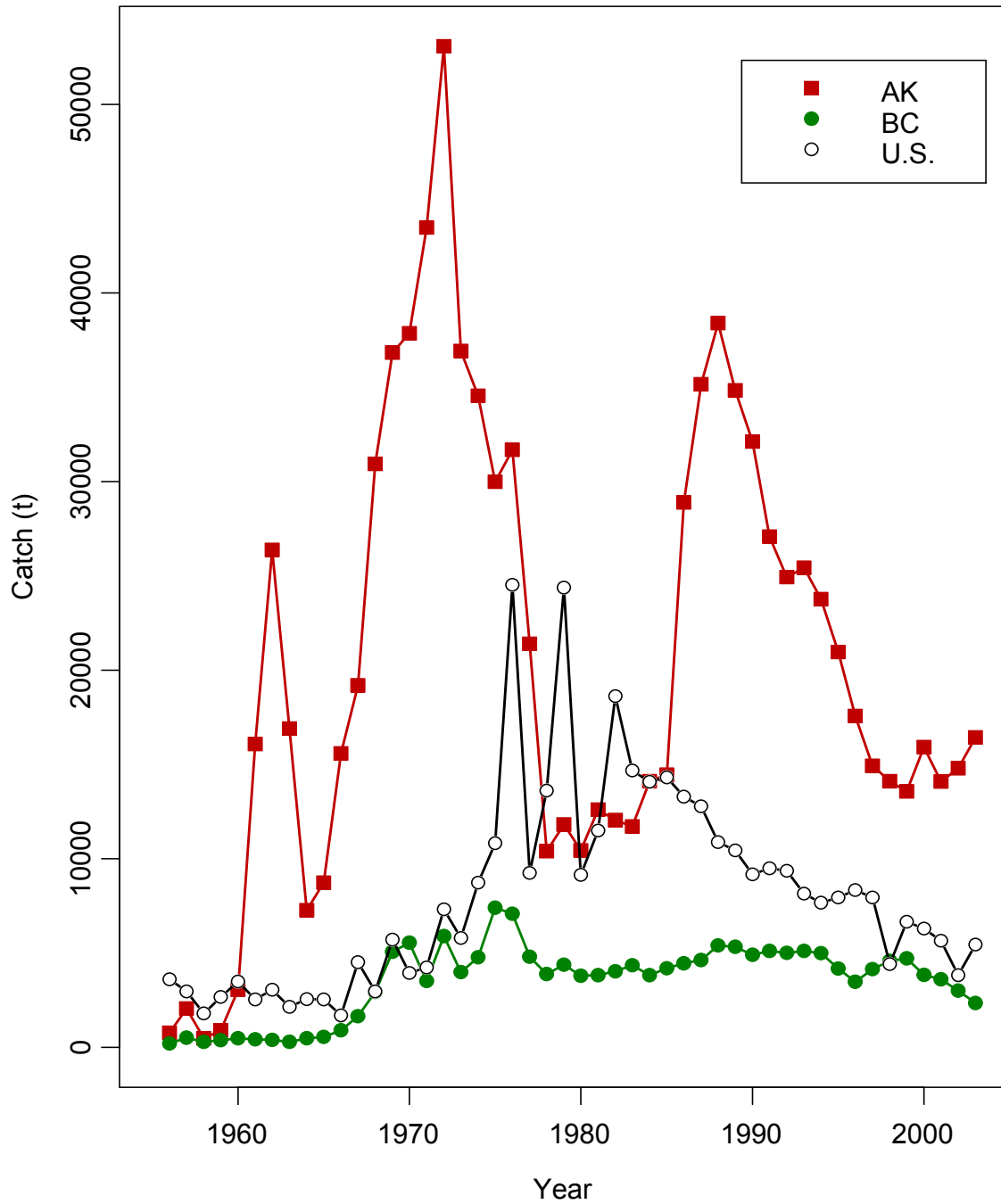


Figure B.2 Comparison of Canadian (filled circle), Alaskan (filled square), and continental U.S. (open circle) annual catches (t).

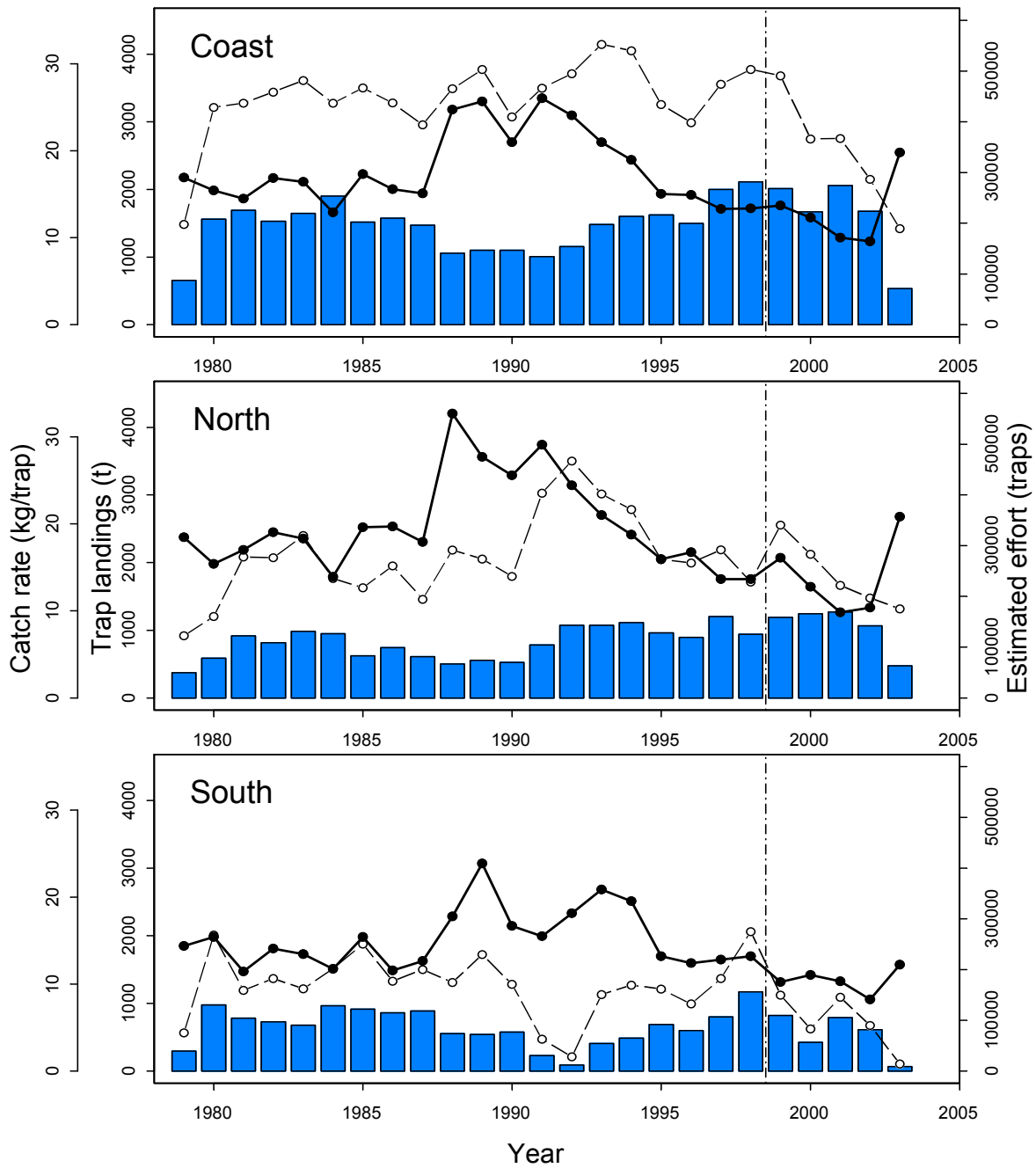


Figure B.3 Nominal trap fishery CPUE (kg/trap, filled circles, solid line), catch (t) (open circles, dashed line) and estimated effort (traps, vertical bars) by area. The vertical dot-dash line indicates the inception of mandatory escape rings in the commercial trap fishery.

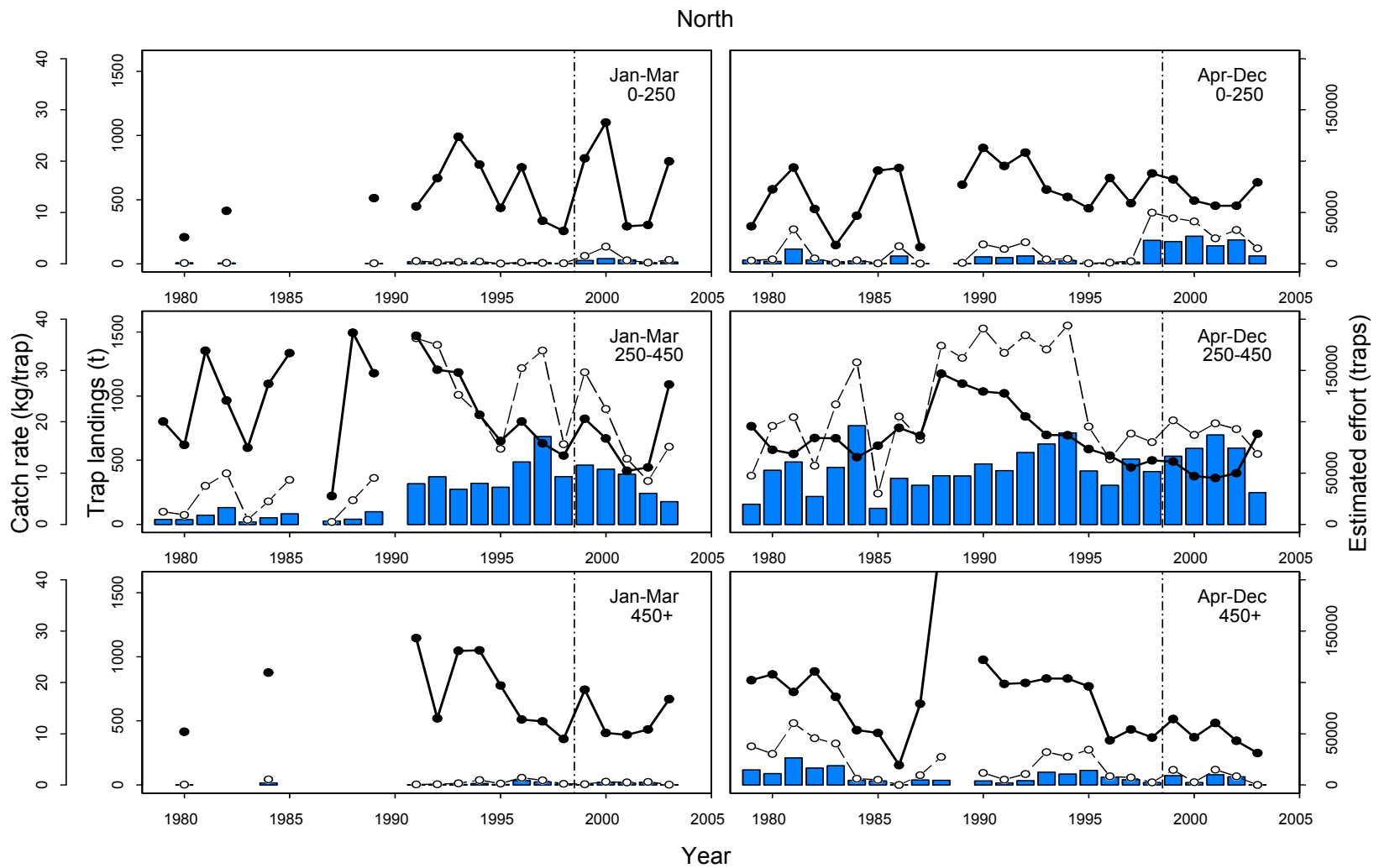


Figure B.4 Annual trap fishery landings (t, dotted line), CPUE (kg/trap, solid line), and estimated effort (traps, vertical bars) by area, season, and depth stratum (fm).

South

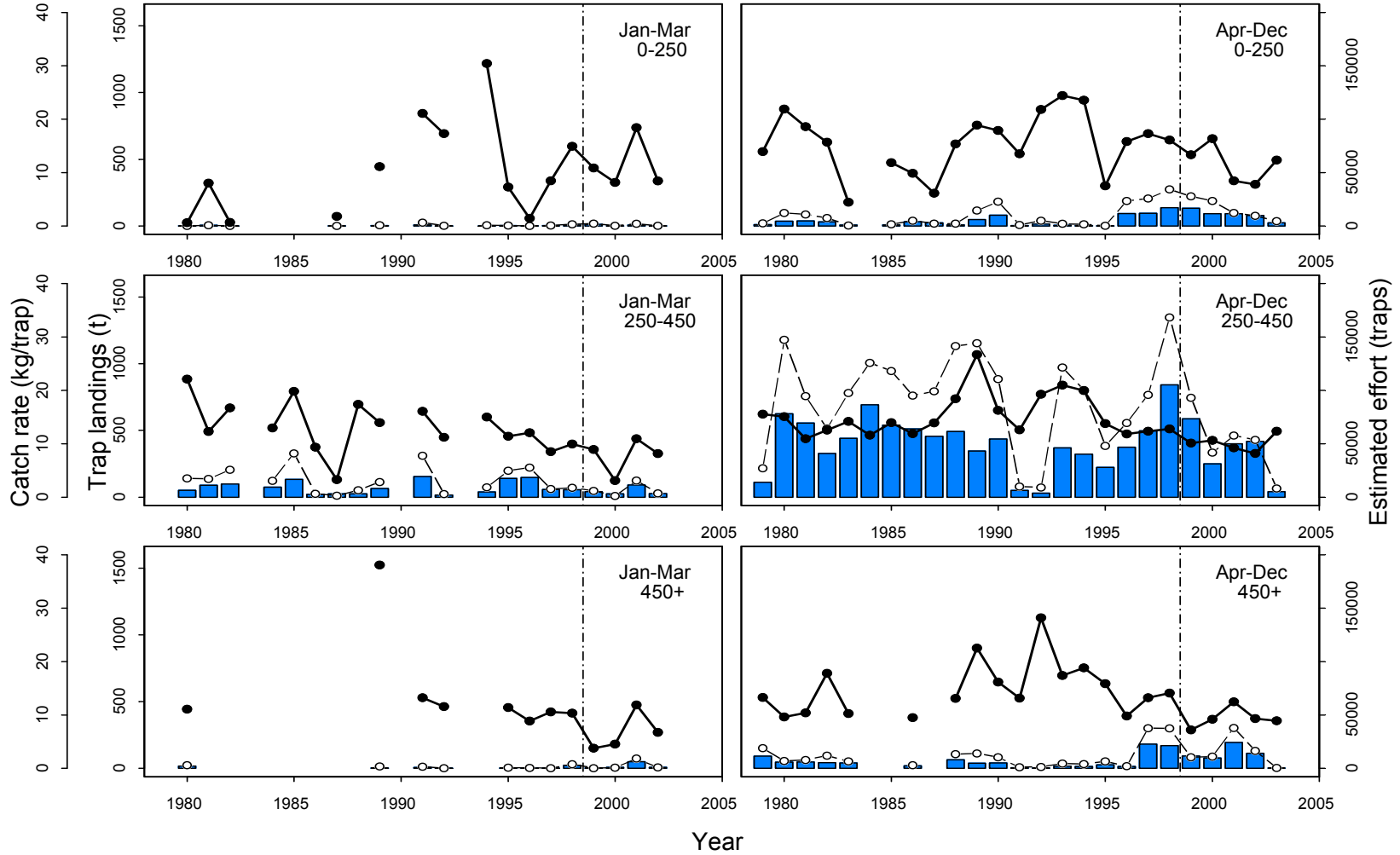


Figure B.4 continued.

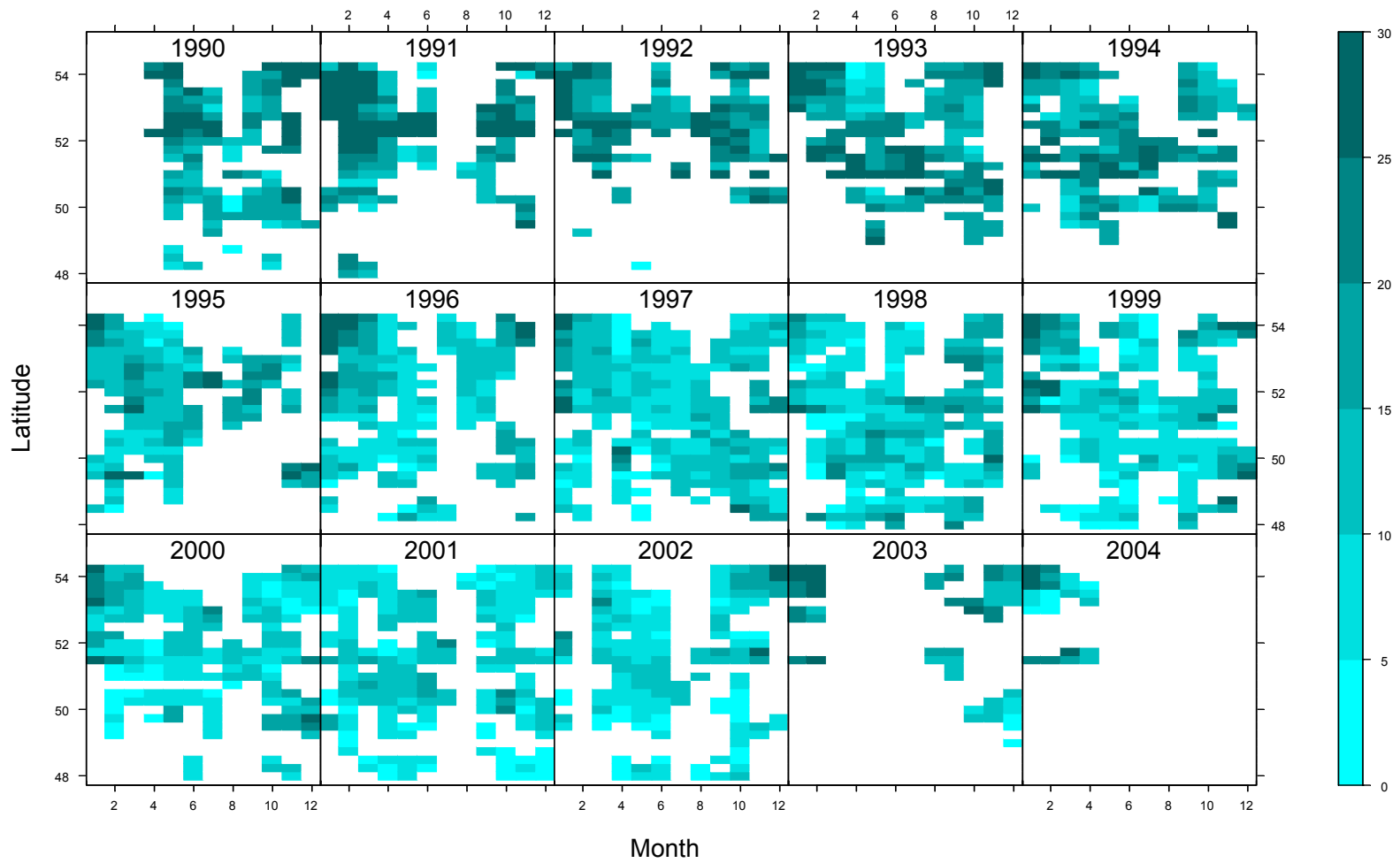


Figure B.5 Sablefish trap CPUE (kg/trap) by latitude, month and year. The intensity of shading is proportional to the catch rate for each block of latitude and month with the 25 to 30 kg/trap category representing 25 kg/trap and greater.

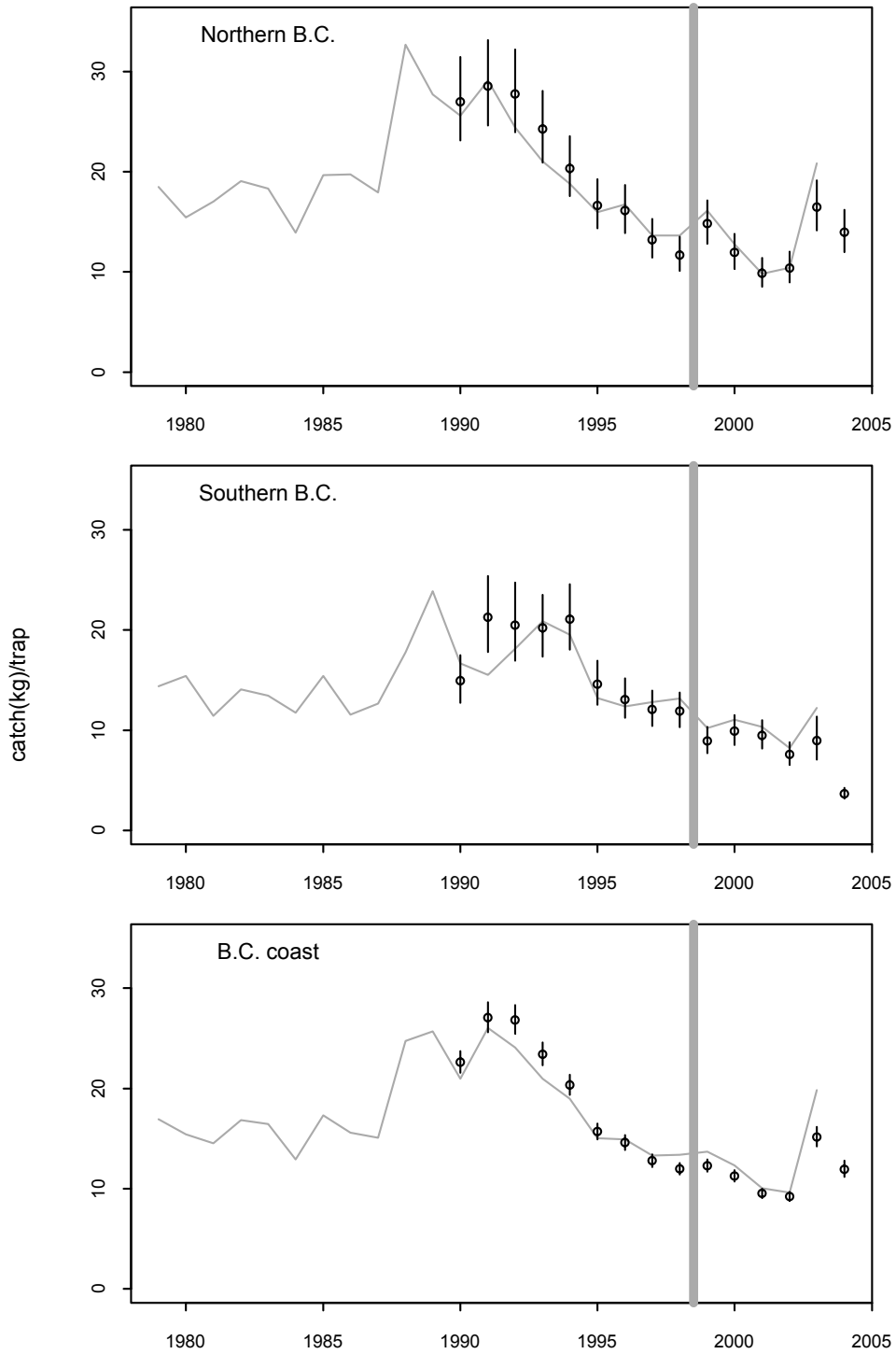


Figure B.6 Estimated *year* effects for the regional (upper two panels) and coast-wide CPUE standardization model (open symbols) with ± 2 standard errors shown by vertical bars. For comparison, the nominal CPUE series are shown (gray lines). Standardized indices have been scaled to have the same mean as the nominal CPUE series over their common year range.

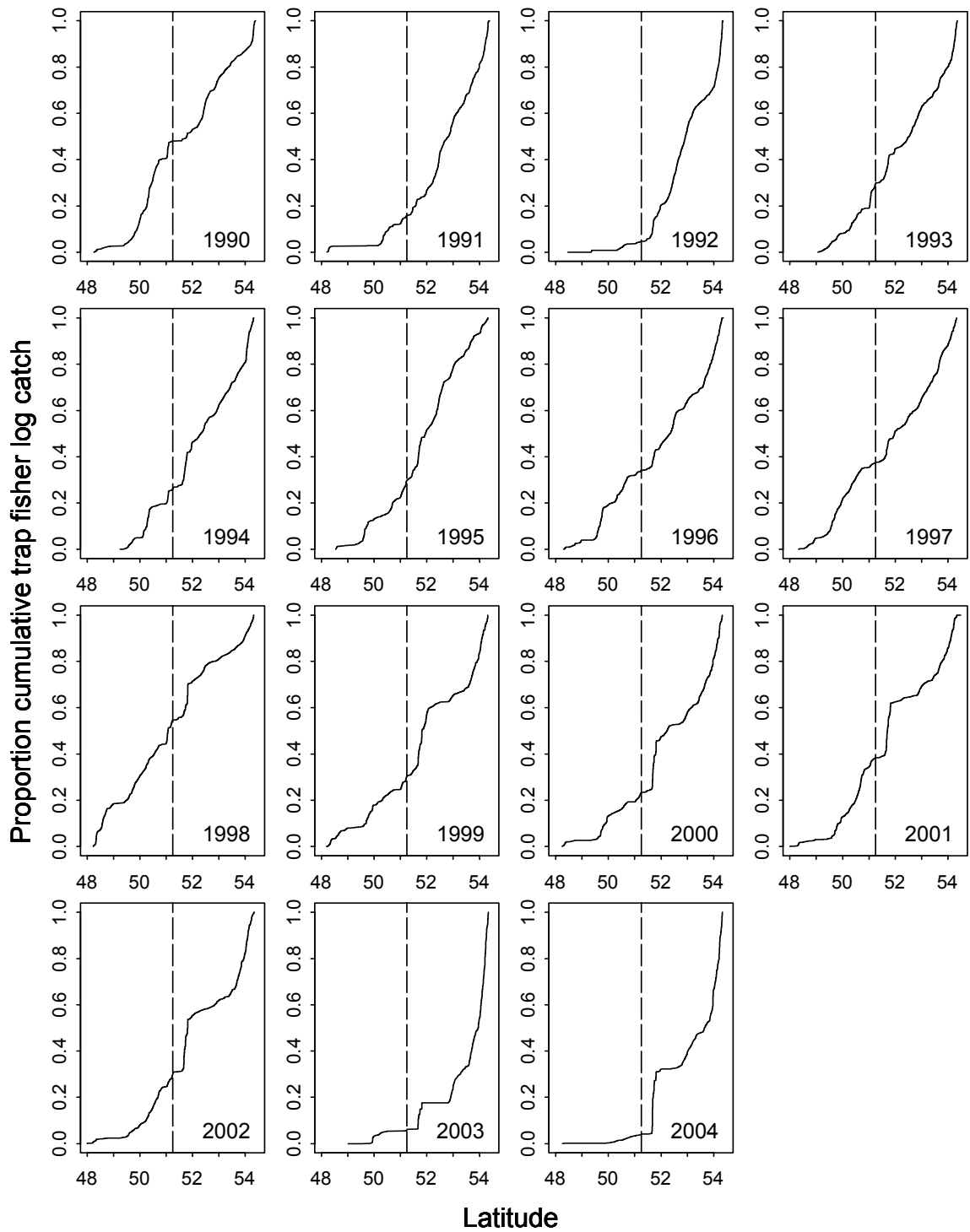


Figure B.7 Cumulative proportion of fisher logbook reported sablefish trap catch by latitude and year. The dashed vertical line represents the division between south and north areas.

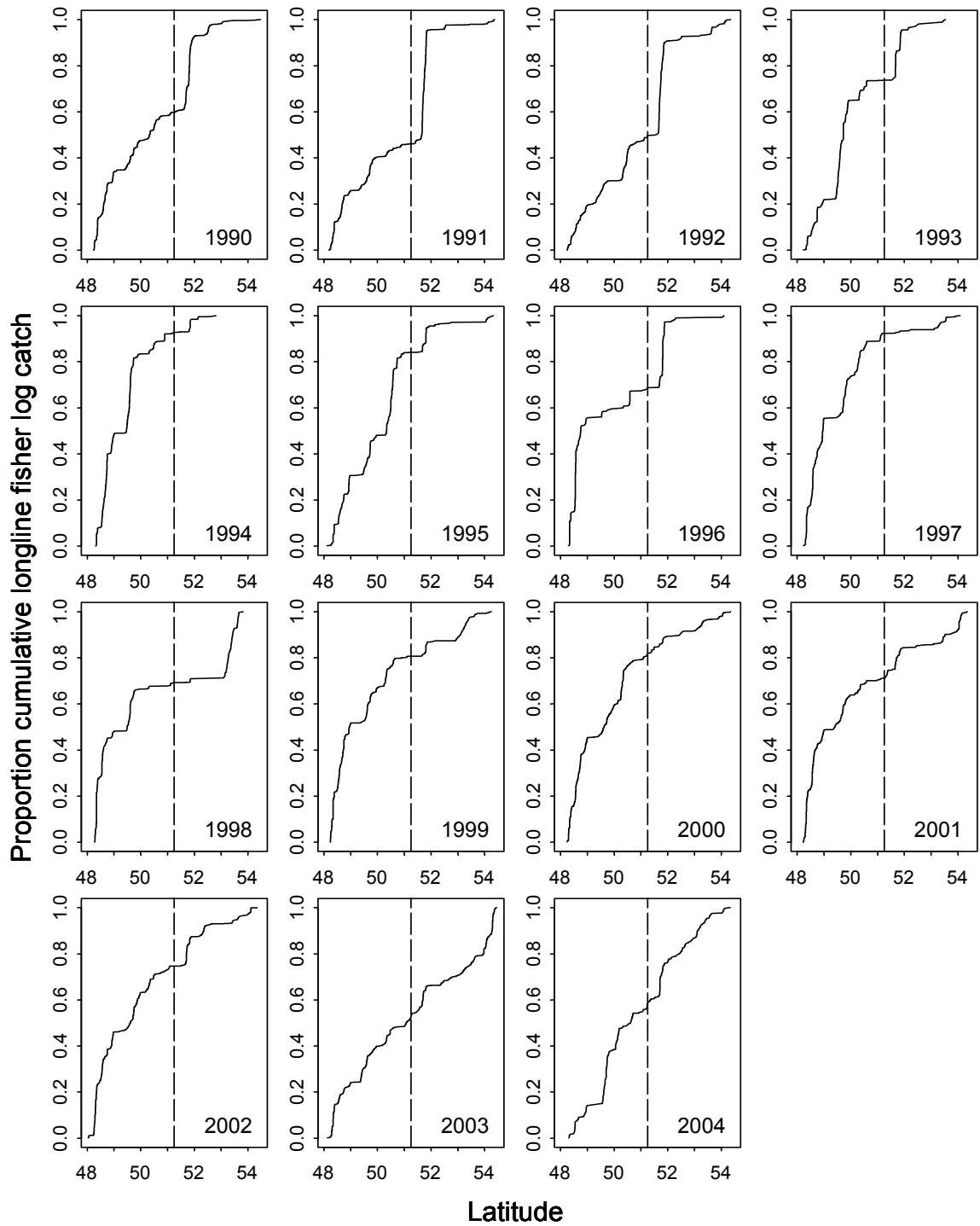


Figure B.8 Cumulative proportion of fisher logbook reported longline catch by latitude and year. The dashed vertical line represents the division between south and north areas.

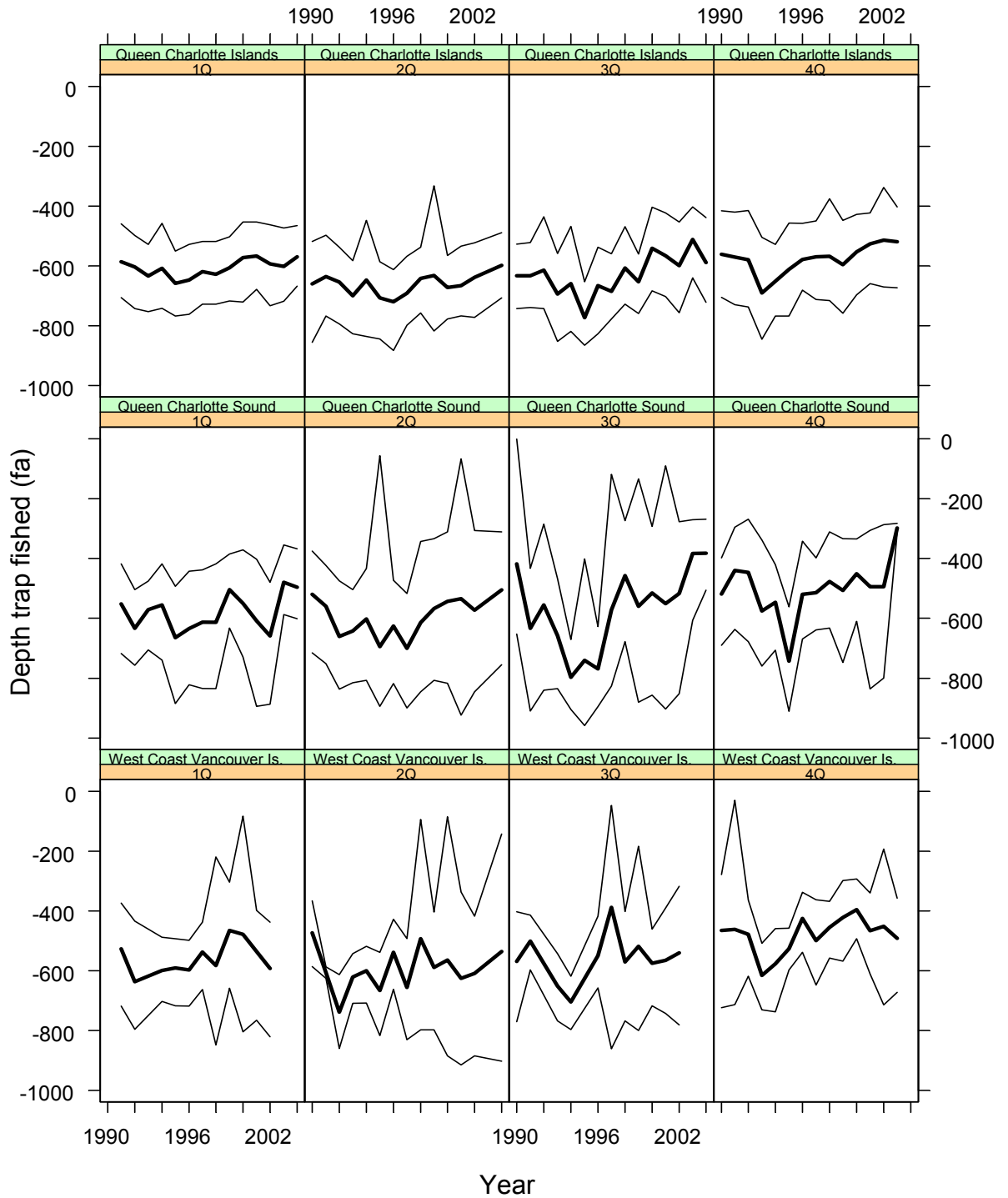


Figure B.9 Depth of fishing by year, quarter, and region. The upper and lower lines represent the 10th and 90th percentiles of depth fished while the thick center line is the mean depth fished.

APPENDIX C ANALYSIS OF TAG RECOVERY DATA

C.1	TAGGING PROGRAM.....	C-1
C.2	TAGGING DATA AND DATA SELECTION	C-3
C.3	EXPLORATORY DATA ANALYSIS OF TAG RECOVERIES	C-4
C.4	ALLOCATION OF TAGS RECOVERED WITH PARTIAL INFORMATION.....	C-5
C.5	LITERATURE CITED.....	C-8

C.1 Tagging Program

Details of the tagging program have been described in previous assessments (e.g., Kronlund et al. 2003, Haist et al. 2004) and in survey data reports (Wyeth and Kronlund 2003, Wyeth et al. 2003, 2004a, 2004b). Sablefish have been tagged in most regions of British Columbia since 1977 (Table C.1, Figure C.1). Integration of tagging operations into the fall survey began in 1991. At the outset of the 1991 survey, replicate standardized sets were made at some localities and sablefish from the second set at each locality were tagged and released. As the 1991 survey progressed, the protocol shifted to tagging sablefish in excess of the biological sampling requirements of the set. For example, if fish from every third trap were sampled, fish from the first and second traps were tagged. This protocol remained in effect for the standardized survey sets through 1995. Standardized sets consisted of 25 traps each baited with approximately 1 kg of frozen squid in a bait bag and were targeted at five 183 m (100 fm) depth strata from 275 to 1189 m (150 to 650 fm, e.g., Wyeth et al. 2003).

In 1994 “tagging sets” directed at capturing sablefish for tag and release became part of the fall survey. Following the protocol of standardized survey sets, the fishing master of the survey vessel had discretion over the exact position of the tagging set within each locality. Tagging sets consisted of strings of 50 to 75 traps baited with approximately 1 kg of frozen squid in a bait bag and, in later years, 3 to 5 kg (6-10 lbs) of loose frozen Pacific hake (*Merluccius productus*) was also added to the traps. Tagging sets were targeted between 457 and 824 m (250 and 450 fm).

From 1991 to 1994, tagging was conducted at the offshore indexing localities (Figure C.2). In 1995, seven offshore “tagging” localities were added for the express purpose of conducting tagging sets. The localities off the West Coast of Vancouver Island (Pisces Canyon, Estevan Point, and Father Charles Canyon) and in Queen Charlotte Sound (Middle Ground) were visited from 1995 through 2003. However, the tagging localities off the West Coast of the Queen Charlotte Islands visited in 1995 were not visited again. Rather, new localities were chosen (Rennell Sound and Tasu Sound) which, when combined with the existing indexing localities, provided better coverage of the coast. Additional localities were visited in 1997 and 1998 (Hogback and Kyuoquot Sound to Ouokinish Inlet). Beginning in 1999 a single tagging set was also conducted at each of the nine offshore indexing localities. Tagging has also been conducted in selected mainland inlets since 1994. For the 2002 survey only, tagging sets were fished

in each of eight depth strata within the standardized survey localities to distribute tags more broadly across the depth distribution of the species. This protocol was replaced in 2003 by an area and depth stratified random design for tag application.

Tagging sets can be classified according to the following scheme:

1. Type 1 (**traditional**) tagging sets consisted of 65 traps and were conducted at tagging or indexing localities and targeted at 250-450 fm (457-824 m). From 2002-2004, the goal of Type 1 sets was to maintain the historical protocol so that existing tagging analyses could be continued. Specifically, 1000 sablefish were tagged in each tagging locality and 300 fish in each indexing locality;
2. Type 2 (**systematic**) tagging sets consisted of 25 traps and were conducted at the offshore indexing localities. The objective of these sets was to release tagged sablefish across the depth distribution of the species in offshore waters. One set was made in each of the seven standardized survey depth strata. All sablefish captured in the Type 2 sets were tagged and released. Type 2 sets were conducted in 2002 only (Wyeth et al. 2004a).
3. Type 3 (**random**) tagging sets used the same gear as the Type 2 sets, but were conducted at randomly positioned fishing sites.

The random tagging sets were positioned as follows. In 2002, five random coordinate pairs were selected from within the Barkley Canyon and Hippa Island indexing localities. In 2003 and 2004 the Type 3 random tagging program was extended to a pilot study consisting of 75 sets allocated according to a stratified random design. The objective of the design was to randomly tag and release fish across depth and spatial strata inhabited by sablefish on the “offshore” B.C. coast. The design had the following characteristics and is described in detail by Wyeth et al. (2004b):

1. Each set consisted of 25 traps baited with approximately 1 kg of frozen squid in a bait bag and 4.5 kg (10 lbs) of frozen offshore Pacific hake loose in the trap.
2. The offshore area was partitioned into five spatial strata with three depth strata within each spatial stratum for a total of 15 strata;
3. For 2003-2004, a total of 5 replicate sets were assigned to each stratum;
4. The sampling unit selected at random within each stratum was a 2 km by 2 km square;
5. The tagging set was required to be contained within the requisite depth stratum and pass through the selected square.
6. In 2003, sablefish caught in every second trap were tagged; the remainder was used for biological samples. In 2004 the tagging and sampling rate was reduced to one out of every three traps and the catch from the third trap was discarded.

The long term plan for the stratified random design is to use the tag-recovery information for abundance estimation and movement studies, and to utilize the catch rates as an index of stock abundance in place of the existing standardized survey. The latter application will require a period of overlap of some years between the existing standardized survey and the new stratified random survey to allow calibration of the two time series.

All sablefish were tagged using a Floy FD-68B T-bar anchor tag until 2000. Beginning in 2001, a Floy FD-94 tag was used that has similar characteristics to the FD-68B model. For tagging sets, most of the sablefish were tagged and released with the exception of fish from an *ad hoc* selection of traps that were used for biological samples. Tagged sablefish were recovered through voluntary returns from the B.C. commercial groundfish fisheries (trawl, trap, and longline) as well as from commercial fishing in Alaska and the continental United States. Some tags are also returned from other commercial and sport fisheries. A reward system is offered through the Canadian Sablefish Association as incentive to return tags.

C.2 Tagging data and data selection

Tag releases by year are listed in Table C.1 for the general geographic regions shown in Figure C.1. Total releases have ranged from 1,717 tagged fish released in 1987 to 41,269 released in 1979. The annual numbers of releases since 1991 are shown in Table C.2 for the offshore localities shown in Figure C.2 and for the stratified random sets. Table C.3 summarizes the annual number of tags recovered for all gear types by release year. The sablefish trap fishery accounts for the majority of tag returns among trap, longline and trawl gear types. Table C.4 shows the summary of tags recovered by trap gear by release year.

Selection criteria applied to the tagging data depend on the specific analysis. Data used in the tagging model described in Appendix E were based on tag release and recovery data current to July 31, 2004. Fish tagged and released were included in the analyses if the following criteria were met:

1. The tag release took place from 1991 to 2003 (consistency of tagging program);
2. The released fish was greater than 450 mm fork length or the length was unknown (adult fish);
3. Tag application occurred from August through December (tags released at consistent time as part of the annual fall survey).
4. For tags released starting in 2002, the set followed a “traditional” fishing protocol (Type 1 sets and those Type 2 sets targeted between 250 and 450 fm (depth strata D2 and D3, 457-824 m));
5. Tag application took place in offshore waters (offshore trap-vulnerable population) as defined by Groundfish Statistical Areas in the following table.

Fisheries and Oceans, Groundfish Statistical Areas		
Major	Minor	Locality
3	all	all
4	all	all
9	all	all
6	8	0, 6, 9, 10, 12, 14, 15
5	11	0, 4, 6-12,

These criteria define the traditional (selected) adult offshore release data. Table C.5 lists the number of traditional releases by release year. Note that in 2002 only a systematic (Type 2) application of tags was conducted across the seven survey depth strata. For 2002 only there were 6,464 “Type 2” tags applied in depth strata other than D2 and D3 that do not meet the selection criteria. In addition, a total of 1,342 tags were applied in a pilot study of 10 random sets (Wyeth et al. 2004a) that do not meet the selection criteria.

Recovered tagged sablefish were included in the tagging analyses provided the following criteria were met:

1. The recovered tag was from a traditional (selected) release;
2. The tagged fish was recovered by a commercial sablefish trap vessel (trap-vulnerable adult population);
3. The tagged fish was not recovered as part of research fishing (sablefish survey sets in particular have a higher probability of tag recapture than the commercial fishery);
4. The tagged fish was not recovered at a seamount (offshore trap-vulnerable population as for releases).

These criteria defined the traditional (selected) recoveries.

C.3 Exploratory Data Analysis of Tag Recoveries

Tagging analyses utilize the assumption that the proportion of tags in the recovered samples is related to the proportion of tags in the population of interest. Thus, examination of the tags recovered per metric tonne (t) of fish caught is a useful first step in exploratory analyses. Tag recovery rates for the traditional (selected) releases and recoveries were plotted by release year and area (Figure C.3, Figure C.4). A small number (0.001) was added to the observed tag recoveries before calculating the recovery rate to accommodate combinations of release year, recovery year, and month where no tags were recovered but catch was recorded. The vertical lines in each panel represent January. The plots for release years 1991 and 1992 in both stock areas are somewhat noisy which is expected given the relatively low number of releases. The following observations can be drawn from inspection of the figures:

1. The decline in the recovery rate was greater in the first three to five years after release than in subsequent years, at least for those release years with sufficient data (eg. 1994 to 1997);
2. For the north stock area, there is a consistent seasonal pattern of decrease in the recovery rate in December through March, with the low point typically occurring in January.
3. The seasonal pattern evident in the north stock area can be seen for some release and recovery years in the south stock area, but is not as consistent as the northern pattern. Indeed, in many recovery years the highest recovery rate observations are highest during the first few months of the year.

For the north stock area, the seasonal patterns are consistent with the hypothesis that an influx of untagged fish enters the B.C. population in the December to March period, causing a reduction in tags per tonne returned through dilution of the tagged population. Apparently these fish subsequently become unavailable to the trap fishery after about March through fishery removals, a behavioral change, and/or movement to areas of reduced vulnerability, i.e., they leave the trap-vulnerable biomass.

C.4 Allocation of tags recovered with partial information

Most traditional (selected) tag recoveries are accompanied by recapture information such as the recovery year, recovery month, and gear type. However, some tags are recovered with partial information where the one or more of the explanatory variables is unknown. In order to utilize these tag returns in the model, an algorithm was developed to allocate tags returned with partial information to known categories of the explanatory variables. The probability of a tag being allocated to a particular category was derived from tags recovered with observed data. The recapture data required by the tagging model included release year, recovery year, recovery month, and gear type. In addition, the area of recapture was considered to allow the possibility of area-specific analyses. The algorithm requires a series of assumptions, beginning with the following two conditions:

1. Recovered tags where the *release year is unknown* are ignored;
2. Recovered tags where the *recovery year is unknown* are ignored.

Given these assumptions, a total of 19,980 tag recoveries from 1991 to 2003 were selected for input to the tagging model. Of these tags, a total of 1,550 had at least one of recovery month, gear or area missing. The categories required for the tagging model are contained in the following table.

Variable	Data Categories	Model Categories
<i>Recovery Month</i>	1,...,12, Unknown	1,...,12, Unknown
<i>Gear</i>	Trap, Trawl, Longline, Other, Unknown	Trap, Other
<i>Area</i>	North, South, Unknown	North, South

Thus, the gear categories Trawl, Longline, and Other in the data were recoded as “Other”.

The distribution of tag recoveries by information case is shown in Table C.6 for tag recoveries from traditional releases used as input to the tagging model. Let “M” indicate the case where recovery month is known, while “m” represents the case where recovery month is unknown. Similarly let gear and area be represented by (G,g) and (A,a), respectively. Thus, the code “MAG” indicates that all three variables are known, while “Mag” indicates that area and gear type are missing.

Previous tagging model analyses for sablefish have generally treated the “observed” tag recoveries to be the sum of tags with complete information and the tags with unknowns that were allocated to known categories. Each step of the allocation algorithm involves computing the probability of a tag with one or more unknowns falling into a particular category for each variable. Blocks of tags that correspond to a particular combination of release year ($i=1991, \dots, 2003$) and recovery year ($j=1991, 2004$) were processed for $j \geq i$. The probability of a tag being allocated to a particular category for any variable was considered to be an attribute of the recovery year. Thus, all tags with observed information for a given recovery year were used to compute the required probabilities. Probabilities for tags recovered with 0 to 3 unknowns must be considered as listed in the following table and described below.

Number of Unknowns	Case	Probabilities Required to Allocate Tags
0	No unknowns	None
1	Gear unknown, month and area known Month unknown, gear and areas known Area unknown, gear and month known	$P(G MA)$ $P(M GA)$ $P(A GM)$
2	Gear and area unknown, month known Gear and month unknown, area known Month and area unknown, gear known	$P(G M), P(A GM)$ $P(G A), P(M GA)$ $P(M G), P(A GM)$
3	Gear, month, and area unknown	$P(G), P(M G), P(A GM)$

Tags were allocated to a category for each recapture variable in fractional amounts. For example, if the probability of “Trap” gear was 0.6 for a given case, then a single tag with unknown gear was allocated as 0.6 to the “Trap” gear category and 0.4 to the “Other” gear category.

Complete Information (1 Case)

No action is required when recapture information is complete for a tag recovery.

One Unknown (3 Cases)

Suppose gear was unknown but the recovery month and area were known. The probability of a tag being allocated to the “Trap” or “Other” gear categories was computed by determining the probability of each gear category *given* recovery month and area, denoted $P(G|MA)$. These calculations were based on the complete data for the recovery year. Thus, the tags with one unknown were processed as followed:

3. Gear Unknown. Allocate tags to gear using $P(G|MA)$ computed from tags with gear, recovery month and area known;

4. Month Unknown. Allocate tags to gear using $P(M|GA)$ computed from tags gear , month and area known.
5. Area Unknown. Allocate tags to area using $P(A|GM)$ computed from tags with gear, month and area known.

Probabilities were computed only from observed information in the sense that when tags were allocated to a gear category, the newly formed “complete” information was not used to compute the probabilities in the next step. The order that the three cases with one unknown are processed does not matter as they occur independently, i.e., only tag recoveries with complete information were used to allocate tags with one unknown.

Two Unknowns (3 Cases)

For cases with more than one unknown, the order that unknown variables were allocated to known categories was determined by considering the quality of the observed data. Tags with unknown gear were allocated first since gear was most likely to possess good observed information and there are only two categories. Tags with unknown month were allocated second because of the larger number of categories. Tags with unknown area were allocated last because it was anticipated that most analyses would not require area information. Thus, tag recoveries allocated to the north and south categories could simply be summed for coast-wide analyses based on release year, recovery year, recovery month and gear. The three cases were processed by “sweeping” the tags with unknowns from unknown to known categories. For example, if gear and area were unknown these tags were first allocated to a gear category. The tags, now assigned a gear category, were then swept into an area category with the result that the known month was now accompanied by an estimated gear and area.

1. Gear and area unknown. (a) Allocate the tags to gear using $P(G|M)$ computed from tag recoveries where gear and month were known, regardless of whether area was known. (b) Allocate the tags to area using $P(A|GM)$ computed from tag recoveries where gear, month, and area were known;
2. Gear and month unknown. (a) Allocate the tags to gear using $P(G|A)$ computed from tag recoveries where gear and area were known, regardless of whether month was known. (b) Allocate the tags to month using $P(M|GA)$ computed from tag recoveries where gear, month, and area were known.
3. Month and area unknown. (a) Allocate the tags to month using $P(M|G)$ computed from tag recoveries where month and gear were known, regardless of whether area was known. (b) Allocate the tags to area using $P(A|GM)$ computed from tag recoveries where gear, month, and area were known.

Only observed data for the given recovery year were used to compute the probabilities for tag allocation within combination of release and recovery year. Note that tags allocated to various categories were not utilized in computing probabilities in subsequent steps to avoid “manufacturing” information.

Three Unknowns (1 Case)

For the case where all recapture variables were unknown for tag recoveries, the tags were processed by applying the following steps:

1. Gear. Allocate the tags to gear category using $P(G)$ computed from tag recoveries with gear known, regardless of whether other variables were known;
2. Month. Allocate the tags to recovery month by using $P(M|G)$ computed from tag recoveries where gear and month were known regardless of whether area was known;
3. Area. Allocate the tags to area using $P(A|GM)$ computed from tag recoveries where gear, month and area were known.

Again, all observed data for the given recovery year were used to allocate tags for a combination of release and recovery year. Only tags where the variables were actually observed were used to form the required probabilities to avoid “manufacturing” information. Area was chosen to be processed last since it was anticipated that most analyses would not require data by area.

Situations arise during tag allocation where a tag with unknowns contains observed information that did not occur in the tags used to compute the category probabilities. For example, suppose a tag with unknown gear was observed for the month of August in the North area. However, the data with complete observed information contained no recoveries for August in the North. In this situation the tag was allocated to month by using the marginal probability $P(M)$ computed from all tag recoveries with month known, regardless of whether gear and area were known. In this way the “dropping” of tags was avoided so that all tags with unknowns were assigned to known categories. The solution to the problem of tag allocation is not unique; other choices of the order to process explanatory variables will lead to slightly different allocation of tags with unknown information.

C.5 Literature Cited

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Table C.1 Total number of tagged sablefish released by year and region for all gears.

Year	Georgia Strait	Hecate Strait	Mainland Inlets	Dixon Entrance	Queen Charlotte Sound	Offshore Queen Charlotte Sound	West Coast Queen Charlotte Islands	West Coast Vancouver Island	Seamount	Total
1977							5,158	5,505		10,663
1978						1,454	5,331	4,111		10,896
1979		10,415			15,121		6,621	9,112		41,269
1980	18	10,674	7,019	466	474	3,110	3,619	4,703		30,083
1981		2,983			9,323		10,430			22,736
1982						1,019	3,008	3,013		7,040
1983							4,002	4,023		8,025
1984					90	5,023	5,379	236		10,728
1985							3,025	5,301		8,326
1987								1,101	616	1,717
1991						69	958	1,420		2,447
1992						420	1,308	1,856		3,584
1993						575	2,487	3,956		7,018
1994			3,435			539	1,321	1,744		7,039
1995			3,199			2,331	5,731	4,644		15,905
1996			3,897			5,035	7,942	11,403		28,277
1997			3,146			3,459	3,919	9,118		19,642
1998			6,009			2,372	2,963	10,622		21,966
1999			9,620			3,731	5,787	8,273		27,411
2000			3,114			3,469	6,216	10,116		22,915
2001			4,117			3,175	3,535	7,442		18,269
2002			3,549			3,433	5,880	6,995		19,857
2003			4,407			4,177	7,474	8,599		24,657
All	18	24,072	51,512	466	25,008	43,391	102,094	123,293	616	370,470

Table C.2 Number of offshore tag releases by locality and for stratified random sets during fall sablefish surveys using trap gear from 1991 to 2003. Note that this summary does not include 899 tags released from a trawl research trip in 1996 as well as 15,139 and 9,355 tags released during spring surveys in 1996 and 1997, respectively.

Locality	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Langara Island-North Frederick	507	217	483	227	154	138		258	846	442	141	562	305	4,280
Rennell Sound						699	508		2,139	2,428	1,357	990	1,001	9,122
Hippa Island		258	504	279	198	325		262	380	366	270	1,307	309	4,458
Buck Point	170	483	570	346	155	230	64	194	289	678	557	1,176	334	5,246
Tasu Sound						715	488	2,013	1,664	1,731	1,124	996	1,068	9,799
Gowgaia Bay	281	350	930	469	1,287	139	109	236	469	561	86	849	305	6,071
Cape St. James				301	145	147		47	839	522	552	1,152	306	4,011
Middle Ground					1,688	1,578	1,082	2,048	2,108	1,953	2,126	977	935	14,495
Triangle Island	69	420	575	238	498	179	66	277	784	994	497	1,304	301	6,202
Pisces Canyon					158	1,284	1,119	2,051	2,016	1,991	1,171	972	1,016	11,778
Quatsino Sound	466	528	687	198	290			156	581	744	659	937	302	5,548
Esperanza Inlet		587	1,396	464	564	196	297	302	291	1,034	348	1,027	321	6,827
Estevan Point					1,360	1,238	1,476	4,321	1,712	2,271	2,608	1,125	1,006	17,117
Father Charles Canyon					1,296	946	1,087	1,172	2,294	2,256	1,764	843	973	12,631
Barkley Canyon	954	741	1,873	882	696	498	535	281	1,379	1,820	892	2,091	326	12,968
Frederick Island					1,954									1,954
Hogback							309							309
Chads Point					956									956
Tasu Sound-Marble Island										10				10
Anthony Island					1,027									1,027
Solander Island				200	280									480
Kyuquot Sound-Ouokinish Inlet								2,339						2,339
Offshore Locality Total	2,447	3,584	7,018	3,604	12,706	8,312	7,140	15,957	17,791	19,801	14,152	16,308	8,804	137,628
Offshore Stratified Random Sets													11,433	11,433
Offshore Total	2,447	3,584	7,018	3,604	12,706	8,312	7,140	15,957	17,791	19,801	14,152	16,308	20,237	149,057

Table C.3 Number of tagged sablefish recovered by all gear types in each year by year of tag release (includes all releases and all recoveries).

Release Year	Recovery Year																													
	Unknown	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	All
1977	3	138	631	266	200	131	73	47	41	27	19	8	12	6	4	9	7	8	1	1	2	10	5	4	2	8	6		2	1671
1978	1		221	319	286	128	51	43	30	9	8	5	9	11	5	3	4	2	1		1	2	3	4	2	1	2	1	1	1153
1979	16			831	1384	616	409	206	169	169	224	65	89	55	34	20	32	26	7	3	22	23	40	20	6	22	15	10	4	4517
1980	5				1077	979	646	388	312	103	113	50	60	71	44	28	22	32	6	2	25	20	16	10	15	24	10	8	5	4071
1981	2					273	583	343	188	99	97	47	53	53	48	32	34	27	4		26	13	16	14	13	10	3	5	2	1985
1982	4						665	356	91	60	18	32	39	24	13	23	15	1		7	11	8	8	5	7	2	6	2	1397	
1983	1							106	39	55	26	19	18	11	3	3	6	1		3	6	1	3	6	4	1	1	1	313	
1984	7							252	166	165	57	39	24	24	25	22	10	2		14	13	17	16	9	8	11	1	2	884	
1985	7								114	347	72	62	43	35	15	31	19	2	1	8	16	25	9	6	9	3	4	3	831	
1987											6	25	21	8	5	2					1	1	2		2	1			74	
1991	3														16	100	48	39	29	17	17	15	8	9	11	5	5	4	326	
1992	14															13	121	97	64	45	29	44	32	9	20	15	6	2	511	
1993	18																6	421	218	75	91	95	72	45	42	29	7	7	1126	
1994	8																13	416	210	227	216	127	76	61	46	14	13	1427		
1995	83																	85	1295	916	593	374	247	165	91	50	41	3940		
1996	101																			441	2141	1341	673	454	373	239	87	61	5911	
1997	109																				1213	2261	907	494	368	239	93	55	5739	
1998	34																					321	1742	1109	751	486	183	112	4738	
1999	21																							234	2280	1432	935	351	274	5527
2000	13																								149	2046	926	315	203	3652
2001	19																									135	1557	408	301	2420
2002	3																										95	896	516	1510
2003	5																											166	823	994
All	477	138	852	1416	2947	2127	1762	1692	1454	817	1088	354	400	341	237	169	293	320	595	819	2192	4749	5019	4257	4938	5498	4716	2617	2433	54717

Table C.4 Number of tagged sablefish recovered by trap gear in each year by year of tag release (includes all releases and all recoveries).

Release Year	Recovery Year																									All				
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		2002	2003	2004	
1977	122	578	187	163	115	66	35	36	17	15	4	9	2		2	3	2			1	5	3		1	3	3		1	1373	
1978		200	246	257	113	47	30	26	7	5	1	3	7	4		2	1				2	1	1			1			954	
1979			617	1146	517	338	132	118	122	180	13	48	17	8	7	10	8	2		9	13	21	9	2	10	7			3354	
1980				991	832	527	283	264	66	56	14	17	20	13	12	5	11	3		8	13	6	5	4	7		1	2	3160	
1981					207	453	231	140	55	45	7	14	8	8	6	11	6	2		12	5	5	6	5	3		1		1230	
1982							521	321	60	34	5	13	13	8	2	5	3	1		4	6	4	3	4	4	1			1012	
1983								72	24	36	4	8	2	1		1				1	3	1	1	1	3				158	
1984								229	122	114	20	19	5	6	9	7	3	1		9	8	12	11	8	2	5		1	591	
1985									75	291	29	44	15	18	5	10	7		1	5	11	23	4	4	3				545	
1987											3	14	5	2	2	1						1		1					29	
1991															13	71	30	18	19	9	13	13	7	2	1	4		2	202	
1992																10	75	58	41	29	23	25	20	5	12	8			306	
1993																	2	261	139	49	56	70	44	13	27	13			674	
1994																	11	317	167	183	184	93	46	43	29	3	6		1082	
1995																		80	1092	742	505	270	142	87	45	9	20		2992	
1996																			334	1851	1107	454	261	216	118	28	33		4402	
1997																					1125	1986	666	301	243	130	27	22	4500	
1998																						296	1381	729	492	285	47	60	3290	
1999																							148	1571	931	564	115	133	3462	
2000																								100	1587	617	119	104	2527	
2001																										116	1161	197	182	1656
2002																											73	613	335	1021
2003																												132	557	689
All	122	778	1050	2557	1784	1431	1232	1206	548	776	100	189	94	68	58	136	148	357	597	1729	4059	4263	3123	3200	3790	3064	1292	1458	39209	

Table C.5 Annual number of traditional (selected) tag releases.

Release Year	Number of Selected Releases
1991	2439
1992	3581
1993	7012
1994	3603
1995	12701
1996	9143
1997	7139
1998	15916
1999	17763
2000	19764
2001	14143
2002	9841
2003	8804

Table C.6 Distribution of traditional recovered tags for different combinations of known and unknown recovery month (M,m), area (A,a), and gear (G,g). Lower case letters indicate the variable was unknown.

Year	MAG	MAg	MaG	Mag	mAG	mAg	maG	mag
1991	13	NA	NA	NA	NA	NA	NA	2
1992	95	7	2	2	NA	1	1	3
1993	117	14	10	6	NA	NA	12	8
1994	321	54	38	12	14	2	71	43
1995	471	10	34	7	9	2	111	34
1996	1004	29	52	4	6	4	228	12
1997	1888	3	41	3	NA	NA	7	NA
1998	2215	2	22	6	1	NA	NA	NA
1999	2107	17	43	4	1	2	1	NA
2000	2440	36	39	5	2	5	2	1
2001	2930	6	44	8	2	5	8	NA
2002	2709	40	76	7	7	NA	1	8
2003	1164	28	41	5	2	3	2	6
2004	956	18	140	1	1	1	1	2

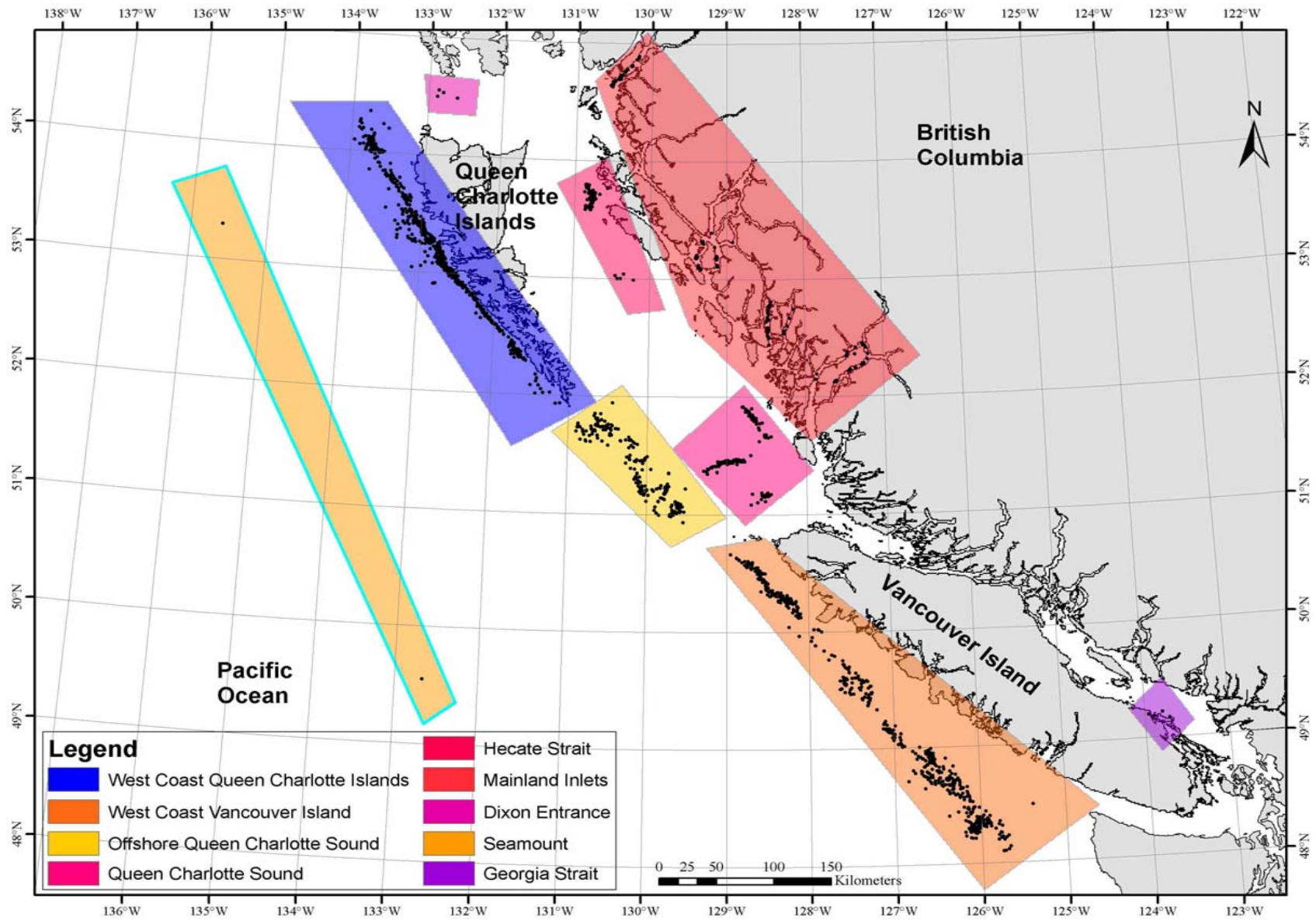


Figure C.1 Sablefish tag release regions. The locations of release sets from 1977 to 2003 are indicated by black dots.

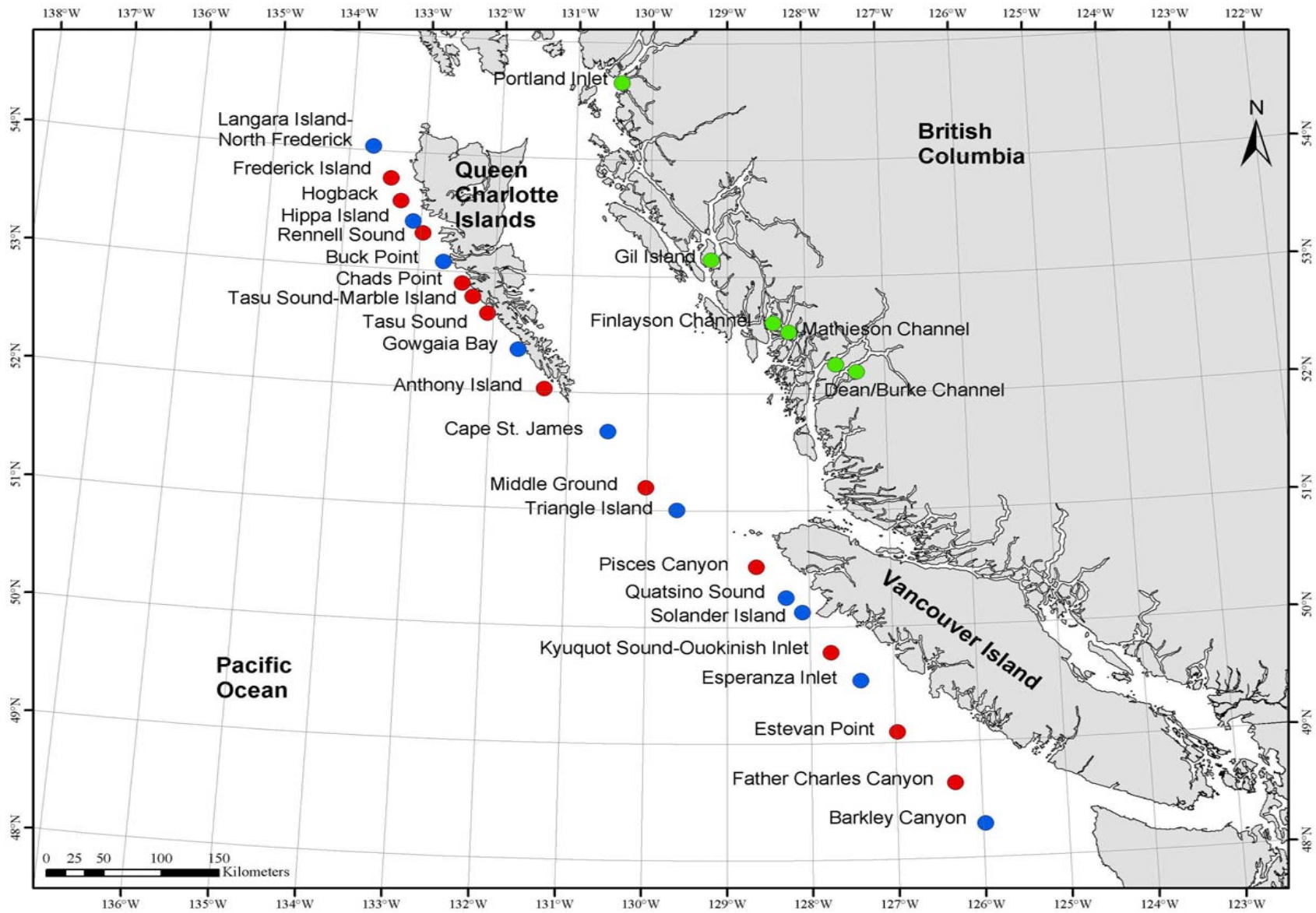


Figure C.2 Tag release localities visited during the annual sablefish stock assessment surveys from 1991 to 2004. Blue circles represent index localities, red circles represent tagging localities and green circles represent inlet localities.

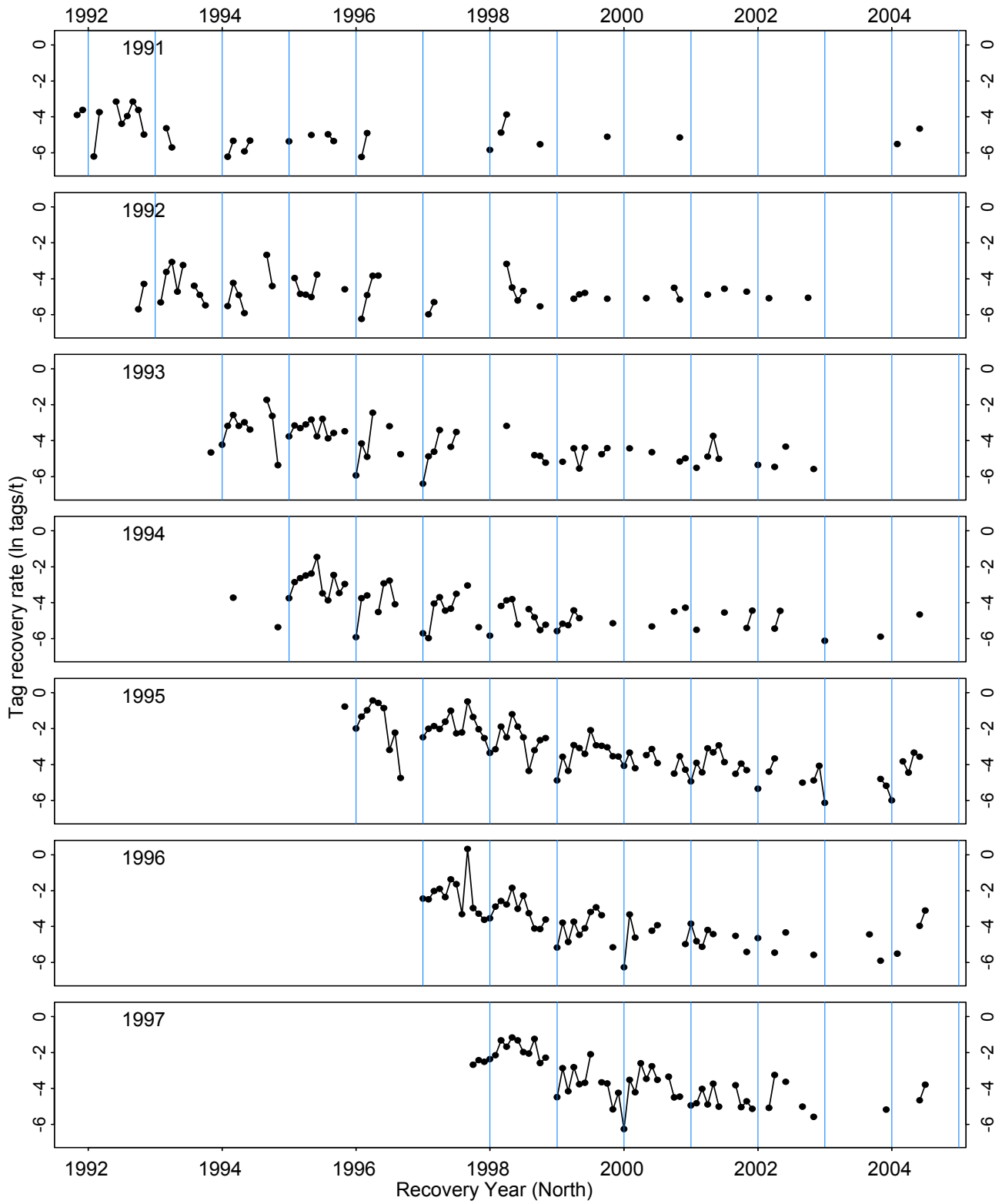
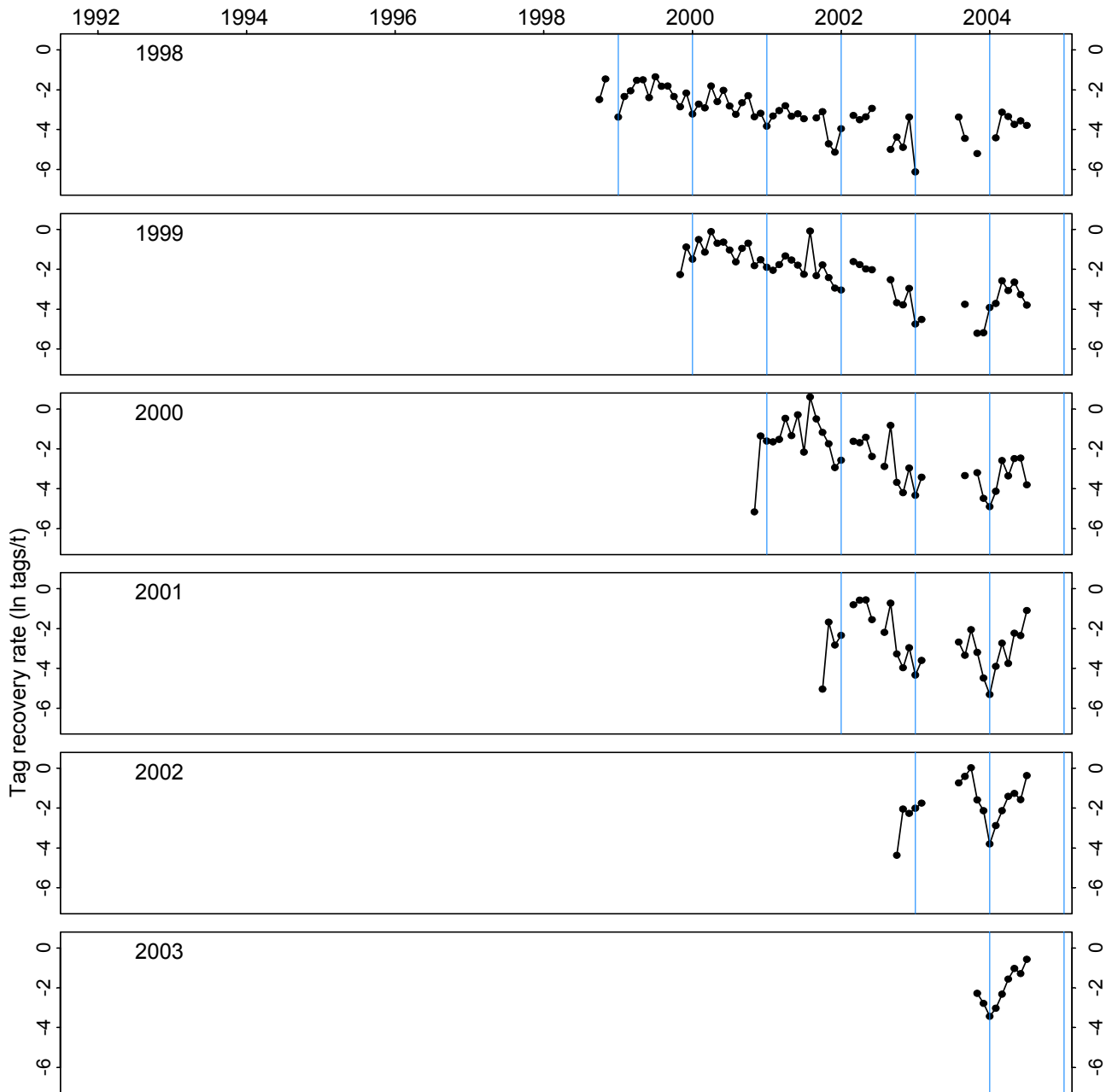


Figure C.3 Tag recovery rate (observed ln tags/t) plotted against recovery year by release year (panels) for the north stock area.



Recovery Year (North)

Figure C.3 continued.

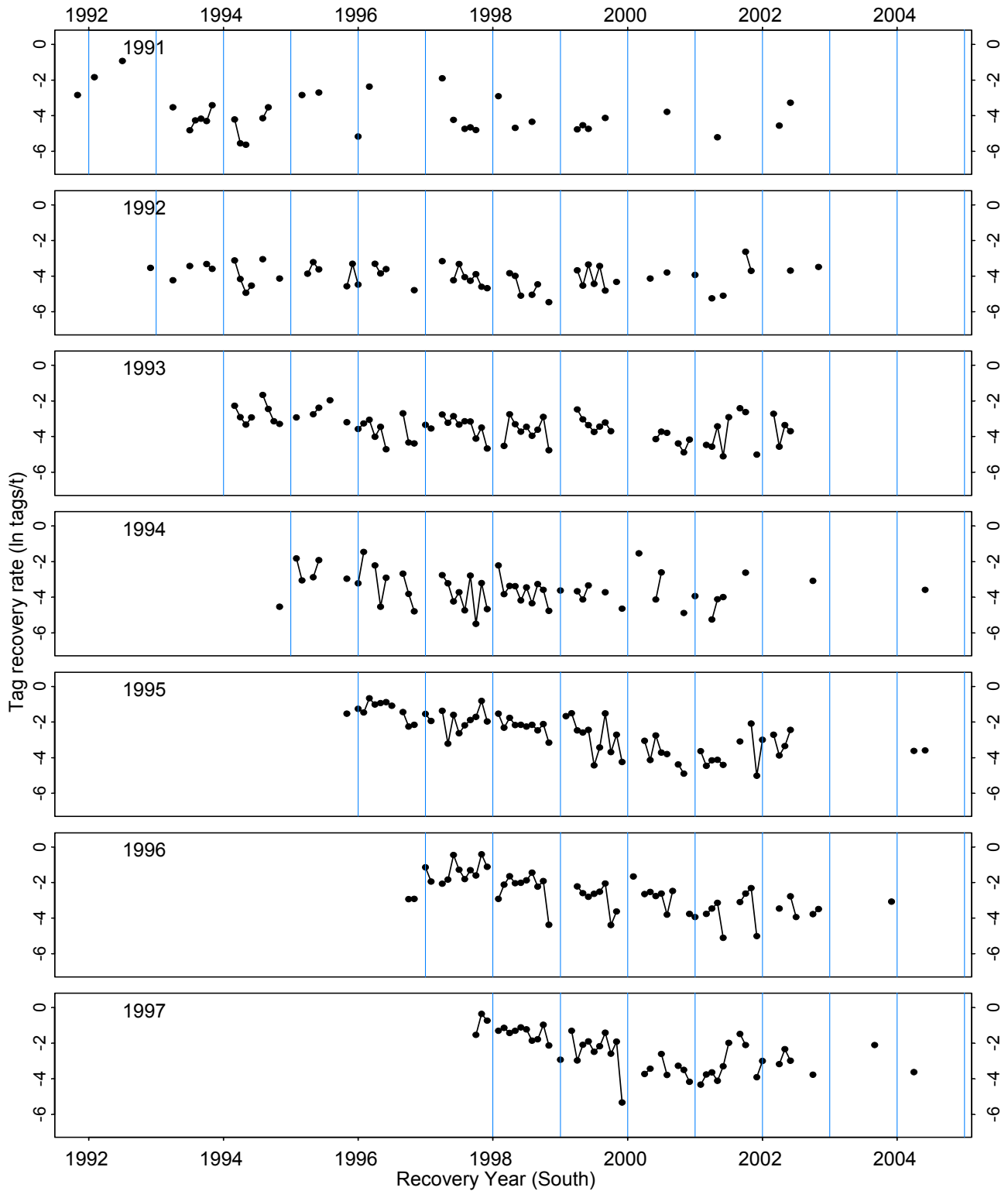
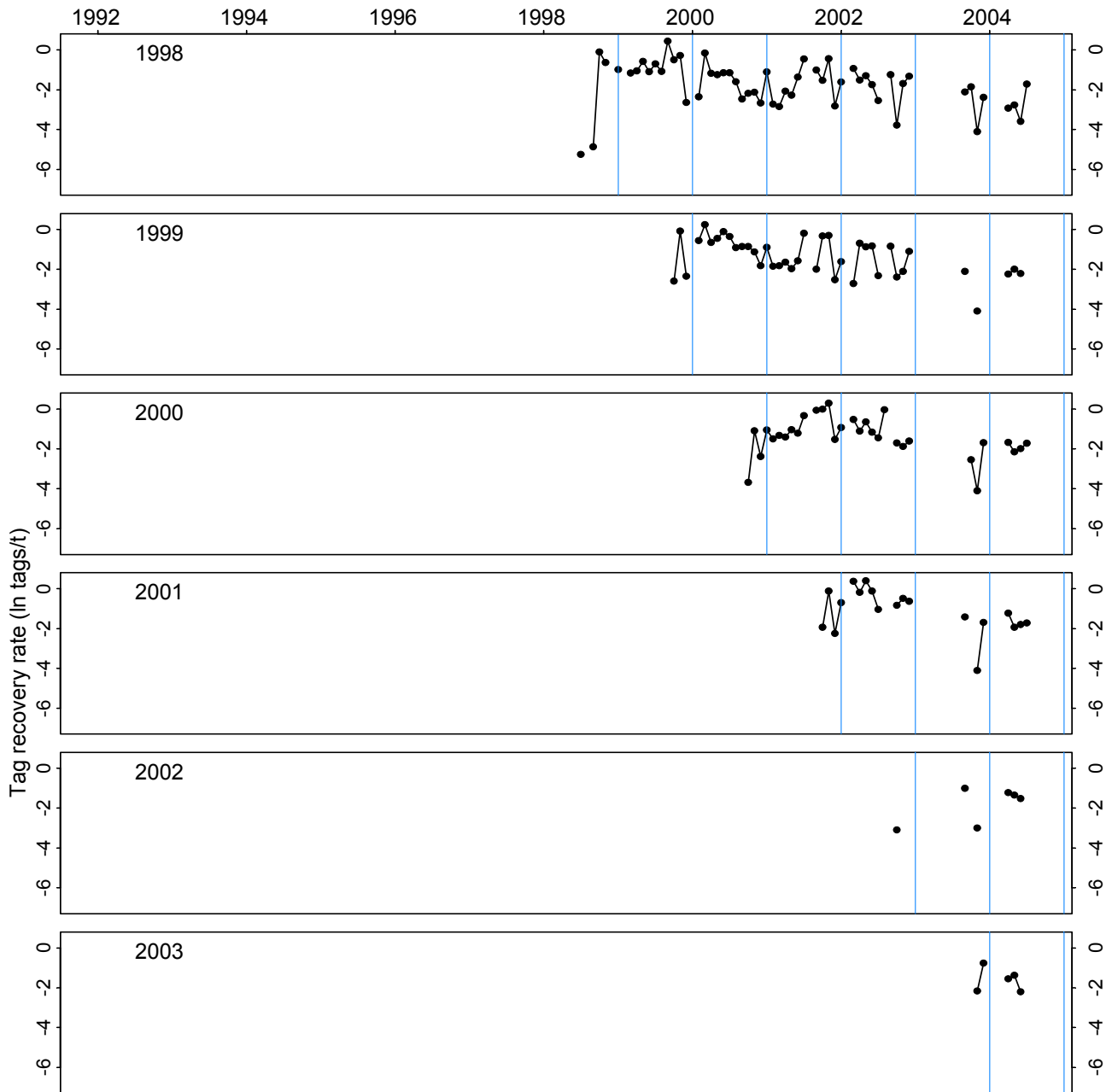


Figure C.4 Tag recovery rate (observed ln tags/t) plotted against recovery year by release year (panels) for the south stock area.



Recovery Year (South)

Figure C.4 continued.

APPENDIX D ANALYSIS OF STANDARDIZED SURVEY DATA

D.1	SURVEY PROTOCOL.....	D-1
D.2	DATA SELECTION AND CALCULATION OF CATCH RATE PER SET.....	D-2
D.3	SURVEY RESULTS.....	D-3
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D.1 Survey Protocol

The protocol for the sablefish standardized survey has been described in previous assessment documents (eg., Kronlund et al. 2004, Haist et al. 2004) and in various technical reports (Wyeth and Kronlund 2003, Wyeth et al. 2003, 2004a, 2004b). Catch rates observed during survey sets have been regarded as an index of trap-vulnerable sablefish by Haist and Hilborn (2000), Haist et al. (2001), Kronlund et al. (2002), Kronlund et al. (2003), and Haist et al. (2004).

The survey used for indexing the trap-vulnerable biomass has been conducted annually since 1988, though only data beginning with the 1990 survey are currently used to develop a stock index (Table D.1). Nine survey localities (Table D.2, Figure D.1) were purposively selected for the survey because they were fished by commercial vessels and were spatially dispersed about 60 nm apart. This spatial arrangement permitted the localities to be visited within a 30 day period given favorable weather. The indexing survey was depth stratified by fishing trap gear within five core depth intervals between 275 and 1189 m (150 and 650 fm) from 1990 to 2004 (Table D.3). Other strata have been added to these five core strata over time. However, only data from strata D1 through D5 have been utilized in the calculation of a catch rate index of trap-vulnerable stock abundance. Spatial positions of the survey sets within each locality were not selected at random; rather the fishing master had discretion to set gear within each designated depth stratum. In general there was little replication of sets by depth and locality during the 1990 to 2004 period except for selected southern localities in 1990, 1991, and 1993 and three selected localities in 2002. In most cases a single set was conducted within each depth stratum for a given locality (Kronlund et al. 2003, Wyeth et al. 2004).

Table D.1 also lists the vessel and skipper used in each survey year. The R/V W.E. Ricker carried out the surveys in 1991 to 1993 under the on-board direction of an experienced skipper from the sablefish commercial fleet. Surveys in other years have utilized a commercial charter vessel and experienced skipper. Standardized surveys conducted from 1996 to 1999, and in 2001 used the same vessel and skipper. Similarly,

the 2000 and 2002 standardized survey shared a common vessel and skipper and that same skipper was employed in 2004. Onboard scientific technicians from Fisheries and Oceans Canada, or technicians provided through contractors, have varied over the 1990 to 2004 series although the survey has employed the same Chief Scientist since 2001.

Surveys were conducted using trap gear as described by Smith et al. (1996) and Wyeth et al. (2003, 2004). Trap design since 1988 has been a modified Korean trap consistent with that used by the commercial sablefish fleet. Beginning in 1990, a standardized string of 25 traps, each trap baited with 1.0 to 1.5 kg of frozen squid, was deployed on each survey set. Catch was recorded in numbers of sablefish per trap and aggregate sablefish weight (kg) per trap. The aggregate weight may be an underestimate of the true catch because fish may be partially eaten or reduced to frames by amphipod predation for some traps. The survey gear was inspected upon retrieval to determine if each trap was actually fishing (“effective”) and not fouled or holed.

Sablefish caught on standardized survey sets, as opposed to sets designated for tag application or other specific projects, were sampled for length, sex, and maturity. Otoliths were excised for subsequent age determination. Sablefish weight and girth were measured and stomachs were sampled for gut content analysis in some years. Tags may have been applied to sablefish caught by survey sets when large catches were achieved (e.g., Wyeth and Kronlund 2003).

D.2 Data selection and calculation of catch rate per set

Data from the standardized survey were assembled from 1990 to 2004. Fishing event data were included in analyses if the following conditions were met:

- the set was made as part of the standardized survey (Access database table field [B02_FISHING_EVENT]![REASON.CODE]=13);
- the trap usability code indicated that the gear was fishing correctly and was not fouled or holed (Access database table code [B02d_Trap_Specs]![USABILITY_CODE]=1) or that at least some traps were fishing correctly (Access database table code [B02d_Trap_Specs]![USABILITY_CODE]==12);
- the depth fished was contained in stratum D1 to stratum D5 (Table D.3), as determined by assigning the set to a depth stratum based on the mean of depths recorded at one minute intervals during deployment of the gear (Access database table field [B02_FISHING_EVENT]![FE_MODAL_BOTTOM_DEPTH]).

Specific sets were excluded from the analysis as identified in Table D.4. Sets where the mean depth of the set fell into depth stratum 0, 6 and 7 were not included in the analyses because their occurrence is limited to the 2002 (D6, D7), 2003 (D0, D6, D7) and 2004 (D0, D6, D7) survey years. The mean depth of one 1994 Esperanza Inlet set was slightly shallower than the boundary of stratum D0 and D1 but was included in the standardized survey index calculation because the minimum and maximum depths of the set straddled the boundary.

The catch rate for each set was computed by summing the number (or weight) of sablefish in each effective trap, C_{ijkl} , and dividing by the number of effective traps for the set, n_{ijk}

$$(1) \quad U_{ijk} = \frac{\sum_{l=1}^{n_{ijl}} C_{ijkl}}{n_{ijk}} ,$$

where U_{ijk} is the mean catch per trap for set k in depth stratum j of survey locality i for year t . Although U_{ijk} is the mean catch per trap for a set, the terms catch rate, or catch per unit effort (CPUE) for the set are used interchangeably. Note that the number of effective traps may differ from 25 traps due to miscounting of traps on deployment of the gear, detection of fouled or holed gear upon retrieval, or lost traps.

D.3 Survey Results

2004 standardized survey results

Table D.5 is a summary of the catches and sampling for the 2004 sablefish standardized survey. There are no criteria applied to the selection of data in this table. Entries in the table show (1) the intended depth stratum rather than the depth stratum actually achieved, (2) the number of traps hauled rather than the traps fishing correctly, and (3) the nominal catch per trap by numbers and weight computed from the table entries. In contrast to previous surveys, the standardized survey vessel did not conduct offshore tagging from 2002 to 2004 since tagging was carried out by a second charter vessel during these years.

Annual survey catch rates

Catch rates are reported for each survey locality in units of mean numbers per trap (Table D.6) and mean weight (kg) per trap (Table D.7) for the five core depth strata (D1-D5) used in calculating the survey-based abundance index.

Boxplots arrayed by year were used to summarize the distribution of catch rates achieved for all sets coast-wide (Figure D.2). The upper panel of Figure D.2 shows the catch rates in units of mean numbers per trap while the lower panel utilizes mean weight (kg) per trap. The lower bound of the each box indicates the first quartile (25th percentile) of the data and the upper bound of the box is the third quartile (75th percentile). The horizontal line that divides the box is the median (50th percentile). The upper and lower whiskers of each boxplot are positioned at 1.5 times the inter-quartile

range. Open circles indicate data values that fall outside the whiskers, or outliers. A filled circle represents the mean value of the data summarized in the boxplot. The lightly shaded rectangle positioned in each box represents an approximate 95 percent confidence interval for the sample median.

The coast-wide trends of survey catch rates show a decline from high values in the early 1990s to a period of relative stability beginning in the mid-1990s (Figure D.2). The 2001 survey produced the lowest mean and median catch rates observed in the time series, with marked reduction of the variance. Catch rates improved from 2001 to 2002 to a level similar to those observed in the mid-1990s. The catch rates in 2003 and 2004 were similar and both years were substantially higher than those observed from the mid-1990s through 2000. Indeed, catch rates in 2003 and 2004 were at a level comparable to those observed during the early 1990s but show greater variability among sets.

Exploratory analysis of time trends in the observed catch rate data (weight per trap) was conducted separately for the north and south stock areas (Figure D.3). As for data aggregated over the entire coast, the survey catch rates in both stock areas show a decline from high values in the early 1990s to a period of relative stability beginning in the mid-1990s. 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 stock area in particular. Catch rates for the north stock area improved in 2002 relative to 2001, and were comparable to those observed in the mid-1990s but were more variable. The mean catch rate in 2003 increased substantially to a historical high for the north, but with substantial variability among sets. Catch rates observed in 2003 for the south also increased greatly to a level similar to that observed in 1992. Catch rates in 2004 were similar to those observed in 2003 for both areas, but with greater variability for the north stock area relative to the south.

Spatial effects

Different catch rate characteristics were observed among the nine indexing localities. Multi-panel displays of catch rates by year for each locality are shown in Figure D.4. Data presented here correspond to depth strata D1 through D5 (Table D.3) which were fished in all survey years. Note that the catch rate scales differ among the panels to allow details of the time trends within each locality to be emphasized. Open circles represent the catch rate (mean weight (kg) per trap) achieved on each set. Filled circles are the arithmetic mean of the catch rates for each year. Two loess (Cleveland 1985) trend lines are superposed on each panel to illustrate the impact of the most recent survey; the solid line is the trend over the entire time series while the dashed line excludes the most recent survey point. The loess trend lines are fit using the observed catch rates rather than the annual means.

In general, time trends among all survey localities show a similar decline in catch rates from highs in the early 1990s. Beginning in the mid-1990s the rate of decline generally decreased or there was no trend through to 2002, depending on the locality.

However, notable increases in trap CPUEs for 2002 were recorded for the north stock area at the Langara Island-North Frederick and Hippa Island survey localities while catch rates at the Buck Point and Gowgaia Bay localities were comparable to those observed in the mid 1990s. Catch rates increased substantially in 2003 and 2004, with similar mean catch rates being observed for most localities between the two years. The Barkley Canyon locality continues to depart in trend from other localities where only stratum D2 returned a significantly improved catch rate, albeit a large value.

Depth effects

In all cases the sets in 2004 achieved the target depth stratum. Catch rates in depth strata D6 and D7 continue to be low, reflecting either lower sablefish densities at these depths and/or decreased efficiency of trap gear at depth. Catch rates at the shallow depth stratum, D0, are generally very low, with the exception of the high catch rate observed at Barkley Canyon. In comparing 2003-2004 and 1993 catch rates, note that 1993 catch rates were high within more depth strata than was the case in 2003-2004. That is, higher catch rates were achieved at strata D4 and D5 in addition to strata D1 through D3.

Catch rates (kg per trap) by year, depth and locality are shown in Figure D.5 for depth strata D1 through D5 which have been targeted in all survey years. The trends apparent at the coast-wide level of aggregation are broadly reflected within each locality and depth. Significant improvements were observed in 2003-2004 catch rates relative to the mid-1990s until 2002. Most increases occurred within depth strata D1 through D3, with small or negligible increases for depth strata D4 and D5 (e.g., Hippa Island). Barkley Canyon showed a modest increase for depth stratum D1 in 2004 with an extremely high catch rate observed for stratum D2. Depth strata D3 through D4 continue to show little evidence of increased abundance. There are two general features of these data to note. First, the variation of observations around the trend line is relatively small. Second, there is interaction among years and depths, e.g., high catch rates were observed at deep depths early in the time series for Barkley Canyon, but low catch rates in the latter half of the time series. Thus, the effect of depth over survey localities depends on which years are considered, but without replication of sets at each combination of locality, depth, and survey year, the interaction effects cannot be estimated. The implication is that depth-dependent year effects exist.

D.4 Selection of a survey-based index of trap-vulnerable abundance

Annual mean catch rates in units of number of sablefish per trap and weight (kg) of sablefish per trap are shown in Table D.8. The annual rates were based on data from depth strata D1 through D5 only since these strata were consistently fished throughout the survey time series. Annual means were computed by

$$(2) \quad U_t = \frac{\sum_{i=1}^{n_t} U_{ti}}{n_t},$$

where $i = 1, \dots, n_t$ indexes all observed catch rates in year t for the coast or by stock area.

Recent stock assessments (Kronlund et al. 2003, Haist et al. 2004) have used a general linear model (GLM) in an attempt to standardize survey CPUE data over the time series and to separate effects due to locality and depth. The model used was specified by

$$(3) \quad U_{ijk} = \mu + \alpha_t + \beta_i + \gamma_j + \varepsilon_{ijk},$$

where μ is the overall mean effect, α_t is the effect of the t th level of the year factor, β_i is the effect of the i th level of the depth factor, γ_j is the j th effect of the locality factor, and ε_{ijk} is a random error component. Random errors were assumed to be normally distributed with mean 0 and variance σ^2 . The model was utilized because if the survey catch rates are assumed to be proportional to stock abundance, the year effects (α_t) from the GLM analysis can be utilized as a stock index (Hilborn and Walters 1992).

This main effects model does not include interaction terms of the form $(\beta\gamma)_{ij}$ since there were very few replicates by depth and locality (Kronlund et al. 2003, Haist et al. 2004). The design of the indexing survey lacks the replication within each combination of locality and depth stratum required to assess interactions among years, localities, and depth. Inspection of the plots of survey catch rates by these explanatory factors (Figure D.5) suggest interaction terms would be important if they could be supported by the data.

In practice, the GLM standardization procedure used in previous analyses achieved little in terms of adjustments for year, locality and depth effects as noted by reviewers of previous stock assessments. This result can be seen by inspection of Figure D.6 which shows three indices of trap-vulnerable abundance based on coast-wide survey data, namely:

1. annual catch rate expressed as the mean number of fish per trap from 1990 to 2004;
2. annual catch rate expressed as the mean weight (kg) per trap for 1990 to 2004;
3. the GLM year effects obtained by Haist et al. (2004) which were derived from application of model (2) for 1990 to 2003.

The first two indices are those reported in Table D.8. The data were rescaled to have the same mean over the period of overlap from 1990 to 2003. The time series were centered on the mean of the weight (kg) per trap catch rate series from 1990 to 2003 and the rescaling preserved the initial coefficient of variation (CV) of each series. Figure D.6 shows that the rescaled series closely overlap with the largest differences occurring in 1990 and 1993. However, the general similarity of the trends implies there is little basis

for choosing among the three indices. Thus, the linear model standardization is not applied for this assessment.

D.5 Summary

Coast-wide and area specific catch rates in 2004 were similar to those observed in 2003. Catch rates in 2003 and 2004 are substantially higher than those observed from the mid-1990s until 2002 and are similar to highs observed during the early 1990s for the north stock area. The trends over time at all survey localities show similar characteristics. Catch rates show typical correlation between mean and variance; higher catch rates are associated with higher observed variance. Survey results over time can be summarized as follows:

- a decline in catch rates from highs in the early 1990s coast-wide and within both the north and south stock areas;
- beginning in the mid-1990s, the rate of decline generally decreased or there was a period of relative stability through to 2000, depending on the survey locality;
- 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 stock area in particular;
- catch rates for the north stock 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, with high variability among sets;
- catch rates in the south stock area exhibit a continuous decline from the mid-1990s to 2002, but show significant increases in 2003 to levels similar to those observed in 1992;
- catch rates in 2004 were similar in level to those observed in 2003 but with reduced variability, nonetheless they remain more variability than similarly high catch rates observed during the early 1990s.

Placement of survey sets within depth strata at the discretion of the fishing master has likely produced higher catch rate values than would be achieved with randomly positioned sets. This issue is not important to the purpose of developing a relative abundance index if bias has been similar over time. The strengths of the survey are the consistency in the conduct of standardized fishing over time and the broad geographic and depth coverage. The credibility of survey catch rates as an abundance index is reinforced by similarities in the time trends in catch rates from 1990 to 2004 among most localities and within most depth strata.

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Table D.1 Indexing vessel timing, and skipper, for 1988 to 2004. Start Date is the date of the first indexing set and End Date is the date of the last indexing haul.

Year	Vessel	Skipper	Start Date	End Date	Trip ID
1988	F/V Vicious Fisher	Fletcher	October 31	November 23	43990
1989	F/V La Porsche	Brynjolfsen	October 21	November 17	43910
1990	F/V Viking Star	D. Farrington	November 08	November 18	43750
1991	R/V W.E. Ricker	A. Farrington	October 10	October 28	43673
1992	R/V W.E. Ricker	Roberts	October 15	November 03	43670
1993	R/V W.E. Ricker	A. Farrington	October 23	November 10	43650
1994	F/V La Porsche	Beauvais	October 15	October 25	43630
	F/V Western Viking	Jones	October 19	November 07	43390
1995	F/V Victor F	Derry	October 15	October 28	43330
	F/V Viking Sunrise	Olsen	October 10	October 25	43350
	F/V Ocean Pearl	Fraumeni/Gold	October 08	October 18	43270
1996	F/V Viking Star	Elvan	October 08	October 20	43210
	F/V Ocean Pearl	Derry	September 27	October 06	43039
1997	F/V Ocean Pearl	Derry	September 27	October 14	42699
1998	F/V Ocean Pearl	Derry	September 24	October 10	41122
1999	F/V Ocean Pearl	Derry	September 29	October 17	40589
2000	F/V Pacific Viking	Melynchuck	October 08	November 11	40517
2001	F/V Ocean Pearl	Derry	October 07	October 29	43233
2002	F/V Pacific Viking	Melynchuck	October 03	November 06	48120
2003	F/V Viking Star	J. Farrington	October 09	November 08	52120
2004	F/V Ocean Marauder	Melynchuck	October 06	October 23	NA

Table D.2 Geographic boundaries of the standard survey localities.

Locality	Latitude North				Longitude West			
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Langara Is.-North Frederick	54°	9'	53°	59'	134°	2'	133°	32'
Hippa Island	53°	32'	53°	20'	133°	24'	132°	55'
Buck Point	53°	14'	53°	1'	133°	10'	132°	35'
Gowgaia Bay	52°	27'	52°	17'	131°	51'	131°	33'
Cape St. James	51°	50'	51°	37'	130°	59'	130°	19'
Triangle Island	51°	8'	50°	58'	129°	55'	129°	31'
Quatsino Sound	50°	25'	50°	12'	128°	38'	128°	8'
Esperanza Inlet	49°	47'	49°	24'	127°	39'	127°	13'
Barkley Canyon	48°	24'	48°	10'	126°	12'	125°	53'

Table D.3 Depth strata boundaries by survey year.

Year	Stratum	Start depth fm (m)	End depth fm (m)
1988-1989	1	200 (366)	300 (549)
	2	300 (549)	400 (732)
	3	400 (732)	500 (915)
1990-2001	1	150 (275)	250 (457)
	2	250 (458)	350 (641)
	3	350 (642)	450 (824)
	4	450 (825)	550 (1006)
	5	550 (1007)	Deeper
2002	D1	150 (274)	249 (457)
	D2	250 (457)	349 (641)
	D3	350 (641)	449 (824)
	D4	450 (824)	549 (1006)
	D5	550 (1006)	649 (1189)
	D6	650 (1189)	749 (1372)
	D7	750 (1372)	999 (1827)
2003-2004	D0	50 (91)	149 (274)
	D1	150 (274)	249 (457)
	D2	250 (457)	349 (641)
	D3	350 (641)	449 (824)
	D4	450 (824)	549 (1006)
	D5	550 (1006)	649 (1189)
	D6	650 (1189)	749 (1372)
	D7	750 (1372)	999 (1827)

Table D.4 List of index sets excluded from survey data analysis.

Year	Location	Set Depth		Reason for exclusion
			Stratum	
1990	Barkley Canyon	23	5	only 3 traps hauled, remainder of the string lost
1994	Cape St. James	3	5	bridge log indicates extra 25 set for vessel, but not in data report, baiting unclear
1994	Gowgaia Bay	6	5	extra 50 traps for vessel, catch not recorded, baiting unclear
1994	Gowgaia Bay	11	2	extra 35 traps for vessel baited with hake and squid bait
1994	Hippa Island	18	5	extra traps for vessel, catch not recorded, baiting unclear
1994	Langara Island-North Frederick	24	5	extra 33 traps for vessel baited with hake and squid bait
1995	Cape St. James	11	3	trap set every second becket
1998	Esperanza Inlet	13	1	unsure count of traps
1998	Buck Point	57	3	tangled with another string
2001	Gowgaia Bay	66	4	set across another vessel's string
2004	Hippa Island	52	5	unsure count of traps

Table D.5 Summary of 2004 standardized survey data by locality.

Locality	Intended Depth Stratum	Set Number	Traps Hauled	Sablefish			Nominal CPUE			
				LSMO Sampled	LSM Sampled	Recovered	Total	Weight (kg)	Fish/ Trap	kg/ Trap
Barkley Canyon	D0	1	25	47	298	0	470	1405	18.80	56.20
	D1	2	24		74	0	213	639	8.88	26.63
	D2	3	24		137	1	800	2349	33.33	97.88
	D3	4	25		115	4	165	336	6.60	13.44
	D4	5	25	47	64	2	113	227	4.52	9.08
	D5	6	25	34	15	1	68	162	2.72	6.48
	D6	7	25	43	58	3	103	286	4.12	11.44
	D7	8	25	32	0	0	32	132	1.28	5.28
Esperanza Inlet	D0	15	23	0	0	0	6	15	0.26	0.65
	D1	14	24	37	86	0	353	1195	14.71	49.79
	D2	13	25	40	93	2	335	962	13.40	38.48
	D3	12	24	46	57	0	112	240	4.67	10.00
	D4	11	25	46	119	0	160	367	6.40	14.68
	D5	10	25	49	77	0	125	378	5.00	15.12
	D6	9	25	29	0	0	29	89	1.16	3.56
Quatsino Sound	D0	16	24	7	0	0	7	15	0.29	0.63
	D1	17	25	33	80	0	143	444	5.72	17.76
	D2	18	25	53	121	0	381	1095	15.24	43.80
	D3	19	25	50	97	1	306	829	12.24	33.16
	D4	20	25	58	0	0	58	130	2.32	5.20
	D5	21	25	56	35	2	93	197	3.72	7.88
	D6	22	24	11	0	0	11	38	0.46	1.58
Triangle Island	D0	29	25	63	0	0	66	232	2.64	9.28
	D1	28	24	68	94	4	413	1203	17.21	50.13
	D2	27	25	45	77	1	446	1247	17.84	49.88

Locality	Intended Depth Stratum	Set Number	Traps Hauled	Sablefish		Recovered	Total	Weight (kg)	Nominal CPUE	
				LSMO Sampled	LSM Sampled				Fish/ Trap	kg/ Trap
	D3	26	25	57	126	1	512	977	20.48	39.08
	D4	25	25	45	61	1	109	233	4.36	9.32
	D5	24	25	41	0	0	41	136	1.64	5.44
	D6	23	25	20	0	0	20	75	0.80	3.00
Cape St. James	D0	30	24	46	0	0	46	135	1.92	5.63
	D1	31	24	53	96	0	247	735	10.29	30.63
	D2	32	24	42	114	17	383	1028	15.96	42.83
	D3	33	25	37	92	1	181	523	7.24	20.92
	D4	34	25	41	43	0	85	244	3.40	9.76
	D5	35	23	16	0	0	16	49	0.70	2.13
	D6	36	24	32	0	0	32	118	1.33	4.92
Gowgaia Bay	D0	43	25	13	0	0	13	48	0.52	1.92
	D1	42	22	65	86	0	317	992	14.41	45.09
	D2	41	25	76	123	2	461	1339	18.44	53.56
	D3	40	25	42	85	1	210	620	8.40	24.80
	D4	39	25	67	0	0	67	197	2.68	7.88
	D5	38	25	26	0	0	26	98	1.04	3.92
	D6	37	25	5	0	0	5	22	0.20	0.88
Buck Point	D0	44	25	18	0	0	18	70	0.72	2.80
	D1	45	25	60	98	0	545	1850	21.80	74.00
	D2	46	24	51	91	0	305	942	12.71	39.25
	D3	47	25	53	91	1	252	667	10.08	26.68
	D4	48	25	51	38	0	86	247	3.44	9.88
	D5	49	25	32	0	1	33	94	1.32	3.76
	D6	50	25	18	0	0	18	61	0.72	2.44
Hippa Island	D0	57	25	12	0	0	12	54	0.48	2.16
	D1	55	25	54	109	0	230	821	9.20	32.84

Locality	Intended Depth Stratum	Set Number	Traps Hauled	Sablefish			Nominal CPUE			
				LSMO Sampled	LSM Sampled	Recovered	Total	Weight (kg)	Fish/ Trap	kg/ Trap
	D2	54	25	47	110	2	365	1080	14.60	43.20
	D3	56	25	47	70	0	139	456	5.56	18.24
	D4	53	25	48	92	0	141	446	5.64	17.84
	D5	52	25	49	41	1	90	204	3.60	8.16
	D6	51	25	23	0	0	23	83	0.92	3.32
Langara Island- North Frederick	D0	63	24	4	0	0	4	21	0.17	0.88
	D1	64	25	45	79	0	255	965	10.20	38.60
	D2	62	25	49	103	1	409	1260	16.36	50.40
	D3	61	25	52	84	0	260	707	10.40	28.28
	D4	60	25	25	0	0	25	85	1.00	3.40
	D5	59	25	25	0	0	25	75	1.00	3.00
	D6	58	25	19	0	0	19	79	0.76	3.16
Total		64	1,580	2,400	3,529	50	11,033	32,048	6.98	20.28

Table D.6 Sample catch rate (mean number fish per trap) of survey index sets by core depth stratum, locality, stock, and year. Sets are assigned to depth strata based on the mean of depth observations taken at one minute intervals. Fouled or holed traps are excluded. All means are calculated using the catch rates observed for each set at the level of aggregation.

Location	Stratum	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Barkley Canyon	1			13.76	23.04		7.92	3.12	7.52	1.46	2.15	2.78	0.16	1.83	3.64	8.88
	2	15.74	6.73	24.65	26.32	22.42	8.92	3.72	6.92	2.16	1.56		0.64	2.52	10.83	33.33
	3	7.38	9.50	18.92	16.78	7.84	6.40	6.08	6.88	2.36	1.87	13.28	2.64	5.84	2.92	6.60
	4	14.85	23.60	21.04	19.44	18.54	10.40	8.24	5.44	7.21	6.53	12.48	8.13	5.88	2.20	4.52
	5	11.72	15.82	19.16	12.56		7.92	9.68	6.64	8.76		11.04	5.28	4.00	4.18	2.72
	Mean	12.52	13.91	19.51	19.25	16.83	8.31	6.17	6.68	4.39	3.73	8.47	3.37	4.02	4.74	11.21
Esperanza Inlet	1			7.48	13.63	9.40	4.84	5.32	10.12	4.04	4.13	6.48	1.68	1.04	19.16	14.71
	2	8.16		12.40	16.76	8.64	8.17	2.40	4.28		2.67	5.00	0.29	1.11	9.76	13.40
	3	5.14		8.24	12.16	6.36	4.72	1.72		1.63	2.32	2.42	0.81	3.47	5.00	4.67
	4	10.33		10.60	20.48	3.52	13.45	2.72	1.58	1.52	2.04	7.33	0.96	5.44	1.80	6.40
	5	9.60		16.36	21.88	8.44	5.25	6.64	5.70	7.42	5.61	3.00	4.81	7.02	5.08	5.00
	Mean	8.4		11.02	16.98	7.27	7.29	3.76	5.19	3.65	3.35	4.85	1.71	3.33	8.16	8.84
Quatsino Sound	1	3.68		5.38	6.88	3.96	3.30	2.52	2.33	2.75	3.50	3.08	1.57	0.84	37.80	5.72
	2	5.70	2.66	8.36	11.63	6.96	3.76	2.56	1.04	4.20	3.28	4.08	0.88	3.00	13.12	15.24
	3	3.30	2.76	7.08	10.24	3.20	2.16	1.88	0.21	5.68	3.32	3.84	5.76	1.96	15.48	12.24
	4	5.40	9.50	14.64	4.08	1.72	3.32	1.76	0.24	2.36	3.60	8.05	5.88	0.58	3.88	2.32
	5	6.90	5.94	9.32	5.32		4.30	2.52	0.52	2.12	4.88	2.24	1.64	1.60	1.13	3.72
	Mean	5.07	5.21	8.96	7.63	3.81	3.37	2.25	0.87	3.42	3.72	4.26	3.15	1.6	14.32	7.85
Triangle Island	1			5.44		3.52	4.48	5.08	2.30	1.64	2.68	4.36	0.96	0.28	11.68	17.21
	2		4.67	11.12	11.56	9.44	7.52	4.72		3.84	3.16		0.78	1.68	14.04	17.84
	3		1.33	10.36	9.20	4.42	7.76	2.84	3.56	2.36	2.67	5.12	0.48	2.88	26.40	20.48
	4		1.71	4.64	7.25	0.36	4.00	1.60	0.44	4.88	1.36	1.12	0.56	0.52	6.06	4.36
	5		1.13	4.32	6.76	0.36	4.28	2.40	1.37	6.28	1.14	1.21	0.44	0.90		1.64
	Mean		2.21	7.18	8.69	3.62	5.61	3.33	1.99	3.8	2.2	3.23	0.65	1.19	12.85	12.31
Southern Stock	Mean	8.5	8.09	11.66	14.39	7.41	6.14	3.88	3.68	3.82	3.25	5.2	2.22	2.75	10.02	8.67
Coast	Mean	8.5	7.46	8.88	11.61	5.49	4.26	3.39	2.7	3.64	2.58	3.47	1.27	2.96	10.05	9.3

Table D.6 Continued.

Location	Stratum	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
Cape St. James	1					1.62	3.17	2.44	1.56	2.13	4.22	2.04	1.08	0.24	20.28	10.39	
	2					3.32	2.08	3.52		3.80	5.74	4.95	2.72	2.56	14.68	15.96	
	3					4.20		4.43	3.24	1.96	3.36	3.08	0.64	6.00	8.96	7.54	
	4					3.91	0.88	1.80	1.52		1.71	1.74	0.17	0.84	1.28	3.67	
	5						1.38	1.64	0.56	1.15	0.38	0.35	0.11	0.32	0.75	0.62	
	Mean					3.26	1.88	2.77	1.69	2.04	3.08	2.43	0.95	1.99	9.19	7.63	
Gowgaia Bay	1					1.81	3.48	3.67	3.48	3.00	0.68	0.58	0.36	2.93	22.56	14.41	
	2		11.75	11.63	14.83		7.24	2.56	4.00	4.84	2.09	6.13	0.42	3.28	19.30	18.44	
	3		4.33	8.71	13.81	9.25	6.40	2.76	1.36	4.72	1.03	2.61	0.69	2.03	7.16	8.61	
	4		2.63	3.56	7.12	3.76	5.40	2.00	0.64	3.29		2.08		1.39	1.92	2.68	
	5		3.96	4.76	6.84		1.68	1.68	0.60	3.92	0.28	1.32	0.35	1.01	0.61	1.04	
	Mean		5.67	7.16	11.28	4.94	4.84	2.53	2.02	3.95	1.02	2.54	0.45	2.06	8.69	9.04	
Buck Point	1			3.12	9.32	2.00	2.40	2.62	0.64	3.85	2.09	2.96	0.44	3.67	19.38	21.96	
	2		7.21	11.71	12.50	6.80	2.72	4.80	3.92	4.80	2.32	4.60	0.67	5.16	21.96	13.04	
	3		2.13	10.32	5.00	4.09	3.92	1.60	0.96		2.04	1.20	0.24	2.84	15.78	10.08	
	4		3.79	7.35	4.16	4.36	1.50		0.48	1.72	0.80	1.72	0.16	0.68	1.16	3.57	
	5		2.29	4.92	3.36	3.12	1.40	3.54	0.60	4.52	0.31	1.24	0.40	0.72	0.54	1.32	
	Mean		3.85	7.48	6.87	4.07	2.39	3.47	1.32	3.72	1.51	2.34	0.38	2.61	11.76	9.99	
Hippra Island	1				1.14	2.96	1.80	2.27		1.96	0.88	1.56	0.56	4.46	1.44	9.54	
	2			4.79	10.84	2.40	2.16	4.21		4.92	1.48	2.44	0.72	5.69	17.63	14.6	
	3			3.76	8.76	2.88	4.40	6.38		6.60	0.84	1.96	0.08	5.52	22.85	5.56	
	4			7.36	6.62	5.52	2.00	4.00		3.92		1.40	0.43	2.00	3.68	5.64	
	5			4.44				2.24	5.13		0.58	2.64	0.52	0.28	2.26	2.16	
	Mean			5.09	6.8	3.44	2.52	4.4		3.6	1.34	1.58	0.41	3.9	10.9	8.84	
Langara Island-North Frederick	1			1.72		1.74	0.28	1.88	2.48	3.40	0.24	2.67	0.08	3.80	8.48	10.20	
	2		10.29	4.16	10.43	3.96	2.71	2.52		6.29	6.44	1.50	0.36	16.16	19.65	16.36	
	3		8.33	1.24	9.28	2.32	2.34	0.98	1.24	2.96	4.20	1.33	0.11	5.12	17.24	10.87	
	4		9.13	4.20	6.04	3.16			1.12	4.76	3.08		0.16	1.56	3.84	0.91	
	5		11.16	6.60	5.92			0.68	2.72	2.08	3.52	2.48	0.44	0.40	0.84	0.56	1.05
	Mean		9.73	3.58	7.92	2.79	1.67	1.82	1.88	4.19	3.29	1.49	0.22	5.5	9.95	7.88	
Northern Stock Coast	Mean		6.42	5.8	8.23	3.66	2.69	3.0	1.73	3.49	2.05	2.08	0.48	3.10	10.1	8.67	
	Mean	8.5	7.46	8.88	11.61	5.49	4.26	3.39	2.7	3.64	2.58	3.47	1.27	2.96	10.05	9.3	

Table D.7 Sample mean catch rate (mean kg per trap) of survey index sets by core depth stratum, locality, stock and year. Sets are assigned to depth strata based on the mean of depth observations taken at one minute intervals. Fouled or holed traps are excluded. All means are calculated using the catch rate observations from each set at the level of aggregation.

Location	Stratum	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Barkley Canyon	1			33.44	54.84		28.44	12.08	23.90	5.21	7.55	8.30	0.38	5.03	9.69	26.64
	2	39.86	12.65	74.00	65.82	58.54	26.33	13.04	20.76	5.84	4.91		1.53	5.50	27.03	97.87
	3	18.98	16.34	39.67	49.46	24.76	21.64	16.20	14.65	6.68	4.26	25.68	5.70	11.90	5.55	13.45
	4	30.24	41.54	41.80	46.64	37.70	26.76	21.28	13.13	14.63	15.14	25.60	17.97	11.12	4.86	9.08
	5	25.40	33.40	39.96	32.58		18.32	23.28	15.71	17.12		27.48	13.71	8.79	8.54	6.49
	Mean	29.08	25.98	45.77	49.32	39.68	24.3	17.18	17.63	9.89	9.4	19.07	7.86	8.47	11.14	30.70
Esperanza Inlet	1			25.48	51.63	24.84	15.08	19.04	28.92	13.00	14.02	20.92	5.84	3.46	53.83	49.79
	2	21.80		36.56	39.12	15.52	26.71	7.80	6.29		7.21	15.42	0.89	3.23	25.96	38.50
	3	13.12		24.16	40.60	15.68	13.60	4.52		4.67	5.90	5.21	1.60	6.61	13.38	10.00
	4	21.13		27.24	54.88	9.56	28.65	7.36	2.90	3.33	4.79	15.46	2.19	9.98	4.42	14.68
	5	18.28		38.12	59.40	21.60	14.55	14.00	10.84	16.23	14.29	7.80	11.50	16.04	12.81	15.12
	Mean	18.94		30.31	49.13	17.44	19.72	10.54	11.05	9.31	9.24	12.96	4.4	7.42	22.08	25.62
Quatsino Sound	1	12.56		20.29	26.96	17.72	11.04	8.04	6.72	10.75	14.41	8.50	4.59	2.72	102.54	17.75
	2	12.00	5.92	27.52	34.93	19.20	12.04	8.60	2.72	13.36	9.62	10.00	2.20	7.69	35.14	43.81
	3	9.72	7.02	20.48	33.36	9.14	5.64	5.00	0.49	14.80	9.05	9.32	11.96	4.00	39.69	33.16
	4	15.94	18.79	35.32	16.08	3.96	8.68	5.88	0.41	8.00	12.58	15.41	10.57	1.26	10.64	5.21
	5	14.72	14.92	22.96	19.96		15.70	8.72	0.86	6.28	14.43	5.96	3.29	3.99	4.16	7.89
	Mean	13.16	11.66	25.31	26.26	11.83	10.62	7.25	2.24	10.64	12.02	9.84	6.52	3.93	38.43	21.57
Triangle Island	1			23.96		9.36	14.48	17.28	8.31	5.48	8.76	13.30	3.34	0.81	27.99	50.13
	2		13.79	33.16	36.04	22.60	24.61	14.92		11.32	8.26		2.06	4.46	36.13	49.89
	3		3.63	26.56	25.20	12.25	26.72	9.24	10.73	7.76	7.88	11.52	1.11	6.58	49.39	39.07
	4		6.96	18.04	33.29	0.76	15.96	7.52	1.25	16.56	4.08	4.12	1.78	1.76	12.82	9.31
	5		5.42	15.20	29.40	1.40	17.28	9.36	5.66	26.00	5.26	4.79	1.53	3.17		5.44
	Mean		7.45	23.38	30.98	9.27	19.81	11.66	6.85	13.42	6.85	9.41	1.97	3.32	27.83	30.77
Southern Stock	Mean	20.02	16.55	31.2	41.07	18.5	18.61	11.66	9.44	10.9	9.38	12.82	5.19	6.23	24.87	27.16
Coast	Mean	20.02	19.34	25.57	36.51	15.57	13.66	11.26	7.72	12.04	7.72	9.3	3.09	8.21	27.59	26.85

Table D.7 Continued.

Location	Stratum	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Cape St. James	1					6.88	11.42	8.11	5.40	7.22	13.67	6.54	3.14	0.74	57.90	31.01
	2					9.56	7.42	13.20		13.20	17.34	14.27	6.51	6.65	40.63	42.83
	3					13.20		14.57	8.86	5.58	9.32	8.79	1.49	14.32	24.75	21.78
	4					16.23	3.08	6.56	4.74		5.22	6.30	0.49	2.16	3.52	10.63
	5						6.54	8.32	2.37	4.73	1.53	1.22	0.42	1.52	2.68	2.23
	Mean					11.47	7.11	10.15	5.36	7.09	9.42	7.43	2.41	5.08	25.90	21.70
Gowgaia Bay	1					7.67	14.08	15.00	12.13	10.76	2.43	2.08	0.94	10.50	71.80	45.08
	2		47.04	41.96	61.25		24.88	8.72	12.22	18.20	5.30	17.63	1.35	9.83	53.77	53.55
	3		15.54	20.25	52.17	35.71	21.20	10.04	3.94	17.08	3.46	8.04	2.20	5.69	19.05	25.37
	4		11.58	11.52	29.56	17.44	19.96	7.52	2.30	13.25		6.36		3.62	7.06	7.88
	5		17.25	18.24	31.64		6.96	6.60	2.78	16.75	1.20	4.52	0.97	3.41	2.39	3.91
	Mean		22.85	22.99	45.36	20.27	17.42	9.58	6.67	15.21	3.17	7.73	1.36	6.41	26.08	27.16
Buck Point	1			12.65	44.12	7.20	9.16	9.19	2.08	14.35	6.63	10.04	1.31	12.23	60.63	74.51
	2		26.75	40.42	33.00	20.28	9.20	13.84	11.05	16.12	5.86	13.24	1.74	13.51	63.96	40.34
	3		5.58	27.36	14.40	11.65	11.68	4.44	2.49		4.12	2.96	0.56	7.75	42.98	26.68
	4		11.33	24.30	15.56	15.80	4.29		1.55	6.20	2.50	5.00	0.49	1.74	3.46	10.42
	5		7.67	16.00	12.84	11.80	4.68	11.04	1.91	14.04	1.20	3.96	1.17	2.30	1.75	3.76
	Mean		12.83	24.15	23.98	13.35	7.8	10.47	3.82	12.68	4.06	7.04	1.06	7.51	34.56	31.14
Hippra Island	1				3.95	9.52	6.80	7.82		7.33	2.64	4.72	2.06	14.78	5.11	33.93
	2			18.46	30.68	9.68	6.76	18.25		17.50	4.12	9.68	1.65	18.31	54.75	43.20
	3			11.64	30.68	9.52	13.52	26.13		22.52	1.73	5.56	0.16	16.15	58.42	18.25
	4			24.64	24.54	13.40	6.77	15.72		15.80		5.08	1.49	5.81	10.16	17.84
	5			14.48			7.56	18.75		2.63	11.13	2.00	0.83	5.72	4.05	
	Mean			17.3	22.88	10.53	8.28	17.33		13.16	4.27	5.41	1.24	11.75	31.21	28.30
Langara Island-North Frederick	1			6.68		7.91	0.84	7.67	12.99	17.16	0.78	9.75	0.44	15.29	26.71	38.59
	2		37.79	14.84	45.61	14.48	12.33	11.84		26.21	23.65	4.42	1.09	53.57	60.70	50.38
	3		30.00	4.64	32.16	7.96	8.64	3.74	4.48	11.88	13.29	3.58	0.17	16.14	50.50	29.69
	4		34.35	14.72	22.72	9.96			3.47	15.56	8.74		0.51	5.24	13.67	3.16
	5		42.92	24.92	27.12		2.60	8.80	6.83	11.80	8.82	1.76	1.12	3.25	1.82	3.33
	Mean		36.26	13.16	31.9	10.08	6.61	7.16	8.15	16.52	11.06	4.79	0.67	18.7	30.68	25.03
Northern Stock Coast	Mean		23.98	19.32	30.98	12.79	9.54	10.94	6	12.94	6.39	6.48	1.35	9.51	29.61	26.60
Coast	Mean	20.02	19.34	25.57	36.51	15.57	13.66	11.26	7.72	12.04	7.72	9.3	3.09	8.21	27.59	26.85

Table D.8 Annual sablefish catch rates from strata D1 through D5 from 1990 to 2004 for the coast.

Year	Numbers per trap	Weight (kg) per trap	Number of Sets
1990	8.497	20.017	23
1991	7.464	19.336	32
1992	8.884	25.569	38
1993	11.607	36.509	42
1994	5.487	15.571	39
1995	4.260	13.665	44
1996	3.388	11.258	45
1997	2.705	7.721	40
1998	3.638	12.037	43
1999	2.581	7.720	45
2000	3.466	9.296	45
2001	1.272	3.092	44
2002	2.960	8.206	78
2003	10.052	27.590	47
2004	9.296	26.855	44

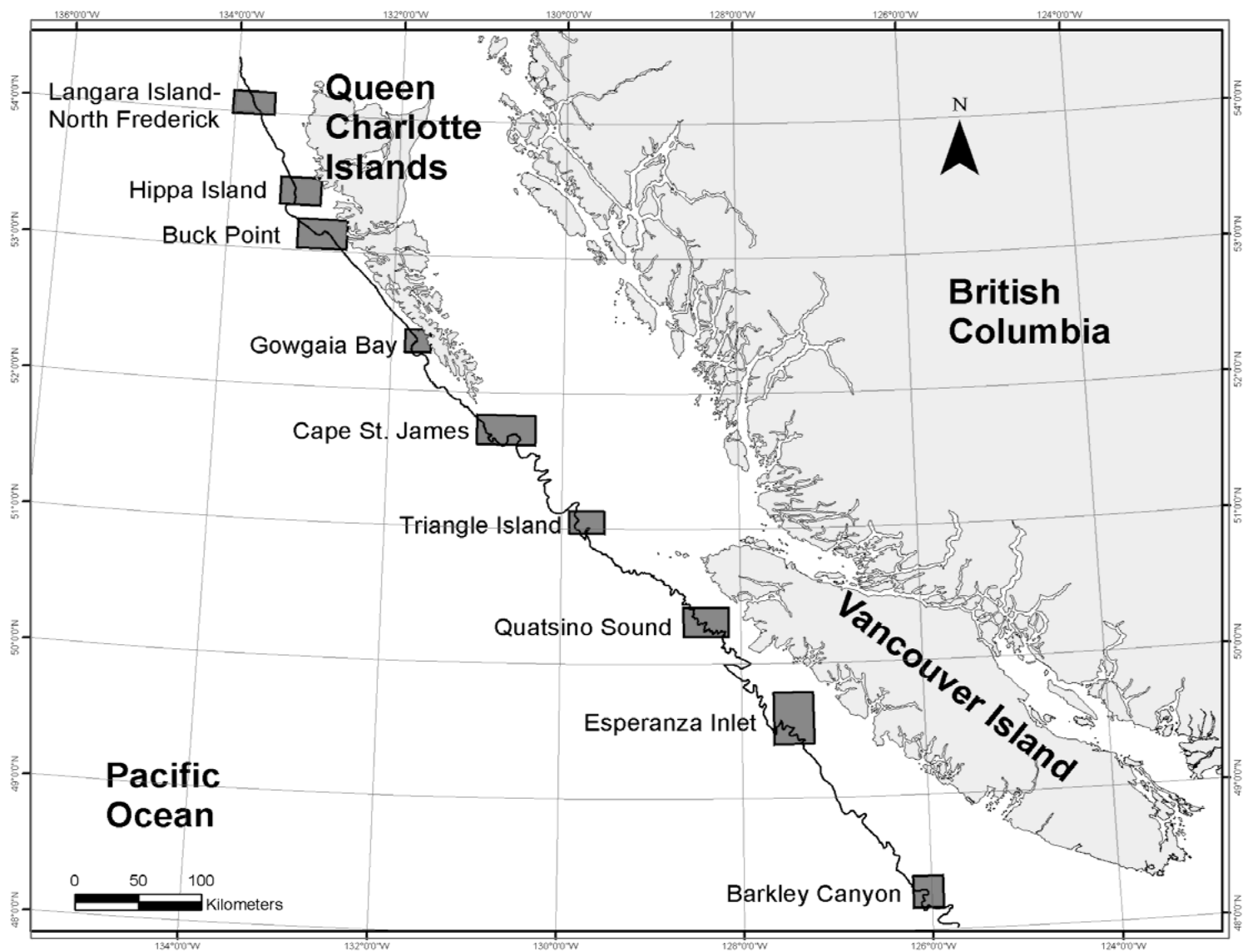


Figure D.1 Standardized survey localities used for indexing trap-vulnerable abundance. The shaded rectangles indicate the locality boundaries. The 1000 m contour is shown.

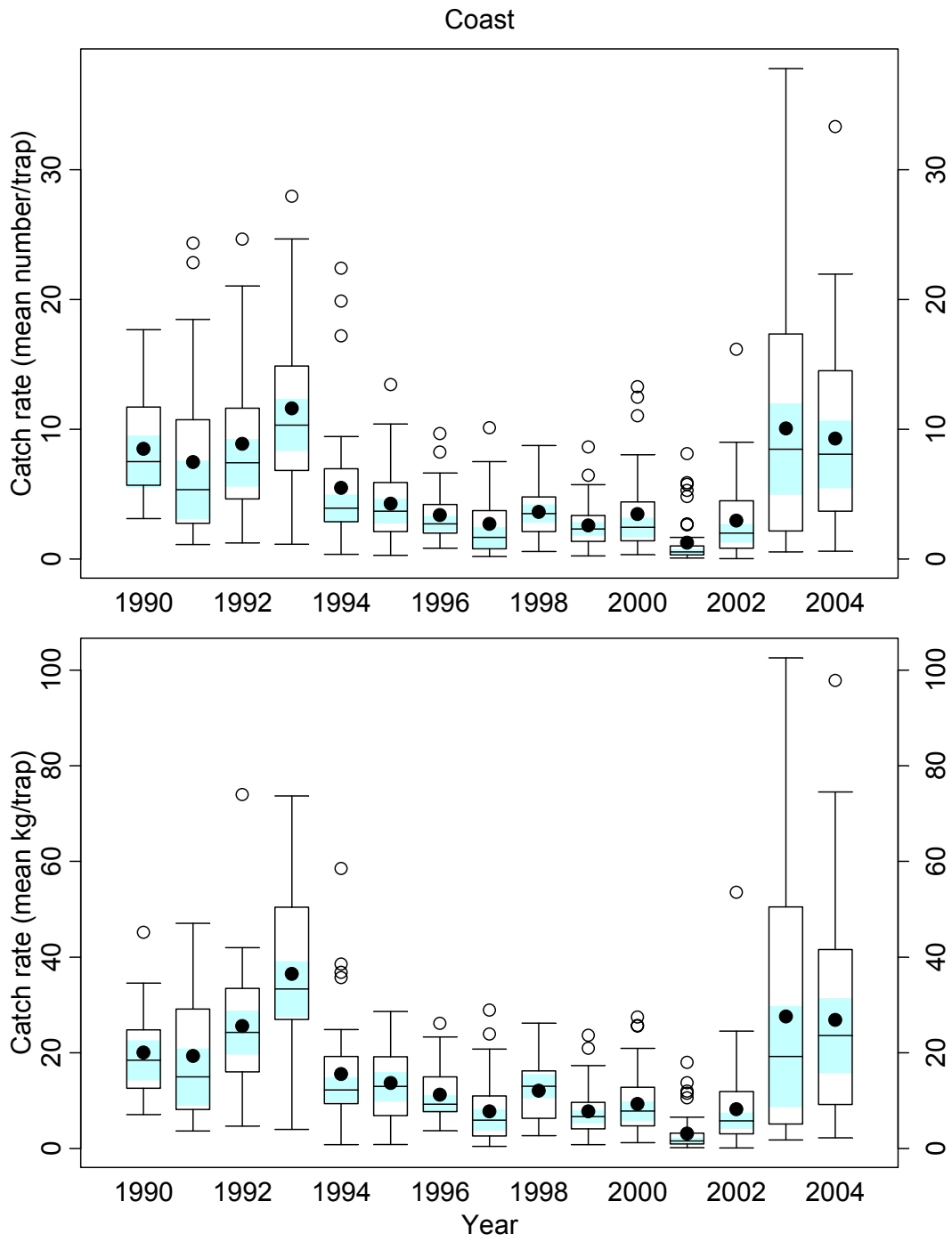


Figure D.2 Distribution of annual catch rates for standardized survey sets conducted coast-wide. Data for depth strata D1 through D5 are shown. The filled circles show the annual mean catch rate. The shaded rectangle for each year indicates an approximate 95 percent confidence interval on the median annual catch rate.

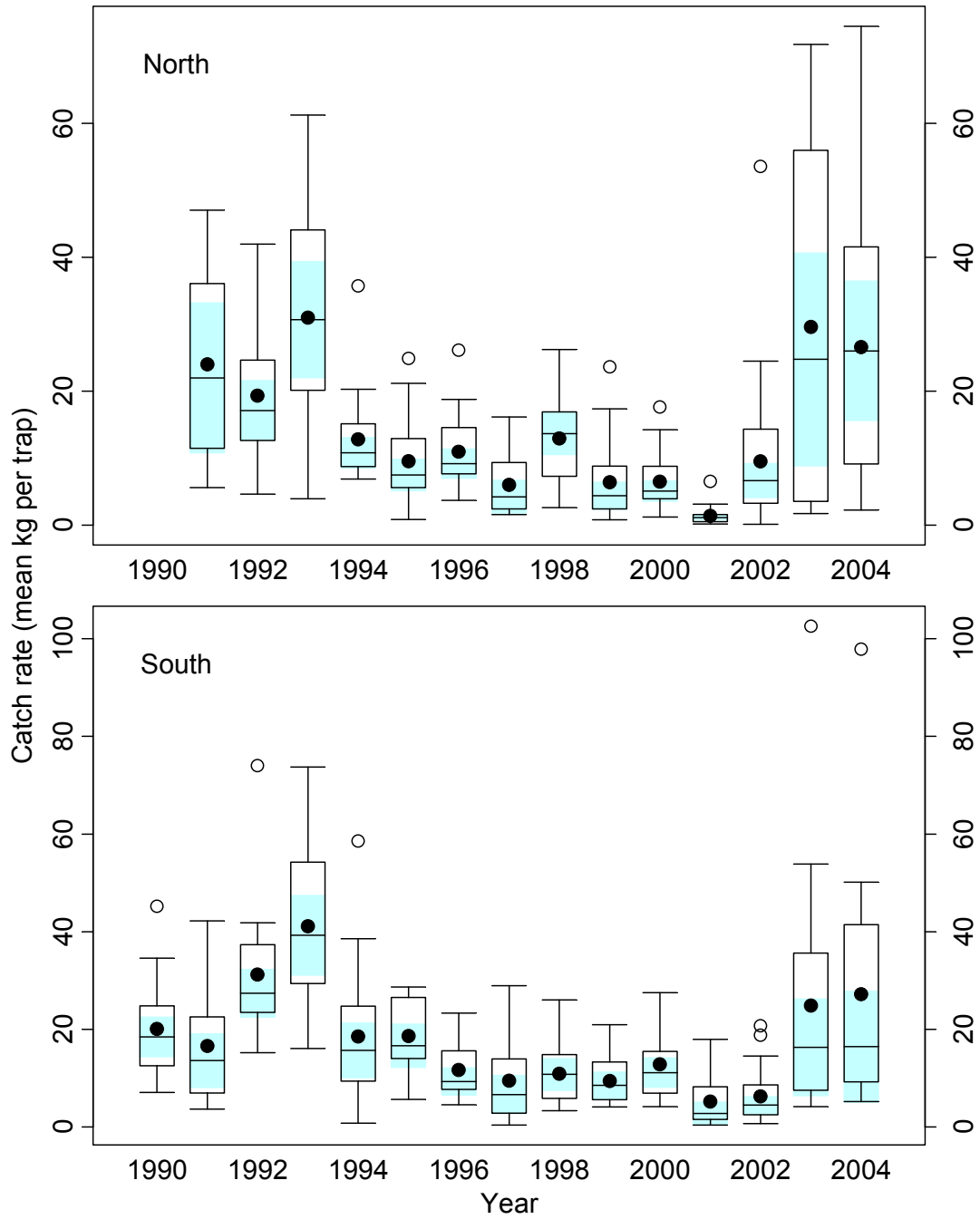


Figure D.3 Distribution of annual catch rates (kg/trap) for standardized survey sets summarized by stock area. Data for depth strata D1 through D5 are shown. The filled circles show the annual mean catch rate. The shaded rectangle for each year indicates an approximate 95 percent confidence interval on the median annual catch rate.

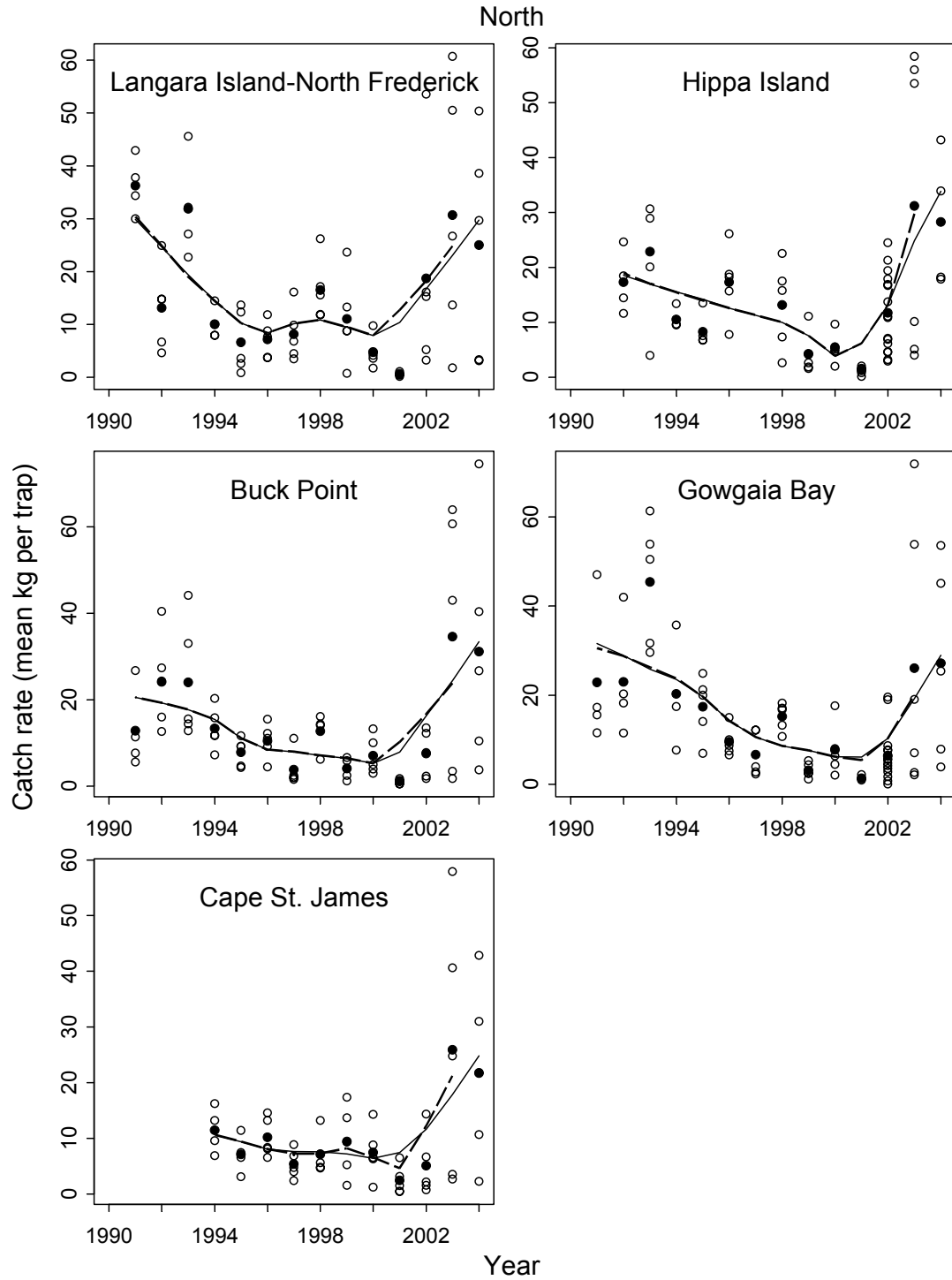


Figure D.4 Catch rates (numbers per trap) for standardized sets by year and locality. Open circles represent the catch rate for each set in depth strata D1 to D5. Filled circles indicate the annual mean of the catch rate observations. The solid curve shows a loess trend line fit to the entire time series, while the dashed line excludes data for 2004.

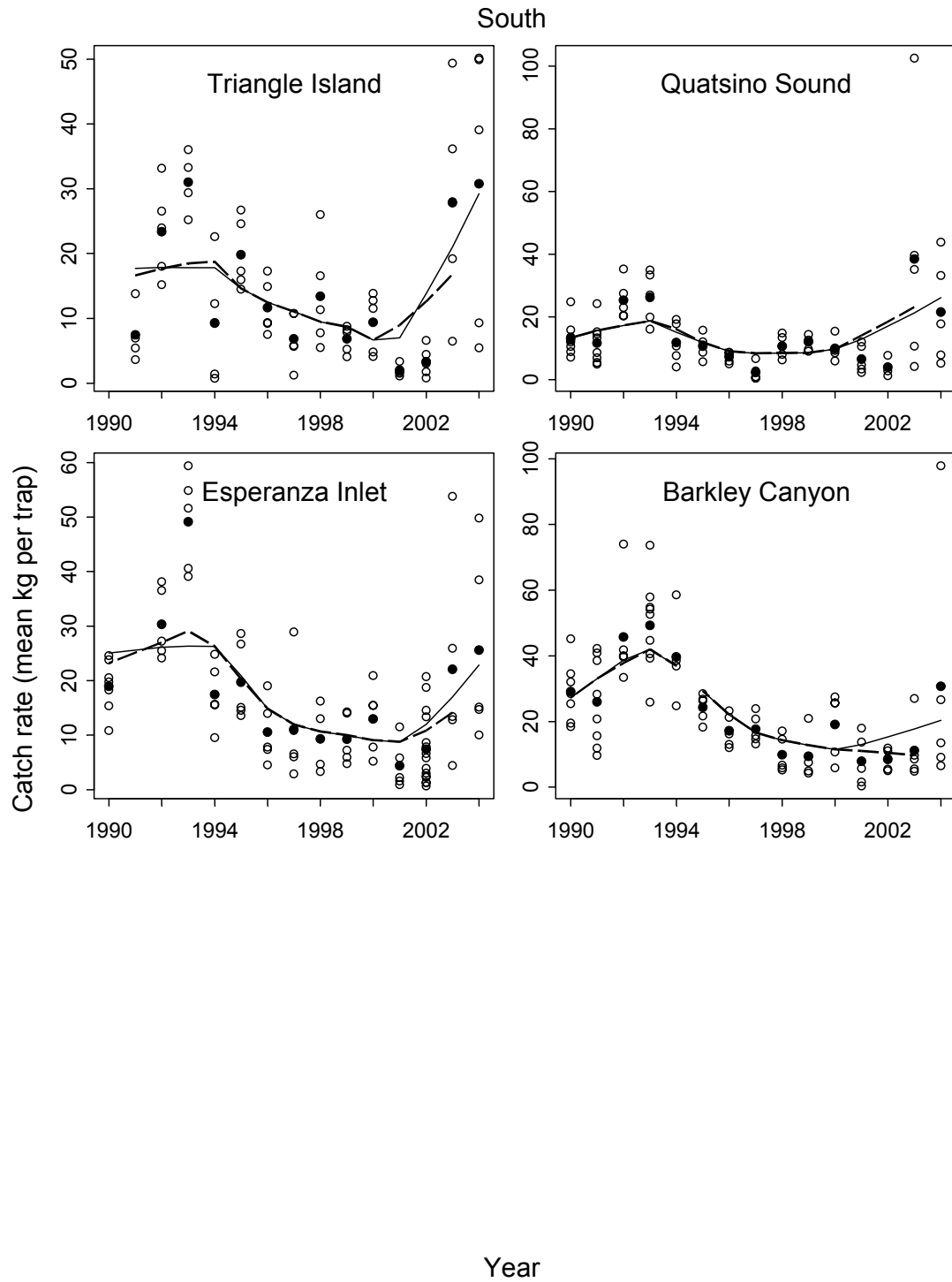


Figure D.4 Continued.

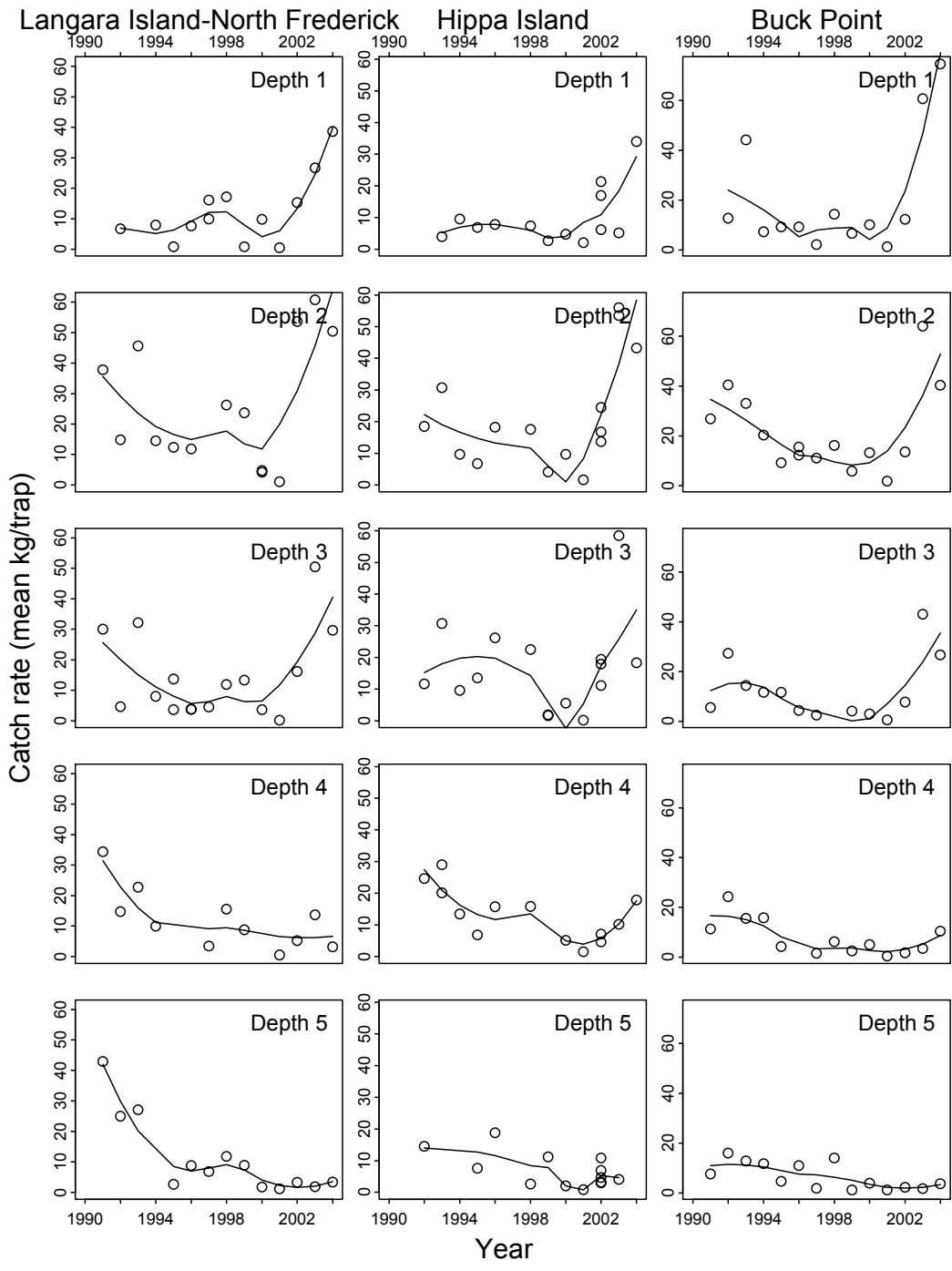


Figure D.5 Survey catch rates (mean kg per trap) by year, depth strata D1 through D5, and locality. The solid curve is a regression smoother through the observed catch rates for each set.

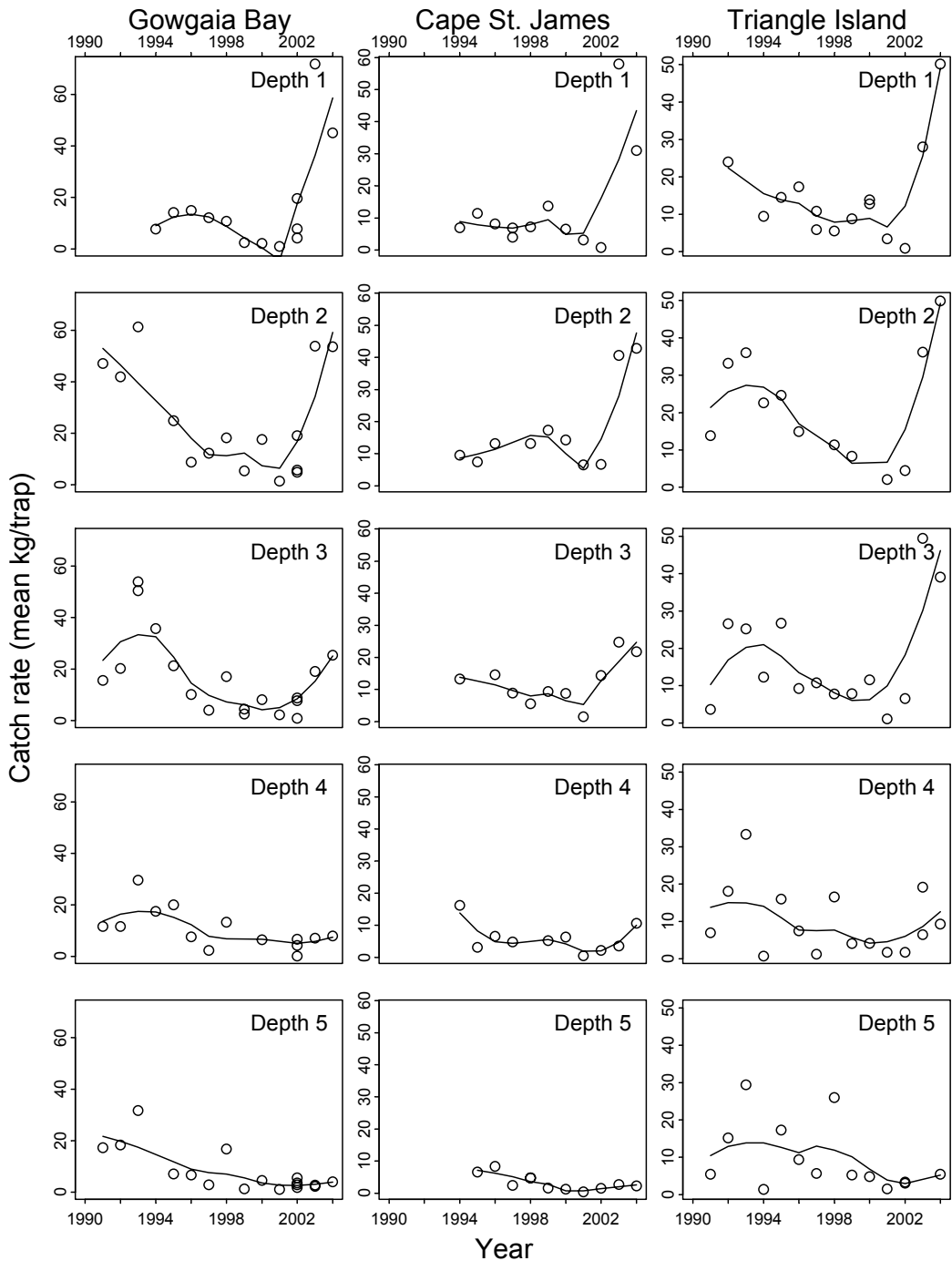


Figure D.5

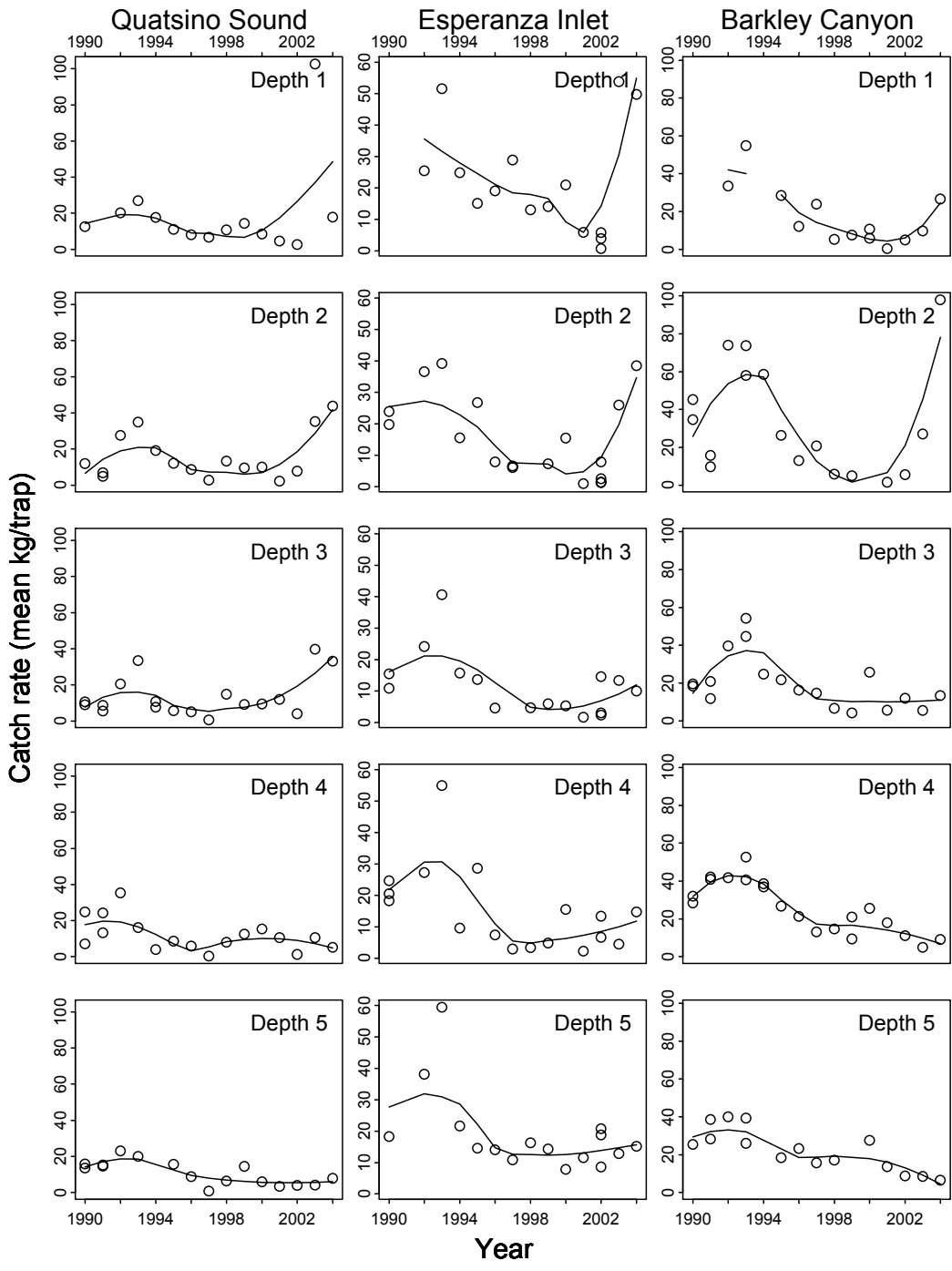


Figure D.5

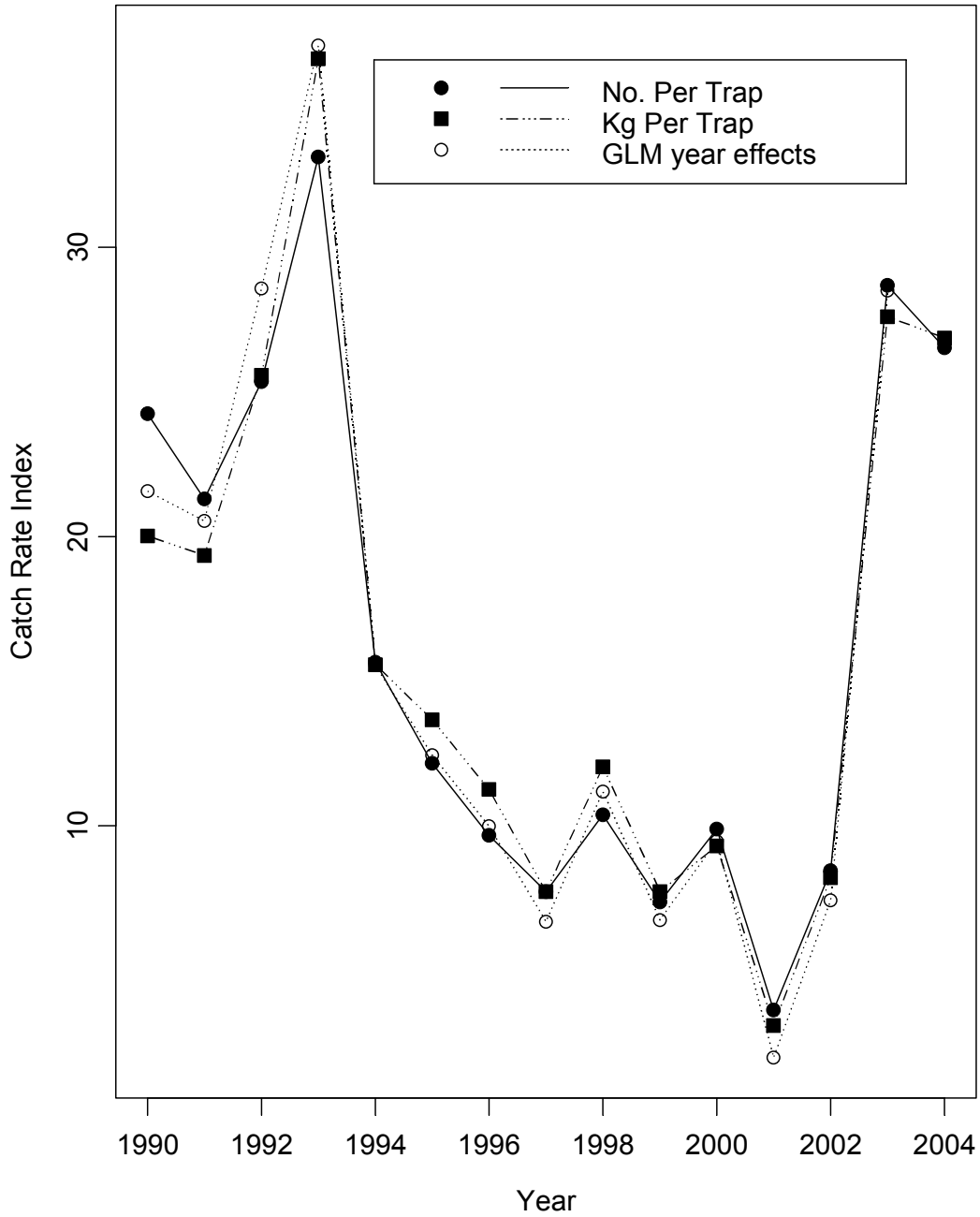


Figure D.6 Three indices of trap-vulnerable abundance based on survey data from depth strata D1 through D5. Each series has been scaled to preserve the coefficient of variation of the original series but centered at the mean of the kg per trap series from 1990 to 2003.