Exhibit C.3
Attachment 4
September 2001

Evaluation of existing *Sebastes* discard assumptions and possible alternatives

Draft for discussion, 8/20/2001

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For most Sebastes, the PFMC currently employs an assumed discard mortality of 16% based on a 1985-87 study of trawl fishery discards, summarized in Pikitch, et al., (NWAFC Processed Report 88-27).

The study observed 5 major fishing strategies (page 6), which were: 1) bottom rockfish trawling (BRF), using roller gear; 2) midwater trawling (MID); deepwater Dover sole trawling (DWD), using a mix of gears, generally outside of 100 fathoms; 4) nearshore-mixed trawling (NSM), using mud (small footrope) gear primarily to target flatfish, and 5) shrimp trawling (SHP), for pink shrimp. The survey sampled 1,470 tows during 139 trips, from June 1985 to December 1987, over a range of tow locations from roughly Cape Blanco, in Oregon, to the Canadian border..

In the text of the report, widow rockfish is the only rockfish species for which discard rates are discussed. On page 9, ratios of estimated total catch-to-landings are reported for 1985,1986, and 1987 as being 1.19, 1.13, and 1.15, respectively. The average across these three years is 1.157, which forms the basis for the 16% discard rate employed by the Council, for widow, as well as other *Sebastes* species. On page 7of the report, the effect of trip limit changes is noted: an estimated discard rate of 5.7% with a limit of 30,000 lb per week, and 52.3% with a limit of 3,000 lb per week.

Additional discard results are presented in Table 3 (page 21) of the report, by species, gear, and limit size. Two of the gear categories in the table correspond to strategies previously identified: midwater and shrimp trawls. Additionally, there is a bottom groundfish trawl category, which it is believed represents a combination of results for the BRF, DWD, and NSM strategies. Bottom trawl discard rates for yellowtail rockfish ranged from 6% to 9%, depending on limit size, and from less than 1% to 8% for POP.

In recent criticism of the PFMC's continued use of a 16% discard assumption, considerable attention has focused on the sensitivity of discard percentages in the Pikitch results to reductions in trip limit size. Since the analysis of widow rockfish in that study forms the basis for the PFMC's current practice, the 52.3% rate observed with very small limits has been suggested as a better alternative.

In evaluating the appropriateness of the current 16% discard assumption for canary and bocaccio, it is important to assess the relevance of the difference in discard rates that is associated with alternative trip limits amounts during the study period. Several key issues should be considered in evaluating the applicability of results--such as the 52.3% widow discard rate--to the current fishery. These include: gear usage on observed trips vs. that in the current fishery, alternative shelf target opportunities available during low-limit periods, changes in relative biomass of species over time, and comparative sample size between observed trip-limit regimes during the study period.

The predominant gear for on-bottom targeting of widow, and most other, rockfish, would have been some form of roller gear, which allows greater access to rocky habitat than the small footrope gear now required for landing any rockfish caught on the shelf. Within the study, the nearshore-mixed strategy, targeting primarily flatfish, represents the best analogy to the current small footrope fishery. However, the discard rates presented in the report represent a combination of all bottom trawl modes of fishing on the shelf. Figure 2 (page 24) does indicate that rockfish comprised a very small percentage of the total catch (~3-4%) in those NSM tows.

In order to address this issue directly, data from the Pikitch study were obtained, and tows where "mud gear" was using in a "nearshore-mixed" strategy were examined separately, with regard to coincident catch rates

of shelf *Sebastes* species, in general, and widow and canary rockfish in particular.

Table 1 shows a summary of catch for the 261 tows meeting this criterion, and also for a "flatfish-target" subset (137) of these tows, where at least 500 lb of flatfish was caught and flatfish comprised at least 70% of the total retained catch. In the larger group, 79% of tows had no canary catch, with a higher percentage (89%) in the flatfish-target group. Of the 912 lb of canary which was discarded in all 261 tows, 877 lb was attributed to a single tow. And, although the "reason for discard" was recorded for many tows in the study, no response is recorded for this tow. Regardless, since the total amount of *Sebastes* caught during the trip on which this tow occurred was less than 1,500 lb, and the Sebastes limit at the time was 25,000 lb once per week, it appears likely that this discard resulted from size-related or other market factors and not limit attainment. It should be noted that greater processor acceptance of smaller rockfish and the mandated use of larger mesh trawl gear (described above) have likely lowered the incidence of size-related discards since the Pikitch study was conducted.

Excluding this tow, the canary discard rate was 4% for flatfish tows and 1% for the larger set of nearshore-mixed tows. The coincident catch rate of canary, relative to the weight of all retained flatfish, ranges from 0.9% to 0.3%, depending on whether the large discard tow is included. This range is consistent with rates determined from examination of more recent logbook data, and considered in the development of 2001 flatfish limits. Beyond canary, there were no catches of widow or yellowtail rockfish in any of the nearshore-mixed, "mud-gear" tows. This also underscores the differences in rockfish encounters between this strategy and the other bottom trawl strategies which contributed to the overall 16% discard estimate for widow rockfish. These results suggest that, even during a period when trip limits would have allowed the retention of large amounts of rockfish, fishermen targeting flatfish with small footrope gear had minimal encounters with rockfish species, including canary.

These results suggest that, even during a period where rockfish limits would have allowed the retention of large amounts of rockfish, fishermen targeting flatfish with small footrope gear had minimal encounters with rockfish species, including canary.

The second issue is the magnitude of alternative rockfish fishing opportunities that were available during the portions of these years in which the 3,000 lb per trip limits were in place for widow rockfish. Table 2 summarizes rockfish trip limits during 1985-87. Limits for widow rockfish were lowered during September-December in 1985, and during October-December in 1986-87. During these periods, however, limits for other rockfish species remained, in general, very similar to their levels earlier in each year. Limits for the *Sebastes* complex were as high as 40,000 lb per trip in the southern management area, and 30,000 lb once per week in the northern area. Additionally, there were no landing limits on lingcod during these years. Therefore, it is likely that significant fishing effort utilizing roller gear continued to be directed towards species in rocky habitat during these periods of reduced widow limits. With continuing opportunity to target all other rockfish species, it is not surprising that discard rates increased dramatically during these periods.

In contrast, during the 2000 fishery, the small footrope limits for minor shelf rockfish did not exceed 1,000 lb per month throughout the year. Other shelf limits included widow rockfish (1,000 lb per month), yellowtail rockfish in the north (1,500 lb per month), POP (500-2,500 lb per month), bocaccio (300-500 lb per month), canary rockfish (100-300 lb per month), chilipepper rockfish (3,750 lb per month), and lingcod (0-400 lb per month). Thus, not only was the gear during the study more suitable for on-bottom targeting of most rockfish than that with which shelf rockfish can be landed currently, the opportunities that existed for targeting other rockfish species when widow limits were low are not comparable to the present trip limit regime. When the limit for a single component species of an assemblage is lowered, relative to the remainder of the assemblage, it is reasonable to conclude that discard of the single species will tend to increase. However, when all limits within the assemblage are reduced, in concert, it is considerably more difficult to infer that, for any of the species, individually, the mere presence of a lower limit will result in a higher discard rate.

A third consideration involves changes in relative biomasses since the Pikitch study. Flatfish now represent the bulk of on-bottom trawling effort on the shelf. And flatfish abundance is currently believed to have been

relatively stable, and perhaps even increased, since the mid-1980s. On the other hand, recent assessments suggest that the current exploitable biomass of canary rockfish is less than one-third of what it was during the mid-1980s. Other rockfish species currently viewed as "overfished" have experienced similar, if not greater, declines over this period. In addition to changes in gear restrictions and targeting opportunities, such changes in relative abundance suggest that rockfish encounter rates in other shelf target small-footrope fisheries should be lower now than during the Pikitch study period.

The final issue is one of sample sizes for the findings reported by Pikitch, et al. The 3,000-lb widow limit was in place for just 5 ½ months of the 36-month study period, and there is also usually less fishing effort in the last few months of the year. In 1985-86, the months with high widow limits averaged over 3,400 mt of rockfish landings, while the months having a 3,000 lb widow limit average roughly 2,300 mt of rockfish landings. The report does not specify the number of samples taken during each quarter, but if the samples sizes were generally proportional to the total trips taken during each, the discard rate calculated for the high widow limit would have been based on a considerably larger number of observations. Even if the same number of trips were observed during each quarter, the high-widow-limit discard rate would have been based on 4 ½ times the observations underlying the low-limit discard rate.

Alternative sources of information

The Groundfish Management Team has spent considerable effort reviewing logbook information in order to develop realistic estimates of the degree to which rockfish species of concern are incidentally caught with other target species. However, the usefulness of these data suffers from the lack of discard information and the dramatic recent changes in management of shelf fisheries. Prior to 1999, limits for rockfish were much higher, and roller gear could be used to target them. In most cases, the data do not clearly identify whether roller gear was used. More recent logbooks reflect the new footrope requirements, but the very presence of lower retention limits, absent estimates of discards, means that the true rockfish co-occurrence rates with small-footrope gear cannot be extracted.

Initial analysis of data from the Enhanced Data Collection Project (EDCP) during 2000 focused primarily on discard in the DTS fishery. However, across all observed tows, discard rates were calculated for a number of species, and presented to the Council in September 2000 (Methot, et al.). Among these, the observed discard rate for widow rockfish was 1%, for canary 12%, for yellowtail 20%, and for lingcod 10%.

In August 2001, a review of bycatch and discard rates was conducted for a subset of EDCP observations, whose species composition was suggestive of a mixed shelf flatfish strategy. This subset contained 105 tows from 1996-98, in depths less than 500 meters, where retained flatfish comprised at least 70% of all retained poundage, and some poundage of flatfish species other than Dover sole was retained. A summary of these tows is presented in Table 3. No canary or widow rockfish were caught in any of these tows, and total catches for yellowtail and lingcod were 202 lb and 1,703 lb, respectively, compared with 147,000 lb of flatfish. This yielded coincident catch rates of 0.1% and 1.2%, respectively, for yellowtail and lingcod. Obviously, the discard rates for canary and widow were 0%, since none were caught; discard rates were 13% and 9% for yellowtail and lingcod , respectively. Although these results reflect a limited sample size, they reinforce conclusions from analysis of the Pikitch data, regarding low encounter rates of rockfish in targeted shelf flatfish fisheries.

The NMFS Shelf Trawl Survey has been suggested as a source of information regarding the co-occurrence of rockfish and other, target species. If validated, these data could be used to evaluate whether current assumptions, based on imperfect logbook data, are reasonable. However, the use of survey data for such purposes has numerous shortcomings, as well. Perhaps foremost is the difference between the random design for selecting survey tow locations and the siting decisions of fishers, faced with a matrix of regulatory/market limits and differential prices among species. If the survey were to provide a reasonable approximation of species mix in the fishery, it would suggest that commercial fishing is an activity where the choices fishers make have little impact on their success or species mix. If fishers were truly unable to affect their likelihood of success, then we would expect to see totally random patterns of success and species mix

across vessels. Instead, we see many vessels that are able to specialize in certain species, and we see some vessels/operators that consistently out-perform or under-perform other members of the fleet.

Few data sources are available for evaluating the degree to which the species mix observed in the survey corresponds to commercial catches in the same area. The Oregon Enhanced Data Collection Project (EDCP) provides one such opportunity. A shelf survey was conducted in one of the EDCP project years, 1998, in which a significant number of tows were observed. Based on the location observed trips during that year, a range bounded by 42.5° N. Lat. and 44.3° N. Lat. was identified for comparing the composition of tows targeting the Dover-thornyhead-sablefish (DTS) complex. The top-40 DTS survey tows within that area were compared with 13 observed commercial tows made in depths less than 500 meters, in which at least 70% of the total poundage was comprised of DTS species. Results of that comparison are summarized in Table 4.

For the three principal target species examined--Dover sole, shortspine thornyheads, and sablefish--the ratios of species weight to DTS weight are quite different between the survey and fishery. Dover represented 64% of the commercial DTS catch, but only 38% of DTS species in the survey. Conversely, sablefish comprised more than half of the survey DTS, but less than one-quarter of the commercial catch. Shortspine accounted for 12% of the commercial catch, but less than 6% of DTS in the survey. The co-occurrence of three non-DTS species--canary and yellowtail rockfish and lingcod--was also examined. Although small amounts of these species were caught in the selected survey tows, the survey ratios were consistently higher than their counterparts from the commercial fishery.

Another important difference between survey and fishery tows is the mesh size of the gear used. The survey uses trawl nets with much smaller mesh than are used in the commercial fishery. As a result, the survey gear will retain a higher percentage of small rockfish than the commercial fishery.

Other factors which could contribute to divergence between survey and fishery species composition differences in tow duration, tow speed, time of day, and season of the year.

Further examination of survey data

Acknowledging the shortcomings of the shelf survey, data from 1977-98 were reviewed with respect to two potential areas of bycatch concern: canary rockfish while targeting arrowtooth, and bocaccio while targeting chilipepper. Table 5 summarizes the amounts of arrowtooth and canary caught in survey tows which had the 25-, 50-, and 100-largest amounts of arrowtooth, annually. The top-100 group includes tows with less than 10 kg per half-hour tow, which would not represent economically viable densities for conducting a target fishery. The top-50 group may also include some, though far fewer, tows for which this would be a concern. In the four surveys since 1989, the ratio of canary weight to arrowtooth weight in the top-25 and top-50 arrowtooth tows has ranged from less than 1% to 7%.

However, the single largest catch of canary routinely accounted for 20-40% of the canary caught in all group tows. The highly skewed nature of the distribution of these tow weight-ratios is illustrated in Table 6. In most years, the median tow ratio was equal to, or close to, zero, even in cases such as the top-25 group for 1980, where the ratio of weights from all tows was 44%. In nearly all cases, the overall ratio was greater than the 75th percentile value among individual tows, and in several cases, greater than the 90th percentile.

The lower panel in Table 6 explores the effect of assuming that the targeting ability of fishers allows them to avoid the highest concentrations of canary. The top-50 arrowtooth hauls are used as the base, and compared with the 90% subset (45 tows) which contained the least amount of canary. The overall ratio is reduced by more than 50% in every year, and the average over the last 4 surveys drops from 4.1% to 1.4%.

A similar analysis was conducted for the ratio of bocaccio observed in the highest chilipepper tows. The fact that there were far fewer positive tows of chilipepper than arrowtooth is evident in that top-50 and top-100

groups include tows with essentially no chilipepper. Even the top-25 group has a low of 2 kg per half-hour tow in 1983. Focusing on the top-25 group, the change in relative biomasses of the two species is reflected in the dramatic reduction in species ratios between the first four surveys (all greater than 30% bocaccio, with a mean of 58%) and the last four (none greater than 7%, with a mean of 3%). As with canary, the single largest tow of bocaccio accounted for a large fraction of the group total (averaging 44%, over the last four surveys).

The distribution of individual tow ratios differs from the canary-arrowtooth case, in that the median values range as high as 50% in the early survey years. However, the median has not exceeded 2% in the last four surveys, averaging less than 1%. Similar to canary, the ratios of total species weights exceed the 75th percentile values of the annual tow distributions in about half the years.

Table 1.--Coincident catch rates of flatfish and Sebastes species observed during the Pikitch discard study (1985-87) for tows made with "Mud gear" (no rollers) using a "Nearshore-mixed" strategy, and the subset of those where at least 500 lb of flatfish were caught and flatfish comprised at least 70% of the retained catch.

	All nearshore-mixed strategy, "mud gear" tows	Flatfish tows
Numer of tows	261	137
# without canary	207	122
% without canary	79.3%	89.1%
All flatfish, Sebastes, sablefish, & lingcod		
Retained + discard	360,915	255,315
Retained [1] (lb)	265,326	182,924
% retained	73.5%	71.6%
All flatfish		
Retained + discard (lb)	292,613	202,748
Flatfish retained (lb)	213,076	143,151
% retained	72.8%	70.6%
All *Sebastes* species		
Retained + discard (lb)	18,700	2,544
% of retained flatfish	7.0%	1.8%
Sebastes discard (lb)	2,947	1,178
Sebastes discard/catch	16%	46%
- excluding the largest single canary discard tow		
Retained + discard (lb)	17,813	1,657
% of retained flatfish	6.7%	1.2%
Sebastes discard (lb)	2,060	291
Sebastes discard/catch	12%	18%
Canary rockfish		
Retained + discard (lb)	5,676	1,352
% of retained flatfish	2.1%	0.9%
Canary discard (lb)	912	907
Canary discard/catch	16%	67%
- excluding the largest single canary discard tow		
Retained + discard (lb)	4,789	465
% of retained flatfish	1.8%	0.3%
Canary discard (lb)	25	20
Canary discard/catch	1%	4%
Widow rockfish		
Retained + discard (lb)	181	14
% of retained flatfish	0.1%	0.01%
Widow discard (lb)	0	0
Widow discard/catch	0%	0%
Yellowtail rockfish		
Retained + discard (lb)	2,405	447
% of retained flatfish	0.9%	0.3%
Yellowtail discard (lb)	0	0
Yellowtail discard/catch	0%	0%

Table 2.--Comparison of trip limits for other rockfish species available during periods with small widow rockfish limits, 1985-87.

	January	February	March	April	May	June	July	August	September	October	November	December
1985												
Widow		30,000 lb trip lim; 1 trip/wk							3000 lb/trip; no lims on freq.			
POP -North		20% total trip wt (no lb lim)			Lesser of: 5,000 lb / trip or 20% total trip wt				5,000 lb / trip or 20% total trip wt			
***Sebastes* -North**		30,000 lb/wk			4/28: 15,000 lb/wk				15,000 lb/wk	10/6: 20,000 lb once/wk;		
***Sebastes* -South**				40,000 lb/trip, no freq lims						40,000 lb/trip, no freq lims		
Yellowtail -North		10,000 lb once/wk			4/28: 5,000 lb/wk					5,000 lb/wk		
1986												
Widow					30,000 lb/wk					3000 lb/trip; no lims on freq.		
POP -North					Lesser of: 10,000 lb / trip or 20% total trip wt					10,000 lb trip / lim or 20%	Vanc. closed	
***Sebastes* -North**					25,000 lb/wk			8/31: 30,000 lb/wk		30,000 lb/wk		
***Sebastes* -South**					40,000 lb/trip, no freq lims					40,000 lb/trip		
Yellowtail -North					10,000 lb/wk				12,500 lb/wk	12,500 lb/wk		
1987												
Widow					30,000 lb/wk; max. 1 ldg/wk > 3000 lb					5,000 lb/wk		
POP					Coastwide: lesser of 5,000 lb/trip or 20% total trip wt					5,000 lb/trip or 20% total trip wt		
***Sebastes* -North**					25,000 lb once/wk					25,000 lb once/wk		
***Sebastes* -South**					40,000 lb/trip					40,000 lb/trip		
Yellowtail -North					10,000 lb/wk			7/22: 7,500 lb/wk		7,500 lb/wk		

Notes: Yellowtail limits were specied as sub-limits of the *Sebastes*-North limits. There were also no limits on lingcod landings during these years.

Table 3.--Bycatch and discard of rockfish and lingcod in 1996-98 trawl fishery tows, observed as part of the Enhanced Data Collection Project, in depths shallower than 500 meters, where retained flatfish species comprised at least 70% of all retained species, and some flatfish other than Dover sole was retained.

	Retained flatfish poundage				
	All species	Dover	Petrale	Arrowtooth	Other flatfish
Retained pounds	147,438	77,173	39,688	10,337	20,240
# of tows	105	94	66	55	64

	Bycatch and discard of selected rockfish species and lingcod			
	Widow rockfish	Yellowtail rockfish	Canary rockfish	Lingcod
Total pounds	0	202	0	1,703
% of retained flatfish	0.0%	0.1%	0.0%	1.2%
# of tows	0	3	0	40
% of all tows with species		2.9%		38.1%
Retained pounds	0	175	0	1,549
# of tows	0	2	0	35
% of all tows: species retained		1.9%		33.3%
Discarded pounds	0	27	0	154
Discard rate		13.3%		9.1%
# of tows	0	1	0	7
% of all tows: species discarded		1.0%		6.7%

Note: observations ranged from 42.4° N. Lat to 48° N. Lat, with roughly 60% occurring from 43-45° N. Lat.; and from depths of 40 m to 500 m, with 30% falling in each of the ranges: 148-200 m and 260-350 m.

Table 4.--Comparison of catch poundage ratios between several species and three combined DTS species (Dover sole, sablefish, shorspine thornyhead), between the top-40 DTS tows of the 1998 shelf trawl survey and the 13 observed 1998 DTS tows in the Oregon EDCP project shallower than 500 meters, in the area bounded by 42.5° N.Lat. and 44.3° N. Lat.

	25th percentile	Median	75th percentile	90th percentile	Largest ratio	Ratio of species wt. to DTS wt.	species lbs in all included tows	smallest tow	largest tow
Dover % of DTS total kg									
Shelf survey	40.5%	64.8%	85.1%	97.4%	100.0%	37.6%	7,431	30	687
EDCP observed tows	42.0%	76.6%	96.3%	96.7%	96.8%	63.9%	13,987	300	2,303
Sablefish % of DTS total kg									
Shelf survey	10.0%	25.4%	53.1%	73.0%	98.1%	56.8%	11,208	0	2,857
EDCP observed tows	3.7%	23.4%	41.6%	52.2%	63.5%	23.9%	5,233	39	1,248
Shortspine % of DTS total kg									
Shelf survey	0.0%	3.2%	7.9%	18.2%	32.8%	5.6%	1,106	0	201
EDCP observed tows	0.0%	5.8%	9.3%	29.0%	47.0%	12.3%	2,684	0	1,009
Canary % of DTS total kg									
Shelf survey	0.0%	0.0%	0.0%	2.9%	45.2%	0.3%	55	0	22
EDCP observed tows	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0	0
Yellowtail % of DTS total kg									
Shelf survey	0.0%	0.0%	0.1%	10.6%	162.8%	0.9%	168	0	52
EDCP observed tows	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0	0
Lingcod % of DTS total kg									
Shelf survey	0.0%	0.0%	0.0%	2.0%	6.7%	0.3%	68	0	29
EDCP observed tows	0.0%	0.0%	0.0%	0.5%	0.8%	0.1%	19	0	10

Note: EDCP tows were selected if at least 50% of the tow was comprised of DTS species.

Table 5.--Comparison of amounts of arrowtooth flounder and canary rockfish for sets of hauls determined by the amount of arrowtooth, for individual survey years.

	1977	1980	1983	1986	1989	1992	1995	1998
Top-25 hauls of arrowtooth								
Arrowtooth flounder								
Sum of kg	4,462	2,887	3,264	3,513	11,938	2,221	6,854	5,952
Smallest haul in group	55	49	42	99	133	34	93	92
Canary rockfish								
Sum of kg	304	1,282	738	83	331	155	30	408
as a % of arrowtooth	6.8%	44.4%	22.6%	2.4%	2.8%	7.0%	0.4%	6.9%
Largest haul in group	133	1,070	282	77	122	41	13	86
% of sum in largest haul	44%	83%	38%	92%	37%	26%	42%	21%
Top-50 hauls of arrowtooth								
Arrowtooth flounder								
Sum of kg	5,450	3,729	4,031	5,394	14,268	2,819	8,319	7,517
Smallest haul in group	30	23	23	54	70	18	32	50
Canary rockfish								
Sum of kg	492	1,285	1,062	390	388	189	85	442
as a % of arrowtooth	9.0%	34.5%	26.3%	7.2%	2.7%	6.7%	1.0%	5.9%
Largest haul in group	133	1,070	282	271	122	41	33	86
% of sum in largest haul	27%	83%	27%	70%	31%	22%	39%	19%
Top-100 hauls of arrowtooth								
Arrowtooth flounder								
Sum of kg	6,622	4,367	4,863	7,208	16,141	3,389	9,286	8,783
Smallest haul in group	17	7	11	25	24	8	12	15
Canary rockfish								
Sum of kg	621	1,996	1,869	685	1,504	214	100	501
as a % of arrowtooth	9.4%	45.7%	38.4%	9.5%	9.3%	6.3%	1.1%	5.7%
Largest haul in group	133	1,070	496	271	794	41	33	86
% of sum in largest haul	21%	54%	27%	40%	53%	19%	33%	17%

Table 6.--Selected moments of the distribution of canary weights as percentages of arrowtooth weights in individual hauls.

	1977	1980	1983	1986	1989	1992	1995	1998
Top-25 hauls of arrowtooth								
25th percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
Median	0.0%	0.0%	0.4%	0.0%	0.3%	0.0%	0.0%	2.3%
75th percentile	3.5%	4.3%	4.2%	0.0%	2.2%	2.8%	0.0%	7.8%
90th percentile	43.7%	28.1%	165.9%	1.9%	17.7%	59.7%	1.9%	31.9%
Maximum	163.4%	875.1%	190.0%	50.7%	78.2%	71.8%	4.0%	71.7%
Ratio of total weights	6.8%	44.4%	22.6%	2.4%	2.8%	7.0%	0.4%	6.9%
Top-50 hauls of arrowtooth								
25th percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%
75th percentile	9.7%	0.0%	4.8%	0.0%	2.2%	7.3%	0.0%	6.1%
90th percentile	32.9%	7.1%	71.4%	6.8%	7.4%	26.8%	2.9%	16.1%
Maximum	226.1%	875.1%	1003.0%	290.3%	78.2%	71.8%	58.2%	71.7%
Ratio of total weights	9.0%	34.4%	26.3%	7.2%	2.7%	6.7%	1.0%	5.9%

Comparison of average canary co-occurrence in the top-50 arrowtooth tows and the subset of that group containing the 90% of the observations with the lowest absolute amount of canary

	1977	1980	1983	1986	1989	1992	1995	1998
All top-50 arrowtooth hauls								
Sum of arrowtooth kg	5,450	3,729	4,031	5,394	14,268	2,819	8,319	7,517
Sum of canary kg	492	1,285	1,062	390	388	189	85	442
Ratio of total weights	**9.0%**	**34.5%**	**26.3%**	**7.2%**	**2.7%**	**6.7%**	**1.0%**	**5.9%**
Sub-group of 45 tows (90%) with the lowest amount of canary								
Arrowtooth								
Sum of kg	5,099	3,210	2,936	4,886	12,122	2,325	5,982	6,763
% of all top-50 hauls	94%	86%	73%	91%	85%	82%	72%	90%
Smallest haul in group	30	23	23	54	70	18	32	50
Smallest haul in top-50	30	23	23	54	70	18	32	50
Canary								
Sum of kg	75	17	95	13	66	53	12	178
Ratio of total weights	**1.5%**	**0.5%**	**3.2%**	**0.3%**	**0.5%**	**2.3%**	**0.2%**	**2.6%**
% of all top-50 hauls	15%	1%	9%	3%	17%	28%	14%	40%
Largest haul in group	12	5	25	4	11	7	3	30
Largest haul in top-50	133	1,070	496	271	794	41	33	86

Table 7.--Comparison of amounts of chillipepper and bocaccio rockfish for sets of hauls determined by the amount of chillipepper, for individual survey years.

	1977	1980	1983	1986	1989	1992	1995	1998
Top-25 hauls of chillipepper								
Chillipepper								
Sum of kg	7,473	2,868	3,182	2,570	6,383	7,599	4,707	6,671
Smallest haul in group	47.6	6.8	2.0	3.4	68.9	7.5	29.8	18.6
Bocaccio								
Sum of kg	2,857	967	2,948	1,719	129	476	202	30
as a % of chillipepper	38.2%	33.7%	92.6%	66.9%	2.0%	6.3%	4.3%	0.5%
Largest haul in group	2,057	286	2,222	1,426	34	326	119	7
% of sum in largest haul	72%	30%	75%	83%	26%	69%	59%	24%
Top-50 hauls of chillipepper								
Chillipepper								
Sum of kg	8,140	2,901	3,195	2,593	7,315	7,648	5,040	6,825
Smallest haul in group	11.3	0.0	0.0	0.0	16.6	0.6	3.7	1.4
Bocaccio								
Sum of kg	3,205	1,046	3,061	1,749	5,216	487	213	48
as a % of chillipepper	39.4%	36.1%	95.8%	67.4%	71.3%	6.4%	4.2%	0.7%
Largest haul in group	2,057	286	2,222	1,426	4,577	326	119	12
% of sum in largest haul	64%	27%	73%	82%	88%	67%	56%	24%
Top-100 hauls of chillipepper								
Chillipepper								
Sum of kg	8,289	2,901	3,195	2,593	7,458	7,655	5,076	6,838
Smallest haul in group	0.7	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Bocaccio								
Sum of kg	4,059	1,106	3,186	1,851	5,546	487	229	70
as a % of chillipepper	49.0%	38.1%	99.7%	71.4%	74.4%	6.4%	4.5%	1.0%
Largest haul in group	2,057	286	2,222	1,426	4,577	326	119	12
% of sum in largest haul	51%	26%	70%	77%	83%	67%	52%	17%
Selected moments of the distribution of bocaccio weights as percentages of chillipepper weights in individual hauls.								
Top-25 hauls of chillipepper								
25th percentile	3%	9%	1%	3%	0%	0%	0%	0%
Median	8%	50%	25%	8%	1%	0%	2%	0%
75th percentile	12%	105%	100%	35%	7%	2%	4%	2%
90th percentile	64%	121%	985%	60%	12%	54%	8%	17%
Maximum	218%	741%	3340%	961%	18%	2283%	399%	22%
Weighted mean	38.2%	33.7%	92.6%	66.9%	2.0%	6.3%	4.3%	0.5%