Evaluation of "stock structure" for the Bering Sea/Aleutian Islands skate complex

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Executive summary
This report is an evaluation of the potential for conservation concerns arising from among-species differences in spatial distribution within the Bering Sea and Aleutian Islands (BSAI) skate complex and the distribution of fishery catches. There are fifteen known skate species in the BSAI distributed among three regions: the eastern Bering Sea (EBS shelf), the EBS slope, and the Aleutian Islands (AI). Skate distribution is highly stratified by depth, and species composition differs between the EBS and the AI. Evaluation of spatial management concerns is seriously hampered by a lack of reliable species-level catch accounting, which is the highest priority for enhancing skate conservation and management. Although too sparse to properly evaluate the issue, the available data suggest that the current spatial management practice (i.e. BSAI-wide harvest specifications and catch accounting) is appropriate for this complex. The overall exploitation rate is low relative to natural mortality. The highest catch rates occur in the region where Alaska skate (the most abundant and data-rich of all species in the complex) is predominant. The spatial distribution of catches mirrors the spatial distribution of the various species. Biomass trends for all species in all areas appear to be stable, although biomass timeseries are too short and estimates too variable for proper evaluation.

It is important to note that the difference in species composition among the different BSAI subareas likely violates the requirement, under the current National Standard guidelines, that stock complexes should only include those stocks that are "sufficiently similar in geographic distribution". This observation alone supports establishing separate management for skate in the EBS and the AI.

Introduction

Although titled an evaluation of "stock structure", this report is essentially an evaluation of the potential for conservation concerns arising from among-species differences in spatial distribution within the Bering Sea and Aleutian Islands (BSAI) skate complex and the distribution of fishery catches. In 2011 the Plan Teams requested that stock structure in BSAI skates be evaluated using a newly created stock structure template. Because matters relating to the species composition of the complex are more important than the structure of any specific skate population, this template is not entirely appropriate for analyzing spatial issues in skates. However, because there has been discussion of separate management in the eastern Bering Sea (EBS) and Aleutian Islands (AI) for many stocks, including skates, this report endeavors to apply the stock structure template to the skate complex in addressing spatial management issues. A particular challenge for analyzing these issues in skates is the lack of species-specific catch data, as described in more detail below. Much of the information presented here is also included in the stock assessment report for BSAI skates.

Overview of the skate complex

Skates (family Rajidae) are cartilaginous fishes which are related to sharks. They are dorso-ventrally depressed animals with large pectoral "wings" attached to the sides of the head, and long, narrow whiplike tails. At least 15 species of skates in three genera, *Raja*, *Bathyraja*, and *Amblyraja*, are distributed throughout the eastern North Pacific and are common from shallow inshore waters to very deep benthic habitats (Eschmeyer et al. 1983, Stevenson et al. 2006). Table 1 lists the species found in Alaskan waters, with their depth distributions and selected life history characteristics.

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The species within the skate complex occupy three different regions within the BSAI fishery management plan (FMP) area (Figs. 1 & 2; Table 2): two regions in the EBS (the EBS shelf, with depths <200 m, and the EBS slope with depths from 200 to 1000 m) and the AI region (with depths from 0 to 1000 m). The vast majority (82%) of the skate biomass exists on the EBS shelf, with the remaining biomass split between the EBS slope and the AI (Fig. 3). Within the EBS species composition varies by depth, with the greatest species diversity between 200 and 800 m (Fig. 4; Stevenson et al. 2006). On the EBS shelf the complex is dominated by a single species, the Alaska skate *Bathyraja parmifera* (Table 2 & Fig. 2), which is distributed throughout the EBS shelf habitat area (Fig. 5). The Alaska skate has accounted for 91-97% of the aggregate skate biomass estimate since species identification became reliable in 1999 (e.g. Table 2). The Bering *B. interrupta* is the next most common species on the EBS shelf, and is distributed on the outer continental shelf (Figs. 2 & 5).

Species diversity of skates is substantially greater on the EBS slope (Fig. 2 and Table 2). The dominant species on the EBS slope is the Aleutian skate *B. aleutica*. A number of other species are found on the EBS slope in significant numbers, including the Alaska skate, commander skate *B. lindbergi*, whiteblotched skate *B. maculata*, whitebrow skate *B. minispinosa*, roughtail skate *B. trachura*, and mud skate *B. taranetzi*. Two rare species, the deepsea skate *B. abyssicola* and roughshoulder skate *Amblyraja badia*, have only recently been reported from the EBS slope bottom trawl survey (Stevenson and Orr 2005). The Okhotsk skate *B. violacea* is also occasionally found on the EBS slope.

The skate species composition in the AI is distinct from the EBS shelf and slope complexes, with different species dominating the biomass and at least one endemic species, the recently described butterfly skate *Bathyraja mariposa* (Fig. 2 & Table 2; Stevenson et al. 2004). In the AI, the most abundant species is the whiteblotched skate. The whiteblotched skate is found primarily in the eastern and far western Aleutian Islands (Fig. 1). Aleutian and Alaska skates are also common in the AI. The mud skate is relatively common in the AI but represents a lower proportion of total biomass because of its smaller body size.

<u>Application of stock structure template</u>

Harvest and trends

Limitations of the catch data: In the BSAI, there is no directed fishery for skates at present. Skates are caught in almost all fisheries and areas of the BSAI, but most of the skate bycatch is in the longline fishery for Pacific cod. Skate catches occur throughout the BSAI reporting area, with the greatest catches in the outer and middle domains of the EBS shelf (Table 3). Historically, fishery-caught skates were almost always recorded as "skate unidentified", with very few exceptions between 1990 and 2004. Due to improvements in species identification by fishery observers, information on the species composition of some catches is available beginning in 2005. However, much of the taxonomic identification of commercially-caught skates remains at the genus level (*Bathyraja* vs. *Raja*). This is largely because most skates are caught in longline fisheries, and many skates either drop off of or are removed from the groundline before being brought on board and cannot be identified to species by the observer. The main result of this problem is that species-specific catch estimates are not available for the BSAI skate complex.

Limitations of the biomass data: Surveys in the EBS slope and AI regions are conducted infrequently, so that only 2 years out of the last decade have surveys in all three areas in the same year. As a result, some of the discussion here focuses on only one year, 2010, the most recent in which all 3 surveys were conducted in the same year. Skates have only been identified to species since 1999, so data on long-term

abundance trends is lacking. Species identification problems still exist for some of the trawl surveys, as evidenced by the large number of skates listed as "skate unidentified" in the 2010 Aleutians trawl survey.

Exploitation rates: The overall exploitation rate for the BSAI skate complex appears low relative to the natural mortality rate (*M*) of 0.1 used to make harvest recommendations for the BSAI skate complex, fluctuating between 0.36 and 0.45 between 2003 and 2010 (Tables 4 & 5). The annual catch is a little more than half the recommended ABC (Table 4). The exploitation rate is slightly lower in the AI, likely because most skate removals occur in the longline fisheries on the EBS shelf. Due to the limitations described above, it is not possible to look at exploitation rates by species. Information regarding *M* is sparse for BSAI skates; the value of 0.1 is considered to be conservative because it is the lowest of range of estimates for the small number of species for which M estimates exist.

Spatial distribution of catch relative to biomass: This report considers the spatial distribution of catches in several different ways.

1) In Table 5, the distribution of catches and biomass estimates between the EBS and the AI is shown for the years 2003-2010. These data indicate that the proportion of the catch occurring in the AI has been increasing slightly over the time period, but that the catch proportion in the EBS (92%) is still slightly high relative to the EBS portion of biomass (89%). Catches in the EBS in particular are likely dominated by Alaska skate, and it should be noted that this analysis cannot be conducted at the species level due to the limitations described above.
2) Table 6 shows a comparison of observed catch and biomass proportions by area in 2010. As described above, interpretation of these data is made difficult by the lack of species-level identification. For the EBS, perhaps the most meaningful result is that the proportion of *Bathyraja* vs. *Raja* skates appears to be similar between catch and survey. In the AI, 25% of the survey biomass is unidentified, which makes it difficult to interpret the apparently disproportionate catch of Alaska skate. *Raja* skates, which make up 1.2% of the AI biomass, are only a negligible fraction of the observed catch.
3) Spatial patterns of observed catch (Figs. 6 & 7) suggest that the patterns of catch by species are very similar to the spatial distributions of those species. Catches of Alaska skate occur mainly in the outer and middle domains of the EBS shelf, whereas catches of commander skate occur only on the EBS slope and in the AI (compare Fig. 2 to Fig. 6). This result is supported when looking at catches along the EBS shelf break at a smaller spatial scale (Fig. 7): catches of Alaska skate occur only at depths <200 m (i.e. on the shelf); catches of commander skate occur only below 200 m (i.e. on the slope); and catches of Aleutian skates occur on both the shelf and slope. These patterns directly reflect the known distribution of these species (Fig. 2).

Population trends: The skate population in the BSAI appears to be stable or increasing, but interpretation of trends for species is difficult due to the short time series and the high level of variability for many of the biomass estimates. Biomass estimates for the EBS shelf have been fairly stable since 1999, with Alaska skate dominating the biomass (Fig. 8). On the EBS slope (Fig. 9) and in the AI (Fig. 10) biomass trends have been fairly stable since 2000. These stable levels are substantially higher than biomass estimates from the 1980s and 1990s (Fig. 11). However survey practices for the slope and AI have changed over this time period and it is unknown whether this affects the skate biomass estimates.

Behavior and movement

Alaska skate movement: A tagging study is currently underway for Alaska skates on the EBS shelf. This is a qualitative conventional tag study designed to gather basic data regarding movements of Alaska skates. Skates were tagged aboard the EBS shelf surveys in 2008-2010 and tags are recovered through the commercial fisheries using a tag reward system. Of 3,000+ tagged skates released, approximately 30 tags have been recovered. The data have not yet been analyzed but should be available soon to provide

information regarding the extent of movement by Alaska skates. Big skates (*Raja rhina*) tagged off the coast of British Columbia have been known to move 100s of kilometers, but it is unknown if and how many other skate species display this behavior.

Genetics and identification of new species

Identification of skate species in Alaska waters is a fairly recent endeavor, and it appears there may be even higher species diversity than previously thought (G. Hoff, AFSC, pers. comm.). A commonly observed species in the western AI that was thought to be a subspecies of Alaska skate has been identified as a separate species, the "leopard skate" (*Bathyraja* sp. cf. *parmifera*; (J. Orr pers. comm.). There is a very clear geographic division between Alaska and leopard skates, with the leopard skate occurring exclusively in the western AI. Phenotypic variation among Bering skates *B. interrupta* has also spurred an investigation of the possibility for population structure or further species division within the Bering skate stock using genetic techniques (G. Hoff, AFSC, pers. comm.).

Management implications

Although the available information suggests that the current management practice (i.e. BSAI-wide harvest specifications and catch accounting) is appropriate for this complex, it should be emphasized that the data do not currently exist to fully evaluate spatial management issues in BSAI skates. The status quo is supported by these observations:

1) Complex-wide exploitation rates are generally low, with the highest rates in the region where Alaska skate (the most data-rich of all species in the complex) is predominant.
2) The spatial distribution of catches mirrors the spatial distribution of the various species.
3) Biomass trends for all species in all areas appear to be stable.

Particular areas of concern regarding this evaluation are:

1) Data do not exist to evaluate species-level exploitation rates.
2) Biomass time series are short and many biomass estimates are highly uncertain.
3) Estimates of M are not available for most species and are not available by area.

It is also important to realize that the difference in species composition among the different BSAI subareas likely violates the requirement, under the current National Standard guidelines, that stock complexes should only include those stocks that are "sufficiently similar in geographic distribution".

The biggest challenge to the continued conservation of skates in the BSAI is the lack of reliable species-level catch accounting. This is a problem that can only be solved by identifying all skates caught in longline fisheries to species. This is a formidable obstacle to overcome, but the author feels this is the single greatest priority for enhancing skate management in the BSAI.

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Stevenson, D. E., Orr, J. W., Hoff, G. R., and McEachran, J. D. 2007. Field guide to sharks, skates, and ratfish of Alaska. Alaska Sea Grant.

Tables

Table 1. Life history and depth distribution information available for BSAI and GOA skate species, from Stevenson (2004) unless otherwise noted.

Species	Common name	Max obs. length (TL cm)	Depth range (m)
Bathyraja abyssicola	deepsea skate	135 (M) 157 (F)	362-2904
Bathyraja aleutica	Aleutian skate	150 (M) 154 (F)	15-1602
Bathyraja interrupta	Bering skate	83 (M) 82 (F)	26-1050
Bathyraja lindbergi	Commander skate	97 (M) 97 (F)	126-1193
Bathyraja maculata	whiteblotched skate	120	73-1193
Bathyraja mariposa [3]	butterfly skate	76	90-448
Bathyraja minispinosa	whitebrow skate	83[10]	150-1420
Bathyraja parmifera	Alaska skate	118 (M) 119 (F)	17-392
Bathyraja sp. cf. *parmifera*	“Leopard” parmifera	133 (M) 139 (F)	48-396
Bathyraja taranetzi	mud skate	67 (M) 77 (F)	58-1054
Bathyraja trachura	roughtail skate	91 (M) 89 (F)	213-2550
Bathyraja violacea	Okhotsk skate	73	124-510
Amblyraja badia	roughshoulder skate	95 (M) 99 (F)	1061-2322
Raja binoculata	big skate	244	16-402
Raja rhina	longnose skate	180	9-1069

Table 2. Species composition of the BSAI skate complex in each region from 2010, the most recent year in which all 3 regional surveys were conducted in the same year.

species	2010 shelf		2010 slope		2010 AI	
	biomass	CV	biomass	CV	biomass	CV
Alaska	366,116	0.06	1,296	0.32	3,663	0.20
Bering	11,992	0.14	2,780	0.16	56	0.45
big	3,445	0.66	0	-	640	0.83
Aleutian	3,332	0.35	18,721	0.22	8,711	0.21
whiteblotched	133	1	4,055	0.14	24,179	0.20
skate unidentified	0	-	0	-	13,245	0.21
Bathyraja sp.	0	-	0.84	1.00	0	-
deepsea	0	-	345	0.64	0	-
mud	0	-	576	0.25	1,511	0.23
roughtail	0	-	2,103	0.16	0	-
commander	0	-	3,393	0.15	0	-
whitebrow	0	-	1,908	0.19	0	-

Table 3. Estimated catch (t) of all skate species combined by reporting area, 2003-2011. Source: AKRO CAS. *2011 data incomplete; reported as of November 3, 2011.

region	**rep. area**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	***2011****
EBS	508	0	0	0	0	0	0	0	0	*6*
	509	1,968	2,160	3,267	3,537	3,577	4,037	5,007	2,793	*5,630*
	512	25	205	15	0	0	29	16	13	*7*
	513	2,757	2,821	4,010	2,667	2,360	2,069	2,541	1,887	*2,341*
	514	279	67	196	221	445	86	134	79	*146*
	516	132	408	239	253	398	488	573	660	*243*
	517	2,863	2,946	3,669	2,399	2,139	2,452	3,166	2,805	*2,202*
	518	25	6	16	11	5	480	56	41	*11*
	519	184	139	104	69	109	185	55	80	*92*
	521	8,946	10,313	8,478	8,351	7,105	7,616	6,184	6,595	*7,562*
	523	306	325	243	283	334	242	263	405	*266*
	524	1,016	2,025	2,151	1,493	1,137	2,568	1,399	1,019	*971*
	530	0	0	0	0	0	0	1	0	*0*
	EBS total	**18,501**	**21,415**	**22,388**	**19,283**	**17,608**	**20,251**	**19,396**	**16,376**	***19,476***
AI	541	302	466	487	563	337	497	452	465	*475*
	542	234	278	126	336	394	577	334	445	*217*
	543	118	141	83	67	276	345	420	428	*30*
	AI total	**655**	**885**	**696**	**966**	**1,007**	**1,419**	**1,206**	**1,337**	***722***

Table 4. Skate complex exploitation rates by area in 2010, the most recent year when all three BSAI surveys were conducted in the same year.

	EBS	AI	BSAI
total catch (t)	16,377	1,338	17,715
ABC (t)			31,523
OFL (t)			37,817
survey biomass estimate (t)	420,196	52,005	472,201
exploitation rate	0.039	0.026	0.038
skate complex common *M*	0.100	0.100	0.100

Table 5. Distribution of skate complex biomass and fishery catch between the eastern Bering Sea (EBS) and the Aleutian Islands (AI), 2003-2010. Data for survey biomass are shown for only those years where all three BSAI regions were surveyed in the same year.

	aggregate skate exploitation rate	proportion of total			
		fishery catch		survey biomass	
		EBS	AI	EBS	AI
2003	0.037	0.97	0.03		
2004	0.043	0.96	0.04	0.89	0.11
2005	0.045	0.97	0.03		
2006	0.039	0.95	0.05		
2007	0.036	0.95	0.05		
2008	0.042	0.93	0.07		
2009	0.040	0.94	0.06		
2010	0.038	0.92	0.08	0.89	0.11

Table 6. Comparative representation of taxonomic groupings of skates in observed catches and survey biomass estimates for the eastern Bering Sea (EBS) and Aleutian Islands (AI) in 2010, the most recent year when all three BSAI surveys were conducted in the same year.

	EBS			
	observed catch		survey biomass	
taxonomic grouping	t	%	t	%
Aleutian	221,474	1.7%	22,053	5.2%
Alaska	6,094,095	47.6%	367,412	87.4%
roughtail	1,809	0.0%	2,103	0.5%
skate unID	23,410	0.2%	0	0.0%
big	136,744	1.1%	3,445	0.8%
longnose	7,436	0.1%	0	0.0%
Bering	285,138	2.2%	14,772	3.5%
Bathyraja sp.	5,941,676	46.4%	1	0.0%
whitebrow	3,203	0.0%	1,908	0.5%
commander	15,025	0.1%	3,393	0.8%
whiteblotched	57,060	0.4%	4,188	1.0%
mud	13,690	0.1%	576	0.1%
Raja sp.	2,347	0.0%	0	0.0%
butterfly	0	0.0%	345	0.1%
Bathyraja total	12,633,171	98.7%	416,751	99.2%
Raja total	146,526	1.1%	3,445	0.8%

	AI			
	observed catch		survey biomass	
taxonomic grouping	t	%	t	%
Aleutian	47,422	4.8%	8,711	16.8%
Alaska	283,013	28.6%	3,663	7.0%
roughtail	1,942	0.2%	0	0.0%
skate unID	931	0.1%	13,245	25.5%
big	135	0.0%	640	1.2%
longnose	25	0.0%	0	0.0%
Bering	3,259	0.3%	56	0.1%
Bathyraja sp.	380,607	38.4%	0	0.0%
whitebrow	1,477	0.1%	0	0.0%
commander	21,644	2.2%	0	0.0%
whiteblotched	203,592	20.5%	24,179	46.5%
mud	46,836	4.7%	1,511	2.9%
Raja sp.	172	0.0%	0	0.0%
butterfly	35	0.0%	0	0.0%
Bathyraja total	989,827	99.9%	38,120	73.3%
Raja total	331	0.0%	640	1.2%

Figures

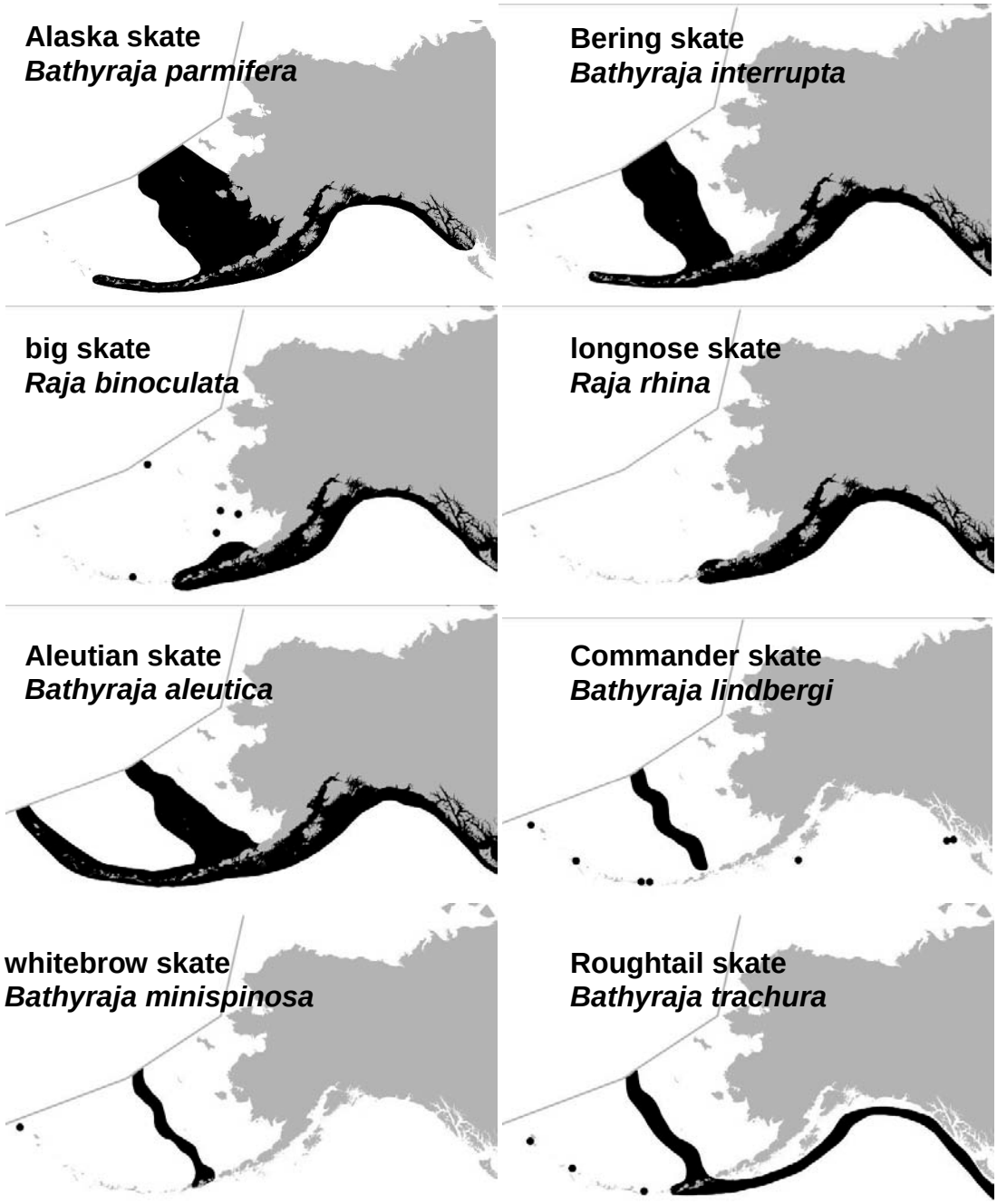


Figure 1. Distribution of skate species in Alaskan waters. These maps were created primarily using survey data, although observer records were included whenever positive species identification was possible (through voucher specimens or photographs). ***(Source: Stevenson et al. 2007)***

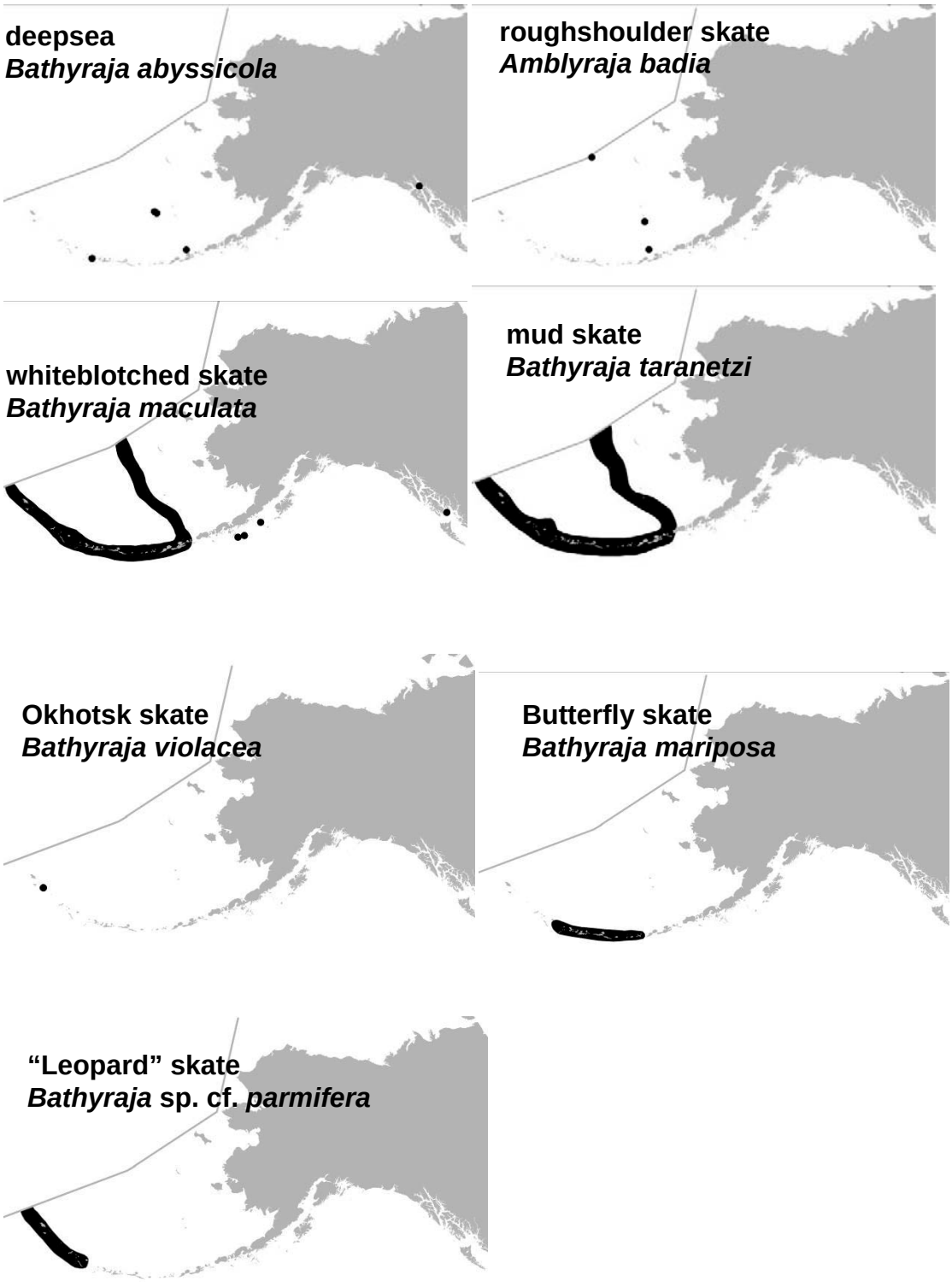


Figure 1 continued. Distribution of skate species in Alaskan waters. (Source: Stevenson et al. 2007)

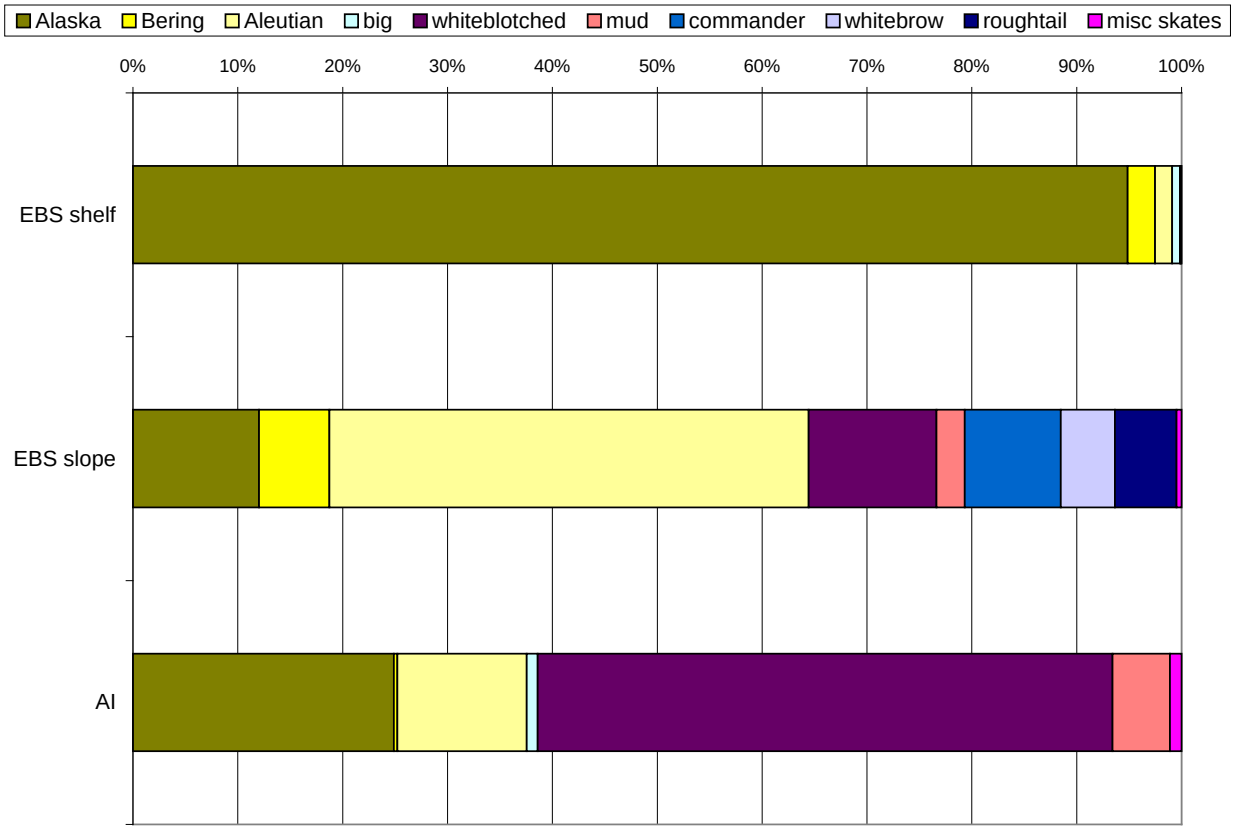
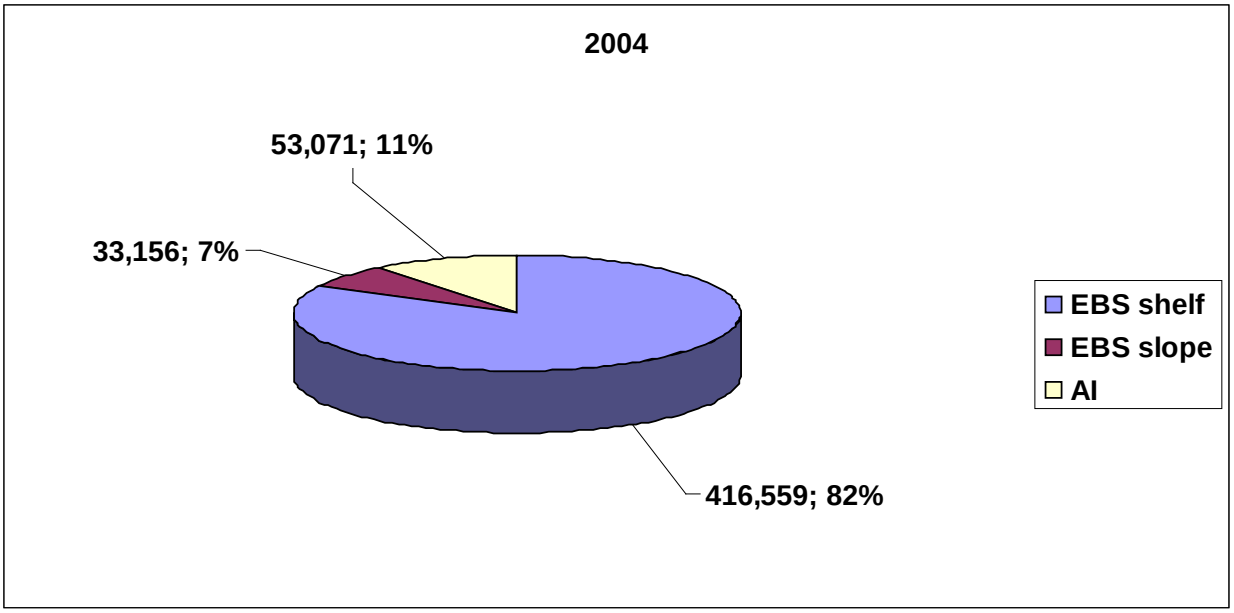


Figure 2. Skate species composition (by weight) by BSAI region, from surveys conducted in 2010. "Misc skates" contains longnose, deepsea, and unidentified skates.



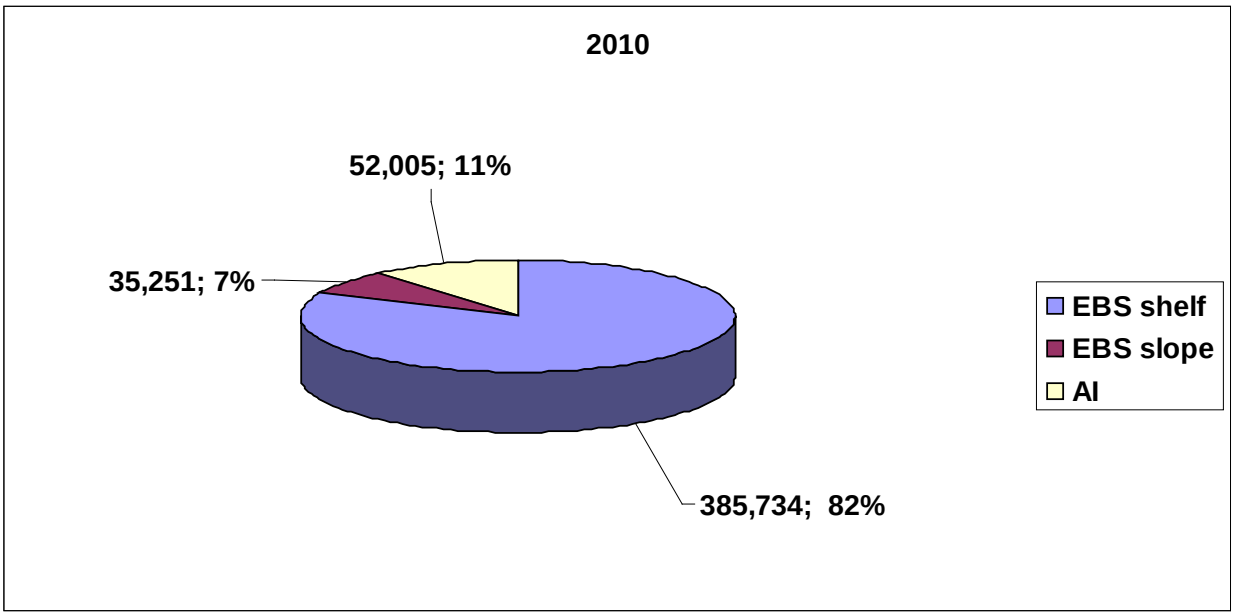


Figure 3. Distribution of skate biomass in the 3 subregions of the BSAI, 2004 and 2010. Data are biomass estimates from AFSC groundfish surveys.

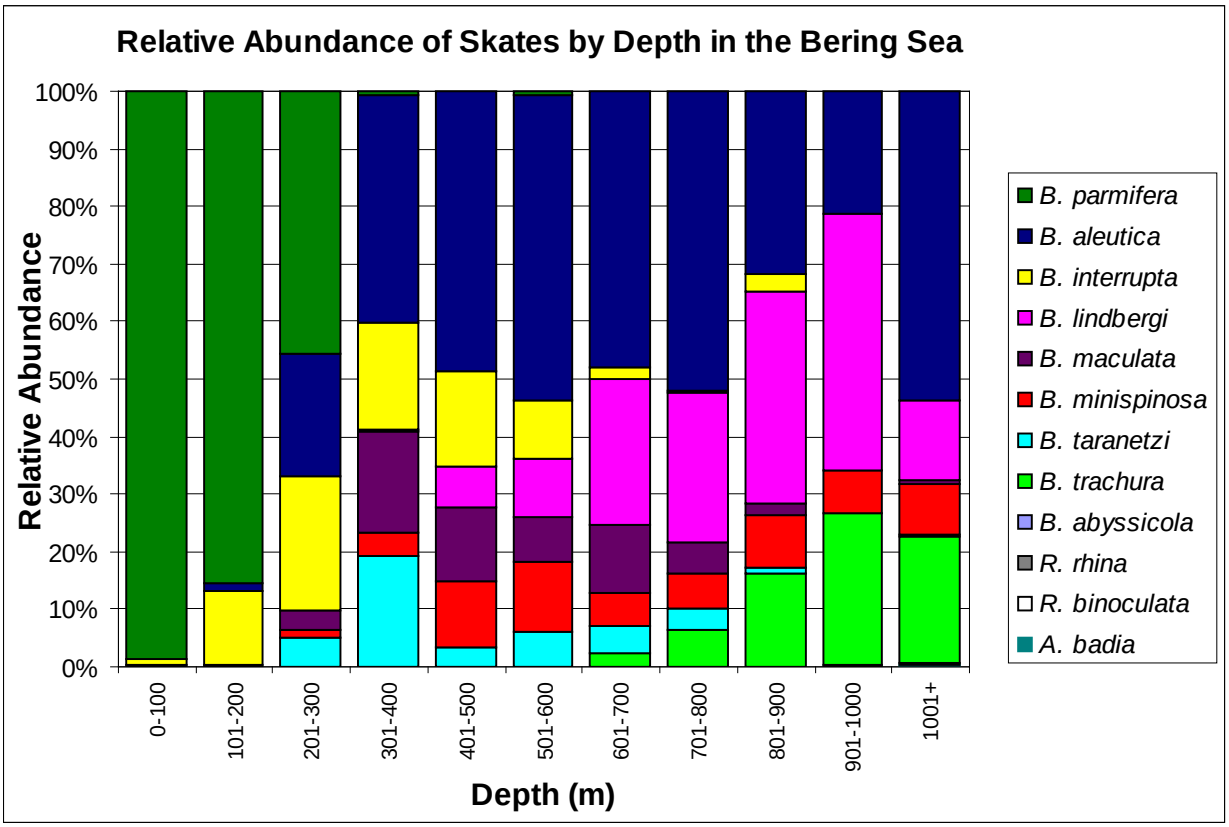


Figure 4. Relative abundance of skate species in the EBS by depth. (Source: Stevenson et al. 2006.)

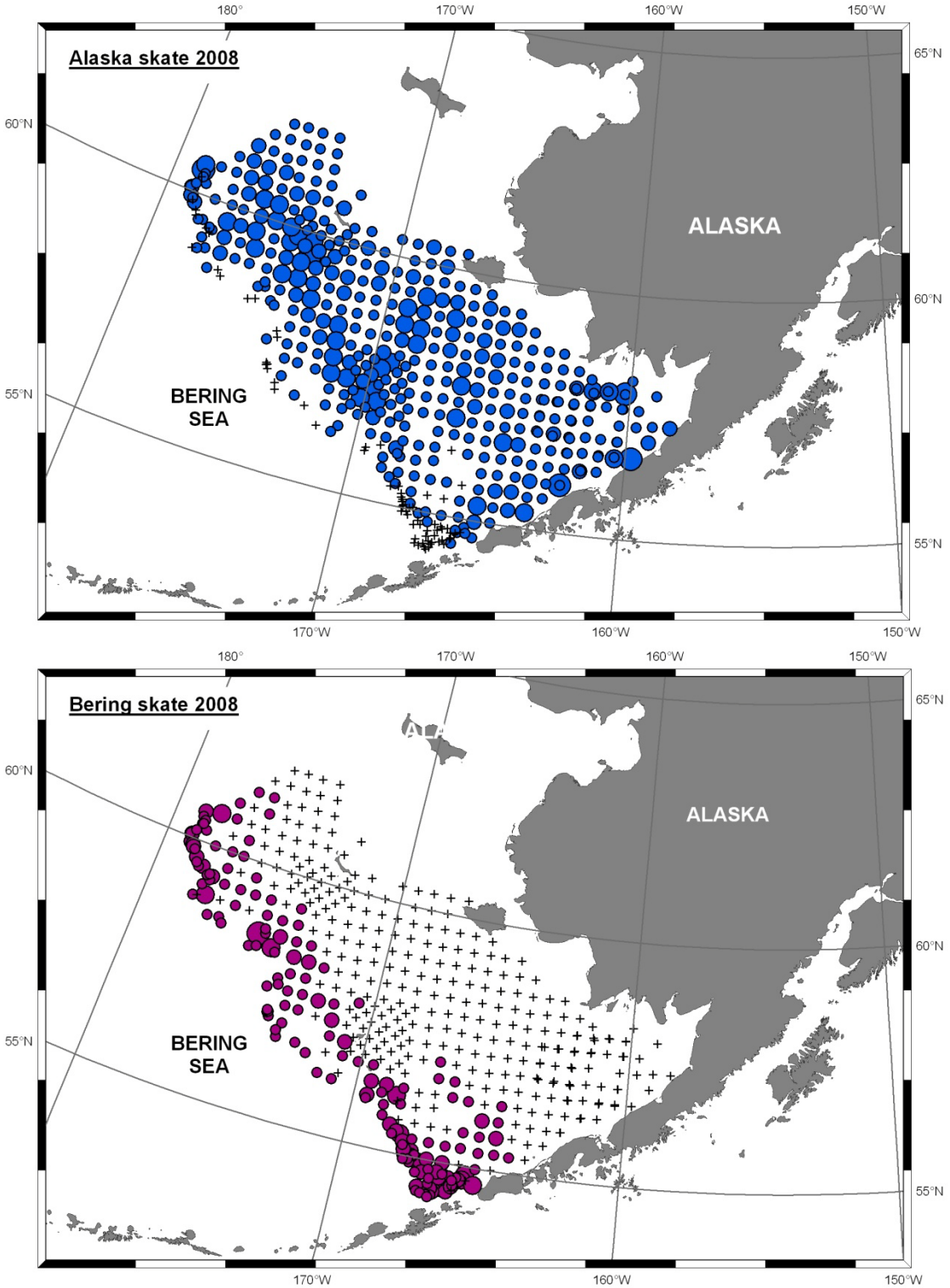


Figure 5. AFSC bottom trawl survey (shelf and slope) catches of Alaska and Bering skates in 2008. Symbol size is proportional to total catch at each survey station; crosses indicate no catch of that species at that station.

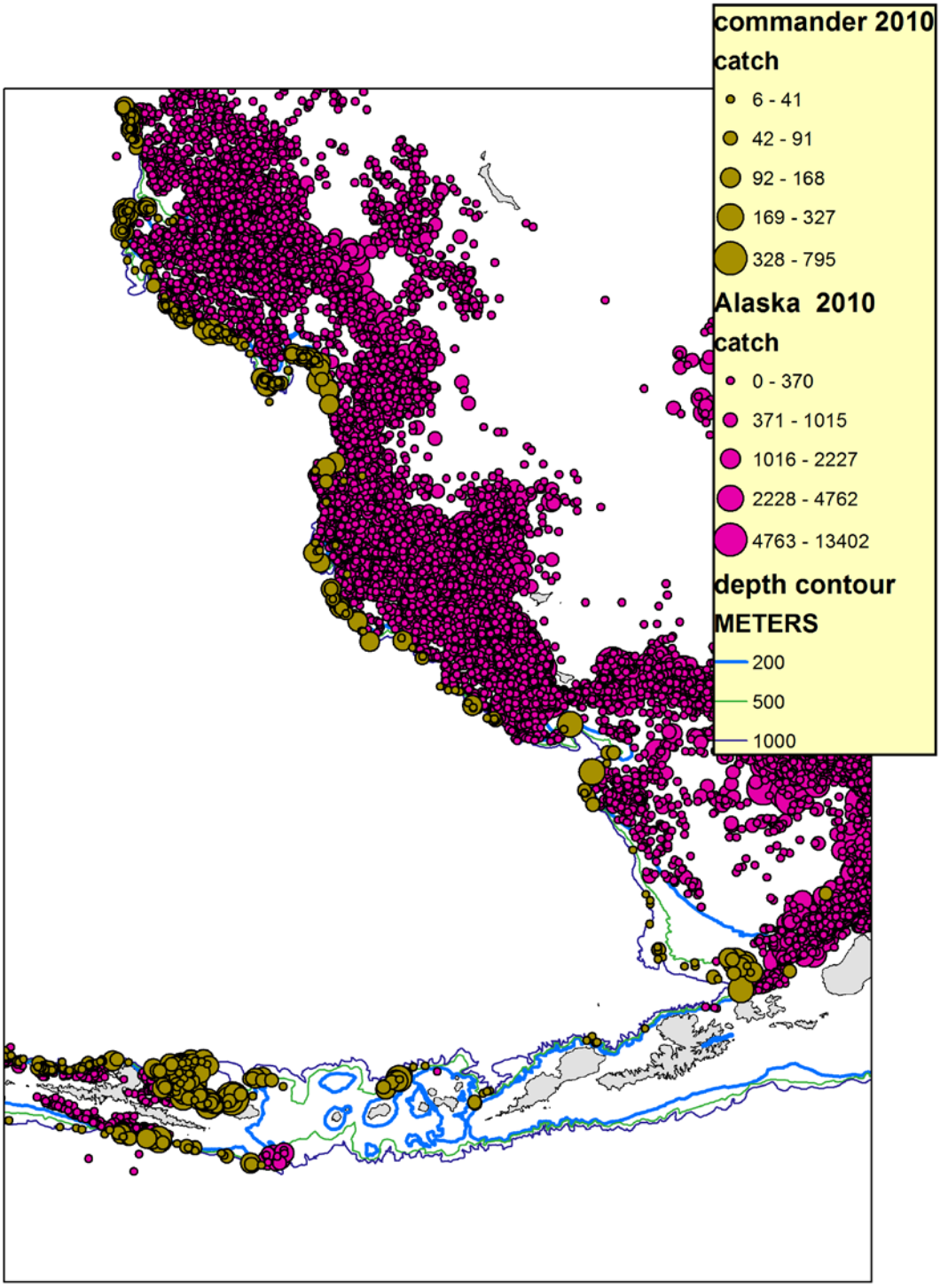


Figure 6. Distribution of catches of two skate species in the eastern Bering Sea and eastern Aleutian Islands in 2010.

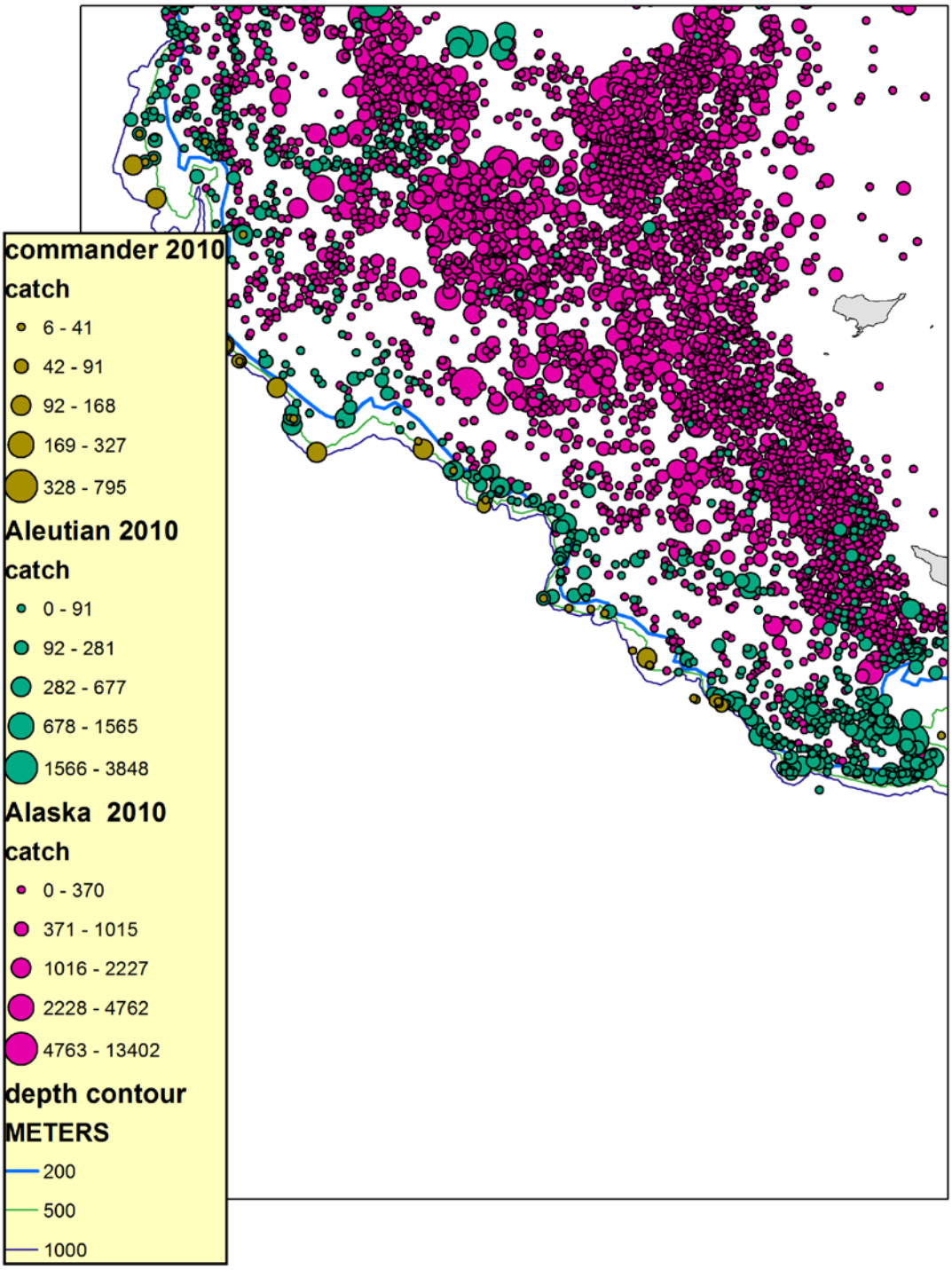


Figure 7. Distribution of catches of three skate species along the eastern Bering Sea slope in 2010.

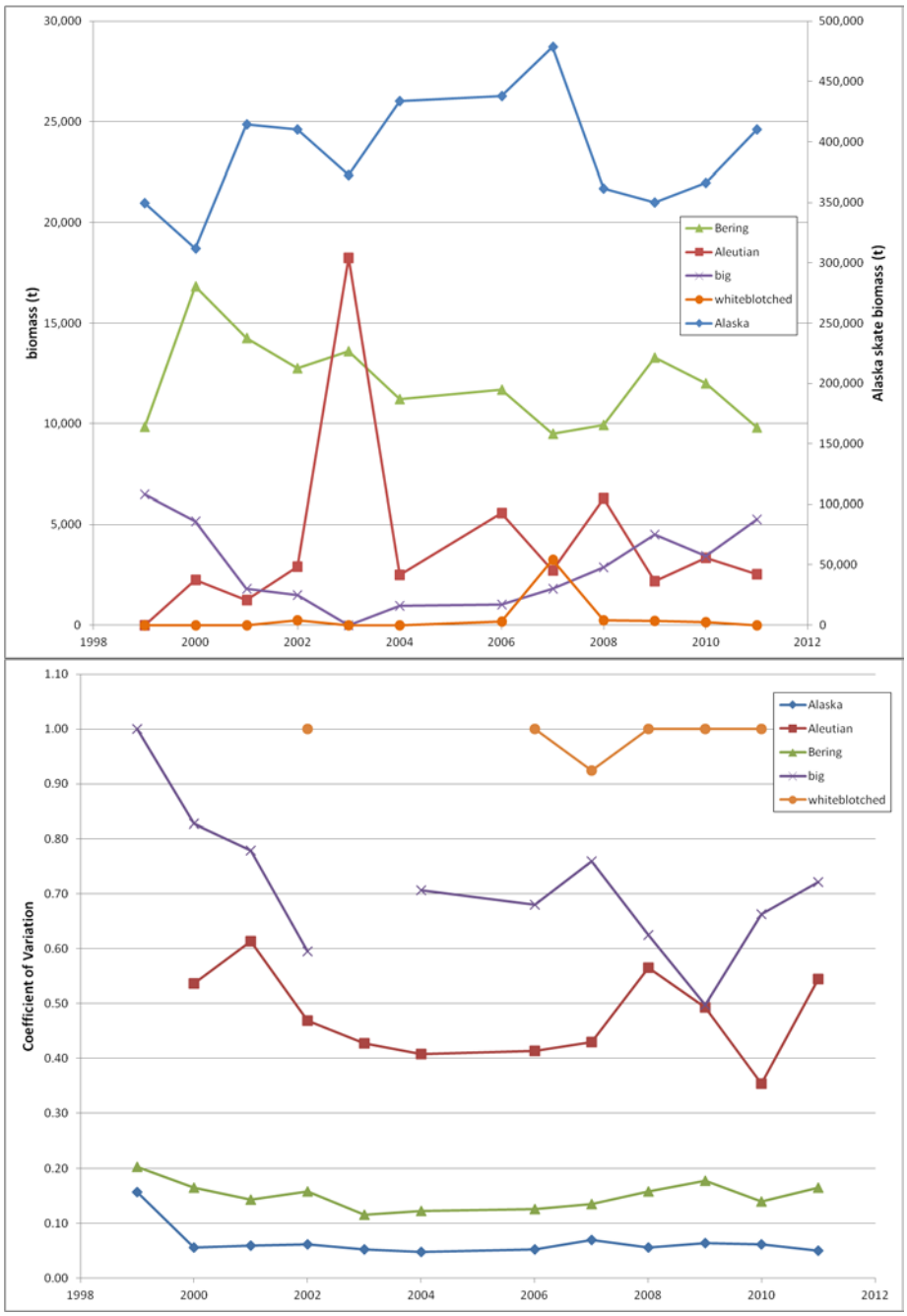


Figure 8. Timeseries of biomass estimates (upper panel) and coefficients of variability (lower panel) for the EBS shelf survey. Note that Alaska skate biomass is much higher than the rest and is on the secondary axis.

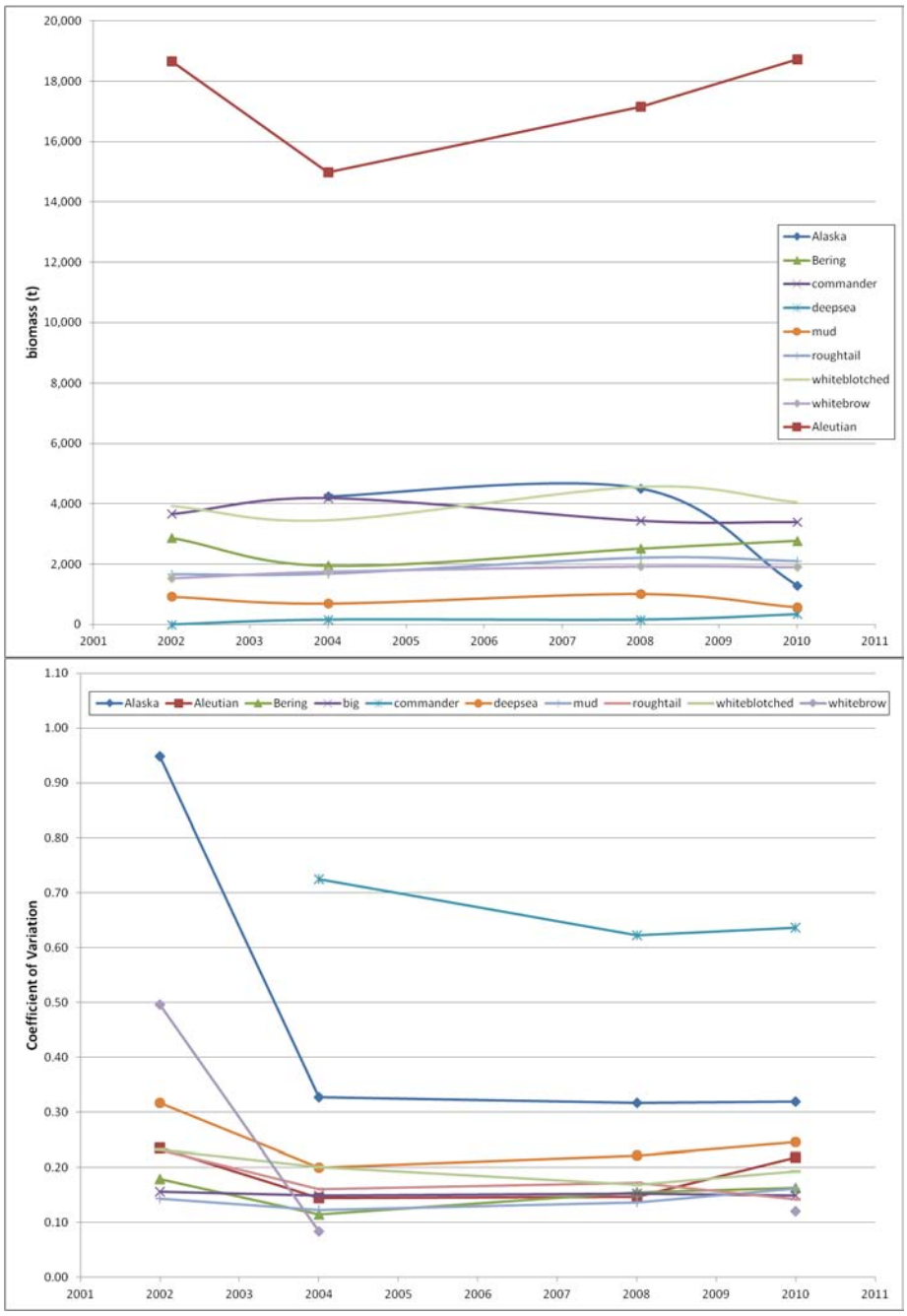


Figure 9. Timeseries of biomass estimates (upper panel) and coefficients of variation (lower panel) for the EBS slope survey.

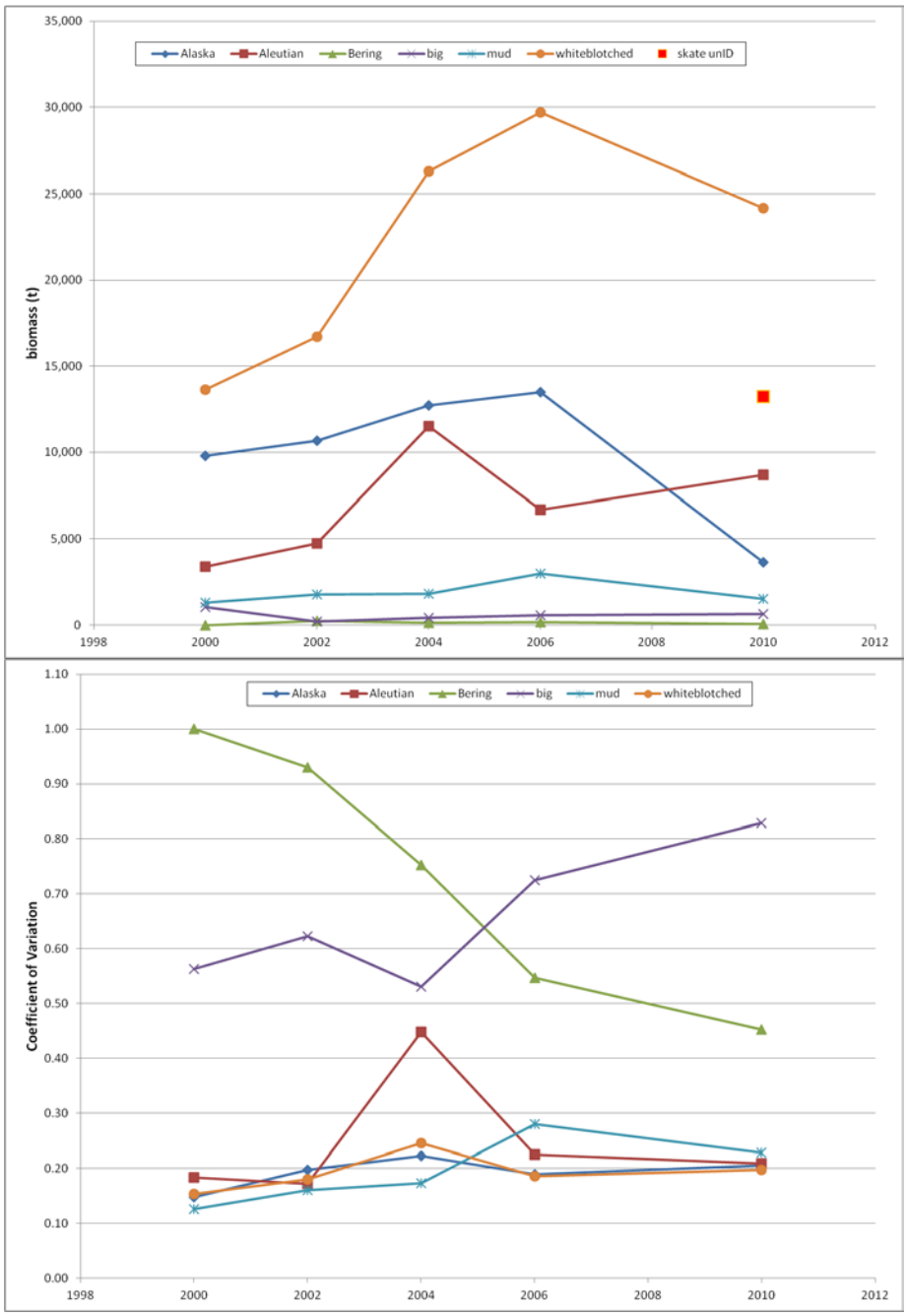


Figure 10. Timeseries of biomass estimates (upper panel) and coefficients of variation (lower panel) for the Aleutian Islands survey.

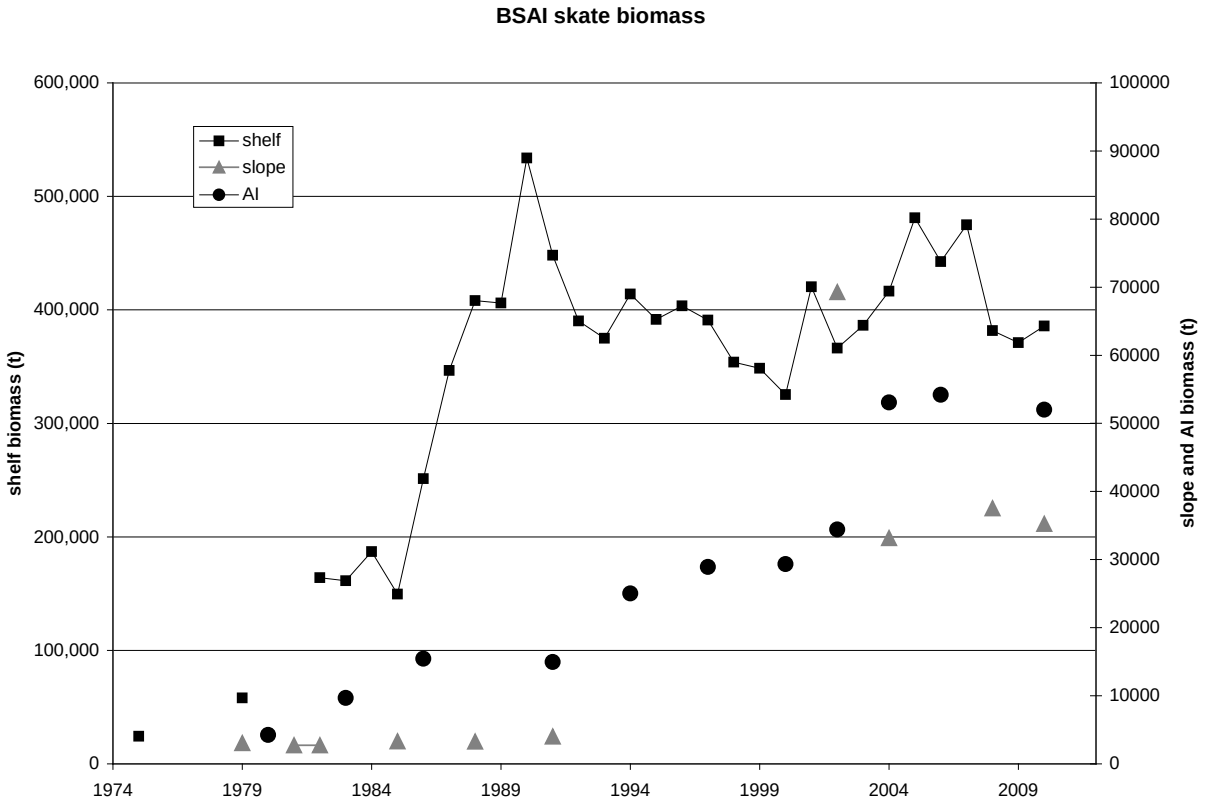


Figure 11. Aggregated skate biomass (metric tons) estimated from RACE bottom trawl surveys in each of the three major habitat areas (EBS shelf, EBS slope, and AI) from 1975 to 2010. Note that slope and AI estimates are much smaller and pertain to the secondary y-axis.