16.3. Bering Sea and Aleutian Islands Skates

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Executive Summary

Summary of Major Changes

Changes in the input data:

1. Total catch weight for BSAI skates is updated with 2004 and partial 2005 data.
2. Biomass estimates from the 2005 EBS shelf survey are incorporated.
3. Life history information has been updated with recent research results.
4. Information on the position of skates within the BSAI ecosystem and the potential ecosystem effects of skate removals are included.

Changes in assessment methodology:
This year, the assessment is formatted into a stand-alone sub-section of the BSAI Squid and Other species SAFE chapter using the required SAFE format for ease of reading and to support more effective management of BSAI skates.

Changes in assessment results:
This year, we recommend applying Tier 5 criteria to the EBS skate complex and the AI skate complex separately, using the default natural mortality rate of M=0.10 and the average of skate complex biomass estimates for each area using surveys since 1996 (past 10 years). Therefore, we recommend:
:

	EBS skates	**AI skates**
1996-2005 avg survey biomass (t)	455,881	36,392
M	0.10	0.10
ABC	34,191	2,729
OFL	45,588	3,639

The proposed FMP amendment to split the Other species complex into groups so that skates can be managed separately has not yet been implemented. Therefore, as in past years, these recommendations for Tier 5 management of BSAI skates are presented so that the BSAI Plan Team and NPFMC SSC can use this information combined with information for sharks, sculpins, and octopus to decide how best to manage the Other species complex in the interim.

Responses to SSC Comments

SSC comments specific to the BSAI Skates assessment: There were no specific BSAI skate comments.

SSC comments on assessments in general:
From the December, 2004 SSC minutes: *In its review of the SAFE chapter, the SSC noted that there is variation in the information presented. Several years ago, the SSC developed a list of items that should be included in the document. The SSC requests that stock assessment authors exert more effort to address each item contained in the list. Items contained in the list are considered critical to the SSC's ability to formulate advice to the Council. The SSC will review the contents of this list at its February meeting.*

This year, an Ecosystem Considerations section for BSAI skates was added to the assessment. All other required SAFE sections have been addressed as information permits for BSAI skates.

Introduction

Description, scientific names, and general distribution

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 (Figure 16.3-1). At least 15 species of skates in two genera, *Raja* and *Bathyraja*, are distributed throughout the eastern North Pacific and are common from shallow inshore waters to very deep benthic habitats (Eschmeyer et al., 1983). Table 16.3-1 lists the species found in the BSAI, some life history characteristics (which are outlined in more detail below), and the depth distribution of each skate species found in Alaska.

The species within this complex occupy different habitats and regions within the BSAI FMP area. In this assessment, we distinguish three habitat areas: the Eastern Bering Sea (EBS) shelf (0 to 200 m depth), the EBS slope (>200 m depth), and the Aleutian Islands (AI) region (all depths). The EBS shelf skate complex is dominated by a single species, the Alaska skate (*Bathyraja parmifera*) (Table 16.3-2). This species is distributed throughout the shelf (Figure 16.3-2). The Bering or sandpaper skate (*Bathyraja interrupta*) is the next most common species on the EBS shelf, and is distributed on the outer continental shelf (Figure 16.3-3). While skate biomass is somewhat lower on the EBS slope than on the shelf, skate diversity is substantially higher on the slope (Figure 16.3-4). Within the EBS, the Aleutian skate (*Bathyraja aleutica*) is found only on the outer EBS shelf (Figure 16.3-5), but it comprises the majority of the EBS slope skate biomass, with Bering and Alaska skates still quite common.

The skate complex in the AI is quite distinct from that described for both the EBS shelf and slope, with different species dominating the biomass, as well as at least one endemic skate species, the recently described *Bathyraja mariposa* (Stevenson et al 2004). In the AI, the most abundant species is the whiteblotched skate, *Bathyraja maculata*(Table 16.3-2). The whiteblotched skate is found primarily in the eastern Aleutians, and also very far out west (Figure 16.3-6). Aleutian skates are also common in the AI. The mud skate, *Bathyraja tanaretzi*, is relatively common in the AI but represents a lower proportion of total biomass because of its smaller size. We note that the common species formerly known as the Alaska skate in the Aleutians looks very different from the Alaska skate found on the EBS shelf (Figure 16.3-7); the Aleutian Islands type has been confirmed to be a separate species (J. Orr pers. comm.).

Management units

In the North Pacific, skate species are part of the “Other species” management category within the Bering Sea Aleutian Islands (BSAI) Fishery Management Plan (FMP). This means that their catch is reported in aggregate as “other” along with the catch of sharks, sculpins, and octopus. (Because catch is officially reported within the Other species complex, estimates of skate catch must be made independently for each year using observer data; see below.) In the BSAI, catch of other species is limited by a Total Allowable Catch (TAC) which is based on an Allowable Biological Catch (ABC) estimated by the NPFMC Scientific and Statistical Committee (SSC). Right now, skates are taken only as bycatch in fisheries directed at target species in the BSAI, so future catches of skates are more dependent on the distribution and limitations placed on target fisheries than on any harvest level established for this category. An FMP amendment was initiated by the NPFMC in 1999 to remove both skates and sharks from the Other species category to increase the level of management attention and control for these potentially vulnerable species groups; this action is still in the process of revision and review. In response to a developing fishery in the GOA, the GOA FMP was amended to remove skates from the other species category. FMP amendments are being proposed to split the Other species category into component groups in both the BSAI and GOA, and this assessment is written as a stand-alone skate assessment in support of this effort to improve Other species management.

Life history and stock structure (general)

Skate life cycles are similar to sharks, with relatively low fecundity, slow growth to large body sizes, and dependence of population stability on high survival rates of a few well developed offspring (Moyle and Cech 1996). Sharks and skates in general have been classified as "equilibrium" life history strategists (Winemiller and Rose 1992), with very low intrinsic rates of population increase implying that sustainable harvest is possible only at very low to moderate fishing mortality rates (King and McFarlane, 2003). Within this general equilibrium life history strategy, there can still be considerable variability between skate species in terms of life history parameters (Walker and Hislop, 1998). While smaller sized species have been observed to be somewhat more productive, large skate species with late maturation (11+ years) are most vulnerable to heavy fishing pressure (Walker and Hislop, 1998; Frisk et al 2001; Frisk et al 2002). The most extreme cases of overexploitation have been reported in the North Atlantic, where the "common" skate *Raja batis* has been extirpated from the Irish Sea (Brander, 1981) and much of the North Sea (Walker and Hislop, 1998) and the barndoor skate *Raja laevis* has disappeared from much of its range off New England (Casey and Myers, 1998). The mixture of life history traits between smaller and larger skate species has led to apparent population stability for the aggregated "skate" group in many areas where fisheries occur, and this combined with the common practice of managing skate species within aggregate complexes has masked the decline of individual skate species in European fisheries (Dulvy et al, 2000). Similarly, in the Atlantic off New England, declines in barndoor skate abundance were concurrent with an increase in the biomass of skates as a group (Sosebee, 1998).

Several recent studies have explored the effects of fishing on a variety of skate species in order to determine which life history traits might indicate the most effective management measures for each species. While full age structured modeling is difficult for many of these relatively information poor species, Leslie matrix models parameterized with information on fecundity, age/size at maturity, and longevity have been applied to identify the life stages most important to population stability. Major life stages include the egg stage, the juvenile stage, and the adult stage (summarized here based on Frisk et al 2002). All skate species are oviparous (egg-laying), investing considerably more energy per large, well protected embryo than most other commercially exploited groundfish. The large, leathery egg cases incubate for extended periods (months to a year) in benthic habitats, exposed to some level of predation and physical damage, until the fully formed juveniles hatch. The juvenile stage lasts from hatching through maturity, several years to over a decade depending on the species. The reproductive adult stage may last several more years to decades depending on the species.

Age and size at maturity and adult size/longevity appear to be more important predictors of resilience to fishing pressure than fecundity or egg survival in the skate populations studied to date. Frisk et al (2002) estimated that although annual fecundity per female may be on the order of less than 50 eggs per year (extremely low compared with teleost groundfish), there is relatively high survival of eggs due to the high parental investment, and therefore egg survival did not appear to be the most important life history stage contributing to population stability under fishing pressure. Juvenile survival appears to be most important to population stability for most North Sea species studied (Walker and Hislop, 1998), and for the small and intermediate sized skates from New England (Frisk et al 2002). For the large and long lived barndoor skates, adult survival was the most important contributor to population stability (Frisk et al 2002). Comparisons of length frequencies for surveyed North Sea skates from the mid and late 1900s led Walker and Hilsop (1998, p. 399) to the conclusion that after years of very heavy exploitation "all the breeding females, and a large majority of the juveniles, of *Raja batis*, *R. fullonica* and *R. clavata* have disappeared, whilst the other species have lost only the very largest individuals." Although juvenile and adult survival may have different importance by skate species, all studies found that one metric, adult size, reflected overall sensitivity to fishing. After modeling several New England skate populations, Frisk et al (2002, p. 582) found "a significant negative, nonlinear association between species total allowable mortality, and species maximum size." This may be an oversimplification of the potential response of skate populations to fishing; in reality it is the interaction of natural mortality, age at maturity, and the selectivity of fisheries which determines a given species sensitivity to fishing and therefore the total allowable mortality (ABC). While we strive to collect information on age at maturity, longevity, and size composition of catch for each skate species in the BSAI to apply it in future assessments, at present we are falling back on the general relationship of total mortality to total biomass (Tier 5), so Frisk's caution is warranted.

Life history and stock structure (Alaska-specific)
Currently there is little life history information available for skate species in the eastern North Pacific, but recent research results are changing this situation. Zeiner and Wolf (1993) determined age at maturity and maximum age for *Raja binoculata* and *R. rhina* from Monterey Bay, CA (estimates of maximum age for *R. binoculata* are 11 and 12 years, males and females respectively, and age at maturity 8-11 years; estimates of maximum age for *R. rhina* are 13 and 12 years, males and females respectively, and age at maturity 6-9 years.) However, these parameter values may not apply to Alaskan stocks. Preliminary results from age and growth research at AFSC suggest that maximum age for the longnose skate *Raja rhina* may be higher than that found by Zeiner and Wolf; in a sample of 127 individuals ages up to 17 years were observed (Gburski 2005 pers. comm.). In the same study, 146 big skates *Raja binoculata* were aged with the highest observed age being 13 years, closer to the results for California big skates. These results are reported in more detail in the GOA skate SAFE (Gaichas et al 2005).

Considerable research has been directed at skates in the Bering Sea over the past two years. Two graduate students at the University of Washington have begun projects detailing aspects of life history and population dynamics of several Bering Sea species. Beth Matta is conducting a study on the reproductive biology and age and growth of *Bathyraja parmifera*, the most common skate species on the eastern Bering Sea shelf. Life history aspects being examined in this project include maximum age, gonadosomatic index (GSI), instantaneous rate of natural mortality (M), maturity, and growth parameters.

Although this project is still in progress, preliminary results are now available. The observed maximum total length of *B. parmifera* was 113 cm for males and 122 cm for females (Table 16-10). Maturity stage was adapted from the definitions of Zeiner and Wolf (1993) and was easily determined at sea, then verified in the laboratory. Length at 50% maturity was estimated at approximately 90 cm for males and 95 cm for females (Table 16.3-1). Further parameter estimates and descriptions of reproductive biology will become available in the upcoming months, and it is expected that Matta's thesis work will be completed before the autumn of 2006.

Gerald Hoff is examining a complex of skates from the eastern Bering Sea slope in the genus *Bathyraja*. This research will investigate several potential skate nursery locations on the outer continental shelf of the southeastern Bering Sea, where fishery data suggests areas of heavy use by skates for the deposition of egg cases. The data collected will help define the habitat necessary for successful reproduction of eastern Bering Sea skates and add to the life history data needed for their stock assessment, conservation and management. Specifically, the study will help determine the diversity of species using the nursery areas, estimate the egg density, developmental state and duration, estimate female fecundity, describe habitat structure and biotic associations with egg cases, and evaluate non-skate species predatory interactions with skates in a nursery area. This study will has entailed a 10-day investigation aboard a chartered research vessel using bottom trawling as an investigative tool to develop a working hypothesis of what constitutes important habitat for skate reproduction and to characterize the skate population using the nursery area. In addition, four seasonal samplings were conducted between fall 2004 and spring 2005. The seasonal sampling is used to monitor the progression of the embryo development and skate reproductive state throughout the year to establish the temporal aspects of the nursery area use.

During the initial 10 day investigation, three species-specific skate nurseries were identified from the investigation including the Alaska skate *Bathyraja parmifera*, the Aleutian skate *B. aleutica*, and the Bering skate *B. interrupta*. Subsequent seasonal sampling was conducted at the *B. parmifera* and *B.*

aleutica sites approximately once every 60 days throughout the following year. Sampling was successful during each attempt at both nursery sites and was conducted during September 2004, November 2004, January 2005, April 2005, June 2005, and July 2005. Seasonal sampling included collecting skate egg cases from each of the two sites to determine the progress of embryo development since the July-August 10-day sampling; and to determine the reproductive status of mature skates utilizing the nursery area. In addition, predatory species were examined for evidence of predation on newly hatched skates.

Biological and physical parameters that may be important in defining skate nursery locations may be correlated with being located in highly biologically productive areas of the ocean. All three nursery were located near the shelf slope interface where highly productive areas can exist due to nutrient upwelling from deeper slope waters. Biomass levels of many large fish species and invertebrates were quite high in the nursery areas during this sampling and this increased biomass may provide a needed food source for large bodied fish species such as skates during the long reproductive cycles of several months that confine them to a single location.

The *B. parmifera* site showed clear seasonality trends as to the timing of egg deposition and hatching events. Both summer and winter proved to be highly productive times for new egg deposition as well as for hatching events. Seasonal trends showed large mass movement into the nursery sites during these times when compared to other sampling periods. Results of cohort analysis suggest that that summer and winter are also the peaks of newly deposited eggs and hatching events. Although there appears to be low level egg deposition throughout the year, evidence from gravid females present at every sampling period, there appears to be two peak periods of deposition. In addition at any given time there are multiple cohorts present in various states of development, resulting in constant hatching and egg deposition throughout the year. In general embryos developed for a year before hatching and once hatched the juveniles appeared to moved out of the nursery area very quickly.

Sources of mortality were evident to skates in the nursery site during this study. Newly deposited egg cases were vulnerable to predation by a snail species which drills holes in the egg case and feeds on the large yolk inside. Predation rates were as high as 13% for *Bathyraja parmifera* eggs and eggs were most likely preyed upon shortly after deposition, before embryo development. A second source of mortality was evident post-hatching from large picivorous fishes. The Pacific halibut *Hippoglossus stenolepis* and the Pacific cod, *Gadus macrocephalus* utilized newly hatched skates as prey items during this study. Data from both species corroborated the seasonality aspect of summer and winter hatching events as the predation levels rose during these seasons. This research is ongoing. We expect to incorporate the results of this research within the BSAI skate stock assessment as information becomes available.

Fishery

Directed fishery

In the BSAI, there is no directed fishery for skates at present; however, skates support directed fisheries in other parts of the world (Agnew et al 1999, NE stock assessment 1999, Martin and Zorzi 1993). A directed skate fishery developed in the Gulf of Alaska in 2003 (Gaichas et al, 2003). There has been interest in developing markets for skates in Alaska (J. Bang and S. Bolton, Alaska Fishworks Inc., 11 March 2002 personal communication), and the resource was economically valuable to the GOA participants in 2003, although the price apparently dropped in 2004. Nevertheless, we should expect continued interest in skates as a potential future target fishery in the BSAI as well as in the GOA.

Bycatch and discards

Skates constitute the bulk of the Other species FMP category catches, accounting for between 51% and 76% of the estimated totals in 1992-2005 (Table 16.3-3). While skates are caught in almost all fisheries and areas of the Bering Sea shelf, most of the skate bycatch is in the hook and line fishery for Pacific cod, with trawl fisheries for pollock, rock sole and yellowfin sole also catching significant amounts (Tables

16.3-4 and 16.3-5). (In this assessment, "bycatch" means incidental or unintentional catch regardless of the disposition of catch-it can be either retained or discarded. We do not use the Magnuson Act definition of "bycatch," which always implies discard.) When caught as bycatch, skates may be discarded (and may survive depending upon catch handling practices) although skates caught incidentally are sometimes retained and processed. Now that there is a market for skates in Alaska (see above), it is difficult to determine whether all retained skate catch was incidentally caught.

Until 2004, the Other species TAC has never been exceeded in the BSAI with the current composition of the category. In 2004, the BSAI open access TAC of 23,124 t was exceeded as of October 23, so all other species, including skates, were put on prohibited status (meaning no further retention is allowed, but catch and discard can continue up to the other species OFL of 81,150 t). In addition, the Other species CDQ reserve of 2,040 t was also exceeded as of November 4, 2004. We note that the TAC of other species was reduced from the ABC recommended by the SSC in December 2003, likely to keep the total catch of groundfish in compliance with the BSAI Optimum Yield (OY) cap of 2 million metric tons (Table 16.3-3). However, if interest continues in developing fisheries within this category, the lower aggregate TAC may restrict retention and utilization of the more valuable components of the other species category (skates and octopus).

Historically, skates were almost always recorded as "skate unidentified", with very few exceptions between 1990 and 2002. However, due to improvements in species identification by fishery observers initiated by Dr. Duane Stevenson within the Observer program in 2003, we can estimate the species composition of observed skate catches in 2004 and 2005 (Figure 16.3-8). Recent observer data indicates that only about 60% of skate catch is now unidentified. This is largely because many skates are caught in longline fisheries, and if the animal drops off the longline as unretained incedental catch, it cannot be identified by the observer (approximately 80% of longline-caught skates were unidentified, and longline catch accounted for almost 75% of observed skate catch). In 2005, observers were encouraged to identify skates dropped off longlines to genus (which can be done without retaining the skate); hence in 2005 nearly half of the unidentified skates were at least assigned to the genus *Bathyraja* (or “Soft nosed skates” in Figure 16.3-8). Of the identified skates, the majority were Alaska skates, *B parmifera*, as would be expected by their dominance of the overall skate biomass in the BSAI. The next most commonly identified BSAI-wide were Aleutian, *B. aleutica*, at 5.5% of identified catch, followed by whiteblotched (*B. maculata*) and Bering (*B. interrupta*) skates at approximately 3% each across the BSAI. When viewed by area (EBS vs AI), it is clear that the majority of Aleutian and whiteblotched skates are caught in AI fisheries, and that the species composition of the catch in the AI is very different from the EBS (Figure 16.3-8).

These observed catches of Bering, Aleutian, and whiteblotched skates for 2004-2005 are higher than would be expected if they were taken in proportion to the overall BSAI biomass distribution of skate species, which is overwhelmingly dominated by Alaska skate biomass from the EBS shelf. The observed skate catches reflect differences in fishery distribution and therefore incidental catch by area. Longline fisheries targeting Pacific cod take much of the incidental skate bycatch, and they tend to operate on the outer EBS shelf and slope where skate species diversity is high and where Aleutian skates are more prevalent than the Alaska skates. Furthermore, fisheries concentrating in the AI take a high proportion of whiteblotched and Aleutian skates, which are more common there than Alaska skates. This observed catch distribution argues against managing skates as a BSAI wide complex based on the total biomass in the FMP area.

Survey Data

<u>Survey biomass in aggregate and by species</u>

The biomass of all skate species combined has shown an increasing trend from 1975-2004 (Table 16.3-6). Because skates as a group are found in nearly all habitats, the uncertainty (measured as the coefficient of variation, CV) in these aggregate biomass estimates is rather low, but that for individual species is more variable (see Table 16.3-2). Unfortunately, due to taxonomic uncertainty, we cannot evaluate individual species trends within the complex for surveys prior to 2000. Recent survey information is used to describe the variable species composition of the skate complex within each of three areas, the EBS shelf, the EBS slope, and the Aleutian Islands. The EBS shelf skate complex is dominated by a single species, the Alaska skate (*B. parmifera*) (Table 16.3-2). This species is distributed throughout the shelf (Figure 16.3-2), and accounts for about 91% of the aggregate skate biomass estimated in 1999. The Bering or sandpaper skate (B. *interrupta*) was the next most common species on the EBS shelf, making up about 6% of aggregate skate biomass. It is distributed on the outer continental shelf (Figure 16.3-3). While skate biomass decreases somewhat on the EBS slope, skate diversity increases substantially (Figure 16.3-4). The Aleutian skate (*B. aleutica*) is found only on the outer EBS shelf (Figure 16.3-5), but it comprises the majority of the EBS slope skate biomass, with Bering and Alaska skates still quite common. The skate community in the AI appears to be different from that described for both the EBS shelf and slope (Figure 16.3-6). In the AI, the most abundant species is the whiteblotched skate, *B. maculata* (45% of aggregate biomass). The whiteblotched skate is found primarily in the eastern Aleutians, and also very far out west (Figure 16.3-6). Alaska and Aleutian skates are also common, composing about 30% and 15% of aggregate biomass, respectively. The mud skate, *B. tanaretzi*, is relatively common but represents a lower proportion of total biomass (~3%) because it is a smaller skate.

Analytic Approach, Model Evaluation, and Results

At present, the available data do not support population modeling for skates in the BSAI, so none of these stock assessment sections are relevant, except for one:

Parameters Estimated Independently: M
An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for skate species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Rikhter and Efanov 1976, Roff 1986). No information was available for any skate stocks in the BSAI FMP area, so M was estimated using the methods as applied to data for California big skate (*Raja binoculata*) and longnose skate (*R. rhina*), which are found in the GOA but are rare in the BSAI. Considering the uncertainty inherent in applying this method to skate species and stocks not found in the BSAI, we elected to use the lowest estimates of M derived from any of these methods (M=0.10, Table 16-14). Choosing the lowest estimate of M is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5. Until we find better information on skate productivity in the BSAI, this is the best interim measure balancing skate conservation and allowing for historical levels of incidental catch in target groundfish fisheries.

Preliminary estimates of maximum age for the Alaska skate (*Bathyraja parmifera*) are17 years for males and 19 years for females (Table 16-10). However, care should be taken in applying these data to estimates of M, as the age estimates have not yet been validated and are based on a relatively low sample size. More accurate estimates of maximum age will become available in early 2006. We will explore estimating M based on species specific maximum age when these studies are complete.

Assemblage analysis and recommendations
Because skates represent a potentially valuable fishery resource as well as a potentially sensitive species group, we recommend that they be managed separately from the Other species complex. There is a reliable biomass time series for the skate complex as a whole in both the EBS and AI, and recently there are also reliable estimates of biomass for each species within the complex.

We further recommend splitting the BSAI skate complex into EBS (shelf and slope combined) and AI management assemblages to account for different species complexes in each area, and to provide increased protection to the endemic skates in the AI. We have shown that the distribution of species differs greatly by areas within the BSAI, and that overall catch is not necessarily in proportion to BSAI-wide biomass due to the distribution of fishing effort. Managing the skate complexes separately between the EBS and AI represents a reasonable compromise which increases protection to the complexes within each ecosystem but maintains a level of management simplicity appropriate to nontarget species complexes. In the event that target fisheries develop for individual skate species in the EBS or AI, we would recommend that target skate species be separated from the complex and managed individually, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specific estimates of productivity.

Projections and Harvest Alternatives

Acceptable Biological Catch and Overfishing Limit

We continue to recommend a Tier 5 approach be applied to the skate complex in each ecosystem if the catch remains incidental and no target fishery develops. Tier 5 is recommended because a reliable estimate of biomass exists for the complex, and the M =0.10 is considered a reasonable approximation of "aggregate skate" M by the Plan Team and SSC. We note that the proxy M was applied to all species although it was based on the most sensitive skate species, so it is more likely an underestimate of M for less sensitive species which results in conservative specifications. Tier 6 is not recommended because the catch history for skates is not considered reliable (reported as "Other"), and average catch for untargeted species is likely to constrain target fisheries if used to specify harvest limits. For the Tier 5 estimate, we recommend using a 10 year average of aggregate skate biomass so that we may include multiple estimates from each of the EBS shelf and slope, and AI bottom trawl surveys, but capture recent biomass levels.

Survey Year	EBS shelf	EBS slope	AI
1996	423,913		
1997	393,716		28,902
1998	354,188		
1999	370,543		
2000	325,292		29,206
2001	419,678		
2002	410,573	69,275	34,412
2003	386,339		
2004	427,713	33,182	53,047
2005	534,569		
average	404,652	51,229	36,392

EBS skate complex ABC

Applying the M estimate of 0.10 to the 10 year average of bottom trawl survey biomass estimates, we calculate an ABC of 0.75 * 0.10 * (EBS shelf biomass of 404,652 t + EBS slope biomass of 51,229 t) = 34,191 t.

EBS skate complex OFL

Using the same method to calculate OFL, 0.10 * (EBS shelf biomass of 404,652 t + EBS slope biomass of 51,229 t) = 45,558 t.

<u>AI skate complex ABC</u>
Applying the M estimate of 0.10 to the 10 year average of bottom trawl survey biomass estimates, we calculate an ABC of 0.75 * 0.10 * (AI biomass of 36,392 t) = 2,729 t.

<u>AI skate complex OFL</u>
Using the same method to calculate OFL, 0.10 * (AI biomass of 36,392 t) = 3,639 t.

Ecosystem Considerations

This section focuses on the Alaska skate (*B. parmifera*) in both the EBS and AI, with all other species found in each area summarized within in the group “Other skates.” We also include supplemental information on the other biomass dominant species in the AI, the Aleutian (*B. aleutica*) and whiteblotched (*B. maculata*) skates. This level of aggregation is necessary due to current data constraints, but improved species specific information will be incorporated as it becomes available.

Skates are predators in the BSAI FMP area, but some species are piscivorous while others specialize in benthic invertebrates (Table 16.3-1). Each skate species would occupy a slightly different position in EBS and AI food webs based upon its feeding habits, but in general skates as a group are predators at a relatively high trophic level. For simplicity, we show the food webs for all skate species combined in each system (Figure 16.3-9; EBS in upper panel, AI in lower panel). In the EBS food web, the skate biomass and therefore the general skate food web position is dominated by the Alaska skate, which eats primarily pollock (as do most other piscivorous animals in the EBS). The food web indicates that aside from sperm whales, most of the “predators” of EBS skates are fisheries, and that cod and halibut are both predators and prey of skates. The AI food web shows skates with different predators and prey than in the EBS, but still at the same moderately high trophic level. Relative to EBS skates, AI skates display more diet diversity (because the species complex is more diverse than in the Alaska skate-dominated EBS), and have more non-fishery predators including sharks and sea lions. These food webs were derived from mass balance ecosystem models assembling information on the food habits, biomass, productivity and consumption for all major living components in each system (Aydin et al in review).

The density and mortality patterns for skates also differ greatly between the EBS and AI ecosystems. The biomass density of Alaska skates is much higher in the EBS than in the AI (Figure 16.3-10 upper left panel) and we now know they are likely separate species between the areas as well. The density of Alaska skates in the EBS also far exceeds that of all other *Bathyraja* species in any area (Figure 16.3-10 upper right panel), but the density of other *Bathyraja* skates is highest in the AI. One simple way to evaluate ecosystem (predation) effects relative to fishing effects is to measure the proportions of overall mortality attributable to each source. The lower panels of Figure 16.3-10 distinguish predation from fishing mortality, and further distinguish these measured sources of mortality from sources that are not explained within the ecosystem models, which are based on early 1990’s fishing and food habits information. While there are many uncertainties in estimating these mortality rates, the results suggest that (early 1990s) fishing mortality exceeded predation mortality for Alaska skates and for other skates in the EBS and AI (and for other skates in the GOA as well). Furthermore, predation mortality appeared to be higher for AI skates than for EBS skates, both for Alaska and other skate species in the early 1990s, suggesting that skates experience higher overall mortality in the AI relative to the EBS. One source of uncertainty in these results is that all skate species in all areas were assumed to have the same total mortality rate, which is an oversimplification, but one which is consistent with the assumptions regarding natural mortality rate (the same for all skate species) in this stock assessment. We expect to improve on these default assumptions as data on productivity and catch for the skate species in each area continues to improve.

In terms of annual tons removed, it is instructive to compare fishery catches with predator consumption of skates. We estimate that fisheries were annually removing about 13,000 and 1,000 tons of skates from the EBS and AI, respectively on average during the early 1990's (Fritz 1996, 1997). While estimates of predator consumption of skates are perhaps more uncertain than catch estimates, the ecosystem models incorporate uncertainty in partitioning estimated consumption of skates between their major predators in each system. The predators with the highest overall consumption of Alaska skates in the EBS are sperm whales, which account for less than 2% of total skate mortality and consumed between 500 and 2,500 tons of skates annually in the early 1990s. Consumption of EBS Alaska skates by Pacific halibut and cod are too small to be reliably estimated (Figure 16.3-11, left panels). Similarly, sperm whales account for less than 2% of other skate mortality in the EBS, but are still the primary predator of other skates there, consuming an estimated 50 to 400 tons annually. Pacific halibut consume very small amounts of other skates in the EBS, according to early 1990s information integrated in ecosystem models (Figure 16.3-11, right panels). The predators with the highest consumption of Alaska skates in the AI are also sperm whales, which account for less than 2% of total skate mortality and consumed between 20 and 120 tons of skates annually in the early 1990s. Pinnipeds (Steller sea lions) and sharks also contributed to Alaska skate mortality in the AI, averaging less than 50 tons annually (Figure 16.3-12, left panels). Similarly, sperm whales account for less than 2% of other skate mortality in the AI, but are still the primary predator of other skates there, consuming an estimated 20 to 150 tons annually. Pinnipeds and sharks consume very small amounts of other skates in the AI, according to early 1990s information (Figure 16.3-12, right panels).

Diets of skates are derived from food habits collections taken in conjunction with EBS and AI trawl surveys. Skate food habits information is more complete for the EBS than for the AI, but we present the best available data for both systems here. Over 40% of EBS Alaska skate diet measured in the early 1990s was adult pollock, and another 15% of the diet was fishery offal, suggesting that Alaska skates are opportunistic piscivores (Figure 16.3-13, upper left panel). Eelpouts, rock soles, sandlance, arrowtooth flounder, salmon, and sculpins made up another 25-30% of Alaska skates' diet, and invertebrate prey made up the remainder of their diet. This diet composition combined with estimated consumption rates and the high biomass of Alaska skates in the EBS results in an annual consumption estimate of 200,000 to 350,000 tons of pollock annually (Figure 16.3-13, lower left panel). EBS other skates also consume pollock (45% of combined diets), but their lower biomass results in consumption estimates ranging from 20,000 to 70,000 tons of pollock annually (Figure 16.3-13, right panels). Other skates tend to consume more invertebrates than Alaska skates in the EBS, so estimates of benthic epifaunal consumption due to other skates range up to 50,000 tons annually, which higher than those for Alaska skates despite the disparity in biomass between the groups (Figure 16.3-13, lower panels). Because Alaska skates and all other skates are distributed differently in the EBS, with Alaska skates dominating the shallow shelf areas and the more diverse species complex located on the outer shelf and slope, we might expect different ecosystem relationships for skates in these habitats based on different food habits for the species. Similarly, in the AI the unique skate complex has different diet compositions and consumption estimates from those estimated for EBS skates. The skate formerly known as Alaska skate in the AI, like its EBS relative, is opportunistically piscivorous, feeding on the common commercial forage fish, Atka mackerel (65% of diet) and pollock (14% of diet), as well as fishery offal (7% of diet; Figure 16.3-14 upper left panel). Diets of other skates in the AI are more dominated by benthic invertebrates, especially shrimp (pandalid and non-pandalid total 42% of diet), but include more pelagic prey such as juvenile pollock, adult Atka mackerel, adult pollock and squids (totaling 45% of diet; Figure 16.3-14 upper right panel). Estimated annual consumption of Atka mackerel by AI (former) Alaska skates in the early 1990s ranged from 7,000 to 15,000 tons, while pollock consumption was below 5,000 tons (Figure 16.3-14 lower left panel). Shrimp consumption by AI other skates was estimated to range from 4,000 to 15,000 tons annually in the early 1990s, and consumption of pollock ranged from 2,000 to 10,000 tons (Figure 16.3-14 lower right panel). Atka mackerel consumption by AI other skates was estimated to be below 5,000 tons annually. The diet composition estimated for AI other skates is likely dominated by the biomass dominant species in that system, whiteblotched skate and Aleutian skate. We include summaries of the limited food habits data for these important AI species in Figure 16.3-5, and hope to improve these diet compositions in the future to make separate consumption estimates for whiteblotched and Aleutian skates along with (former) Alaska skates in the AI.

Examining the trophic relationships of EBS and AI skates provides a context for assessing fishery interactions beyond the direct effect of bycatch mortality. In both areas, the biomass dominant species of skates feed on commercially important fish species, so it is important for fisheries management to maintain the health of pollock and Atka mackerel stocks in particular to maintain the forage base for skates (as well as for other predators and for human commercial interests). Because skates are at a relatively high trophic level in both systems, predation mortality is less significant than fishing mortality. Therefore, the assessment of skate population dynamics and response to fishing should be continued and improved as fishing represents the largest explained source of mortality in the EBS and AI (especially since this mortality is not from targeted fishing, but from incidental catch).

Data gaps and research priorities

Because fishing mortality appears to be a larger proportion of skate mortality in the EBS and AI than predation mortality, highest priority research should continue to focus on direct fishing effects on skate populations. The most important component of this research is to fully evaluate the productive capacity of skate populations, including information on age and growth, maturity, fecundity, and habitat associations. All of this research has been initiated for major skate species in the EBS and AI; it should be fully funded to completion.

Although predation appears less important than fishing mortality on adult skates, juvenile skates and skate egg cases are likely much more vulnerable to predation. This effect has not been evaluated in population or ecosystem models. We expect to learn more about the effects of predation on skates, especially as juveniles, with the completion of Jerry Hoff's research on skate nursery areas.

Skate habitat is only beginning to be described in detail. Adults appear capable of significant mobility in response to general habitat changes, but any effects on the small scale nursery habitats crucial to reproduction could have disproportionate population effects. Eggs are limited to isolated nursery grounds and juveniles use different habitats than adults. Changes in these habitats have not been monitored historically, so assessments of habitat quality and its trends are not currently available. We recommend continued study on skate nursery areas to evaluate importance to population production.

We do not see any conflict at present between commercial fishing and skate foraging on pollock or atka mackerel, but we do recommend continued monitoring of skate populations and food habits at appropriate spatial scales to ensure that these trophic relationships remain intact as fishing for these commercial forage species continues and evolves.

Ecosystem Effects on Stock and Fishery Effects on the Ecosystem: Summary

In the following table, we summarize ecosystem considerations for BSAI skates and the entire groundfish fishery where they are caught incidentally. Because there is no “skate fishery” in the EBS or AI at present, we attempt to evaluate the ecosystem effects of skate bycatch from the combined groundfish fisheries operating in these areas in the second portion of the summary table. The observation column represents the best attempt to summarize the past, present, and foreseeable future trends. The interpretation column provides details on how ecosystem trends might affect the stock (ecosystem effects on the stock) or how the fishery trend affects the ecosystem (fishery effects on the ecosystem). The evaluation column indicates whether the trend is of: *no concern, probably no concern, possible concern, definite concern,* or *unknown.*

Ecosystem effects on BSAI Skates *(evaluating level of concern for skate populations)*

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Pollock	Increasing to steady population currently at a high biomass level	Adequate forage available for piscivorous skates	No concern
Atka mackerel	Cyclically varying population with slight upward trend overall 1977-2005	Adequate forage available for piscivorous skates	No concern
Shrimp Benthic invertebrates	Trends are not currently measured directly, only short time series of food habits data exist for potential retrospective measurement	Unknown	Unknown
Predator population trends			
Sperm whales	Populations recovering from whaling?	Possibly higher mortality on skates? But still a very small proportion of mortality	No concern
Steller sea lions	Declined from 1960's, low but level recently	Lower mortality on skates?	No concern
Sharks	Population trends unknown	Unknown	Unknown
Changes in habitat quality			
Benthic ranging from shallow shelf to deep slope, isolated nursery areas in specific locations	Skate habitat is only beginning to be described in detail. Adults appear adaptable and mobile in response to habitat changes. Eggs are limited to isolated nursery grounds and juveniles use different habitats than adults. Changes in these habitats have not been monitored historically, so assessments of habitat quality and its trends are not currently available.	Continue study on small nursery areas to evaluate importance to population production	Possible concern if nursery grounds are disturbed or degraded.

Groundfish fishery effects on ecosystem via skate bycatch *(evaluating level of concern for ecosystem)*

Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Skate catch	Varies from 12,000 to 20,000 tons annually	Largest portion of total mortality for skates	Possible concern
Forage availability	Skates have few predators, and skates are small proportion of diets for their predators	Fishery removal of skates has a small effect on predators	Probably no concern
Fishery concentration in space and time	Skate bycatch is spread throughout FMP areas	Potential impact to skate populations if fishery disturbs nursery or other important habitat; but small effect on skate predators	Possible concern for skates, probably no concern for skate predators
Fishery effects on amount of large size target fish	Size of bycaught skates not measured	Unknown	Unknown
Fishery contribution to discards and offal production	Skate discard a relatively high proportion of skate catch, some incidentally caught skates are retained and processed	Unclear whether discard of skates has ecosystem effect	Unknown
Fishery effects on age-at-maturity and fecundity	Skate age at maturity and fecundity are just now being described; fishery effects on them difficult to determine due to lack of unfished population to compare with	Unknown	Unknown

Summary

2005 Recommendations	EBS skates	AI skates
M	0.10	0.10
Tier	5	5
Biomass	455,881	36,392
F OFL	0.10	0.10
Max F ABC	0.075	0.075
Recommended F ABC	0.075	0.075
OFL	45,588	3,639
Max ABC	34,191	2,729
Recommended ABC	34,191	2,729

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Tables

Table 16.3-1. Life history and depth distribution information available for BSAI and GOA skate species, from Stevenson (2004) unless otherwise noted.

Species	Common	Max Length (cm)	Highest Observed Age	Age Mature, Length Mature[2]	Feeding mode[3]	N embryos / egg case[1]	Depth range (m)	Natural Mortality estimate[6]
Bathyraja abyssicola	deepsea skate	140	?	?	?	?	362-2940	0.10
Bathyraja aleutica	Aleutian skate	150	14[8]	?	predatory	1	29-950	0.10
Bathyraja interrupta	Bering skate (complex?)	80	19[8]	?	benthophagic	1	37-1372	0.10
Bathyraja lindberghi	Commander skate	93	?	?	?	1	160-1193	0.10
Bathyraja maculata	whiteblotched skate	120	?	?	predatory	1	84-1193	0.10
Bathyraja mariposa[4]	butterfly skate	76	?	?	?	1	90-448	0.10
Bathyraja minispinosa	whitebrow skate	82	?	?	benthophagic	1	160-1420	0.10
Bathyraja parmifera	Alaska skate	113 (M) 122 (F)[7]	17 (M) 19 (F)[7]	94 cm (F) 90 cm (M)[7]	predatory	1	17-600	0.10
Bathyraja sp, cf parmifera	"Leopard" parmifera	133 (M) 139 (F)	?	?	predatory	?	48-251	0.10
Bathyraja tanaretzi	mud skate	70	?	?	?	1	58-1054	0.10
Bathyraja trachura	black skate	85	?	?	?	1	213-1504	0.10
Bathyraja violacea	Okhotsk skate	73	?	?	benthophagic	1	47-520	0.10
Raja badia	roughshoulder skate	98	?	?	?	?	1280-2322	0.10
Raja binoculata	big skate	244	13[8]	8-12 yrs, 109-130 cm	predatory[9]	1-7	16-800	0.10
Raja rhina	longnose skate	180	17[8]	7-10 yrs, 74-100 cm	predatory[9]	1	25-675[5]	0.10

[1]Eschemeyer, 1983. [2]Zeiner and Wolf, 1993. [3]Orlov, 1998 & 1999 (benthophagic eats mainly amphipods, worms. Predatory diet primarily fish, cephalopods). [4]Stevenson et al 2004. [5]Allen and Smith, 1988. [6] Gaichas et al, 1999. [7] Preliminary results from Matta, 2005, and Hoff 2005, unpublished data. [8]Gburski (AFSC), pers comm. [9]Wakefield 1984.

Table 16.3-2. Species composition of the EBS and AI skate complexes from most recent AFSC bottom trawl surveys.

		2005 EBS shelf		2004 EBS slope		2004 Aleutians	
Skate species	**common**	**bio (t)**	**cv**	**bio (t)**	**cv**	**bio (t)**	**cv**
Bathyraja abyssicola	deepsea	0		164	0.72	0	
Bathyraja aleutica	Aleutian	8,112	0.56	15,039	0.14	11,518	0.45
Bathyraja interrupta	Bering	8,007	0.18	1,957	0.11	147	0.75
Bathyraja lindbergi	Commander	0		4,167	0.15	0	
Bathyraja maculata	whiteblotched	1,070	1.00	3,433	0.16	26,246	0.25
Bathyraja minispinosa	whitebrow	0		1,771	0.22	34	1.00
Bathyraja parmifera	Alaska	514,548	0.05	4,248	0.33	12,742	0.22
Bathyraja taranetzi	mud	184	0.85	698	0.20	1,799	0.17
Bathyraja trachura	roughtail	0		1,677	0.13	1	0.98
Bathyraja violacea	Okhotsk	341	0.70	8	0.99	0	
Raja binoculata	big	2,307	0.71	0		422	0.53
Raja rhina	longnose	0		0		0	
skate unid (all others)		0		20	0.52	142	0.38
Total skate complex		534,569	0.05	33,182	0.08	53,050	0.16

Table 16.3-3 Skate catch proportion of Other species TAC, with time series of ABC, OFL, and catch.

Year	**Other species ABC**	**Other species TAC**	**Other species OFL**	**Other species catch**	**BSAI skate catch**	**Skate % of Other species catch**
1991	28,700	15,000		17,199		
1992	27,200	20,000	27,200	33,075	16,962	51%
1993		22,610		23,851	12,226	51%
1994	27,500	26,390	141,000	24,555	14,223	58%
1995	27,600	20,000	136,000	22,213	14,892	67%
1996	27,600	20,125	137,000	21,440	12,643	59%
1997	25,800	25,800		25,176	17,747	70%
1998	25,800	25,800	134,000	25,531	19,318	76%
1999	32,860	32,860	129,000	20,562	14,080	68%
2000	31,360	31,360	71,500	26,108	18,877	72%
2001	33,600	26,500	69,000	27,178	20,570	76%
2002	39,100	30,825	78,900	28,619	21,279	74%
2003	43,300	32,309	81,100	28,703	18,836	66%
2004	46,810	27,205	81,150	27,266	19,238	71%
2005	53,860	29,000	87,920	*19,857	*13,716	69%

sources: Other species ABC, TAC, OFL, and catch from AKRO website
BSAI skate catch 1992-1996 from Fritz 1996, 1997, 1997-2002 from Gaichas et al 2004
BSAI skate catch 2003-2005 from AKRO, *2005 data complete as of October 4, 2005

Table 16.3-4. Estimated catch (t) of all skate species combined by target fishery, gear, and area, 1997-2002. Source: Gaichas AFSC.

Target fishery	gear	1997	1998	1999	2000	2001	2002
Arrowtooth	hook n line		0.65	9.72	1.31		0.49
	trawl	1.62	117.64	17.74	43.02	89.98	81.55
Arrowtooth Total		1.62	118.29	27.46	44.33	89.98	82.04
Atka mackerel	trawl	110.51	130.81	126.66	71.50	80.57	73.30
Flatheadsole	trawl	777.22	1,867.59	1,215.15	1,655.80	1,752.36	1,530.37
Other	hook n line		10.42	26.07	52.48	70.43	31.17
	trawl						8.82
Other Total			10.42	26.07	52.48	70.43	39.98
OtherFlats	trawl	39.18	103.15	69.22	115.16	20.09	58.48
Pacific cod	hook n line	13,298.81	13,534.64	9,651.09	12,975.65	14,116.58	14,059.10
	pot	1.50	0.01	0.11	0.06	0.10	0.00
	trawl	715.23	770.48	984.30	1,053.86	631.91	1,400.41
Pacific cod Total		14,015.53	14,305.12	10,635.50	14,029.56	14,748.59	15,459.51
Pollock	trawl	349.73	405.67	375.87	598.19	627.58	807.04
Rock sole	trawl	679.20	558.69	322.21	334.28	820.60	836.61
Rockfish	hook n line	110.27	6.73	0.69	1.70	4.42	0.84
	trawl	30.05	39.94	53.61	50.53	47.67	78.14
Rockfish Total		140.32	46.67	54.30	52.23	52.09	78.99
Sablefish	hook n line	266.00	110.10	109.54	115.86	194.11	233.13
	pot			0.09	0.01	0.06	0.01
	trawl		0.06			1.24	
Sablefish Total		266.00	110.16	109.63	115.87	195.41	233.14
Turbot	hook n line	140.82	280.84	319.92	317.36	187.07	120.80
	pot			1.22			
	trawl	16.13	18.67	17.34	23.92	16.66	7.76
Turbot Total		156.95	299.51	338.48	341.28	203.73	128.57
Unknown	hook n line	0.11	2.00	1.16	0.95	0.21	
	trawl		1.09		0.01	0.11	
Unknown Total		0.11	3.09	1.16	0.95	0.32	
Yellowfinsole	trawl	1,210.99	1,358.70	778.11	1,464.90	1,908.69	1,950.67
Grand Total		17,747.37	19,317.86	14,079.84	18,876.53	20,570.46	21,278.69

FMP area	area	1997	1998	1999	2000	2001	2002
AI	541	569.98	640.25	462.61	501.96	540.77	288.88
	542	200.87	369.17	239.96	608.31	422.64	217.74
	543	86.30	119.02	99.79	698.20	1,546.14	188.84
AI Total		857.15	1,128.45	802.36	1,808.47	2,509.56	695.46
EBS	509	1,920.87	2,317.12	2,033.62	2,830.27	3,092.09	3,112.51
	512	0.92		14.33		91.68	132.82
	513	2,572.53	2,605.18	1,993.53	2,641.56	2,726.15	4,036.76
	514	134.61	40.86	203.65	101.55	83.42	223.02
	516	74.26	73.35	199.06	122.64	249.95	336.13
	517	3,499.07	4,820.64	3,514.42	4,910.51	4,378.18	4,394.10
	518	49.00	82.65	80.14	52.09	101.80	65.00
	519	42.69	106.07	57.86	83.01	96.52	68.93
	521	7,066.94	7,205.81	4,420.95	5,724.41	6,517.25	7,327.22
	523	548.85	455.37	404.81	284.01	324.73	314.50
	524	980.48	482.36	355.11	318.01	399.14	572.23
EBS Total		16,890.22	18,189.41	13,277.48	17,068.06	18,060.90	20,583.23
BSAI Total		17,747.37	19,317.86	14,079.84	18,876.53	20,570.46	21,278.69

Table 16.3-5. Estimated catch (t) of all skate species combined by target fishery, gear, and area, 2004-2005. Source: AKRO CAS. Similar catch estimates are not available before 2004 at this time. *2005 catches are reported as of October 4, 2005 and thus do not represent a complete year.

Region	Target	2003	2004	2005*
AI	Atka mackerel	74	94	88
	Cod	177	478	205
	Flatfish	154	227	94
	Rockfish	61	16	26
	Sablefish	55	8	23
	Unknown Target	11	6	3
AI total		**531**	**829**	**439**
EBS	Atka mackerel	20	35	21
	Cod	14,530	15,128	10,194
	Flatfish	3,069	2,472	2,436
	Pollock	452	673	611
	Rockfish	11	6	4
	Sablefish	2	2	2
	Unknown Target	220	91	10
EBS total		**18,305**	**18,409**	**13,278**
BSAI total		**18,836**	**19,238**	**13,716**

Region	Area	2003	2004	2005*
AI	541	242	449	267
	542	197	246	113
	543	92	134	59
AI total		**531**	**829**	**439**
EBS	508	0	0	0
	509	1,920	1,886	2,227
	512	25	204	15
	513	2,769	2,659	2,363
	514	280	60	166
	516	130	383	231
	517	2,726	2,612	2,028
	518	14	3	2
	519	181	130	57
	521	8,937	8,299	4,682
	523	307	266	103
	524	1,016	1,906	1,404
EBS total		**18,305**	**18,409**	**13,278**
BSAI total		**18,836**	**19,238**	**13,716**

Table 16.3-6. Skate biomass (tons) with coefficient of variation (cv) from bottom trawl surveys of the Eastern Bering Sea (EBS) shelf, EBS slope, and Aleutian Islands (AI), 1975-2005.

year	EBS shelf	EBS shelf cv	EBS slope	EBS slope cv	AI	AI cv
1975	24,349	0.19				
1976						
1977						
1978						
1979	58,147	0.14	3,056	0.26		
1980					4,257	0.25
1981			2,743	0.12		
1982	164,084	0.10	2,723	0.10		
1983	161,041	0.08			9,683	0.12
1984	186,980	0.08				
1985	149,576	0.11	3,329	0.10		
1986	251,321	0.15			15,436	0.19
1987	346,691	0.09				
1988	409,076	0.10	3,271	0.21		
1989	410,119	0.08				
1990	534,556	0.11				
1991	448,458	0.09	4,031	0.25	14,967	0.17
1992	390,466	0.09				
1993	375,040	0.07				
1994	414,235	0.08			25,014	0.10
1995	391,768	0.08				
1996	423,913	0.06				
1997	393,716	0.07			28,922	0.14
1998	354,188	0.05				
1999	370,543	0.17				
2000	325,292	0.06			29,123	0.09
2001	419,678	0.06				
2002	410,573	0.06	69,275	0.50	34,421	0.11
2003	386,339	0.05				
2004	427,713	0.05	33,182	0.08	53,068	0.16
2005	534,569	0.05				

Table 16.3-7. Estimates of M based on life history for skate species. "Age mature" was given a range for M estimates by the Rikhter and Efanov method to account for uncertainty in this parameter.

Species	Area	Sex	Hoenig	Age mature	Rikhter & Efanov	Alverson & Carney	Charnov	Roff
Big skate	CA	*males*	0.38					
	CA	*females*	0.35					
	CA			8	0.19			
	CA			9	0.16			
	CA			10	0.13			
	CA			11	0.12			
	CA			12	0.10			
Longnose skate	CA	*males*	0.32			0.31	0.44	0.23
	CA	*females*	0.35			0.45	0.29	0.03
	CA	*both*					0.31	
	CA			7	0.22			
	CA			8	0.19			
	CA			9	0.16			
	CA			10	0.13			

Figures

Figure 16.3-1 Skate diversity on the Bering Sea slope: five species of skate captured in a single trawl haul on the NMFS Bering sea slope survey, 2002. Species include *Bathyraja minispinosa* (whitebrow), *B. taranetzi* (mud), *B. maculata* (whiteblotched), *B. aleutica* (Aleutian), and *B. lindbergi* (Commander).

The following CPUE maps were created using data from the RACE Bering Sea Groundfish Survey. The survey data used spans from 1982 to 2004. However, identification problems were apparent for certain species during the early years of the survey. In this case, only the years in which we are confident the species were being identified correctly were used for these maps. The data shown is the average CPUE for each station for the appropriate years. All the CPUE data is in Kg/ha and the scale changes appropriately for each species.

Figure 16.3-2 Alaska Skate (*Bathyraja parmifera*)
Average CPUE 2001 - 2004

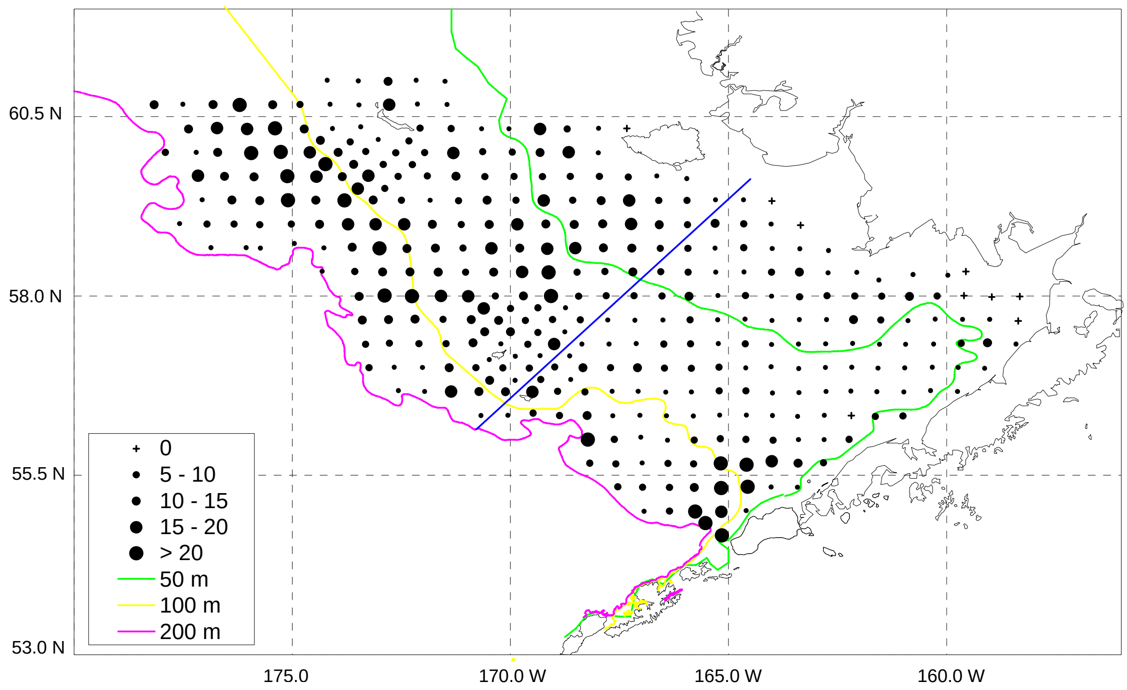
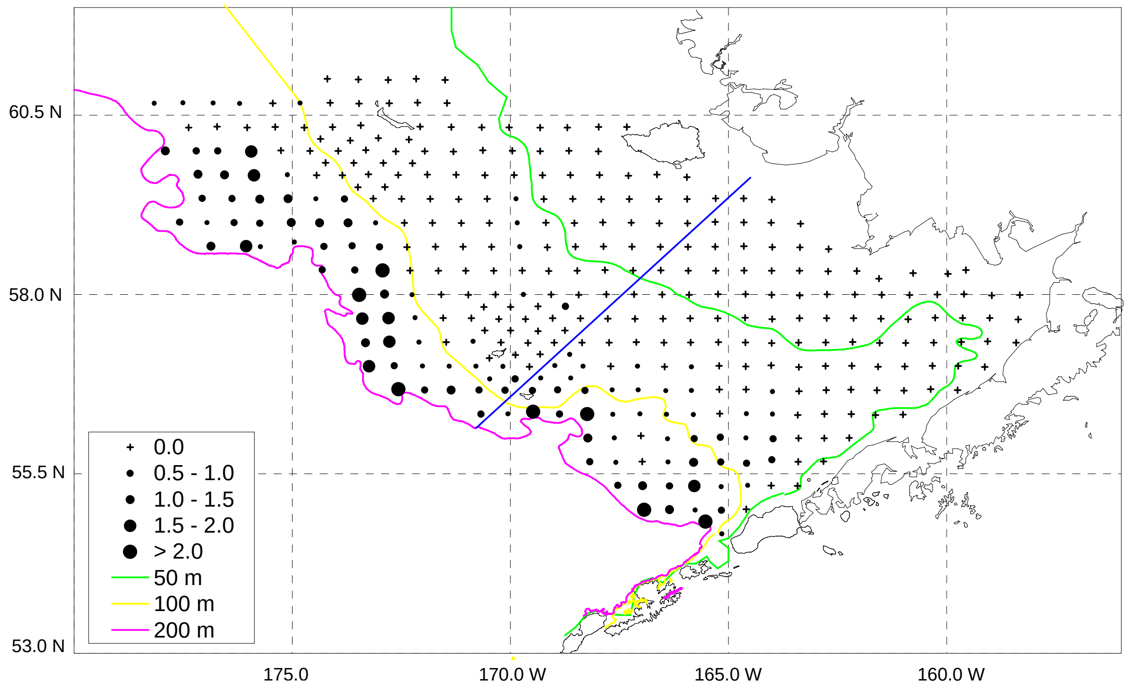


Figure 16.3-3 Bering Skate (*Bathyraja interrupta*)
Average CPUE 2001 - 2004



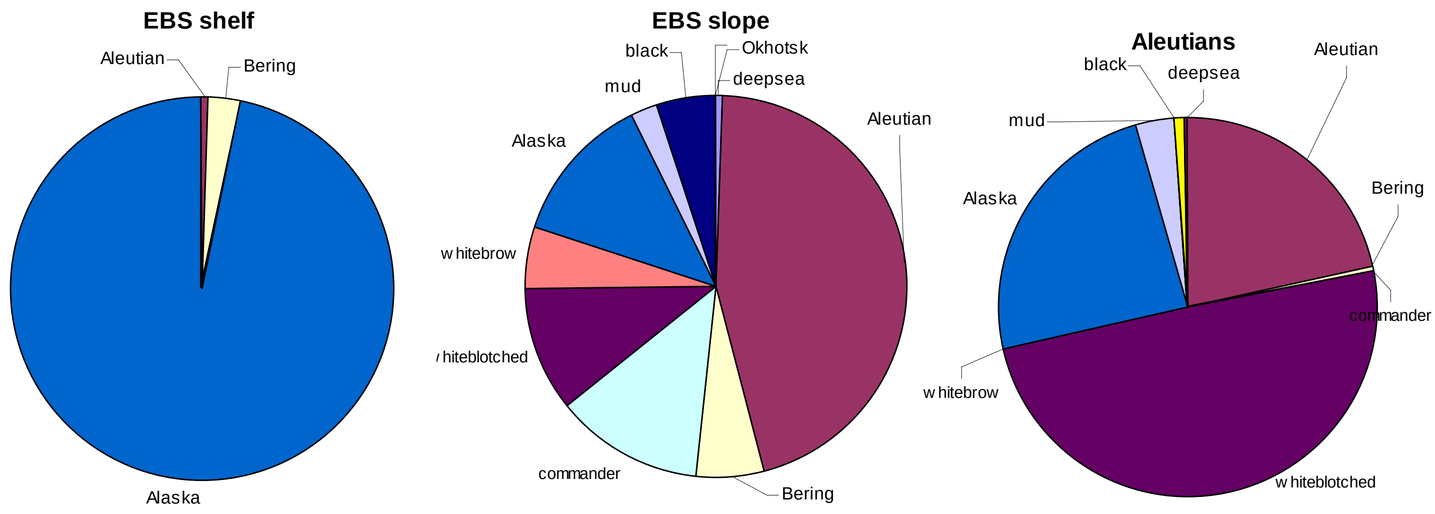
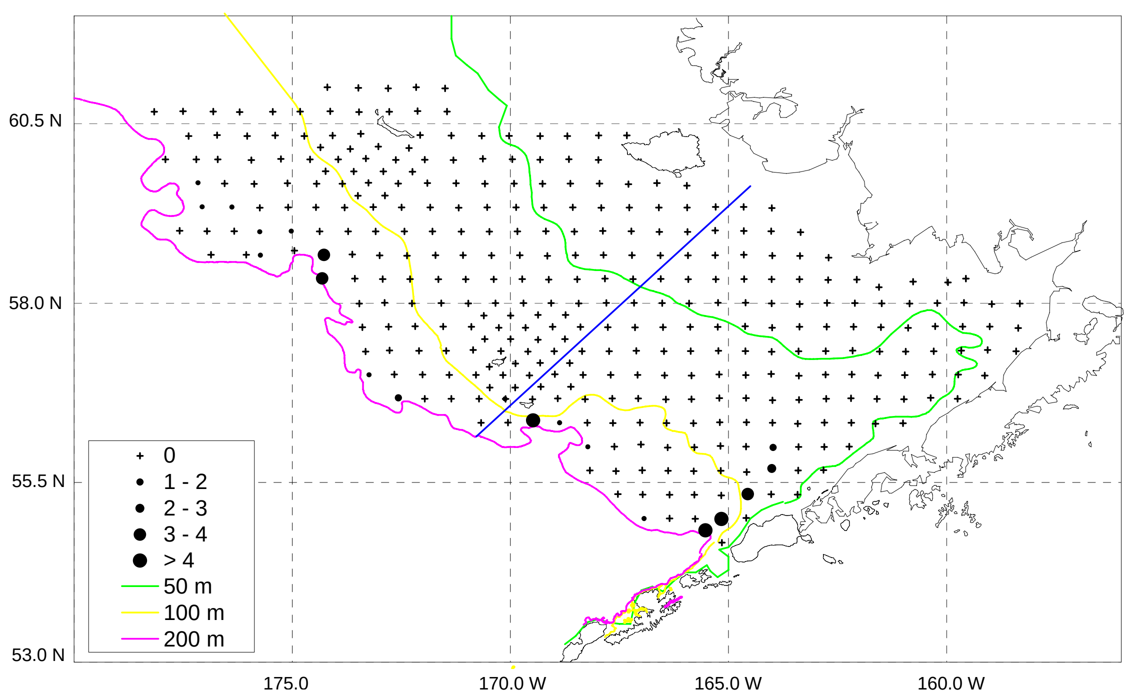


Figure 16.3-4 Skate species composition by area, EBS shelf (left), EBS slope (center), and AI (right). All data are from 2004 bottom trawl surveys; 2005 EBS shelf species composition has not changed.

Figure 16.3-5 Aleutian Skate (*Bathyraja aleutica*)
Average CPUE 2001 - 2004



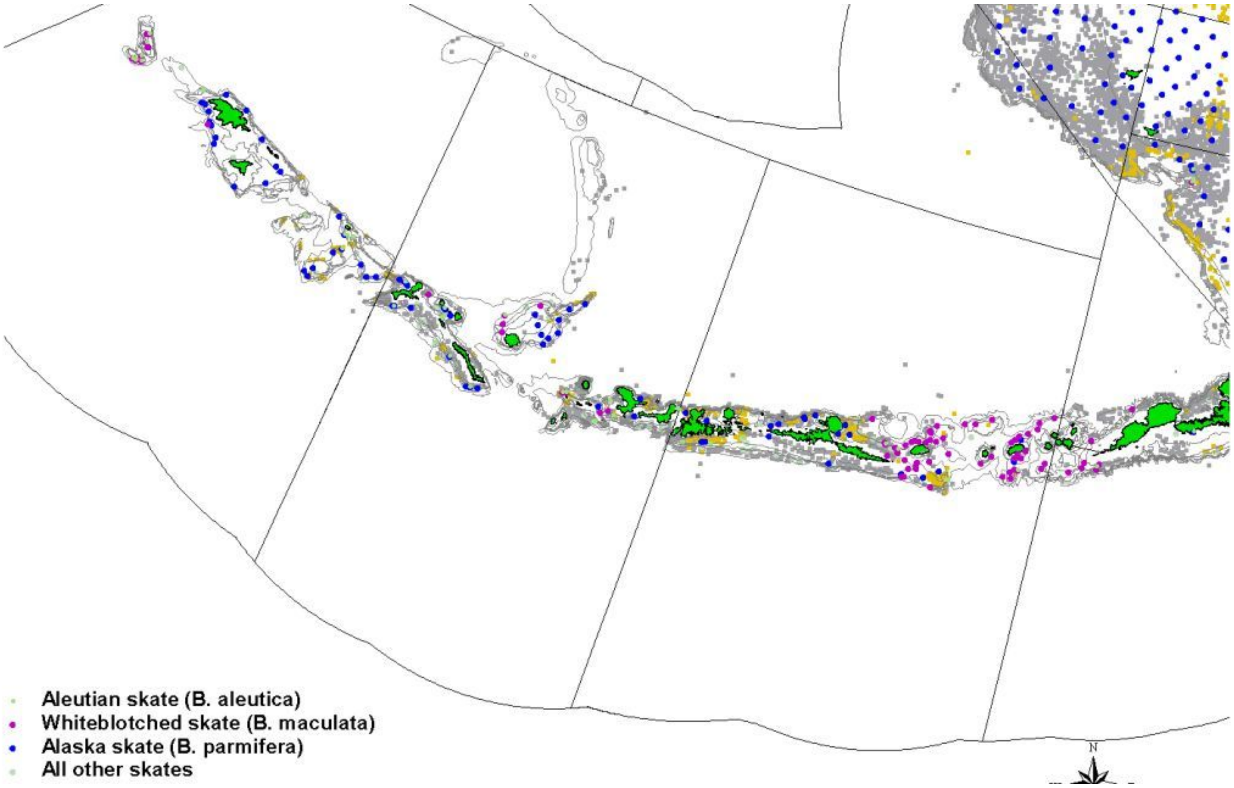


Figure 16.3-6 Aleutian skate distribution from NMFS bottom trawl surveys. Specimens of *B. parmifera* in the AI on this map have now been described as a new species (see below).

Figure 16.3-7 Skate diversity in the Aleutians: a new skate species from the Aleutian Islands (left) formerly thought to be the same species as the extremely common Alaska skate, *B. parmifera* (from the EBS, right).

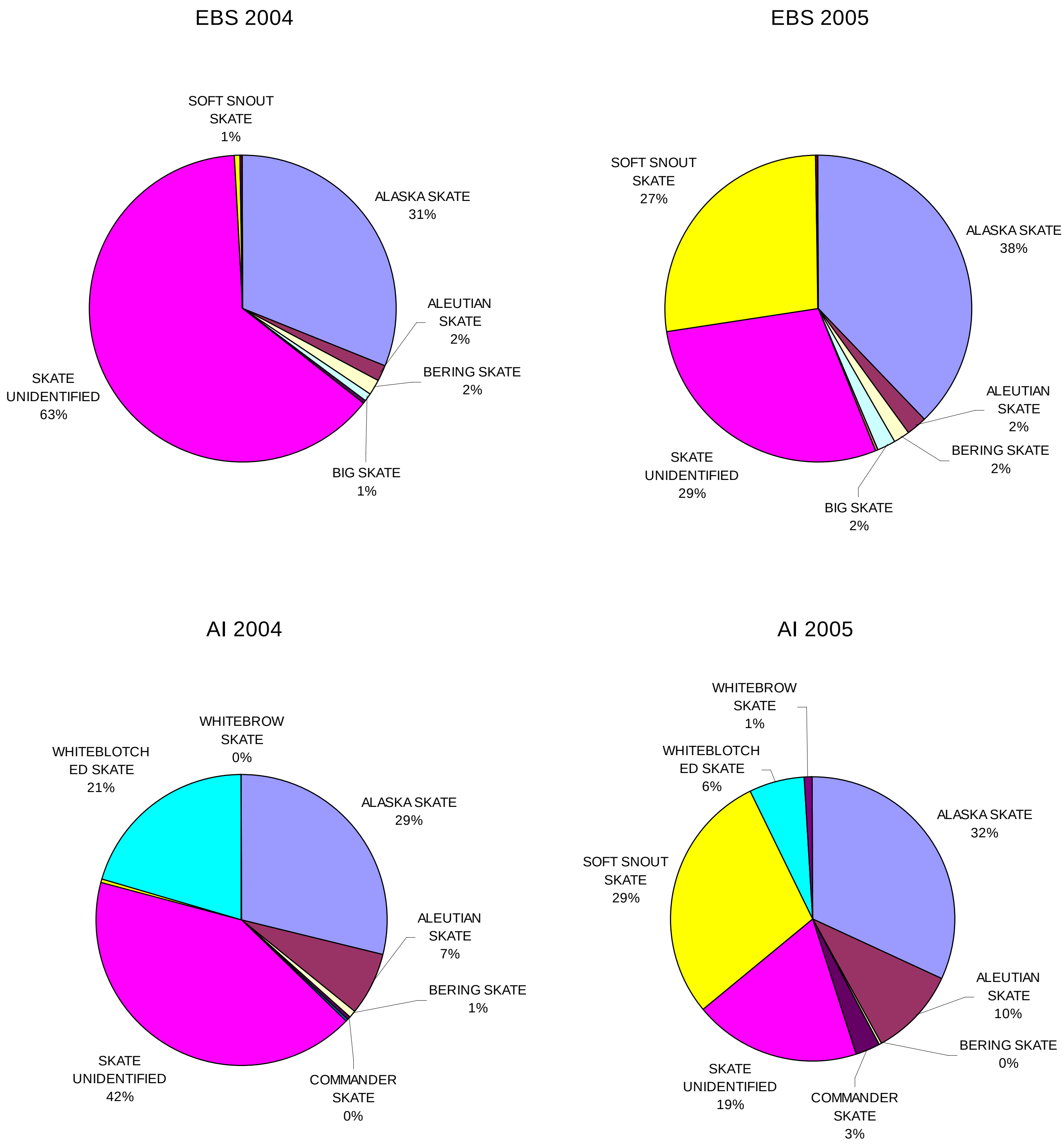


Figure 16.3-8. Identification of observed incidentally caught skates in EBS (upper) and AI (lower) groundfish fisheries, 2004 (left) and 2005 (right), from NMFS Groundfish Observer database.

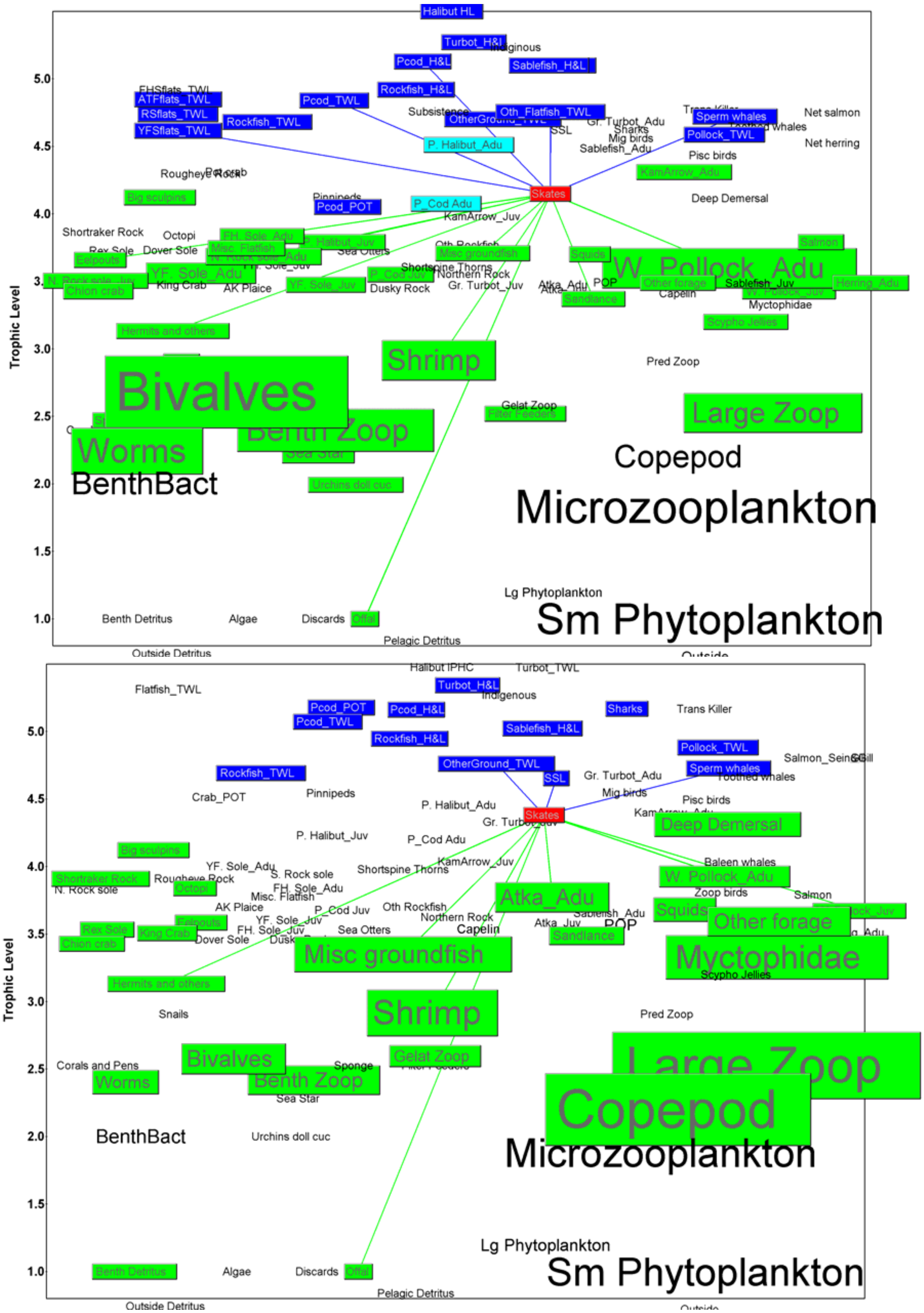


Figure 16.3-9 Skate food webs, EBS (upper), and AI (lower), with skate species aggregated in each area.

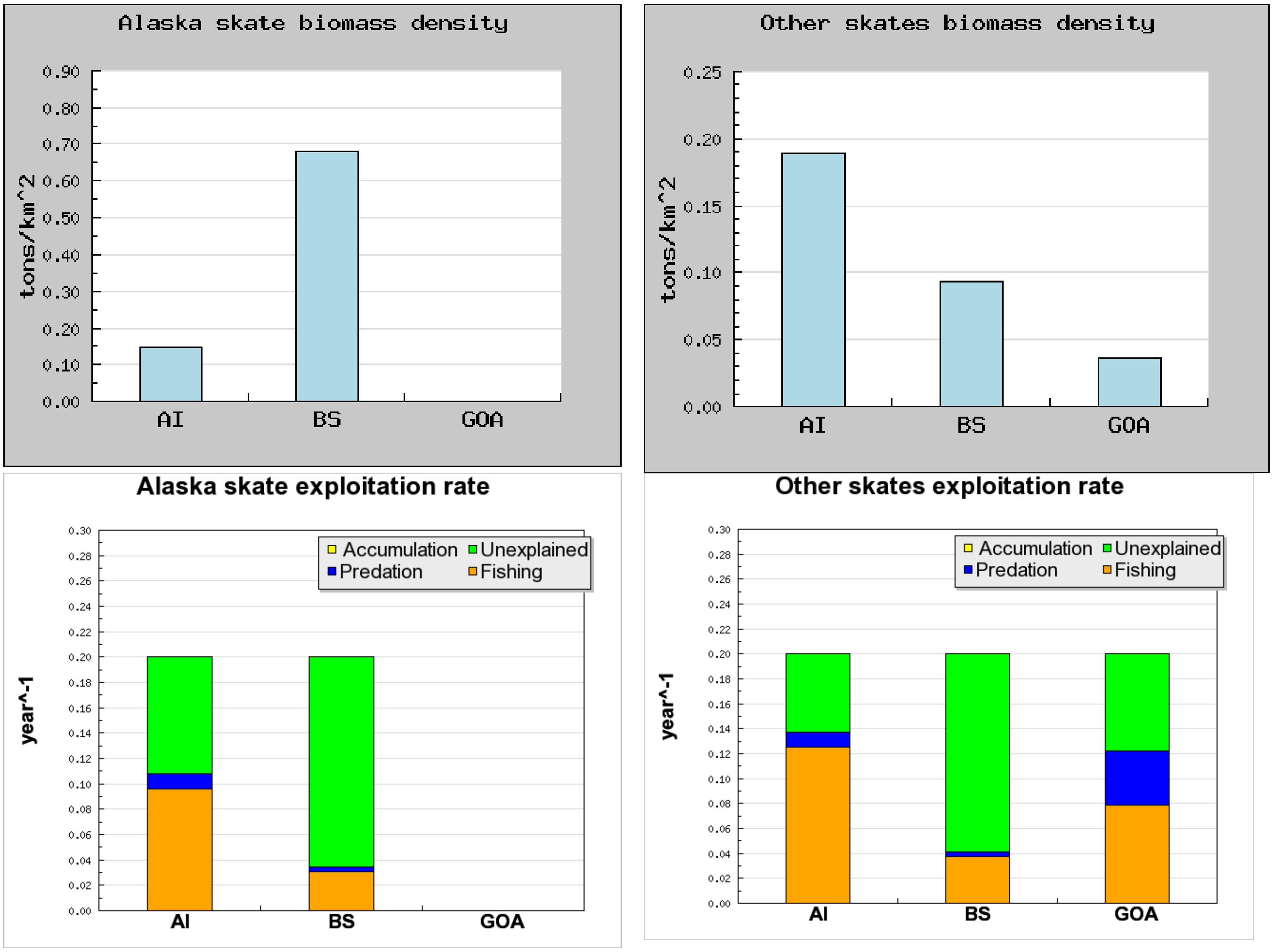


Figure 16.3-10 Comparative density (upper) and exploitation rate (lower) of Alaska (left) and all other *Bathyraja* (right) skates AI, EBS, GOA (early 1990s, before fishery in GOA). (Alaska skates are a very small component of skate biomass in the GOA, and are therefore not modeled separately.) Note that the GOA Other skates plot does not include the most common species in that region, the big skate (*Raja binoculata*) and longnose skate (*R. rhina*)—see the GOA skate SAFE for information on those skates.

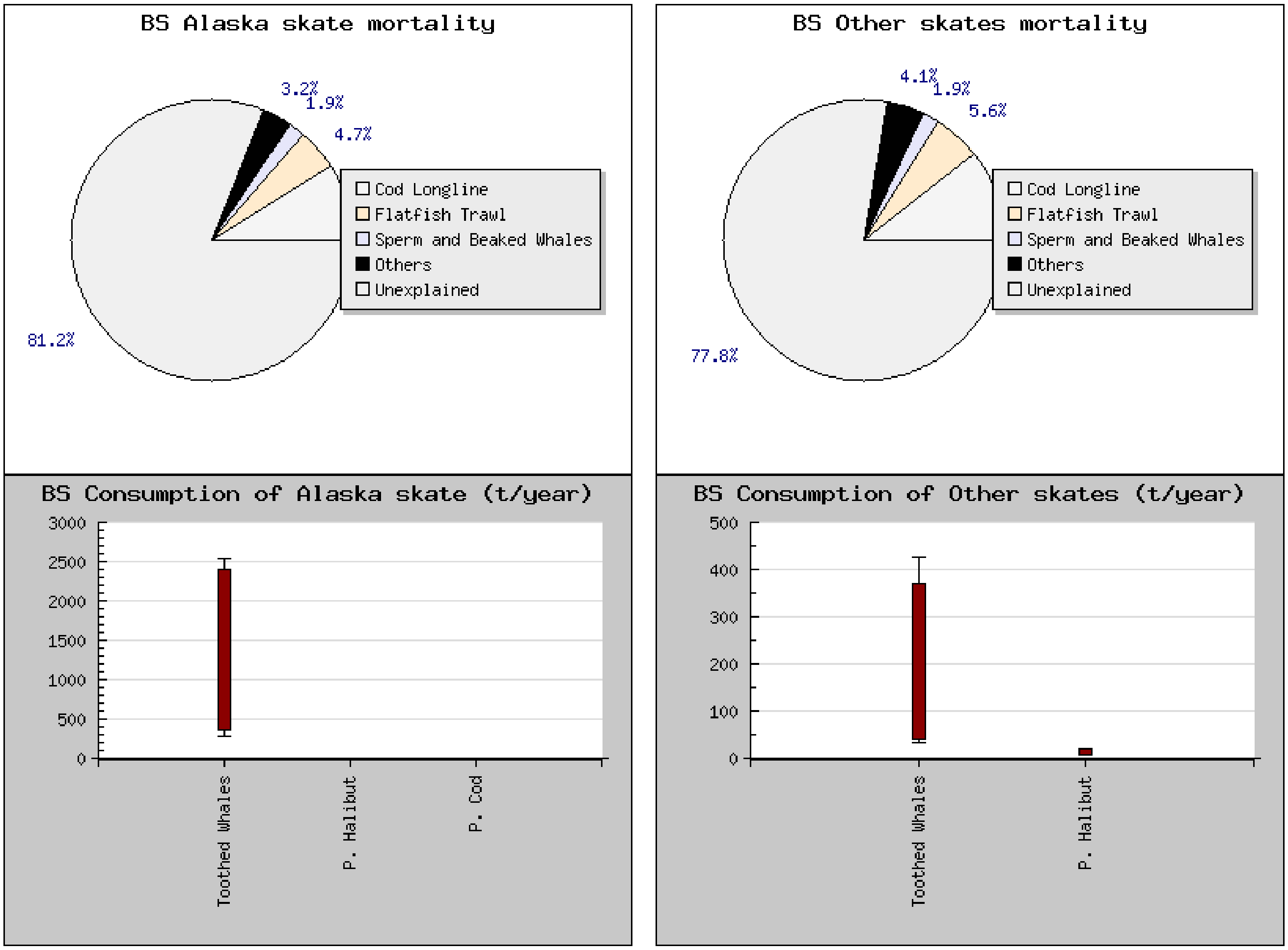


Figure 16.3-11 Mortality sources and consumption of skates in the EBS —mortality pie (upper) and estimates of annual consumption by predators (lower) for EBS Alaska skates (left) and all other EBS skates (right).

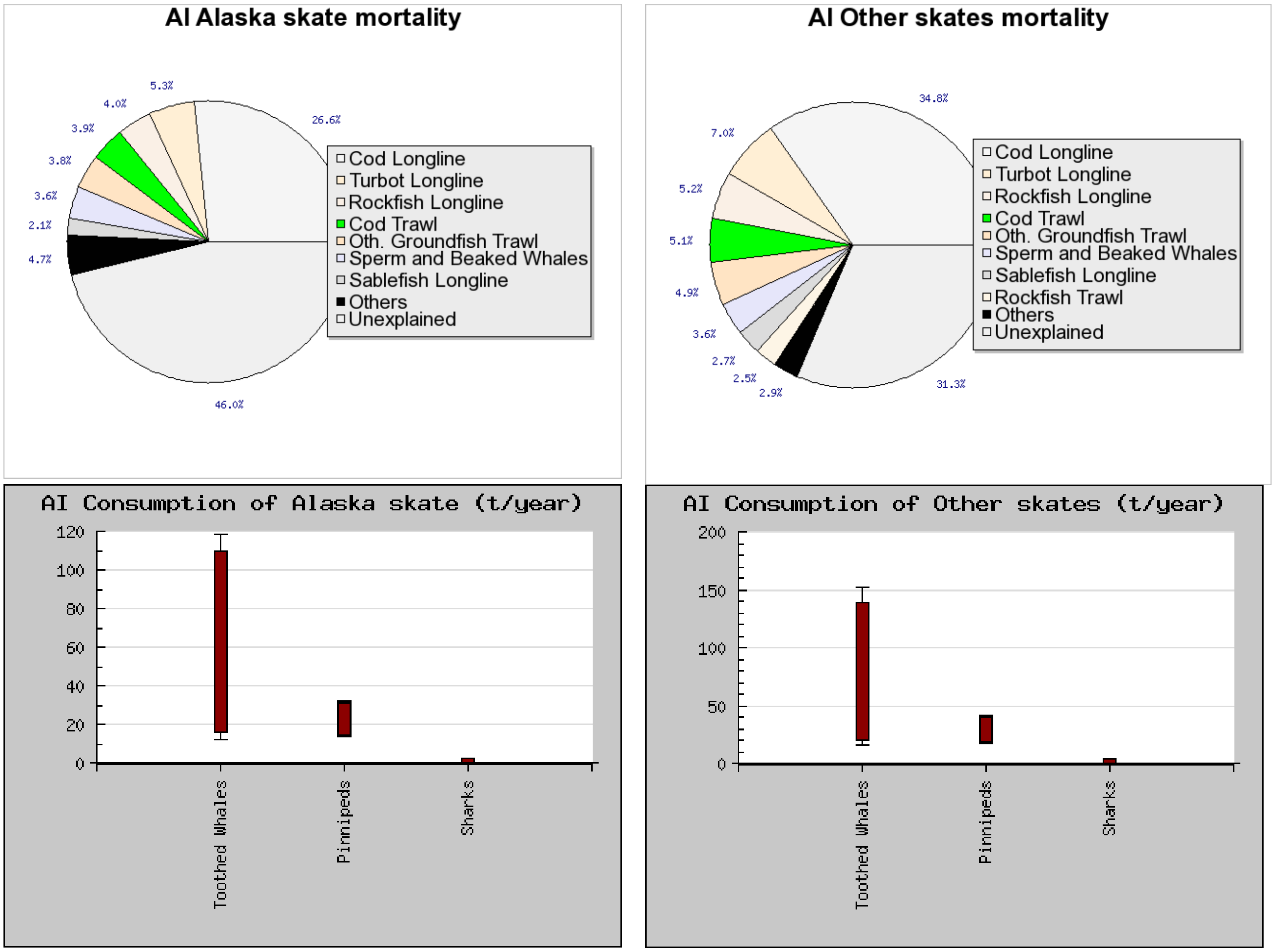


Figure 16.3-12 Mortality sources and consumption of skates in the AI—mortality pie (upper) and estimates of annual consumption by predators (lower) for AI (former) Alaska skate (left) and AI other skates (right).

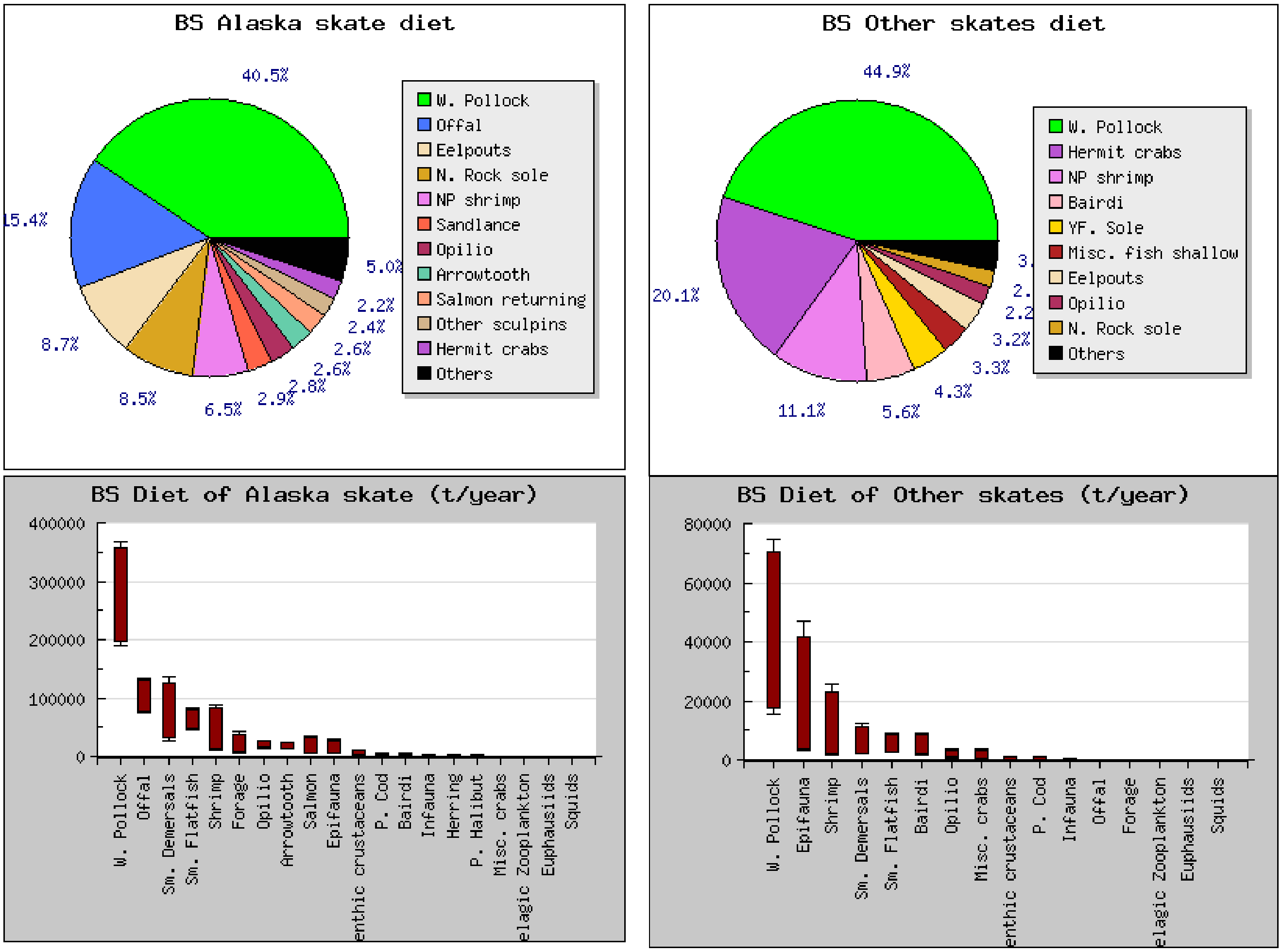


Figure 16.3-13 Diet composition (upper) and annual estimated prey consumption by skates (lower) for EBS Alaska skates (left) and Other skates (right)

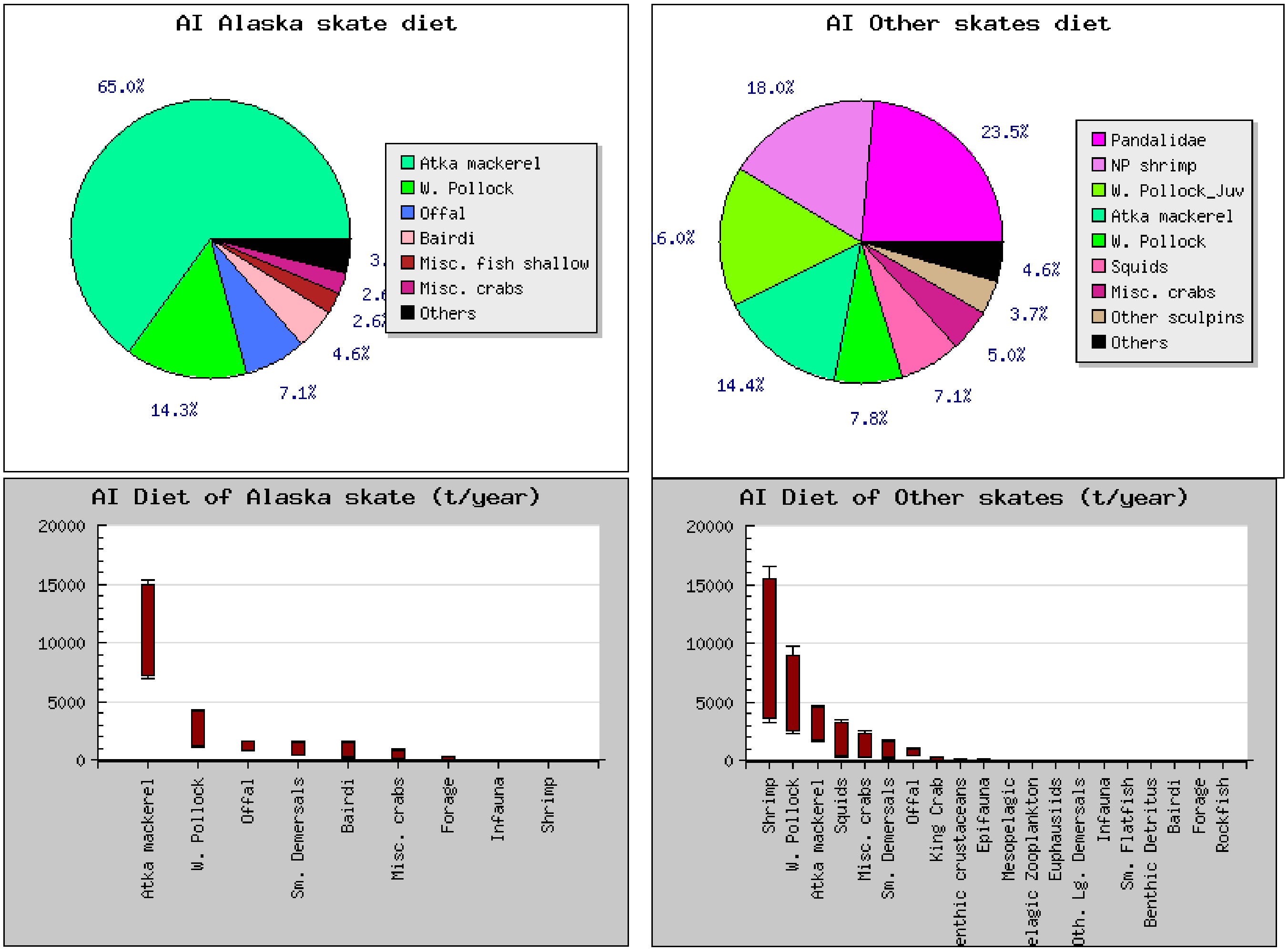


Figure 16.3-14 Diet composition (upper) and annual estimated prey consumption by skates (lower) for AI Alaska skates (left) and Other skates (right)

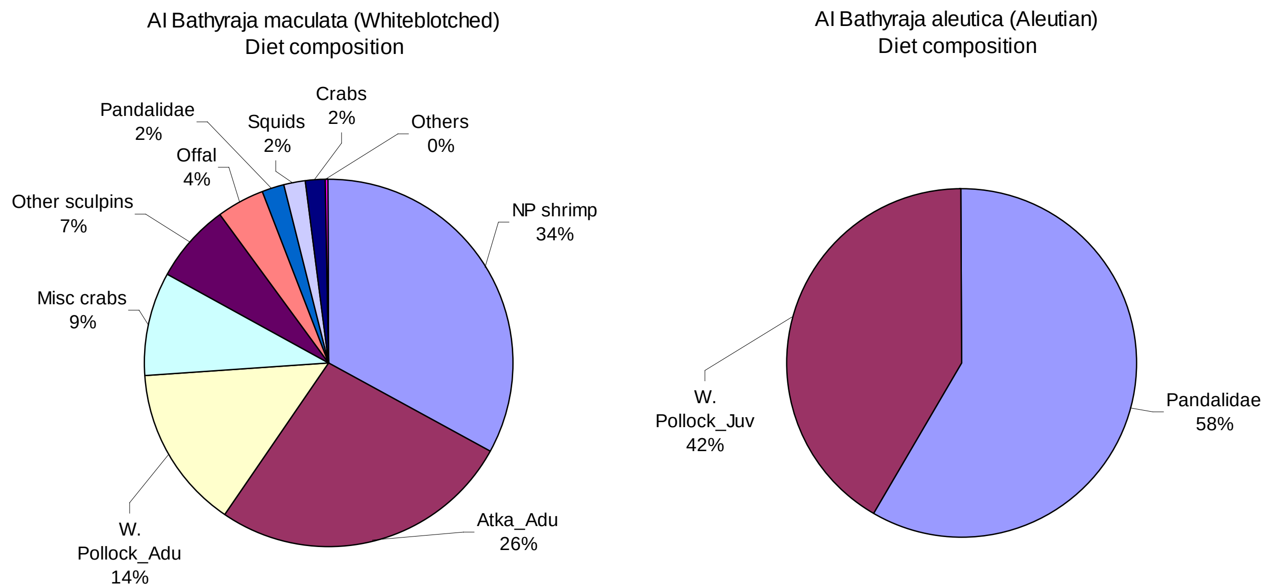


Figure 16.3-15 Diet composition details for the other two biomass dominant skate species in the Aleutian Islands (which are included in the “Other skates” group in the previous figure): whiteblotched skate, *Bathyraja maculate* (left), and Aleutian skate, *B. aleutica* (right). Note that these diet compostions are based on fairly limited sampling.

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