Observer-reported skate bycatch in the commercial groundfish fisheries of Alaska

Duane E. Stevenson (contact author)

Kristy A. Lewis

Email address for contact author: duane.stevenson@noaa.gov

NMFS, Alaska Fisheries Science Center
Fisheries Monitoring and Analysis Division
7600 Sand Point Way NE
Seattle, Washington 98115

Abstract—We analyzed skate catch data collected by observers in the North Pacific Groundfish Observer Program (NPGOP) from 1998 through 2008 to document recent changes in the identification of skates by observers and to examine the species composition of observed skate catch in Alaska's groundfish fisheries as well as recent trends in skate retention by commercial fishermen. Historically, almost all skate bycatch has been reported by NPGOP observers as "skate unidentified." However, since 2004 observers have been trained to identify skates to the genus and species level. In 2008 over 95% of all skates were identified at least to the genus level, and over 50% were identified to species. The most common species of skates identified by observers in groundfish fisheries are *Bathyraja parmifera* (Alaska skate), *Raja binoculata* (big skate), and *Bathyraja aleutica* (Aleutian skate). Species composition of reported skate catch generally reflects recent survey-derived biomass estimates, with *B. parmifera* dominating the catches in the Bering Sea and, to a lesser extent, in the Aleutian Islands region, and species of the genus *Raja* dominating catches in the Gulf of Alaska. A relatively high percentage of the skate catch on longline vessels is still reported at the family or genus level because of difficulties in the identification of skates not brought onboard the vessel. For the larger skate species, the proportion retained for processing has increased in recent years as the market price for skate product has increased. Although observed skate catch does not give a complete account of skate bycatch in the fisheries of the region, observer data provide critical information for the appropriate management of skate populations in Alaska.

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Skates are large, long lived fishes with relatively slow growth rates and low reproductive potential (Ebert, 2005; Ebert et al., 2008). These aspects of their life history, combined with their relatively low mobility and benthic habitat, make skates particularly vulnerable to fishing pressure and slow their recovery from population declines; yet few countries have management plans for skates or other chondrichthyan species (Stevens et al., 2000). In cases where skates are targeted by fisheries, population declines can be rapid (Agnew et al., 2000). Moreover, because discard mortality can be high (Stobutzki et al., 2002; Laptikhovsky, 2004), skate populations may be dramatically affected by fishing activity even if they are not targeted directly (Brander, 1981; Casey and Myers, 1998; Dulvy et al., 2000; Stevens et al., 2000). In addition to population declines, fishing pressure may lead to significant shifts in community structure because declines in some species of a skate assemblage may be masked by increases in other, more resilient species (Agnew et al., 2000; Dulvy et al., 2000; Stevens et al., 2000). Therefore, effective management of skate populations requires species-specific data on abundance trends and exploitation rates.

Skates are regularly caught in nearly all of the commercial groundfish fisheries currently prosecuted in Alaska waters, including fisheries targeting Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), yellowfin sole (*Limanda aspera*), and other species (Ormseth et al., 2009). In addition to their ubiquitous presence as bycatch species, skates have been targeted in Alaska waters on a short-term regional basis. An unregulated fishery targeting *Raja binoculata* (big skate), *R. rhina* (longnose skate), and assorted species of *Bathyraja* (including Alaska skates) developed in the central Gulf of Alaska (GOA) in February 2003. Shifting economic conditions and fishing seasons soon made other target species more valuable, but this short-lived fishery revealed that skates can quickly become an attractive alternative target when other fisheries are closed (Matta, 2006). More recently, the Alaska Department of Fish and Game (ADF&G) approved a pilot fishery for big and longnose skates in the state-managed waters of Prince William Sound (ADF&G Emergency Order #2-G-E-04-09) in 2009. Elsewhere in Alaska skates are still managed as part of a large nontarget species complex, although beginning in 2011 skates in the Bering Sea and Aleutian Islands will be managed as a separate unit.

Recent advances in the taxonomy of the skates of the North Pacific and Bering Sea (Ishiyama and Ishihara, 1977; Ishihara and Ishiyama, 1985, 1986; Stevenson et al., 2004, 2007, 2008) have facilitated increasingly detailed identification of skates by observers in the commercial fisheries of Alaska. The resulting wealth of detailed catch data now permits an examination of skate bycatch on a level that was not previously possible. The objectives of this study are 1) to document recent changes for the identification of skates in the NPGOP, and 2) to provide an overview of potential management concerns by ex-

amining the species composition of observed skate catch (OSC) in Alaska's groundfish fisheries and recent trends in skate retention by commercial fishermen.

Materials and methods

All data used for this study were extracted from the North Pacific Groundfish Observer Program (NPGOP) database maintained by the Fisheries Monitoring and Analysis (FMA) Division of the National Marine Fisheries Service's (NMFS) Alaska Fisheries Science Center. This database houses all biological data collected by groundfish observers onboard commercial fishing vessels operating in the waters of Alaska's federal Exclusive Economic Zone (EEZ). For an overview of the database, see the FMA Division website (National Marine Fisheries Service, http://www.afsc.noaa.gov/FMA/fma_database.htm, accessed November 2009).

Federal law requires observers to be present at all times on commercial fishing vessels of 125 ft (38.1 m) or more in length overall (LOA) operating in the federal EEZ. For vessels from 60 to 124 ft (18.3 to 37.8 m) LOA, observer coverage is required for only 30% of fishing days and for vessels less than 60 ft (18.3 m) LOA no observer coverage is required. The catch data used for this study were taken from trawl hauls and longline sets during which an observer was present and was sampling, so that the catch statistics presented here do not represent the total catch of the fisheries in this region, nor do they represent biomass estimates. For some commercial fisheries in the area, pot gear is used, but observers rarely encounter skates in these fisheries, and therefore such data are not included in this study.

The process used by observers to determine the species composition and catch weights of sampled hauls depends on gear type. Observers on trawlers may determine the species composition of a haul by identifying and weighing the entire catch, which is usually not possible, or by choosing a random sample (generally 300 kg or more) of the catch and identifying and weighing all taxa within the sample. The proportion by weight of each taxon in the sample is then extrapolated to the total catch weight, which may be determined by a number of methods, including flow scale readings, codend measurements, or bin volume estimates. On longline vessels, observers randomly select a "tally period" as the gear is being retrieved. During this tally period, the observer identifies and counts specimens, including specimens that drop off the line or are intentionally discarded. A subset of the specimens identified during the tally period (15 or more per species, when possible) is retained onboard the vessel and weighed to determine an average weight for each taxon. That average weight is then applied to all specimens identified during the tally period, and the resulting proportional species composition is extrapolated to the total gear set to obtain a total catch weight for each species for each set. The basic data unit used for this study is the extrapolated catch weight for each taxon from each observed haul or set (hereafter trawl hauls and longline sets will be collectively referred to as "hauls"). The total observed skate catch (OSC) was calculated by summing extrapolated catch weights for all skate taxa (including the following unidentified skate groups: "skate unidentified," "*Bathyraja* sp.," and "*Raja* sp.") across all hauls in which skates were identified. Scientific and common names for skate taxa follow Stevenson et al. (2007).

From the inception of the NPGOP through the sampling year 2002, observers were not trained to identify skates and were therefore not required to identify them beyond the family level. During 2002 and 2003, a field identification key was developed (Stevenson, 2004) and experienced observers began receiving training in skate identification during annual briefings. Feedback from experienced observers was used to refine the identification materials and classroom training, and beginning with the 2004 sampling year, all new and returning observers were provided with skate identification training and materials for identification of skate in the field. Since 1 January 2004 all observers have been required to identify skates to the species level when possible. Because of these changes in observer identification training and policies, two separate but overlapping time frames were used in this study. To investigate the trends in observed skate catch and the history of skate identification by observers an 11-year time frame was chosen and queries were restricted to data collected from 1 January 1998 through 31 December 2008. For investigations of species-level trends in observer data, queries were restricted to data collected from 1 January 2004 through 31 December 2008—a period that corresponds with the time period in which all new and returning observers have been trained to identify skates to the species level. Regions were defined on the basis of NMFS management areas: Bering Sea comprises the Bering Sea NMFS management areas 509–524; the Aleutian Islands region comprises NMFS management areas 541–543; and the Gulf of Alaska comprises NMFS management areas 610–650 (Fig. 1). All catch proportions are presented as a percentage of total observer reported catch weight.

The targeted resource was not directly recorded in observer catch data, so that for the purposes of this study, the term "target species" is defined as the predominant species in the catch. "Predominant species" was defined as the species accounting for the highest percentage of the extrapolated weight in the species composition sample and was determined on a haul-by-haul basis. Percent retained data are subjective estimates made by observers using visual approximations, along with information provided by the vessel's captain or factory manager. Mean retention rates used here are weighted averages calculated annually for each species with the following equation:

$$\frac{\sum_j R_{ij} C_{ij}}{\sum_j C_{ij}},$$

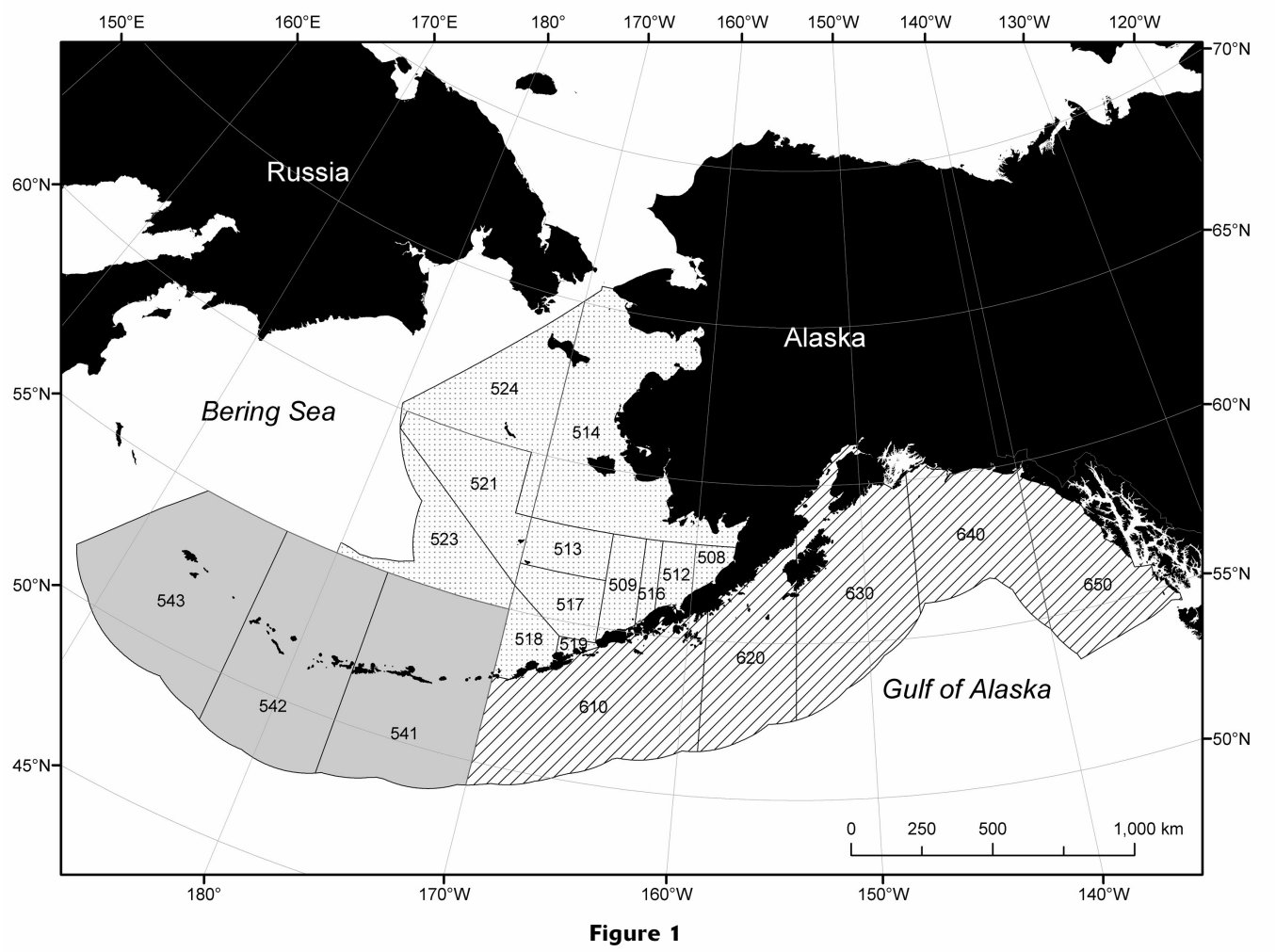

Figure 1

Map showing NMFS management areas in which observed skate catch was examined from 1998 through 2008. Stippled areas=Bering Sea, shaded areas=Aleutian Islands, diagonal hatching=Gulf of Alaska.

where R_{ij} = the observer reported retention rate of species i in haul j; and
C_{ij} = the extrapolated catch weight of species i in haul j.

Historical skate price information was derived from Alaska state fish-ticket data, and was compiled for the study period by Terry Hiatt (unpubl. data[1]). An annual mean price was determined for each taxon by 1) calculating the exvessel price paid per pound round weight at each delivery to all processors where the purchase of raw skates from Alaska waters was recorded, and then 2) calculating the simple average of those delivery price points over the calendar year. Round weight refers to intact whole specimens. For deliveries consisting of nonwhole specimens, round weight (in pounds) was calculated from net delivery weight by using a product recovery rate (PRR) of 0.32 for "wings" and 0.9 for gutted animals (National Marine Fisheries Service, http://www.fakr.noaa.gov/rr/tables/tabl3.pdf, accessed November 2009). Each annual mean represents at least 334 (range: 334–2247) data points.

Results

Skate species composition reported by observers over the past decade has changed considerably. Up to and including 2002, over 98% of OSC was reported as "skate unidentified" (Table 1). In 2003, less than 90% of OSC was unidentified, and the proportion of unidentified skates has continued to drop through 2008, a year in which only 2% of OSC was unidentified. Because the proportion of unidentified skates has dropped, the proportions of skates identified to the genus level (*Bathyraja*) and to the species level (*Bathyraja parmifera*, *Raja binoculata*, etc.) have continued to rise. In 2008, 46% of OSC was identified to the genus level and approximately

[1] Hiatt, T. 2009. NMFS Alaska Fisheries Science Center, Seattle, WA 98115.

Table 1

Species composition (% by weight) of observed skate catch by year reported in Alaska's groundfish fisheries for 1998–2008. * = less than 0.1%.

Taxon	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2004–2008
Skate unidentified	99.7	99.6	99.5	98.6	98.6	88.7	61.3	25.2	21.4	7.1	2.4	23.2
Bathyraja sp.	*	*	0.1	1.1	0.2	0.4	0.5	39.3	34.2	42.6	47.4	33.1
Bathyraja parmifera (Alaska skate)	*	*	0.1	0.2	0.7	7.9	30.2	27.2	36.6	40.0	40.1	34.8
Bathyraja aleutica (Aleutian skate)	*	*	*	*	0.1	0.7	2.2	2.6	1.9	2.5	2.7	2.4
Bathyraja interrupta (Bering skate)	*	*	*	*	*	0.3	1.6	1.5	1.1	1.3	2.7	1.7
Bathyraja maculata (whiteblotched skate)	*	*	*	*	*	0.1	1.1	0.4	0.7	0.5	1.0	0.7
Bathyraja lindbergi (Commander skate)	*	*	*	*	*	*	0.1	0.2	0.1	0.2	0.2	0.2
Bathyraja taranetzi (mud skate)	*	*	*	*	*	*	0.2	0.1	*	0.1	0.3	0.2
Bathyraja trachura (roughtail skate)	*	*	*	*	*	*	0.1	*	0.1	0.1	*	0.1
Bathryaja minispinosa (whitebrow skate)	*	*	*	*	*	*	*	*	*	*	*	*
Raja sp.	*	*	*	*	*	*	*	0.1	0.5	*	0.1	0.1
Raja binoculata (big skate)	0.3	0.4	0.3	*	0.2	1.7	2.3	2.3	2.4	3.7	2.1	2.5
Raja rhina (longnose skate)	*	*	*	*	*	0.2	0.5	1.0	1.0	1.9	1.0	1.1

52% was identified to species (i.e., *Bathyraja parmifera* and other species).

The portion of the OSC that was identified to the species level was dominated by *Bathyraja parmifera*, *Raja binoculata*, and *Bathyraja aleutica* (Aleutian skate), which accounted for 40.1%, 2.1%, and 2.7%, respectively, of OSC in 2008 (Table 1). These proportions have remained relatively stable since observers began identifying skates in 2004, with *B. parmifera*, *R. binoculata*, and *B. aleutica* averaging 34.8%, 2.5%, and 2.4%, respectively, of the annual OSC from 2004 through 2008. Seven other species of skates, including *R. rhina* and six species of *Bathyraja* (*B. interrupta, B. maculata, B. lindbergi, B. taranetzi, B. trachura, B. minispinosa*), have been regularly reported in smaller proportions by observers since 2004. Although unidentified skates now constitute less than 5% of OSC, a large proportion of skates are still identified only to the genus level ("*Bathyraja* sp." and "*Raja* sp.").

The species composition of OSC varied by region and by gear type within each region. During the 2004–08 period, *Bathyraja parmifera* was the most commonly observed species in both the Bering Sea and Aleutian Islands region (Table 2). In the Bering Sea, no other single species made up more than 1.7% of OSC, and a large percentage of skates were identified only to the genus level. Species composition profiles were similar for both types of trawl, but for fisheries using longline gear a much higher percentage of skates were not identified to the species level.

In the Aleutian Islands, *B. parmifera* again accounted for a higher proportion of OSC than any other species (Table 2). However, notable proportions of *B. maculata* and *B. aleutica* were reported in this region as well. As in the Bering Sea, a large proportion of the skates were not identified to the species level, and most of the unidentified skates and skates identified to genus were encountered in fisheries using longline gear. The species composition profile for pelagic trawl gear in the Aleutian Islands, with only two species reported and *B. interrupta* accounting for over 80% of OSC, was markedly different from any of the other region-gear combinations reported in our study. However, that profile was based on only two species composition samples in which skates were reported.

The species composition of OSC was quite different in the Gulf of Alaska, where the two species of *Raja* (*R. binoculata* and *R. rhina*) are more common, accounting for over half of OSC in the region (Table 2). Among species of *Bathyraja*, *B. aleutica* accounted for the highest proportion in the Gulf of Alaska. The proportion of skates not identified to the species level was considerably lower in the Gulf of Alaska than in either the Bering Sea or Aleutian Islands, and the species composition

Table 2

Species composition (% by weight) of observed skate catch by region and by gear type within each region of Alaska for 2004–2008. Regions: BS=Bering Sea, AI=Aleutian Islands, GOA=Gulf of Alaska. Gear types: 1=Nonpelagic trawl, 2=Pelagic trawl, 3=Longline. * = less than 0.1%.

	BS				AI				GOA			
Taxon	1	2	3	All	1	2	3	All	1	2	3	All
Skate unidentified	0.6	1.4	33.5	24.2	3.9	*	25.1	17.6	2.4	3.5	16.7	9.6
Bathyraja sp.	1.9	1.5	47.5	34.5	4.7	*	40.7	28.0	2.2	3.3	16.5	9.4
Bathyraja parmifera	90.0	92.8	14.9	36.6	50.9	*	18.0	29.6	3.6	9.4	2.8	3.2
Bathyraja aleutica	3.0	2.4	1.2	1.7	16.1	*	3.7	8.0	9.5	9.8	13.7	11.6
Bathyraja interrupta	1.3	1.3	1.7	1.6	1.1	80.6	0.4	0.7	5.9	6.3	3.0	4.4
Bathyraja minispinosa	0.1	*	*	*	0.1	*	0.1	0.1	*	*	*	*
Bathyraja maculata	0.4	*	0.2	0.2	17.2	*	9.3	12.1	*	*	0.2	0.1
Bathyraja lindbergi	*	*	0.1	0.1	0.2	*	1.7	1.1	*	*	0.2	0.1
Bathyraja taranetzi	0.2	0.1	*	0.1	5.2	19.4	0.6	2.2	*	*	*	*
Bathyraja trachura	*	*	*	*	0.1	*	0.2	0.2	*	*	1.4	0.7
Raja sp.	*	*	*	*	*	*	*	*	0.6	0.3	4.6	2.6
Raja binoculata	2.4	0.4	0.7	1.0	0.4	*	0.2	0.3	52.3	24.8	19.6	35.7
Raja rhina	0.1	*	*	*	*	*	*	*	23.4	42.6	21.3	22.4
Total	100	100	100	100	100	100	100	100	100	100	100	100

profiles varied more by gear type than in the other two regions. All three gear types were dominated by species of *Raja*, but *R. binoculata* accounted for over 50% of OSC from nonpelagic trawl gear, whereas *R. rhina* was the dominant species in pelagic trawl and longline gear. As in the other two regions, proportions of unidentified skates were much higher on longliners than on vessels with other gear types, although a much higher percentage of skates were identified to the species level even with longline gear in the Gulf of Alaska.

Significant amounts of skate bycatch were encountered by observers in fisheries targeting a variety of commercial groundfish species, including Pacific cod, walleye pollock, Atka mackerel, shallow-water flatfishes (primarily yellowfin and rock soles), and others. During the 1998–2008 study period, nearly 72% of OSC was reported in longline fisheries, and over 65% was reported in longline hauls targeting Pacific cod (Table 3). Nonpelagic trawl fisheries accounted for only 22% of OSC, most of which was reported in hauls targeting miscellaneous flatfishes. Pelagic trawl fisheries, essentially all of which target walleye pollock, accounted for very little of OSC (6%). These results reflect the percentages for the Bering Sea, a region in which over 90% of OSC was reported. In the Aleutian Islands significant numbers of skates were also encountered on trawlers targeting Atka mackerel, and in the Gulf of Alaska on trawlers targeting deepwater flatfishes (arrowtooth flounder and Greenland turbot).

The percentage of OSC retained by commercial fishermen has increased over the past decade (Fig. 2). In 1998, overall mean skate retention was just over 12%, and that figure steadily increased to a peak of nearly 40% in 2003. For the most recent 4 years (2005–08) overall skate retention has remained relatively consistent at around 30–35%. Species-level retention data were erratic from 1998 through 2003. They have become more stable since 2004 when observers began consistently identifying skates to the species level, but the annual mean retention for some of the species, particularly the genus *Raja*, still appears relatively inconsistent from year to year. Since 2004, the largest species of skates (*Raja binoculata*, *R. rhina*, *Bathyraja parmifera*, *B. aleutica*, and *B. maculata*) have generally been retained at 30% of OSC or above, and smaller species, such as *B. interrupta*, *B. lindbergi*, *B. taranetzi*, and *B. minispinosa*, have been retained at lower levels (5–15%).

Discussion

From the inception of the NPGOP through 2003, field identification tools for the skates of Alaska were limited, and skate bycatch data were collected at a very basic level. Almost all skates were reported by observers as "skate unidentified." However, from 2004 through 2008 this situation changed rapidly. With the development and deployment of a field guide and the implementation of an observer training protocol (Stevenson, 2004), the proportion of skates identified to the species level has increased dramatically. For the last year included in this study, over 95% of OSC was identified at least to genus, and that proportion may continue to rise in future years

Table 3

Observed skate catch (in tons) by region, gear type, and target species reported in Alaska's groundfish fisheries for 1998–2008. Target species is defined as the predominant species (by % weight) in the catch. * = less than 100 tons.

Region / Gear type	Target species: Pacific cod (*Gadus macrocephalus*)	Misc. flatfishes	Walleye pollock (*Theragra chalcogramma*)	Arrowtooth (*Atheresthes stomias*) or Turbot (*Reinhardtius hippoglossoides*)	Pacific halibut (*Hippoglossus stenolepis*)	Atka mackerel (*Pleurogrammus monopterygius*)	Rockfishes (*Sebastes* sp.)	Sablefish (*Anoplopoma fimbria*)	Other	Total
Bering Sea										
Nonpelagic trawl	2606	18,400	2476	1677	*	*	*	*	1367	26,675
Pelagic trawl	*	*	8912	*	*	*	*	*	*	8967
Longline	90,314	*	206	967	461	*	*	*	2714	94,766
Aleutian Islands										
Nonpelagic trawl	491	*	*	*	*	1021	443	*	*	2067
Pelagic trawl	*	*	*	*	*	*	*	*	*	*
Longline	3850	*	*	256	497	*	*	140	793	5597
Gulf of Alaska										
Nonpelagic trawl	437	756	*	1393	*	*	262	*	448	3445
Pelagic trawl	*	*	*	*	*	*	*	*	*	*
Longline	1486	*	*	*	443	*	*	319	286	2566
All areas										
Nonpelagic trawl	3534	19,177	2563	3123	101	1072	744	*	1823	32,187
Pelagic trawl	*	*	8967	*	*	*	*	*	*	9061
Longline	95,650	*	208	1229	1401	*	*	493	3794	102,929
Total	99,222	19,253	11,738	4366	1504	1077	843	544	5630	144,177

as training methods and identification tools are further refined.

Patterns of species composition in OSC generally parallel recent biomass estimates for regional skate populations derived from bottom trawl surveys. *Bathyraja parmifera* accounts for the large majority of OSC, which is not surprising given that *B. parmifera* is the most abundant species of skate encountered in bottom trawl surveys conducted in Alaska waters (Stevenson et al., 2008). In fact, *B. parmifera* is particularly common on the Bering Sea continental shelf, where its populations make up about 95% of the total skate biomass (Acuna and Lauth, 2008; Lauth and Acuna, 2009) and where commercial fishing effort for walleye pollock, Pacific cod, and flatfishes is concentrated. Many of the other species encountered by observers in the Bering Sea are recorded from fishing activity on the upper continental slope, where *B. aleutica*, *B. maculata*, and *B. interrupta* populations

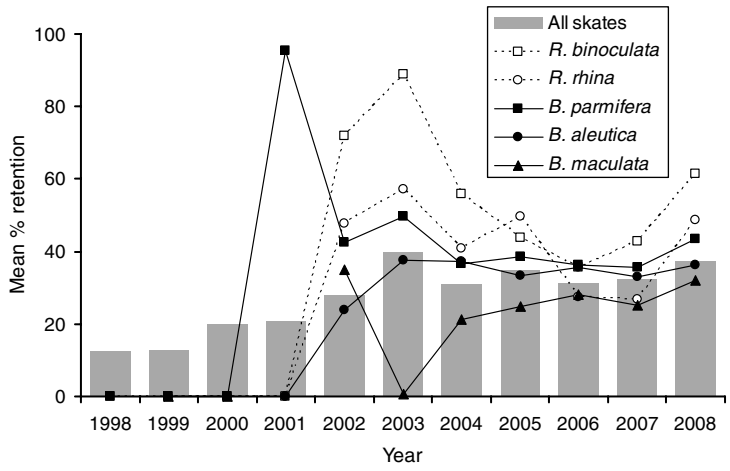

Figure 2

Overall mean percent retention of skate catch in commercial fisheries for each year from 1998 through 2008 (gray bars), as well as mean percent retention for *Raja binoculata*, *R. rhina*, *Bathyraja parmifera*, *B. aleutica*, and *B. maculata*.

are concentrated (Hoff and Britt, 2003, 2005, 2009; Stevenson et al., 2008).

In the Aleutian Islands, over 50% of OSC consists of *B. parmifera*, *B. maculata*, and *B. aleutica* (Table 2), which are the top three species in terms of recent biomass estimates for the region (Zenger, 2004; Rooper, 2008; Rooper and Wilkins, 2008). However, the proportion of *B. parmifera* is higher (29.6% of observed skate catch) and that of *B. maculata* considerably lower (12.1%) in commercial catches in the Aleutian Islands than their biomass estimates in the region (20–25% and 48% of total skate biomass, respectively) would indicate. The reasons for these differences in relative catch weight are unclear, but may be due to geographically and bathymetrically concentrated commercial fishing effort. Skate populations in Alaska are primarily segregated by depth, and *B. maculata* tends to be found in deeper waters than those inhabited by *B. parmifera* (Rooper, 2008; Stevenson et al., 2008). Therefore, shallow-water fisheries are more likely to catch *B. parmifera*, and although observers reported skates in the Aleutian Islands from depths to 2000 m, the majority of OSC came from 200 m or less. Thus, Aleutian populations of *B. parmifera* may be disproportionately affected by fishing activity because of the shallow depth distribution of this species.

The two species of *Raja* (and unidentified *Raja*—"*Raja* sp.") account for over 60% of OSC in the Gulf of Alaska. These results are also consistent with fishery-independent survey data, which indicate that *Raja binoculata* and *R. rhina* are the most abundant species in the Gulf of Alaska, making up about 37% and 33%, respectively, of the skate biomass in the region (Stevenson et al., 2008; von Szalay et al., 2009). Among species of *Bathyraja* in the Gulf of Alaska, survey-derived biomass estimates indicate that *B. aleutica* is the most common, and indeed *B. aleutica* accounts for a greater proportion of OSC in this region than all other species of *Bathyraja* combined.

Deepwater skate species, such as *B. lindbergi*, *B. minispinosa*, and *B. trachura*, are rarely reported by observers in any of the three regions, probably due to the relatively small amount of fishing effort targeting deepwater species. Other species known to be rare in Alaska waters, such as *B. abyssicola*, *B. mariposa*, and *Amblyraja badia*, have been only rarely reported by observers, and only *B. mariposa* has been confirmed by photographs and collected specimens.

Although the percentage of unidentified skates in observer species composition data has declined to a very low level, a large percentage of OSC is still identified only to genus. These less specific skate identifications are largely the result of uncertainty with identification in the field. Because observers encounter a relatively high diversity of skates, particularly of the genus *Bathyraja*, and must often interpret subtle characteristics to identify skates to the species level, they are encouraged to identify a skate only to the genus level if the specimen is not brought to hand for inspection or if the identification of the specimen is questionable. As a result, species composition of OSC is clearly affected by fish-handling practices and observer sampling methods on vessels with different gear types. Observers in trawl fisheries select their species composition samples at random from the catch after it is onboard the vessel. Therefore, the entire composition sample is weighed, and all specimens in the composition sample are identified in hand. In contrast, on longline vessels species composition data are collected as the gear is being retrieved, and not all of the specimens in the composition sample are brought on board and weighed. Some specimens counted during the tally period, particularly larger species such as many of the skates common in Alaska waters, become "drop-offs." These specimens are retrieved to the surface on the line but either fall off before they can be brought onboard or are intentionally released to save strain on the gear, the personnel, and the fishes. Therefore, many of the skates in the composition sample from longline vessels are not brought to hand for identification, and are recorded at the genus level. Thus, the way the catch is handled and sampled in longline fisheries largely explain the influence of gear type on the species composition profiles reported here (Table 2).

The influence of longline data is significant because the majority of OSC in Alaska waters comes from longliners. In fact, the data presented here (Table 3) indicate that the longline fishery for Pacific cod in the Bering Sea accounts for more skate bycatch than all other federally managed groundfish fisheries combined. This result must be interpreted with some caution because differences in observer coverage for different fisheries and regions may have influenced these figures, and a predominant species is not a precise indicator of a target fishery. But it is clear that longliners targeting Pacific cod catch a lot of skates. Moreover, longline gear is often fished deeper than trawl gear, and therefore may affect a greater diversity of skate species than gear fished in more shallow water because skate diversity in Alaska waters tends to be highest on the continental slope (Stevenson et al., 2008). Therefore, as long as a high proportion of skates encountered on longliners are identified only to genus, a potentially important segment of species-specific catch data is still not available for analysis.

The presence of skates in the catch of pelagic trawls may seem counterintuitive because skates are generally benthic, substrate-oriented fishes unlikely to be found in the path of midwater nets. Indeed, the amount of skate catch reported in pelagic trawls (about 6% of OSC) is much lower than in the other two gear types. There are two general explanations for the skates that are collected in pelagic nets: either the skates were swimming up in the water column or the net contacted the seafloor. The target of most pelagic trawling in Alaska is walleye pollock, a species that is often found very close to the bottom, and catch data from pelagic trawlers often include a variety of benthic species, such as flatfishes and sculpins, in addition to skates. Therefore, it is likely that at least a large proportion of the skate

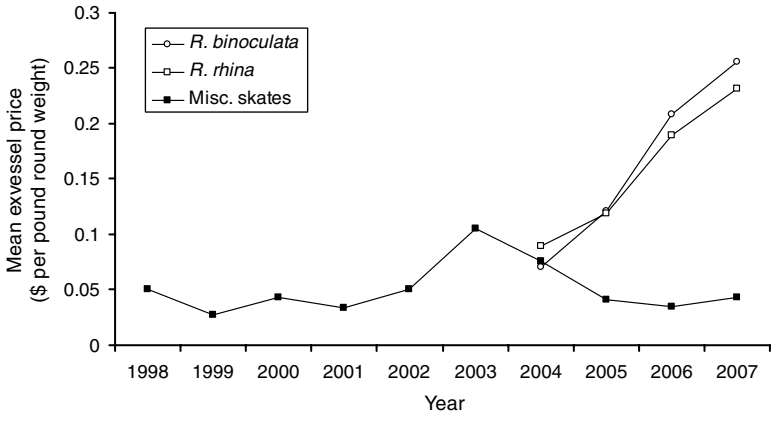

Figure 3

Annual mean exvessel price paid by processors in Alaska for big skate (*Raja binoculata*), longnose skate (*Raja rhina*), and miscellaneous skates from 1998 through 2007.

catch in pelagic trawls is the result of the net contacting, or at least coming very close to, the seafloor.

Historically, skates have not been considered valuable by Alaska's commercial fishermen. Even though skates are large fishes that represent a significant potential source of protein, retention of skates in the commercial fisheries of Alaska has been low. However, groundfish observer data, coupled with exvessel pricing information, may indicate that this situation is beginning to change. Overall mean retention was less than 15% in the late 1990s, and presumably before that time as well; however, it has increased to 30–35% in recent years. Species-level catch data collected since 2004 indicate that the large species (such as both species of *Raja*, *Bathyraja parmifera*, and *B. aleutica*) are retained at a higher rate than smaller species, and that retention rates for the large species are not necessarily consistent from year to year. The general increase in retention rates may reflect changes in the market value for skate products. Although the mean exvessel price for general skate catch has remained fairly stable over the past decade (Fig. 3), the price paid to Alaskan fishermen for big skates and longnose skates has risen sharply. Since 2004, when processors began reporting landings data by species owing to changes in the Fishery Management Plan for groundfish of the Gulf of Alaska, the mean annual price paid for big and longnose skates has nearly tripled.

Although the data presented here signify a dramatic improvement in the information available to fishery managers, some noteworthy gaps persist. The data presented here represent only sampled hauls on vessels requiring observer coverage in federally managed fisheries, and therefore other sources of skate bycatch are not represented. Commercial fishing activity in the Bering Sea and Aleutian Islands is conducted primarily on large vessels, which are required to have 100% observer coverage, and therefore observer data should provide a good representation of skate bycatch in those regions. In contrast, many of the commercial vessels operating in the Gulf of Alaska are small enough that observer coverage is only required on 30% of fishing days or is not required at all. Therefore, observer data for this region may provide much less reliable estimates of skate bycatch. Because the two species of the genus *Raja* are common in the Gulf of Alaska, and are among the largest skate species in the region, the unobserved catch of those species is of particular concern. Disproportionate retention of larger skates is prevalent in many fisheries worldwide, and as larger, more vulnerable species are removed, smaller species may become more abundant (Russ, 1991; Agnew et al., 2000; Cedrola et al., 2005; Swain et al., 2005). In the North Atlantic, severe reduction in biomass for some larger, less resilient skate species has been accompanied by an increased biomass for smaller, more resilient species (Casey and Myers, 1998; Walker and Hislop, 1998; Dulvy et al., 2000). Species-specific observer data on skate bycatch can document this phenomenon, but only if the data are representative of total fishing effort. Therefore, undocumented sources of skate bycatch, as well as nonspecific data from observed longline fisheries (see above comments on longline species composition data), present significant remaining challenges to fishery managers.

Observer data on skate bycatch in the groundfish fisheries of Alaska represent a rich source of information for managers charged with protecting skate populations from future overexploitation. The species-level catch data now being collected by observers have facilitated the development of an age-structured stock assessment model for *B. parmifera* (B. Matta, personal commun.[2]), which is a critical aid in setting appropriate catch limits for the species, and similar models for other species

[2] Matta, Beth. 2009. NMFS Alaska Fisheries Science Center, Seattle, WA 98115.

are on the horizon. These fishery-dependent data can now be compared directly with fishery-independent survey data, creating two independent lines of evidence for management strategies. Specific catch data may also be used to identify areas in which the most vulnerable species may be most heavily impacted and thus can help identify areas in which restrictions or closures are necessary. Although observer data do not give a complete account of skate bycatch in the fisheries of Alaska, the information currently provided allows this diverse assemblage of species to be managed in a more biologically appropriate way than was possible in the past. As fishing pressure on Alaska's skate populations increases, the consequences of data deficiencies will be magnified, and observer data will play an increasingly important role in protecting skates from the declines in biomass and shifts in community structure that have befallen these fishes in other parts of the world.

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