Recent Contributions to the Knowledge of the Skates of Alaska

by
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Figure 1. *Raja binoculata* (big skate). Photo by Duane Stevenson.

The fish family Rajidae, commonly known as the skates, includes about 280 species of primarily benthic fishes found throughout the world's oceans from tropical to cold temperate latitudes. *The fishes of Alaska* (Mecklenburg et al., 2002), the most recent inventory of Alaska's fishes, lists 12 species of skates known to occur in the Gulf of Alaska, Aleutian Islands, and Bering Sea from the intertidal zone to depths of over 1500 m, and at least 2 other species have been discovered in the region since the publication of that volume as described in *Bathyraja mariposa: a new species of skate (Rajidae: Arhynchobatinae) from the Aleutian Islands* (Stevenson et al., 2004a) and *New records of two deepwater skate species from the Bering Sea* (Stevenson and Orr, submitted). Many of these species are widely distributed, with ranges extending south along the coast of North America as well as into the western North Pacific, Sea of Okhotsk, and Sea of Japan.

Alaska's skate fauna includes representatives of two genera: *Raja* and *Bathyraja*. The genus *Raja*, commonly known as the "stiff-snout" skates because they have a robust rostral cartilage, includes approximately 30 species worldwide and a North Pacific assemblage of 6 species ranging from the Gulf of California to the Bering Sea and into the western North Pacific. This North Pacific Assemblage is thought to be a cluster of closely related species and will probably be recognized as a separate genus in the future. The genus *Bathyraja*, also known as the "soft-snout" skates due to their flexible rostral cartilage, includes over 40 species distributed throughout the world's oceans. *Bathyraja* is the most broadly distributed as well as the most diverse of all the skate genera, and the greatest diversity of *Bathyraja* occurs in the North Pacific. The majority of Alaska's skate species are included in this genus, although some authors include one or two of the species in the genus *Rhinoraja*. In general, members of the genus *Bathyraja* tend to be smaller and inhabit deeper waters than species of *Raja*.

Many skate species attain very large sizes (*Raja binoculata* reaches over 2 m in length and may weigh well over 70 kg) (Fig. 1) and can be locally abundant. Therefore, skate populations represent a large proportion of the groundfish biomass in Alaskan

waters, particularly on the Bering Sea shelf, and are important components of the food web dynamics and nutrient cycling in Alaska's marine ecosystems. However, due to their large size, relatively long life expectancy, and low fecundity, skates may be particularly vulnerable to fishing pressure. In the North Atlantic where fisheries target skate populations, several species are in a state of decline and at least two species have been extirpated from large portions of their native range. Furthermore, skate populations may be adversely affected by fishing activity, even if they are not directly targeted.

Although they represent a large proportion of the worldwide diversity of cartilaginous fishes (roughly 35% of elasmobranch species currently known are skates), skates are morphologically conservative and differences among species or even genera are often subtle. Moreover, the limits of morphological variation in many species are poorly known, and as a result skates have been very challenging to identify in the field, especially in the North Pacific. These challenges are compounded by the fact that skates are generally large fishes and are difficult to collect, preserve, and curate. Therefore, they are poorly represented in museum collections and difficult to study in the laboratory. As a result of identification difficulties and a relative lack of commercial importance, species-specific data on skate populations are often not available, and catch statistics are commonly recorded only at the aggregate level. This is a concern because apparent stability or increases in aggregate skate catches may mask declines in some components of those species aggregates, particularly the larger species.

Recent emphasis on ecosystem-level management of federally regulated marine fisheries and the recent development of a commercial fishery targeting skates in the Gulf of Alaska have underscored the need for basic biological data on these fishes. As these needs are recognized, researchers and fishery managers will require a level of detailed information on the diversity and distribution of skates in Alaskan waters that was previously not available. In response to these needs, scientists at the Alaska Fisheries Science Center (AFSC) have been involved in several projects that have advanced our knowledge of the skates of the North Pacific and Bering Sea. This research feature article describes several of those efforts.

Field Identification

The *Atlas and zoogeography of common fishes of the Bering Sea and Northeastern Pacific*, (Allen and Smith, 1988) noted several problems with skate data in the National Marine Fisheries Service (NMFS) survey database and concluded that further study was needed to clarify the distribution of these species. The problems were largely a reflection of the poor state of skate systematics and the lack of useful field identification tools. In fact, until recently, a comprehensive field guide to the skates of Alaska was not available for use on the Center's Resource Assessment and Conservation Engineering (RACE) Division surveys. AFSC scientists began to consistently identify skates to the species level beginning in 1997 during the Aleutian Islands triennial groundfish survey. For several years, identifications were based on a dichotomous key provided by John McEachran of the Texas A&M University (later incorporated into the key of Mecklenburg et al.). Recently, McEachran's key was refined, developed into a color field guide, and integrated into the on-deck field guides used on groundfish surveys. This field guide incorporates geographic and bathymetric distribution information for each species as well as high-resolution color photos taken on recent RACE surveys. Another version of this field guide, included in *Identification of skates, sculpins, and smelts by observers in North Pacific groundfish fisheries (2002–2003)* (Stevenson, 2004), has been developed for use by groundfish observers and includes a dichotomous key to the skates of Alaska. These tools have greatly facilitated species-level identification of skates in the field.

Confidence in field identifications has also been improved with the establishment of a voucher collection process that allows for laboratory verification or reidentification of significant specimens. This process involves labeling and photographing the specimen on deck, then preserving it and shipping it back to the laboratory for identification and further study. Many of these specimens collected as vouchers have provided the material to recognize previously undescribed species in the region. The majority of specimens collected as part of the voucher process, including primary types of new species, are now archived at the University of Washington Fish Collection. This collection provides loans and access to these and other specimens to researchers world-

wide. Other type material, which serves as verified examples of new species, has been distributed to fish collections around the United States, including the U.S. Natural History Museum at the Smithsonian Institution, the California Academy of Sciences, and the Los Angeles County Natural History Museum. In addition, tissue samples from many specimens have been collected for genetic studies and are stored in the University of Washington and in the University of Kansas Natural History Museum, Division of Ichthyology. From this vouchered tissue collection, genetic markers have been developed by Mike Canino and Ingrid Spies of the RACE Division to identify all of the common skates of Alaska (see below).

Documenting Diversity

As survey personnel have been trained to recognize species-level differences among skates and field identifications have improved, a clearer picture of skate diversity has begun to emerge. The geographic and bathymetric ranges of each species are now known with greater certainty than ever before. Generally, in Alaskan waters, skate diversity is higher on the continental slope than on the shelf as many species are found only near the shelf break and deeper. The area of greatest skate diversity is the eastern Aleutian Islands and southeastern Bering Sea (Fig. 2). On the AFSC's Bering Sea slope bottom trawl survey, it is not uncommon to encounter five or six species of skates in a single haul. This survey covers the bathymetric range of a "deepwater" assemblage of *Bathyraja*, which includes species such as the whitebrow skate (*B. minispinosa*), roughtail skate (*B. trachura*), and Commander skate (*B. lindbergi*), all of which inhabit the upper continental slope and are rarely encountered on the continental shelf. In contrast, skate diversity is particularly low on the Bering Sea shelf, where the fauna is dominated by one species, *B. parmifera*. This species accounts for over 90% of the skate catch on the AFSC's Bering Sea shelf bottom trawl survey. In the Gulf of Alaska, skate diversity tends to be greatest in Shelikof Strait, where it is not uncommon to encounter three or four species of skates in a single haul, particularly at the deeper survey stations. Skates of the genus *Raja* contribute more to the diversity in this region than in other parts of Alaska.

Although skate species diversity is particularly low on the Bering Sea shelf, total skate biomass appears to be greater in this area than in any other region of Alaskan waters (Fig. 3). Skates are encountered in nearly every haul on the Bering Sea shelf survey, and they often occur in large numbers, particularly on the outer shelf in the northern Bering Sea. Skate biomass also appears to be high in parts of the central and western Aleutian Islands, where large species like the whiteblotched skate, *B. maculata*, and the Aleutian skate, *B. aleutica*, are encountered in large numbers along with several smaller species. In the Gulf of Alaska, big skates and longnose skates (*R. binoculata* and *R. rhina*, respectively), which are the largest species of skates in Alaskan waters, make up a higher proportion of the catch. These large species are most common in the Kodiak Island region.

In addition to improvements in distribution data, new species of skates are being discovered and others newly recorded from Alaskan waters. Using morphological characteristics such as counts of vertebrae, fin rays, and thorns, measurements of body shape, overall shape of clasper cartilages, and body color, AFSC scientists James Orr and Duane Stevenson have examined and identified hundreds of skate specimens collected in Alaska. In summer 2003 they traveled to the Zoological Institute of St. Petersburg, National Science Museum of Tokyo, Tokyo University of Fisheries Museum, and Hokkaido University Museum of Zoology to examine skate specimens collected from the western Pacific, Sea of Okhotsk, and western Bering Sea. Examination of these western Pacific specimens and collaboration with worldwide skate experts such as John McEachran have provided a larger context in which to interpret the diversity of skates in Alaskan waters.

A skate species new to science, *B. mariposa* (Fig. 4), was recently described from the central Aleutian Islands in *Bathyraja mariposa*: *a new species of skate (Rajidae: Arhynchobatinae) from the Aleutian Islands* (Stevenson et al., 2004). This species was discovered during the 2002 Aleutian Islands bottom trawl survey aboard the chartered vessel *Morning Star* near the Islands of Four Mountains. Its color pattern immediately distinguished it from other skate species known from the area, and further investigation revealed differences in clasper morphology,

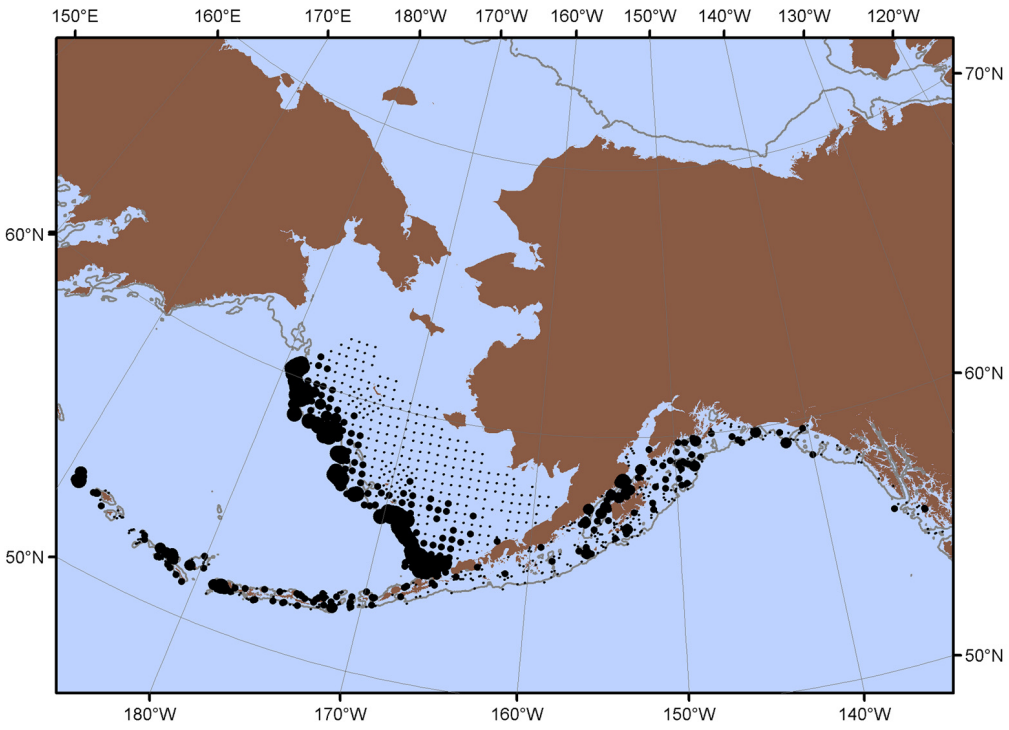

Figure 2. Number of skate species collected per haul in the most recent AFSC surveys.

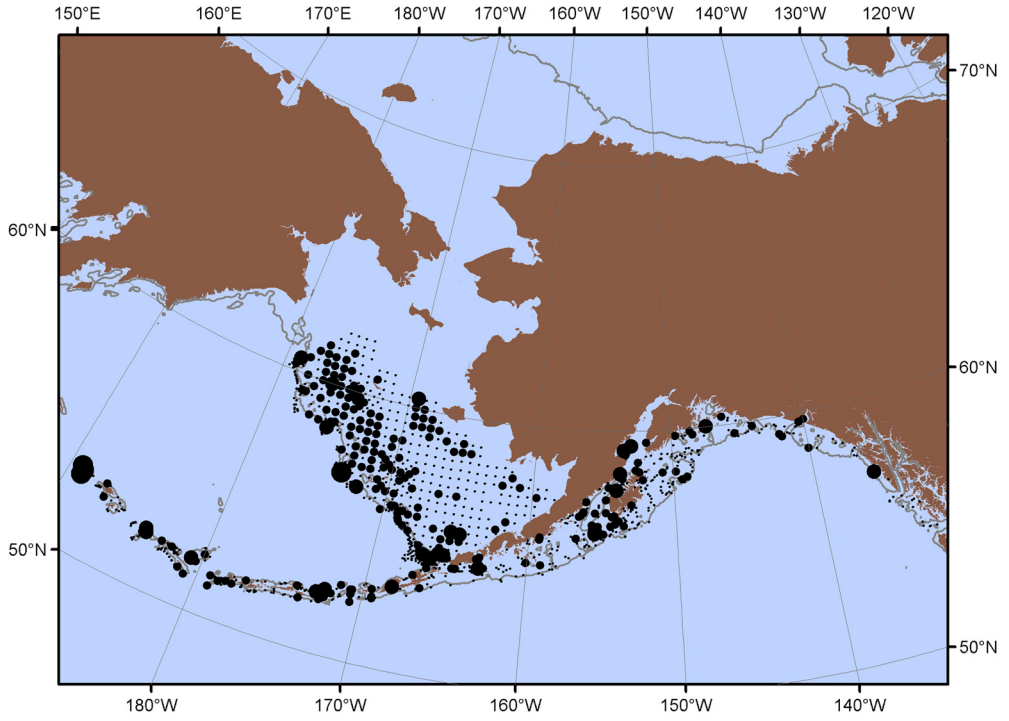

Figure 3. Total skate catch per haul in the most recent AFSC surveys.

Figure 4. *Bathyraja mariposa* (Butterfly skate). Photo by Gerald Hoff.

the pattern of denticles on the dorsal surface, and vertebral counts, all of which confirmed this as a species unknown to science. Since its discovery, more than 20 specimens of this species have been collected on RACE surveys. Furthermore, another new skate species has recently been recognized in the Aleutian Islands, and a description of that species is currently under way. Information on the species in the poster *Bathyraja parmifera (Rajidae: Arhynchobatinae), and related species, including preliminary data on a new species from the Aleutian Islands* (Orr et al., 2004), was presented at the 2004 Western Groundfish Conference and 2004 Annual Meeting of the American Society of Ichthyologists and Herpetologists. Additionally, at least one species previously unknown from Alaska has recently been collected on RACE surveys in the Bering Sea. In total, AFSC research has added three species to the list of skates known from Alaskan waters, and more are sure to come.

The most significant gaps that remain in our knowledge of the distribution of skates in Alaska are in deepwater habitats. Although the Bering Sea slope survey covers depths to over 1200 m, surveys covering the Aleutian Islands and Gulf of Alaska have rarely extended below 500 m. Therefore, the deeper waters of these regions are poorly known, and many of the deepwater skate species may have more extensive ranges than are currently documented. As RACE surveys continue to probe the deeper regions of the Gulf of Alaska, Aleutian Islands, and Bering Sea additional discoveries are likely to be made and our knowledge of the distribution of many skate species will certainly improve.

Enlisting Observers

Fishery observers deployed through the North Pacific Groundfish Observer Program (NPGOP) collect an enormous amount of catch data that are used by a wide range of researchers and fisheries managers. Due to time constraints and the perceived difficulties with species-level identification of skates, observers have historically classified all skates encountered in groundfish fisheries as "skate unident." As interest in skate populations has increased, the need for additional sources of data on skate abundance, distribution, and possible fishery effects on skate populations has become clear. Because groundfish observers provide a potentially rich source of data on skate populations, a test study was conducted to determine the feasibility of a policy change that would require all observers to identify skates to the species level (Stevenson, 2004). This study involved the development of a series of identification tools designed for use by groundfish observers in the field, as well as a training curriculum designed to enable observers to accurately identify skates at sea. The results of this study indicated that

Figure 5. *Bathyraja parmifera* (Alaska skate) egg case from the southeastern Bering Sea. Photo by Gerald Hoff.

the tools and training provided observers with an effective means of identifying skates to the species level, and that the additional time commitment that would be required to complete these identifications would be minimal.

Beginning in January 2004, the skate identification curriculum was integrated into the fish identification portion of NPGOP observer training. Since that time, all groundfish observers have been identifying skates to the species level whenever possible, creating a wealth of additional data that is already being used by scientists and fisheries managers.

Other Studies

The current level of interest in skate biology has provided impetus for a number of projects currently being conducted by AFSC research scientists. For example, Gerald Hoff of the RACE Division is researching skate nursery areas in the southeastern Bering Sea in order to gain insight into the reproductive behavior of the Alaska skate (*B. parmifera*) (Fig. 5) and Aleutian skate (*B. aleutica*). His research focuses on the characterization of skate nursery areas and approaches for nursery conservation. Beth Matta of the Center's Resource Ecology and Fisheries Management (REFM) Division is conducting an age and growth study on the Alaska skate (*B. parmifera)* in the eastern Bering Sea. Her study focuses on age and size at maturity estimates for this abundant skate species. She is also developing an age-at-length key to describe growth and the age composition of Alaska skates in the eastern Bering Sea. Chris Gburski of REFM is conducting age and growth studies for species in the Gulf of Alaska, focused primarily on the commercially important longnose skate (*R. rhina*) and big skate (*R. binoculata*) (Fig. 1). The results of this work will be shared with biologists in the REFM Division to improve skate stock assessments. Mike Canino and Ingrid Spies of the RACE Division are working to develop a molecular assay that can be used to identify skates on the basis of tissue samples. Future genetic studies in conjuction with on-going morphological work will be directed toward elucidating the phylogenetics of skates. The AFSC is also providing data and logistical support to scientists conducting several reproductive and life history studies on skates at the Pacific Shark Research Center at Moss Landing Marine Laboratory. These and other ongoing projects are providing valuable contributions to our knowledge of the skates of Alaska, and all have been facilitated by the recent advances in the taxonomy and field identification described above.

Accurate and reliable field identifications are the foundation on which all biological science rests. As we continue to refine and improve our ability to identify skates in the field, our ability to conduct scientifically rigorous investigations on the skate populations of Alaska improves dramatically. As new taxa are recognized and described, we are developing a better understanding of the basic components of the marine ecosystems of the North Pacific and Bering Sea. Ultimately, these studies augment the agency's ability to provide effective stewardship of Alaska's marine resources.

This article has been revised since it was published in print to include additional information on other skate studies conducted within the AFSC's Age and Growth Program.

Additional Reading

(Publications by Stevenson and Orr cited in the preceeding article are available for downloading from the publications section of the AFSC web site at *www.afsc.noaa.gov*.)

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