Landings Composition of the Northeast U.S. Skate, Rajidae, Wing Fishery and the Effectiveness of Prohibited Species Regulations

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Introduction

There are seven species of skates (family Rajidae) commonly encountered on the continental shelf waters off the northeastern United States, including winter skate, *Leucoraja ocellata*; little skate, *L. erinacea*; rosette skate, *L. garmani*; clearnose skate, *Raja eglanteria*; thorny skate, *Amblyraja radiata*; smooth skate, *Malacoraja senta*; and barndoor skate, *Dipturus laevis*. However, only winter and little skates are targeted by regional fisheries, while the other species are largely taken as bycatch (NEFMC, 2003).

Little skates are targeted in a relatively small-scale fishery that provides bait to American lobster, *Homarus americanus*, fishermen. The species that grow to larger maximum sizes, winter (up to 137 cm TL: Sulikowski et al., 2003), thorny (up to 111 cm TL: NEFMC, 2010), and barndoor (up to 152 cm TL: Bigelow and Schroeder, 1953) have historically been harvested for their "wings" (i.e., pectoral fins) to supply seafood markets mainly in Europe (NEFMC, 2003). Little, rosette, clearnose, and smooth skates do not typically reach sizes considered marketable for the skate wing fishery (NEFMC, 2003).

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ABSTRACT—The skate (Rajidae) fishery off of the northeastern United States is managed as a stock complex of seven species. However, landings have not been reliably reported by species, hindering stock assessments and effective species-level management. This study was designed to characterize regional and interannual variation in the species composition of landings in the skate wing fishery. Port samplers were trained to properly identify skate wings landed at regional seafood dealers. Of the 92,833 skate wings sampled between 2005 and 2012 at ports in Maine, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, over 98% were identified as belonging to winter skate, Leucoraja ocellata. *The wings of thorny skate,* Amblyraja radiata, *and barndoor skate,* Dipturus laevis, *both prohibited species, comprised the remainder of the sampled landings. While illegal landings of prohibited skates were more prevalent in Gulf of Maine ports, compliance with the prohibitions improved during the study period, possibly due to NMFS outreach efforts. These results demonstrate the relative effectiveness of species prohibitions in the skate fishery and may help improve stock assessments for skates.*

The relative abundance of these species is annually monitored by the NMFS Northeast Fisheries Science Center's (NEFSC) bottom trawl research survey (McEachran and Musick, 1975; Azarovitz et al., 1997). However, fishery catches are not typically reported by species, and the seven species have been managed together as a "stock complex" since 2003, when the New England Fishery Management Council (NEFMC) and NMFS first implemented the fishery management plan for skates (NEFMC, 2003).

The skate wing fishery is centered in New England states, but extends as far south as New Jersey. The majority of landings occur in Massachusetts and Rhode Island and are primarily derived from bottom trawl and gillnet vessels that fish for a mix of groundfish species including Atlantic cod, *Gadus morhua*; flounders (Pleuronectidae); and goosefish, *Lophius americanus* (NEFMC, 2010).

Historically, most skates were discarded, but the increasing value of skate wings in recent years has resulted in increased landings in the United States and worldwide (Fig. 1) (Dulvy and Reynolds, 2002; NEFMC, 2010). Between 1983 and 2002, before management of the skate fishery began, total skate landings in the northeastern United States (including bait and wings) increased from approximately 883 to 16,283 t per year (Fig. 1). Consequently, the overall skate discard rate (the proportion of the total catch that is not retained) in the region has declined from over 90% in the mid-1980's to less than 40% in recent years (NMFS, 2011).

In 2012, the northeastern United States accounted for 59% of total U.S. skate landings (NMFS, 2013). Approximately 4,455 t of skate wings (equivalent to about 10,113 t whole weight) were landed in the region during the 2012 fishing season, valued at $5.3 million. In recent years, skates have represented the dominant elasmobranch resource harvested in U.S. waters, with nationwide skate landings being more than double that of all sharks combined (including "dogfish sharks," Squalidae and Triakidae) in 2012 (NMFS, 2013).

A common challenge in stock complex fisheries is disaggregating catch data and allocating it to the appropri-

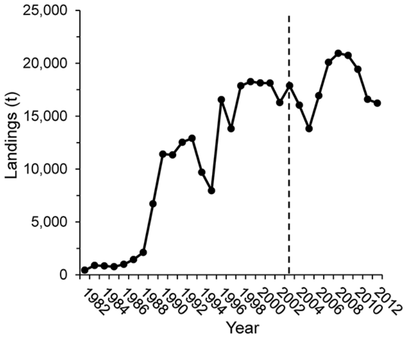


Figure 1.—Total annual landings of skates off the northeastern U.S., 1982–2012. The dashed line indicates the year 2003 in which U.S. management of the skate fishery was implemented.

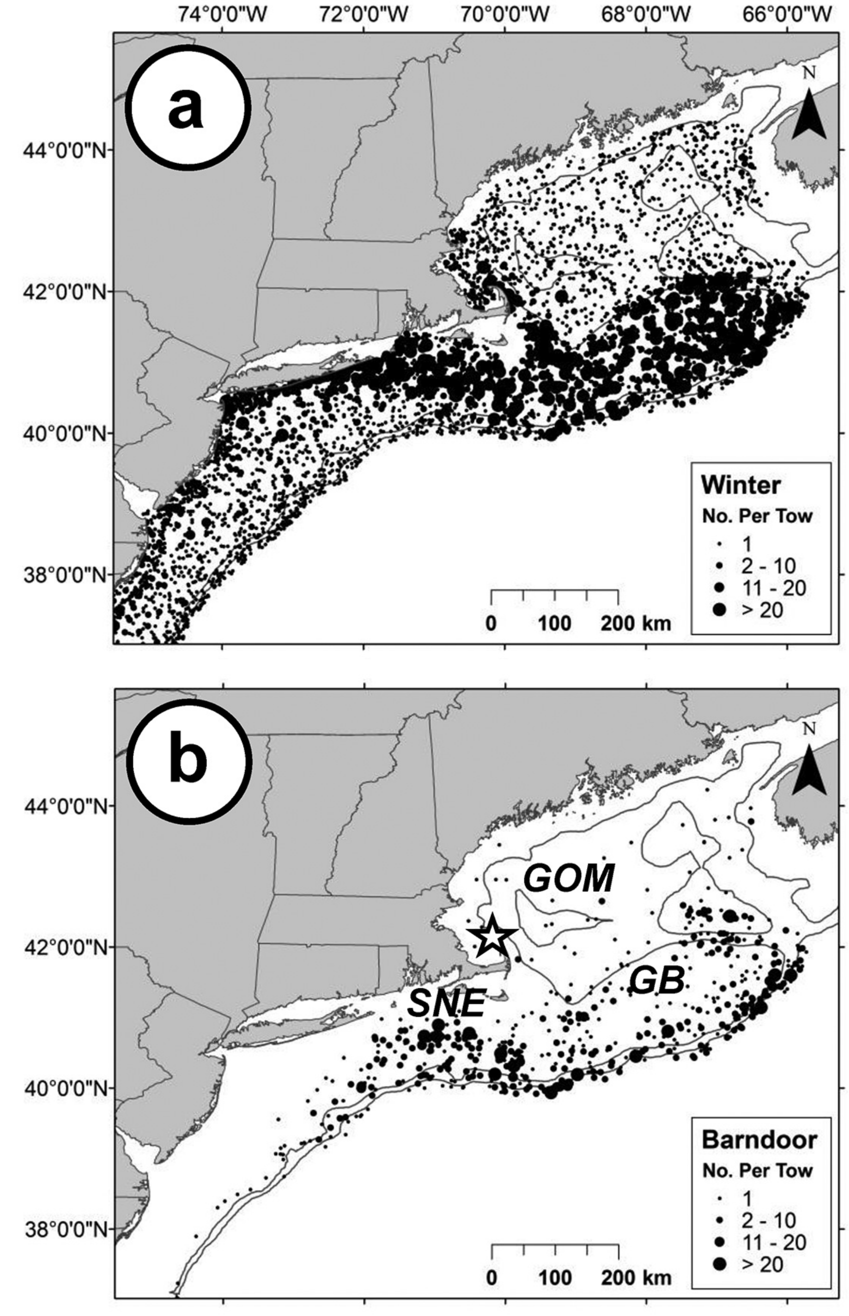


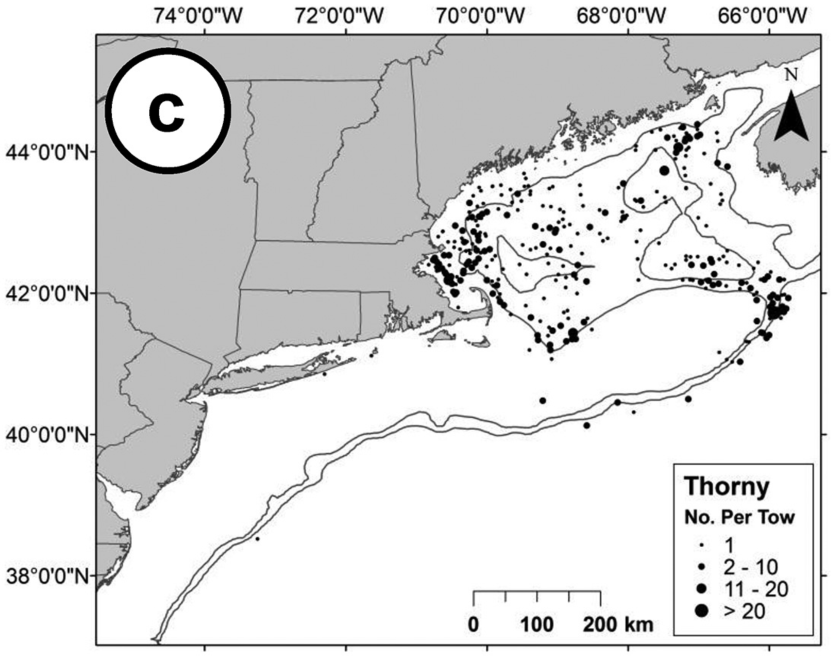
Figure 2.—Distributions of winter (a), barndoor (b), and thorny (c) skates in the study area from the NEFSC spring and autumn bottom trawl surveys, 2005–10. The gray lines represent the 100 and 200 m bathymetric contours. In (b), the star symbol identifies the location of Provincetown, Mass., separating Gulf of Maine (GOM) from Georges Bank (GB) and southern New England (SNE) ports.

ate species. This is particularly challenging in elasmobranch fisheries that often include species of similar appearance (Stone et al., 1998; Machado et al., 2004; Figueiredo et al., 2007; Stevenson and Lewis, 2010; Silva et al., 2012). Without accurate species composition information, it is difficult to assess the impacts of fishing on each stock and determine if the exploitation rate is sustainable (Stevens et al., 2000; Figueiredo et al., 2007; Morgan et al., 2009; Ward-Paige et al., 2012). The majority of the skates landed for the wing fishery are processed (wings removed, carcasses discarded) at sea, making species identification even more difficult. One of the initial goals of the Skate FMP was to improve species-level reporting of landings and discards (NEFMC, 2003). Ultimately, this information could lead to more efficient, species-specific assessment and management (Hogan et al., 2013). While investigations into the population dynamics of individual species have been attempted (Frisk et al., 2008; Gedamke et al., 2009; Frisk et al., 2010; NMFS[1, 2]), the difficulty in accurately disaggregating landings and discard estimates to the species level has been a major impediment in assessing individual stocks.

The 2006 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act included

[1]NMFS. 2007. Assessment of the northeast skate species complex. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., 44th Northeast Reg. Stock Assessment Workshop (SAW 44), Northeast Fish. Sci. Cent. Ref. Doc. 07-10, 661 p.

[2]NMFS. 2009. The Northeast Data Poor Stocks Working Group Report, December 8–12, 2008 meeting: Part A. Skate species complex, deep sea red crab, Atlantic wolffish, scup, and black sea bass. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Northeast Fish. Sci. Cent. Ref. Doc. 09-02, 180 p.



requirements for annual catch limits (ACL's) that account for scientific and management uncertainty for every federally managed stock or stock complex in the United States. Due to the inability to reliably monitor catch of individual skate species, the NEFMC elected to manage the complex under a single, aggregate ACL. Commercial landing quotas and possession limits were also implemented for the skate wing and bait fisheries, rather than for individual species (NEFMC, 2010).

However, these two fisheries have very different levels of fishing effort, spatial distribution, and species composition (NEFMC, 2003, 2010). While winter skates are considered the primary target of the skate wing fishery (NEFMC, 2003, 2010), the contribution of other species to the landings has not been directly estimated. Indirect methods, such as prorating the NMFS trawl survey species composition in a given area to fishing trips in the same area, have been attempted (NMFS[2]) but remain uncertain and require validation.

The varied life histories, distributions (Fig. 2), and population status of each species suggests that more species-specific management would be preferable (Hogan et al., 2013). For example, winter skate is primarily distributed on Georges Bank and off southern New England and is presently at a high level of relative abundance (Fig. 2a; Frisk et al., 2008, 2010; Hogan et al., 2013). However, thorny and smooth skates, prohibited species distributed in the deeper waters of the Gulf of Maine (Fig. 2c), are very low in relative abundance (Nye et al., 2009; NMFS, 2011). The barndoor skate, once argued to be nearing extinction (Casey and Myers, 1998), is mainly distributed along the southern edge of Georges Bank (Fig. 2b) and has significantly increased in relative abundance in recent years (NMFS, 2011). Managing such species together as a single unit increases scientific and management uncertainty, and potentially reduces the efficiency of the fisheries that harvest them (Reuter et al., 2010; Hogan et al., 2013).

For example, the optimum yield of an abundant stock may have to be partially foregone due to the poor status of another stock within the complex (Hogan et al., 2013). Additionally, the decline of one or more species may be masked by the relative stability of aggregated multi-species catch trends (Dulvy et al., 2000; Wakeford et al., 2004). However, before more species-specific management of the skate complex can be considered, more data are needed on the species composition of landings and discards.

Possession and landing of thorny, smooth, and barndoor skates have been prohibited since 2003 due to their low levels of relative abundance (NEFMC, 2003). All three species were considered overfished and are currently under legally-mandated stock rebuilding programs. Without adequate documentation of the species being landed, it is difficult to quantify the effectiveness of these possession prohibitions. Thorny skate is of particular concern due to its declining survey biomass and overfished condition in U.S. waters (Nye et al., 2009; NMFS[2]), and the degree to which this species is being protected is not known. Thorny skate is categorized as a "Species of Concern" by the NMFS Protected Resources Division, and it is also listed as "Critically Endangered" in U.S. waters by the IUCN (Kulka et al., 2009). Given its vulnerable life history characteristics (Sulikowski et al., 2005, 2006), even small amounts of fishing mortality could significantly hinder the thorny skate's recovery in U.S. waters.

On 22 August 2007, due to concerns that some vessels were still landing thorny skates, NMFS issued a letter to all commercial skate permit holders increasing awareness of the prohibited species regulations.[3] However, whether this outreach effort resulted in any measurable impact on fishing behavior has not previously been assessed.

While more species- or region-specific catch limits may be warranted for the skate complex (Hogan et al., 2013), it is not known if current fishery-dependent monitoring capabilities would be sufficient to make such a transition. The purpose of this study was to quantify the species composition of landings in the skate wing fishery by sampling the wings landed

[3]Letter is available online at: http://www.greateratlantic.fisheries.noaa.gov/nero/nr/nr07.html.

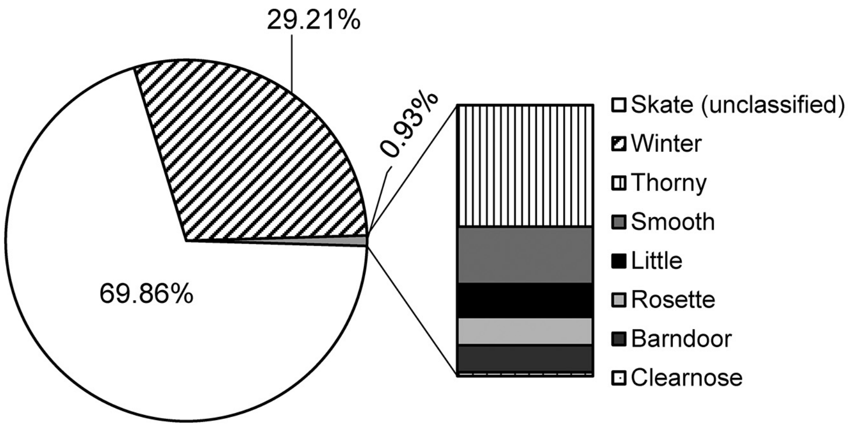


Figure 3.—Species composition of northeastern U.S. skate wing landings as reported by seafood dealers, 2005–12.

at northeast U.S. fishing ports. This investigation will help better characterize the landings portion of the total catch in the skate wing fishery and help determine if prohibited species regulations are adequately enforced.

Materials and Methods

Skate wings were sampled at ports in Maine, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, including the dominant ports of the skate wing fishery (NEFMC, 2010). Sampling effort was not standardized across ports, months, or years, but occurred opportunistically in conjunction with routine port sampling of fishery harvests conducted by NMFS in this region. However, sampling was comprehensive during the study period, with samples occurring in every month of the year across the region. At the point of landing, NMFS port samplers trained in skate species identification examined wings as they were being offloaded from fishing vessels. Unique characteristics on the pectoral fins, such as coloration, spotting patterns, and spines, allowed samplers to differentiate between the various species (Collette and Klein-MacPhee, 2002), and species identification guides were readily available.

Totes of unsorted skate wings were randomly selected and set aside for sampling. A typical tote can contain up to about 68 kg of skate wings. All of the wings in each tote were identified, counted, and weighed by species. Mean individual wing weights were calculated for each species. Given the distinct differences between the wings of the various species and training using whole skate specimens, confidence in port sampler identification was high.

The frequency of each species in the landings was compared between years (2005–12) and port regions and were expressed as percentages of the total number of sampled wings. Due to the distinct biogeographic boundary extending from Cape Cod to Georges Bank, and the different skate species assemblages associated with that boundary (Fig. 2; McEachran and Musick, 1975; Collette and Klein-MacPhee, 2002), the sampling area was divided into two regions. Gulf of Maine (GOM) ports were those extending from Portland, Maine, to Provincetown, Mass., on Cape Cod. Georges Bank/southern New England (GB/SNE) ports included all ports south of Provincetown, Mass. Vessels landing in GOM ports predominantly fish in areas characterized by the GOM skate species assemblage (although a minority of trips that land in GOM ports also fish on GB), and vessels landing in ports south of that region primarily fish in areas characterized by the GB/SNE skate species assemblage.

For comparison, the species codes routinely reported by seafood dealers to the NMFS Northeast Region dealer database were examined. These reports are used to separate skate wing and bait landings for in-season monitoring of commercial quotas. Eight possible species codes may be reported for skate wing landings: one for each of the seven species in the complex, plus an “unclassified wings” code (NEFMC, 2010). The total weight of landings of each species was extrapolated by assigning the species composition proportions of the sampled landings to the total reported landings by the fishery. Aggregate skate wing landing weights were converted to whole weight equivalents using the accepted conversion factor of 2.27 (NEFMC, 2003). To determine if species relative abundance influenced the observed landings composition, these results were compared to skate biomass indices (3-year moving averages of stratified mean weight per tow) from the NMFS trawl survey (NMFS, 2011).

Results

Seafood Dealer Reporting

The most common species code reported by seafood dealers for skate wings was the “unclassified wings” code (69.9% of landings) (Fig. 3). This was followed by “winter skate” (29.2% of landings) and a small amount of “thorny skate” (0.4% of landings) (Fig. 3). All other species codes were rarely reported and collectively accounted for the remaining 0.5% of landings.

Port Sampling

During the study period (2005–12), a total of 92,833 skate wings were examined from 768 samples. A total of 91 samples were collected from GOM ports (13,743 wings), and 677 samples were collected from GB/SNE ports (79,090 wings), reflecting the relative volume of landings between the regions (Tables 1, 2). Three species were documented in the skate wing landings: winter, thorny, and barndoor

Table 1.—Species composition (%) of sampled landings and total skate wing landings in Gulf of Maine ports, 2005–12.

Year	Winter	Thorny	Barndoor	No. wings sampled	Total wing landings (t)
2005	61.88%	27.07%	11.05%	181	408
2006	49.96%	50.04%	0.00%	1,275	364
2007	94.15%	4.34%	1.51%	4,103	661
2008	99.32%	0.68%	0.00%	885	534
2009	97.10%	2.90%	0.00%	1,587	647
2010	95.36%	4.64%	0.00%	1,876	941
2011	100.00%	0.00%	0.00%	2,083	442
2012	100.00%	0.00%	0.00%	1,753	312

skates. The mean (±1 s.d.) individual wing weights were 0.80 ± 0.17 kg for winter skate, 1.16 ± 0.40 kg for thorny skate, and 0.99 ± 0.38 kg for barndoor skate. Winter skate wings were collected in every sample, and represented the dominant species across years and regions (98.5% of the total wings sampled). The remainder of sampled landings was comprised of thorny skate (1.4%) and barndoor skate (0.1%), both of which are prohibited species.

In GOM ports, winter skate comprised from 50.0 to 100.0% of the landings per year (mean = 87.2%) (Table 1). Reflecting its higher abundance in the GOM, thorny skate was the next largest component of GOM landings, ranging from 0.0 to 50.0% of the landings per year (mean = 11.2%) (Table 1). The percent occurrence of thorny skate in the sampled landings was considerably higher in 2005–06 (mean = 38.6%) than in 2007–12 (mean = 2.1%). The only other species collected in the GOM was barndoor skate, which represented 0.0–11.1% of landings per year (mean = 1.6%) (Table 1).

By contrast, landings in GB/SNE ports were completely dominated by winter skate (96.2–100.0% per year; mean = 99.1%) (Table 2). Thorny skate was found in 0.01–3.6% of landings per year (mean = 0.8%), and barndoor skate was found in 0.0–0.2% of landings per year (mean = 0.03%) (Table 2). The percent occurrence of thorny skate landings in this region also declined between the 2005–06 (3.1%) and 2007–12 (0.06%) periods. Despite a greater availability of barndoor skates adjacent to GB/SNE ports (Fig. 2b), very few barndoor skates were found in sampled landings in this region (Table 2).

Relative Abundance and Extrapolated Landings by Species

The relative abundance indices for winter, thorny, and barndoor skates from the 2005–12 NMFS trawl surveys are shown in Fig. 4a. Winter skate biomass far exceeded that of other species, with a mean (±1 s.d.) annual survey biomass of 6.00 (± 2.71) kg per tow. Winter skate continues to be above its target biomass of 5.66 kg per tow. Barndoor skate biomass averaged 1.07 ± 0.09 kg per tow, and thorny skate biomass averaged 0.36 ± 0.15 kg per tow over the study period. Barndoor skate biomass slightly increased during the study period and is nearing its regulatory biomass target of 1.57 kg per tow (Fig. 4a). Thorny skate biomass declined slightly (Fig. 4a), and this species remains well below its regulatory "overfished" biomass threshold of 2.06 kg per tow.

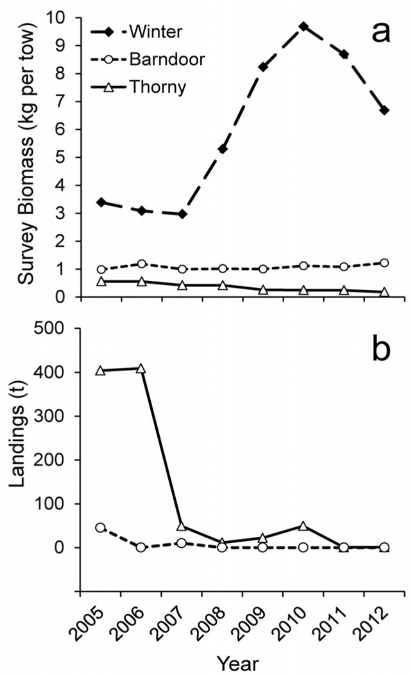


Figure 4.—Relative survey abundance of winter, barndoor, and thorny skates (a) and estimated commercial landings of barndoor and thorny (prohibited) skates (b) in the northeastern U.S. skate wing fishery, 2005–12. Relative survey abundance points represent the 3-year moving average stratified mean weight per tow from the NMFS Northeast Fisheries Science Center bottom trawl survey. Estimated landings values are based upon seafood dealer-reported total skate wing landings multiplied by the species composition proportions in Tables 1 and 2.

Table 2.—Species composition (%) of sampled landings and total skate wing landings in Georges Bank/Southern New England ports, 2005–12.

Year	Winter	Thorny	Barndoor	No. wings sampled	Total wing landings (t)
2005	96.20%	3.61%	0.19%	1606	7369
2006	97.41%	2.59%	0.00%	6482	8764
2007	99.80%	0.20%	0.00%	8537	10,124
2008	99.92%	0.08%	0.00%	10,473	9840
2009	99.97%	0.03%	0.00%	10,070	10,559
2010	99.94%	0.06%	0.00%	13,213	9195
2011	99.99%	0.01%	0.00%	13,714	6101
2012	99.91%	0.01%	0.08%	14,995	5939

Annual skate wing landings (converted to whole weight) ranged from 7,777 t in 2005 to 11,206 t in 2009 (Tables 1, 2). The ports in the GB/SNE region accounted for the vast majority of coastwide landings, with GOM landings representing only 4.0–9.2% of the total (Table 1). The magnitude of landings of each species was extrapolated (Fig. 4b) when the species composition proportions from port sampling (Tables 1, 2) were applied to the total landings in each region. As expected, winter skates dominated the landings, averaging 8,911 ± 1,977 t per year. Thorny skate landings were much lower than winter skate but were still comparatively high in 2005 (404 t) and 2006 (409 t), given their prohibited status. However, from 2007 to 2012, landings fell dramatically and averaged only 22 ± 22 t (Fig. 4b). Barndoor skate landings were very low throughout the study period, with a high of 45 t in 2005 (Fig. 4b). Survey biomass did not influence the proportional landings of thorny and barndoor skates, as thorny skate landings regularly exceeded that of barndoor skate despite having notably lower abundance (Fig. 4).

Discussion

This is the first study to use port sampling data to quantify species composition in this fishery, and our results suggest that sampling of the northeast U.S. skate wing fishery landings can provide a great deal of information that could improve management of the skate complex, including better species-specific monitoring, assessment, and regulatory compliance. This research effort provided new insights into the species composition of the skate wing fishery, estimated the magnitude of landings of each of the component species, and demonstrated high compliance with prohibited species regulations. It also highlighted the inadequacy of maintaining the "unclassified" reporting option for potentially monitoring species-specific skate landing trends.

Fishery-dependent sampling can be very useful in elasmobranch fisheries that are frequently considered to be data-poor. As there is ongoing concern regarding the exploitation of elasmobranchs around the world (Stevens et al., 2000; Dulvy et al., 2008; Ward-Paige et al., 2012; Dulvy et al., 2014), it is critical to improve our understanding of commercial fisheries that harvest them. Given the growing importance of skates and rays to global fishery catches relative to sharks, and their significant conservation concern (Dulvy et al., 2014), more research on these species groups is warranted to inform responsible conservation and management.

Port sampling and at-sea observers have proven very valuable to skate and ray fisheries management in several regions around the world (Machado et al., 2004; Wakeford et al., 2004; Stevenson and Lewis, 2010; Silva et al., 2012). For example, an experimental port sampling study used to characterize the species and size composition of skate and ray landings in Portugal found that landings were comprised of eight rajid species, but dominated by just blonde ray, *Raja brachyuran*, and thornback ray, *R. clavata* (Machado et al., 2004). Additionally, Silva et al. (2012) compared the species composition of skate landings reported by U.K. commercial vessels to the species composition estimated by at-sea observers. They found broad agreement between vessel and observer reports for the primary species landed (cuckoo ray, *Leucoraja naevus*; thornback ray, and blonde ray), but more variability in the contribution of 10 other less common species.

It is clear that monitoring species-specific landing trends in the skate fishery is intractable with an "unclassified" species reporting option for vessels and seafood dealers. Due to either a lack of confidence in species identification, or the lack of an incentive to attempt to identify the species, the vast majority of dealers used the "unclassified wings" code in their reports. However, the dominance of winter skates in the landings identified by port samplers should make it relatively simple for dealers to accurately report winter skate wing landings.

Not only are the other six managed skate species rarely, if ever, found in the landings, but the other species large enough for the wing market (thorny and barndoor) are prohibited species. Their wings are visually distinct from those of winter skate, and identifiable with minimal training (Collette and Klein-MacPhee, 2002). There are more than a dozen species of skates caught in U.K. fisheries in the eastern North Atlantic which were unclassified in landing reports for many years (Silva et al., 2012). However, as of 2008, all skate landings in this region were required to be reported by species, and fishery-dependent sampling demonstrated that species-level reporting by vessels was largely accurate for the dominant species (Silva et al., 2012).

In response to these concerns, in 2014 the NEFMC and NMFS implemented Framework Adjustment 2 to the Skate FMP, which permanently removed the "unclassified" species reporting option, and required species-specific reporting of skates by all vessels and dealers (NEFMC, 2014). A new skate species identification guide was developed and distributed by NMFS to support this transition.[4] It is anticipated that these regulatory changes will improve species-specific catch monitoring in the skate fisheries.

There are two reasonable hypotheses for the observed decline in the occurrence of prohibited thorny skates in the landings over the course of the study: 1) the availability of thorny skates to the fishery declined, and/or 2) compliance with the prohibited species regulations increased. Availability could decline either by changes in the spatial distribution or magnitude of fishing effort (i.e., to areas away from concentrations of thorny skates) and/or by declines in the relative abundance of thorny skates.

Overall fishing effort in the region's trawl and gillnet fisheries declined during the study period due to changing groundfish regulations (Brodziak et al., 2008), and some distributional shifts in fishing effort could have influenced the composition of skate landings. However, the relative abundance of thorny skate also declined during the study period, possibly affecting availability. Thorny skate trawl survey biomass steadily declined from 0.56 kg per tow in 2005 to 0.18 kg per tow in 2012, a decline of 68% (Fig. 4a). Given the comparatively high estimated landings of thorny skates prior to 2007 (Fig. 4b), as well as discard mortality in groundfish fisheries (Mandelman et al., 2013; NMFS[1]), this level of fishing mortality may have negatively impacted the population. However,

[4]ID guide is available online at: http://www.greateratlantic.fisheries.noaa.gov/stories/2014/skateidguide214.pdf.

more research is needed to investigate the causes of the thorny skate's decline off the northeastern United States, as overfishing is only one potential influence. Shifting distribution patterns and warming trends in the Gulf of Maine may also be playing a role in this species' availability to the NMFS trawl survey (Frisk et al., 2008; Nye et al., 2009).

Since the sharp decline in thorny skate landings was concurrent with the release of the prohibited species letter by NMFS in 2007, it appears that it may have had a significant effect in improving compliance. Prior to this outreach effort, fishing vessels and dealers may have been ignorant or dismissive of the prohibition on possession of thorny skates. Awareness and compliance with the prohibition on barndoor skate appears to be particularly high since their increased availability was not reflected in the landings composition. Due to the comparatively high profile of barndoor skate conservation concerns (Casey and Myers, 1998), including petitions to list them under the Endangered Species Act and their easily distinguishable morphological features, more fishermen were likely aware of the prohibition on barndoor skates than other species and discarded them when captured.

The estimated composition of skate landings appears to demonstrate high (>98%) compliance with the prohibited species regulations. Compliance with prohibited skate regulations in U.K. fisheries also appears to be high, with most prohibited species being discarded (Silva et al., 2012). If landings composition in the skate wing fishery simply reflected the species composition of the survey (i.e., the proportional abundance of winter, thorny, and barndoor skates), then prohibited species would likely be found in over 20% of the landings. Even though prohibited species landings are currently very low in the U.S. skate wing fishery, continued outreach and enforcement efforts are needed to maintain compliance, and allow these vulnerable stocks to rebuild.

It is possible that the 2005 and 2006 landing compositions more closely reflect skate landings composition prior to the implementation of skate fishery regulations in 2003. Since the species composition of skate wing landings was essentially unknown prior to the initiation of this study, data from 2005 and 2006 could be used as proxies to reconstruct historic landings composition. This information, coupled with long-term skate landings data and relative abundance information from the NMFS bottom trawl surveys, could improve species-specific catch time series used in stock assessments. Estimates of species- and gear-specific trends in discarding and discard mortality remain uncertain, but are also still needed to estimate total skate catch and fishing mortality (Mandelman et al., 2013; NMFS[2]). Some skate species appear to be more resilient to capture and discard in commercial trawl fisheries than others (Mandelman et al., 2013), further highlighting a need for more species-specific management (Hogan et al., 2013).

This improved characterization of landings in the skate wing fishery should help reduce scientific uncertainty and improve the likelihood of successful species-level stock assessments. Similar sampling efforts in the skate bait fishery would improve our understanding of the species composition distinct to that fishery and have similar benefits to management of the overall skate complex. In future years, if skate discard rates continue to decline, monitoring of landings composition will become even more valuable. It could also provide the logistical means to accurately monitor species-specific fishery quotas, and allow the fishery to move away from less efficient stock complex management.

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