NORTHEAST SKATE COMPLEX FISHERY MANAGEMENT PLAN

Update on Thorny Skate Rebuilding

A whitepaper prepared by the
Skate Plan Development Team
New England Fishery Management Council

Draft for March 2022 meetings of the Skate Advisory Panel and Committee

New England
Fishery Management Council

Questions for Advisory Panel and Committee:

- Does the draft white paper meet expectations regarding the potential scope of this document? If not, what other topics should be covered?
- Is there other information that could be informative that is not yet included?
- Do fishermen's observations and knowledge about thorny skate align with what has been described through scientific literature? What are the areas of agreement and difference?
- For the section on potential management approaches, what other approaches could be explored through this paper? For example, are there possible gear or area-based measures to explore?

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1. INTRODUCTION

Thorny skate (*Amblyraja radiata*) is managed under the Northeast Skate Complex Fishery Management Plan (Skate FMP) and is considered to be overfished but not experiencing overfishing. While the stock is in year 20 of a 25-year rebuilding plan, abundance has steadily declined, and survey biomass estimates have shown the stock to be persistently low. In December 2022, the Council approved the development of a white paper detailing potential approaches to support rebuilding thorny skate. This paper summarizes the state of knowledge about thorny skate and progress towards rebuilding and identifies potential approaches to managing the species.

2. BACKGROUND

2.1. Habitat and distribution

The species is broadly distributed and is found from the Barents Sea to the North Sea, to waters off Iceland, Greenland, and Labrador, down to its southern extent in the Northwest Atlantic Ocean in waters off New York (Map 1). Thorny skate have been found in waters ranging from 20-1,400 meters in depth, across a broad array of substrate types (sand, gravel, mud, broken shell), and water temperatures ranging from -1.3 to 14°C. Comparisons of the NEFSC Bottom Trawl Survey and Cooperative Bottom Longline Survey suggest that thorny skate are caught more on rough bottom than on smooth (Sosebee et al. 2016). These surveys also suggest that the species prefers colder, deeper waters, with catch rates highest from depths of 40 - 95m and temperatures below 10°C (Link and Sosebee 2008; Richardson 2017).

A 2006 Canadian assessment of thorny skate on the Grand Banks noted a concentration of biomass when the species was at historically low abundance in the 1990s (Kulka 2006). Warming water temperatures over 1968-2007 have been correlated with thorny skate shifting towards deeper, cooler habitat in its U.S. range (Nye et al. 2009), however, they appear to have concentrated since 1999 in a shallow, warm, basin in the western Gulf of Maine (Sosebee et al. 2016, Figure 2). Range contraction has been observed for thorny skate with biomass declines, consistent with other North Atlantic species such as Atlantic cod and is likely driven by density-dependent effects, and there is evidence that thorny skate seek out warmer

waters at low abundances (Swain and Benoit 2006). While thermal barriers seem to not prevent movement towards more suitable habitat, bottom substrate complexity, prey availability, and changes in ocean chemistry have been suggested as possible obstacles (Sosebee et al. 2016; Pennino et al. 2019; Kneebone et al. 2020). Additionally, there is little evidence that thorny skate engage in long-distance migration, and the species appears to be largely sedentary (Kneebone et al. 2020). With the apparent constriction of their U.S range into the Gulf of Maine, individuals would therefore be less likely to disperse into more suitable habitat, and may be reproductively isolated from other sub-populations (Grieve et al. 2020; Kneebone et al. 2020). The fact that this contraction appears despite observed habitat preferences is a worrying sign for the species. With the pace of ocean warming in the Gulf of Maine so rapid, the quality of habitat for the species may be unlikely to improve.

2.2. Life history

Thorny skate is a large-bodied skate with a size and age-at-maturity comparable to the winter skate. Size-at-maturity varies substantially in different parts of their range however, with more northerly waters correlated with a smaller size-at-maturity. In the Gulf of Maine and eastern Scotian Shelf, two distinct reproductive morphs have been documented, with an eastern Gulf of Maine phenotype that reaches maturity around 20 inches and a larger western Gulf of Maine phenotype that reaches maturity around 33 inches (Lynghammar et al. 2014). Geographic diversity in lifespan is also documented, with thorny skate in the Gulf of Maine averaging 16 years, and their smaller, more northerly counterparts on the Scotian Shelf averaging 20 years. Current genetic research is investigating the spatial population structure of thorny skate across its range and determining if there may be any genetic distinctions between the two reproductive morphs within the Gulf of Maine (Kneebone, personal communication).

2.3. Diet and predation

Thorny skate eat a wide variety of copepods, krill, polychaetes, amphipods, fish, and crustaceans, depending on availability and body size. In the Gulf of Maine, fish are the primary food source, with herrings being especially important (Link and Sosebee 2008; Richardson 2017). On the Grand Banks, declines in thorny skate biomass were correlated with similar declines in the biomass of snow crab, an important prey species in that region (Pennino et al. 2019).

The egg capsules of the species are a reported food source for Atlantic halibut, monkfish, and Greenland shark, while adults are prey for many large demersal fishes, including cod, as well as sharks, seabirds, other skates, and marine mammals (Richardson 2017). Thorny skate are also a minor food source for gray seals, comprising ~6% of their diet based on a study from the Scotian Shelf (Beck et al. 2007). Predation from gray seals may be contributing to the natural mortality of thorny skate, particularly as the population of gray seals has increased from 15,000 in the 1960s to 505,000 in 2014, and have reached as far south as Southern New England (Swain et al. 2015; Richardson 2017). If this is occurring, this effect is likely localized, only impacting skates at less than 100m of depth in close proximity to gray seal haul-out areas (Richardson 2017). More importantly, predation may be a factor in habitat selection, driving skates away from areas of higher risk.

2.4. Fishing mortality

Thorny skate was landed in target fisheries prior to a prohibition of commercial retention in the U.S. in 2003, and is still caught as bycatch predominantly in bottom trawl fisheries, but also longline, gillnet, and scallop dredge (Sosebee et al. 2016). In the U.S., total catch declined from over 5,000 mt in the late 1960s and 1970s, to 200-300 mt since 2008, with about 100-200 mt attributed to dead discards (Figure 3, Table 1). The species accounted for ~1% of total skate discards (live and dead), or 400-600 mt(Sosebee et al. 2016, Figure 3).

While landings of thorny skate are reported by dealers, compliance with the prohibition on thorny skate possession is likely very high (Sosebee et al. 2016). Based on port sampling data, the percentage of thorny skate identified in skate wing landings declined from 3.61% in 2005 to 0.01% in 2012 (Curtis and Sosebee 2016). Due to issues with speciation in the landings and observer data, the NEFSC attributes

skate catch to species by using catch proportions in the NMFS bottom trawl survey. Thus, estimated landings of thorny skate reported here are based on a proportion at length by species in the survey and are thought to be overestimated, as no method was used to adjust this proportion based on the rate of fishery compliance.

Mandelman et al (2013) found GOM trawl-caught thorny skate discard mortality to be 23% (Mandelman et al. 2013). This value has been used in place of the 50% discard mortality assumption since the 2014-2015 Specifications Action. This rate has been further verified by research on longer-term (> 72 hour) discard mortality, which concluded that skate length was the most important predictor of discard mortality (Knotek et al. 2019). With the contraction of thorny skate into the western Gulf of Maine (Figure 2), an area of higher fishing effort, bycatch of the species may be occurring.

2.5. Stock status

Like other species managed in the Skate FMP, thorny skate is considered overfished if the most recent three-year moving average of the bottom trawl survey biomass index is below its biomass threshold reference point ($B_{threshold}$), which is ½ $B_{MSY\ proxy}$. The $B_{MSYproxy}$ is the 75th percentile (average for barndoor) of its survey biomass index, measured in kg/tow during a specific set of years for each species (1963-2007 fall survey for thorny). $B_{threshold}$ for thorny skate is 2.06 kg/tow.

Thorny skate have been designated as overfished since the establishment of the Skate FMP. Biomass has decreased from 5.6 kg/tow in the NEFSC bottom trawl survey in the 1970s to 0.15 kg/tow from 2019 and 2021 (Annual Monitoring Report for Fishing Year 2021, Figure 4). With $B_{MSYproxy}$ for the species at 4.13 kg/tow, the species is currently at 3.6% of the biomass target.

Like other skates, thorny skate are subject to overfishing if the percent change in the 3-year moving average of the survey biomass index declines by more than the average coefficient of variation (CV) of the survey time series. If so, fishing mortality is assumed to be greater than F_{MSY}. For thorny skate, the percent change is –20%. For example, the % change between the average index in 2012-2014 and 2013-2015 was +26.3%, so overfishing was not occurring. Overfishing has not occurred since that time. Thorny skate were consistently experiencing overfishing prior to 2013. However, biomass has fluctuated at very low levels with no clear trend.

In 2011, a petition was filed to list thorny skate under the Endangered Species Act (ESA). NOAA Fisheries determined that a status review was not warranted at that time (76 FR 78891) (Grieve et al. 2020). A subsequent petition was submitted in 2015, which was followed by a comprehensive status review under the ESA. The review concluded that the species was ultimately unlikely to become extinct and an ESA listing was unwarranted. This determination was supported by an estimate that the abundance of thorny skate in the Gulf of Maine, Georges Bank, and the Scotian Shelf could be as high as 6 million fish (Sosebee et al. 2016), as well as the stability of the current thorny skate population across its wide geographic range in which tagging and genetic studies have suggested a high degree of connectivity and diversity (Richardson 2017).

2.6. Canadian waters

Thorny skate are one of the most common skate species in Canadian waters, and generally the species has remained stable there, with some notable exceptions. On the Scotian Shelf and Bay of Fundy, where the historical density of thorny skate was very high, there has been a 90% decline in abundance ("Status Updates for Thorny Skate in the Canadian Atlantic and Arctic Oceans and Smooth Skate" 2017; Jubinville et al. 2021, Figure 5). On Georges Bank, which was minor component of the Canadian population, this decline was 62% ("COSEWIC Assessment and Status Report on the Thorny Skate (Amblyraja radiata) in Canada" 2012). On the Grand Banks, thorny skate experienced a 68% decline between the 1970s and the early 1990s. In general, thorny skate in the northern part of their Canadian range have fluctuated in abundance with no long-term trend. The species has a status of "Special Concern" by the Committee on the Status of Endangered Wildlife in Canada, describing "A Wildlife

Species that may become threatened or endangered because of a combination of biological characteristics and identified threats."

In Canada, thorny skate landings are not prohibited and are caught in targeted skate fisheries throughout the Atlantic coast. While winter skate are the predominant target species in the skate fishery on the Scotian Shelf and elsewhere in Atlantic Canada, the skate fishery on the Grand Banks is considered a directed thorny skate fishery. In Canada, thorny skate remain a major source of discards for both the trawl and gillnet fleets (Benoit 2013).

2.6. Vulnerability to climate change

The Gulf of Maine is experiencing the warmest water temperatures on record. This is causing decreasing salinity, declines in primary productivity, and increased stratification of the water column, leading to decreased nutrient cycling and deoxygenation of the water (Pershing et al. 2021). As a boreal, sedentary species, thorny skate may be particularly vulnerable to these effects. A climate change vulnerability assessment found thorny skate to have both a high exposure to climatic stressors as well as a high biological sensitivity to those stressors (Hare et al. 2016). A study that modeled species distribution shifts under climate change suggests that thorny skate habitat may diminish in area by ~25% under a CO_2 doubling scenario (Kleisner et al. 2017), and a subsequent study projected the species' abundance in U.S. waters to decrease by 30-40% by mid-century, and up to ~70% by 2100 if climate emissions are not aggressively mitigated alongside active reduction of atmospheric CO_2 (Grieve et al. 2021, Figures 6 and 7). As thorny skate generally reside in habitat with a narrow thermal range, their ability to adjust to increasing water temperature may be limited. Research on dogfish suggests that thorny skate may also be less likely to exploit novel habitats under unfavorable conditions (Schwieterman et al. 2019).

Analysis of a 20-year oceanographic time series of the Gulf of Maine has shown both warm and saline water intruding into the eastern Gulf of Maine at 50-180 meter depths from the North Atlantic Slope, as well as significant declines in primary production over the length of the time series (Balch et al. 2022). As a slow-growing and long-lived fish, there is evidence that such decreases in primary productivity can inhibit recovery from overfishing (Hutchings and Reynolds 2004; Hilborn and Litzinger 2009). Waters in the eastern Gulf of Maine have a higher minimum bottom temperature than in the western Gulf of Maine, despite a lower maximum temperature; thorny skate may be actively avoiding this warm, saline water.

3. FISHERY REGULATIONS AFFECTING THORNY SKATE

The original Skate FMP, implemented in September 2003, prohibited possession of thorny skates throughout its range in U.S. waters (largely located in the Gulf of Maine; NEFMC 2003)This also established a rebuilding plan for thorny skate, and without the ability to determine F_{MSY}, defined the use of a three-year survey averages to evaluate progress towards rebuilding the population to $B_{MSYproxy}$. While the 1996 amendments to the MSA require 10-year rebuilding timelines, it allows for flexibility to account for the biological and ecological considerations of the stock as well as cases where management requires international agreement. Due to data limitations, the rebuilding period was undefined in the original FMP due to a lack of data supporting an estimate of rebuilding potential, but a 25-year (10 years plus one 15-year generation) maximum rebuilding period was put into place via Amendment 3 that set 2028 as the final year of the rebuilding plan.

Thorny skate also likely benefits from regulations that reduce effort in the fisheries primarily responsible for bycatch, such as closed areas, days-at-sea, catch limits, and other effort controls within the Northeast Multispecies, Monkfish, and Scallop FMPs. These regulations were not designed to reduce thorny skate bycatch, and their effectiveness is unknown.

4. PRIOR COUNCIL DISCUSSIONS ON THE REBUILDING OF THORNY SKATE

In 2009, specific skate habitat closures designed to conserve thorny skate were proposed through Amendment 3, but these were rejected by the Council. The rationale for this rejection was that their

effectiveness would be limited, as there was low fishing effort in the recommended areas already, and because of the potential for effects on fisheries targeting other species. In the establishment of the 25-year rebuilding period for thorny skate, Amendment 3 cautioned that predicting the pace of rebuilding would be impossible given data limitations and limited understanding of the species' population dynamics.

Despite the prohibition on possession since 2003, thorny skate was subject to overfishing continuously through 2013. In 2013, there was renewed discussion about potential approaches to address the lack of rebuilding progress. NOAA Fisheries sent a letter to the Council indicating that overfishing needed to be addressed for thorny skate, although no timeline for action was specified. In response, the Skate Committee recommended that the PDT should develop alternative measures, and there was Committee consensus that a possession prohibition was insufficient. Addressing the lack of rebuilding progress for thorny skate was then listed as a Council priority in 2014, but no timeframe was agreed upon. The status of thorny skate then changed in 2014; overfishing was no longer occurring. In 2015, the PDT brought a memo to the Skate Committee regarding issues about managing skates as a complex. One proposal considered was to manage thorny skates under the Northeast Multispecies FMP. Ultimately, the Committee found this to be overly complicated and likely to create additional confusion. While there was a desire for further exploration of measures that would promote rebuilding, the Council has not set this as a priority since.

In 2020, the Committee recommended that a literature review on recent thorny skate research be conducted by the PDT, and the PDT has been providing research updates in the Annual Monitoring Reports to the SSC during specifications setting. The Regional Office was prepared to send a letter to Council regarding the failure of thorny skate rebuilding but was waiting until the results of the skate assessment that was scheduled for 2021. This assessment was pushed back until the summer of 2023, and no letter was issued. In 2022, the Council set the development of this white paper on thorny skate rebuilding as a 2023 work priority.

5. POTENTIAL APPROACHES

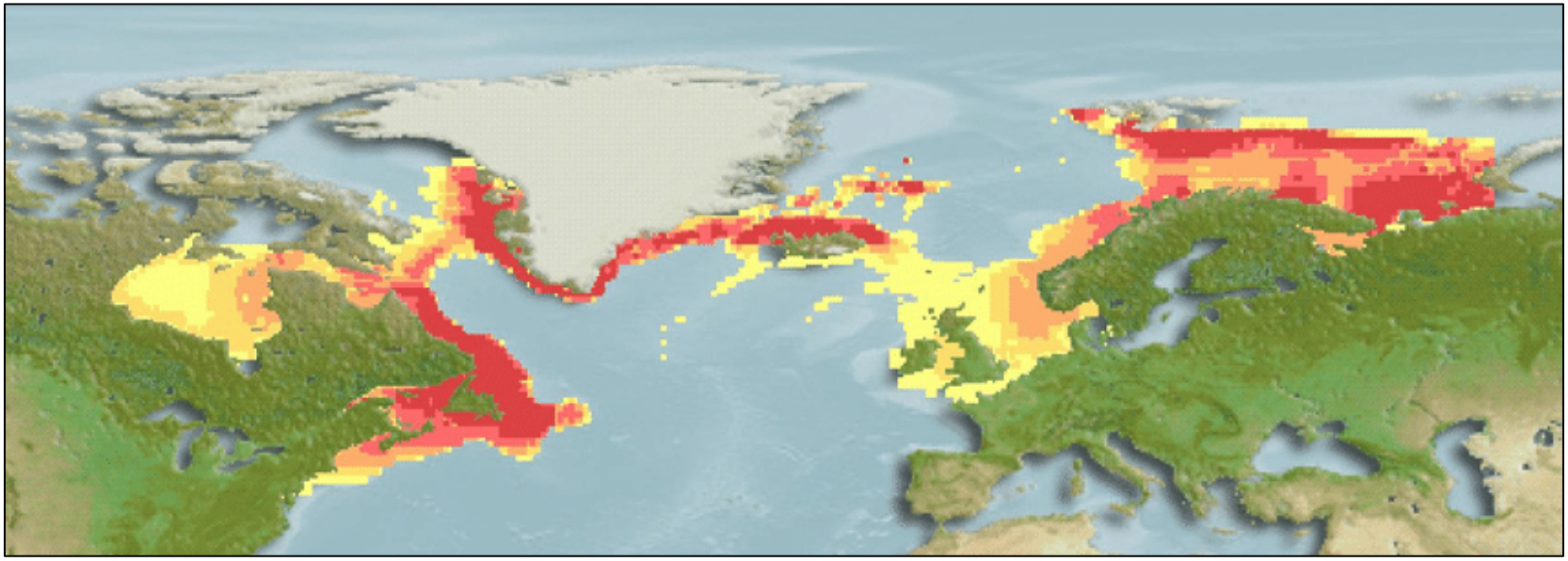
Below are some approaches that the Council could develop to promote thorny skate rebuilding. If a species is not rebuilt within the plan timeline, the rebuilding plan needs to be reviewed by either the relevant Council or NMFS Regional Fisheries Office, the reasons for failure evaluated, and a new rebuilding plan implemented.

Designate closed areas to minimize thorny skate bycatch. Due to the species aggregating in the western Gulf of Maine where fishing effort is higher, thorny skate bycatch may be an important barrier to rebuilding. An upcoming study on thorny skate bycatch hotspots could provide insight into this issue, and due to the sedentary behavior of thorny skate, closures protecting these areas might promote the conservation and recovery of the species (Kneebone et al. 2020).

Consider gear configurations that reduce thorny skate bycatch. Skate-specific gear restrictions could be applied to skate bait and/or wing trips and may be implemented through a framework adjustment (50 CFR 648.321(b)(11)). Prior research on fishing gear configurations that reduce flatfish catch could be considered. The PDT has noted to the Committee in the past that the Skate FMP does not have specific gear requirements. If a vessel has a federal limited access fishing permit, it must make a federal declaration or declare out of fishery (DOF). All vessels fishing for skates while on a declared NE multispecies, monkfish, or scallop trip using a day-at-sea must follow the gear regulations for the declared fishery. Any modifications to gear regulations in those fisheries would need to be revised within those FMPs. There are a few scenarios where a vessel can declare out of the fishery and have skate-specific gear requirements, such as if a vessel is fishing within a skate exemption area in Southern New England or the Mid-Atlantic. In this case, possession and landings of skate or skate parts must be at most 10%, by weight, of all other species on board, or 500 lb of skate wings, whichever is less.

MAPS, TABLES AND FIGURES

Map 1. Thorny skate range and probability of occurrence (Richardson 2017).



Map 2. Fixed kernel utilization distribution (UD) of positive thorny skate tows for four time periods from the NEFSC bottom trawl survey. Northeast multispecies year-round closed areas and habitat closed areas shown; warmer colors indicate higher density of thorny skate presence.

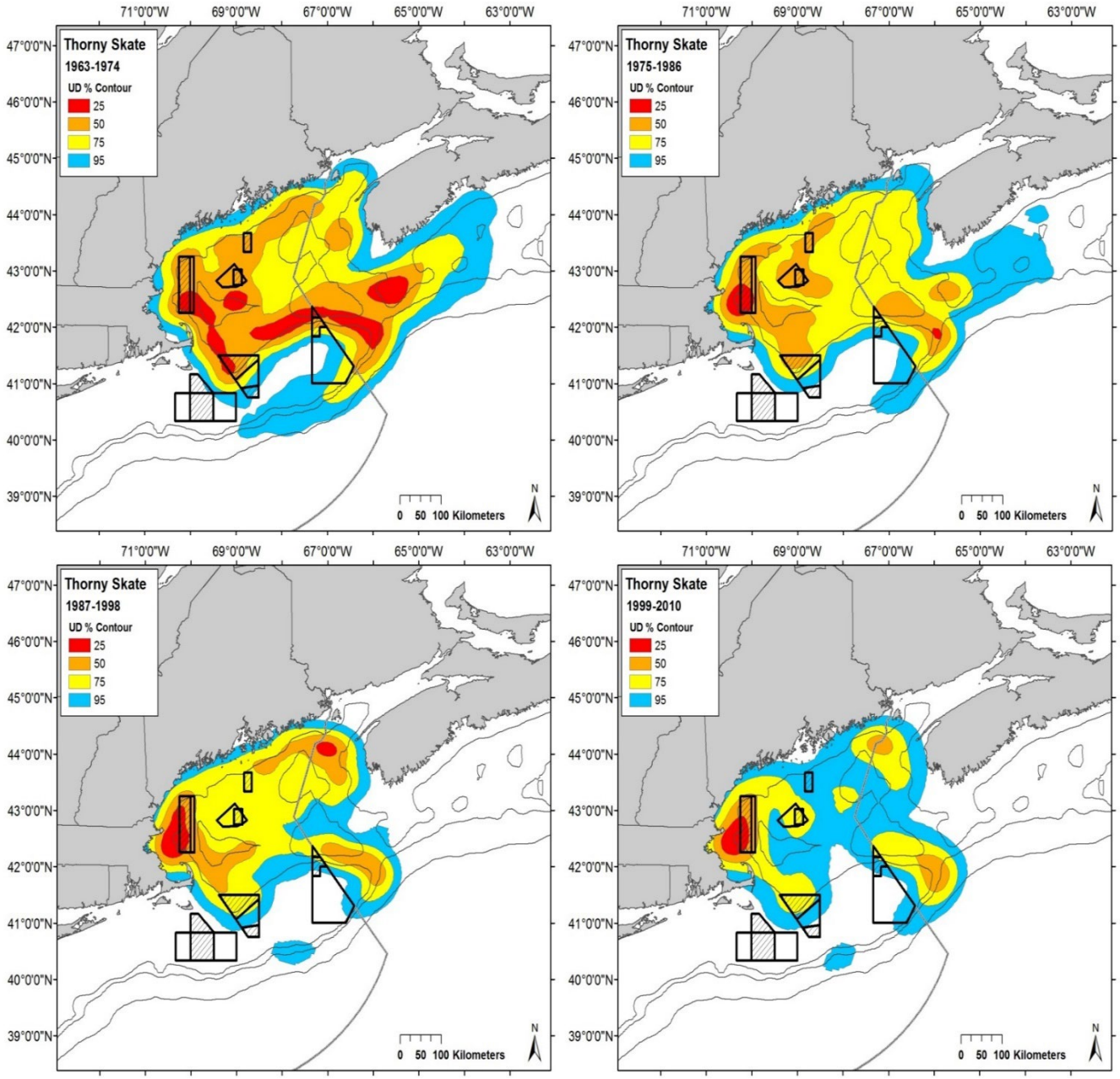


Table 1. Landings and dead discards of thorny skate by gear type from 2009-2019 (NEFSC data, accessed March 2023)

Year	Discards (mt)				Landings (mt)	Total Catch (mt)
	Longline	Otter Trawl	Sink Gillnet	Scallop Dredge		
2009	1	69	9	27	90	196
2010	4	89	12	23	203	330
2011	2	73	9	29	120	232
2012	1	62	7	34	71	175
2013	2	89	8	44	123	266
2014	1	74	7	53	177	312
2015	2	57	6	73	93	230
2016	1	60	8	37	103	209
2017	1	37	8	38	23	106
2018	0	61	5	58	42	167
2019	0	63	3	55	46	167

Note: Landings are attributed to species using NEFSC survey proportions at length. A 50% discard mortality rate is assumed for all gear except for otter trawl, which used a 23% rate.
Source:

Figure 1. Landings and dead discards of thorny skate by gear type from 1968-2019. Landings are attributed to species using NEFSC survey proportions at length (NEFSC data, accessed March 2023). A 50% discard mortality rate is assumed for all gear except for otter trawl, which used a 23% rate.

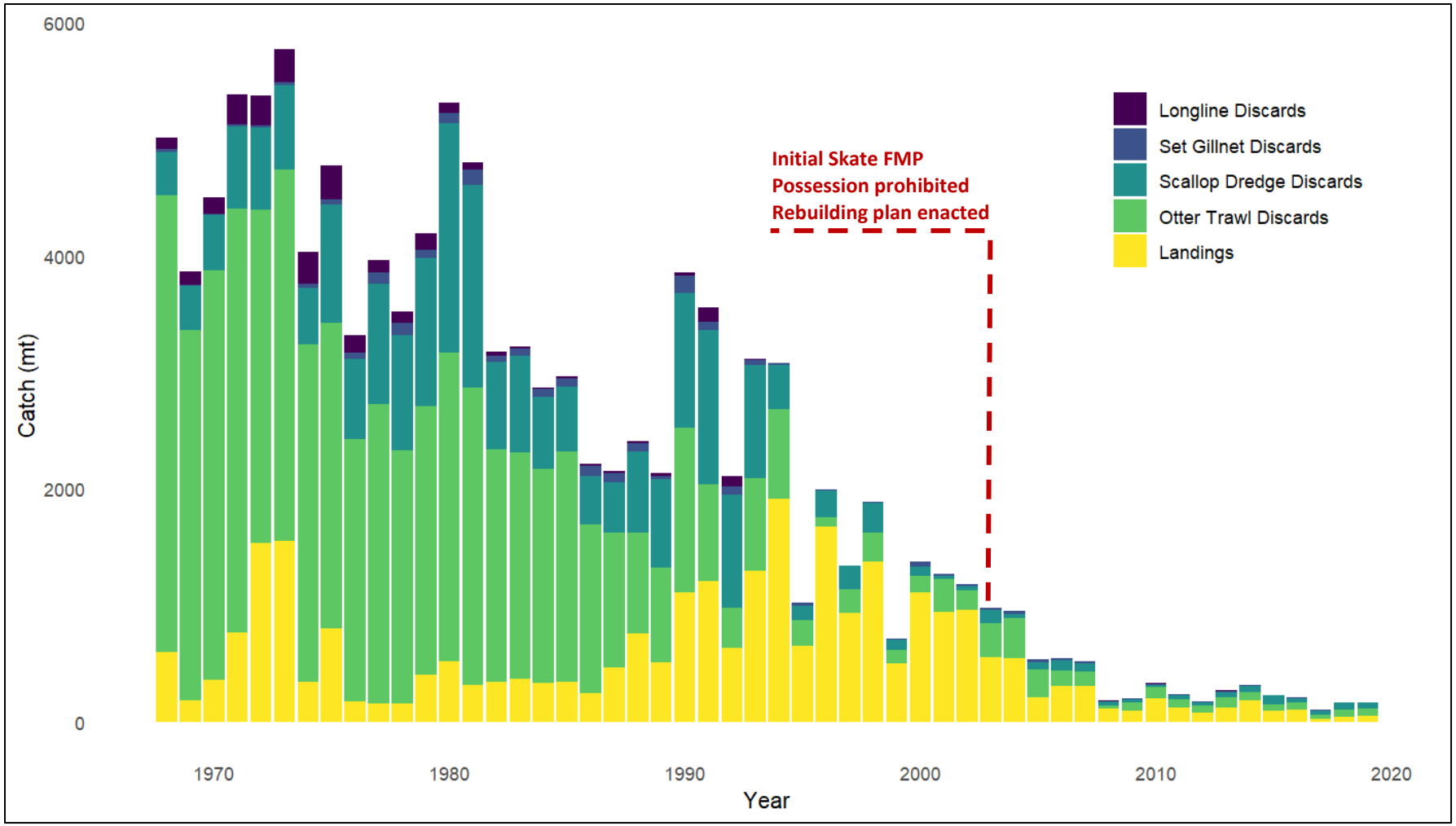


Figure 2. Abundance of thorny skate (*Amblyraja radiata*) from the NEFSC spring (circles) and fall (squares) bottom trawl surveys from 1963-2015 in the Gulf of Maine to Southern New England offshore region (Sosebee et al. 2016).

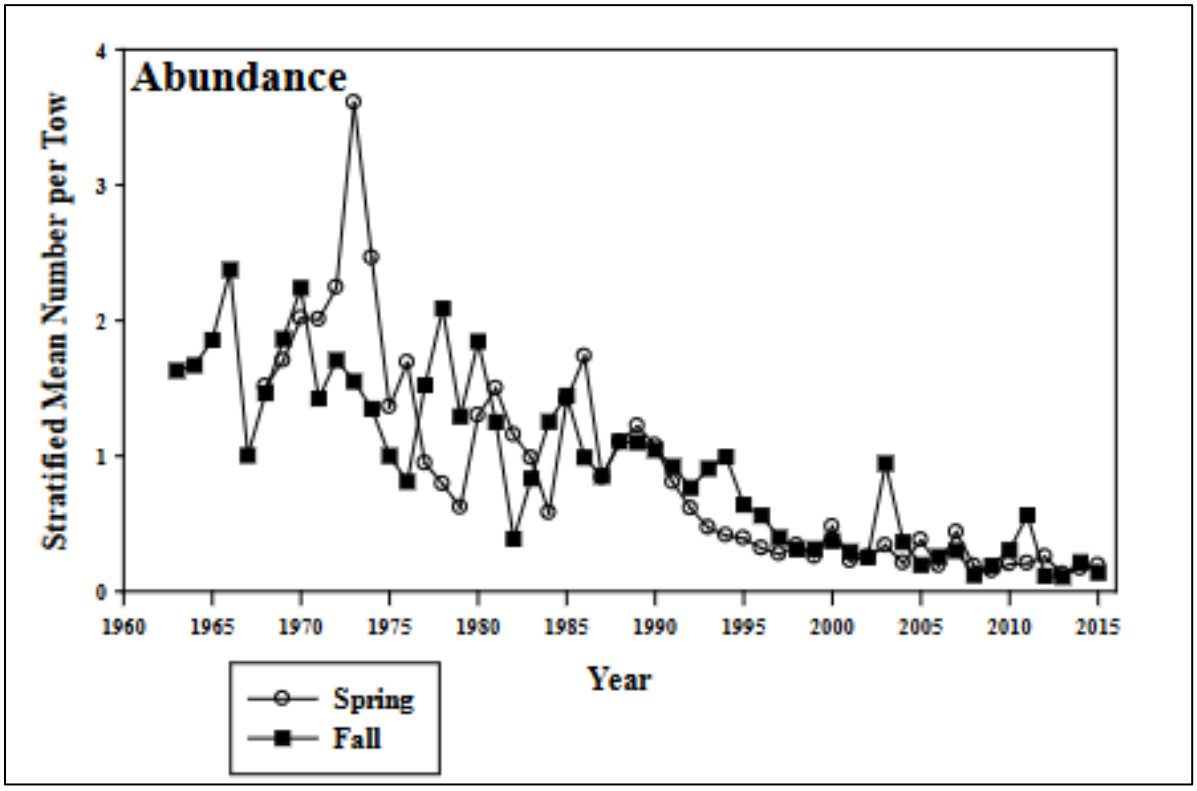


Figure 3. NEFSC survey biomass index for thorny skate (kg/tow). Thin line with symbols are annual indices, thick line are 3-year moving average, the thin horizontal lines are the biomass threshold and target developed through 2007/2008 with consistent strata sets (NEFMC 2022).

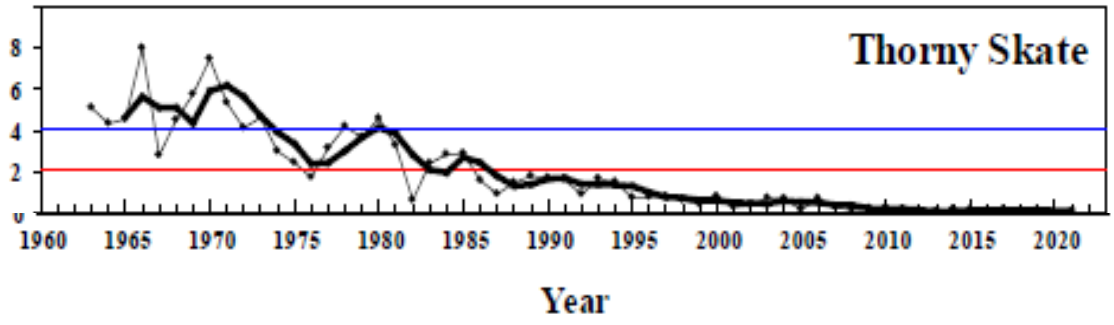


Figure 4. Biomass index for Thorny Skate in NAFO Div. 4X (Western Scotian Shelf and Bay of Fundy) from the DFO-MAR summer research survey represented by the solid black line. The straight long dashed-dot line indicates the long-term survey average (1970-2016). The dashed line represents the medium-term 15-year average (2002-16), and the short, dotted line represents the short-term 5-year average (2012-16) ("Status Updates for Thorny Skate in the Canadian Atlantic and Arctic Oceans and Smooth Skate", 2017).

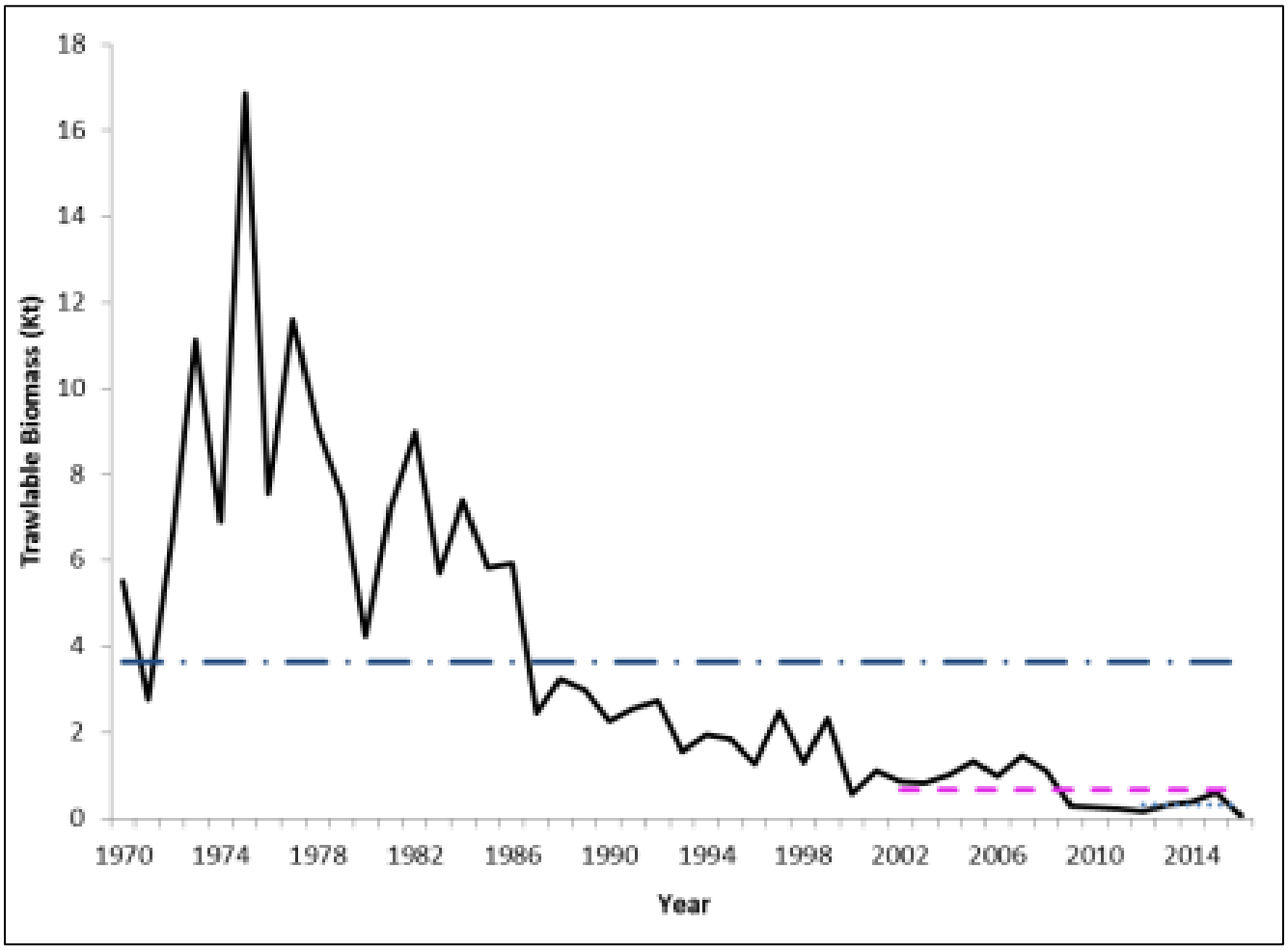


Figure 5. Projected change in catch per unit effort of thorny skate in an area by the 2046–2065 period from the 1986-2005 period under a "business as usual" emissions scenario. Subplots are split by season and capture methodology of training data set. Bottom trawl models (a, b, d, e) are split by length of the training series, while longline models (c, f) were trained with all available years (Grieve et al. 2021).

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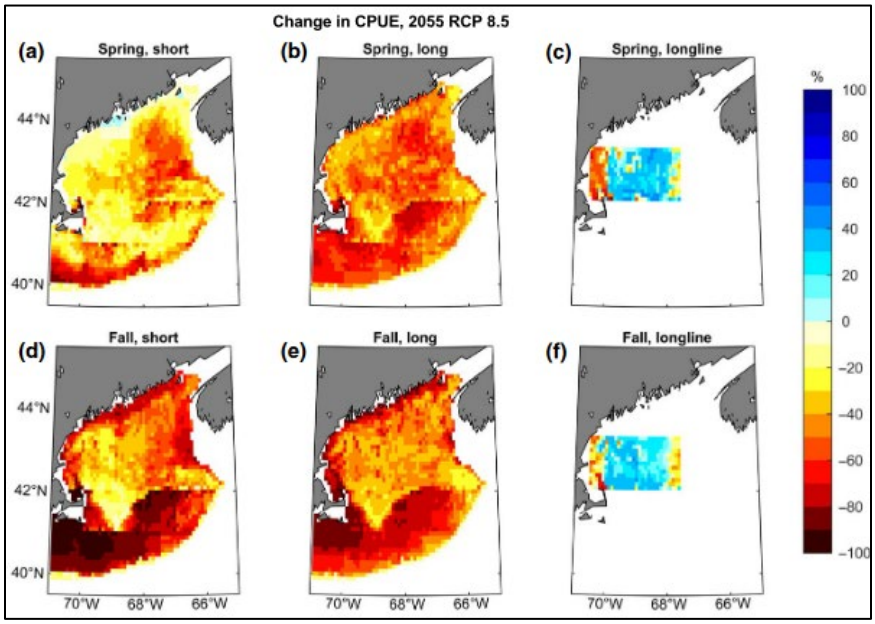
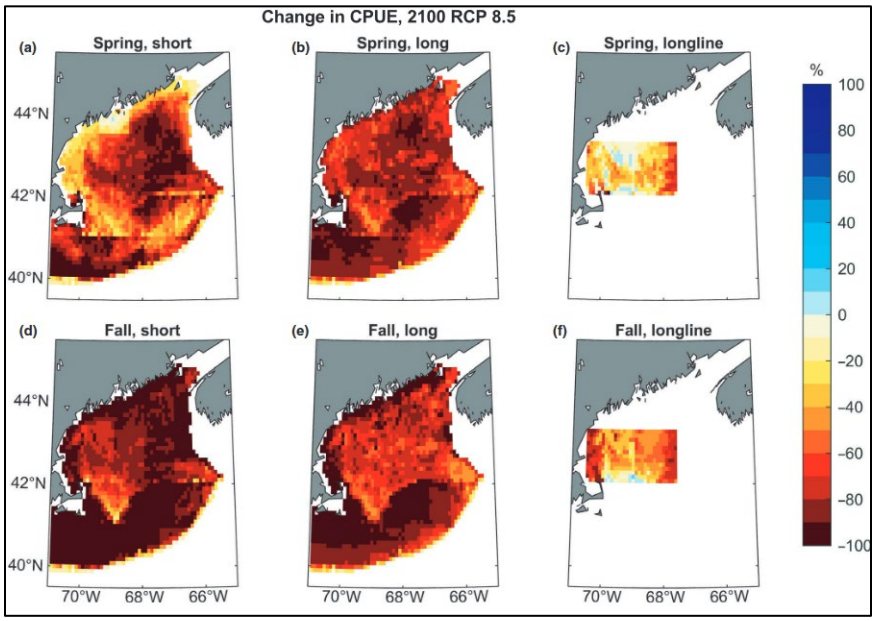


Figure 6. Projected change in catch per unit effort of thorny skate in an area by the 2081–2100 period from the 1986–2005 period under a "business as usual" emissions scenario. Subplots are split by season and capture methodology of training data set. Bottom trawl models (a, b, d, e) are split by length of the training series while longline models (c, f) were trained with all available years (Grieve et al. 2021).



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