Food web impacts of warming-driven migration shifts of top predators in the Mid-Atlantic Bight (MAB)

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Abstract of the Thesis

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Warming is now a key feature of the global ocean, but some regions experience more rapid warming. Sea surface temperatures in the northwest Atlantic shelf increased at rates faster than much of the global ocean. Consequently, the region is rich with observations of climate-driven shifts in spatial distribution. Changes in the extent and timing of migrations have been observed, but the ecosystem-wide implications of such changes have rarely been assessed. In marine ecosystems, the effects that warming has on migrations of large, predatory fish are particularly important because of the influential role these predators have on ecosystem processes. In scenarios where large, migratory predators are affected by warming, lower trophic levels may experience atypical predation pressures. When coupled with the bottom-up effects associated with warming, these scenarios become complex and difficult to predict. Using a mass balance model (Rpath) of the Mid-Atlantic Bight, we simulated the effects of warming-driven changes in the extent and timing of large predator migrations. We show that shifts in the migration patterns of top predator species, such as sharks, can have a profound effect on food webs. These effects extend beyond prey species, indicating that both direct and indirect considerations must be made in future exploration of similar migration shifts.

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Acknowledgments

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Food web impacts of warming-driven migration shifts of top predators in the Mid-Atlantic Bight (MAB)

Introduction

Global oceans are absorbing over 90% of the heat trapped in the atmosphere due to the anthropogenic increases in greenhouse gases, resulting in increasing ocean temperatures (Birkmanis et al. 2020). Warming ocean temperatures have already caused changes in the distribution, phenology, community composition, abundance, and demography in marine organisms (Poloczanska et al. 2013). Spatial shifts in distribution have been and continue to be a common consequence of ocean warming (Nye et al. 2009; Burrows et al. 2011; Pinsky et al. 2013; Kleisner et al. 2016). Although changes in spatial distribution have been described globally and are known to profoundly affect ecosystems and human well-being (Pecl et al. 2017), the rates of change and the mechanisms underlying distributional shifts can be vastly different. An observed shift can result from entirely different mechanisms and thus can have potentially different ecological consequences. The most documented mechanism is the movement of species to track its preferred temperature range. Shifts in spatial distribution are typically most pronounced and rapid in species that have strong thermal preferences and/or the ability to thermally track within their environments (Birkmanis et al. 2020). Some species, particularly forage fishes, are capable of actively tracking temperatures within their environments (Nye et al. 2009; Nye et al. 2011; Henderson et al. 2017). Many species have a lagged response to changes in temperature and timing of seasonal temperature transitions and potentially indicate other mechanisms causing shifts in spatial distribution (Henderson et al. 2017). When species do not closely track temperature trends, availability of benthic habitat (Roberts et al. 2020), dispersal capability or other traits may prevent rapid movement (Pappalardo et al. 2015). Other species may respond indirectly to warming, but directly to shifts in their prey species (Record et al. 2019).

Species that do not respond to temperature changes quickly via movement may still exhibit shifts in distribution but will shift more slowly through region-specific changes in individual growth rates, recruitment, and population growth rates. Spatial differences in population productivity (Xu et al. 2018; Simpson et al. 2011) may cause subpopulations at the leading edge of climate velocity to increase in abundance and subpopulations at the trailing edge to decrease in abundance. This mechanism results in shifts that lag temperature trends as a direct result of the life history of the species. Thus, for long-lived species the response to temperature may be very slow. As this mechanism is a direct result of a change in biomass within an ecosystem food web impacts may be strong.

Lastly, warming-driven changes in the extent and timing of migration patterns are another mechanism behind shifts in spatial distribution, but the ecosystem-wide effects of migration changes have rarely been assessed (Heupel et al. 2015). Under warming scenarios, it is expected that the migrations of some species may occur earlier or later or that the timing of migrations and residency in different regions of an ecosystem may change (Lundberg and Moberg 2003). In marine ecosystems, the effects that warming has on migrations of large predatory fish are particularly important because of their influential role on ecosystem processes including trophic cascades (Speed et al. 2010;

Birkmanis et al. 2020). In scenarios where large, migratory predators are affected by warming, lower trophic levels may experience atypical predation pressures that have profound ecosystem consequences (Nagelkerken and Munday 2016; Bell et al. 2017; Furey et al. 2018).

Shifts in spatial distribution of some large predator species have tracked the spatial shifts of prey species (Nagelkerken and Munday 2016). However, warming sometimes directly changes the spatial distributions of predator species. One mechanism by which this occurs is a change in the migration pattern of a species (Nagelkerken and Munday 2016). Species with affected migrations can experience longer or shorter migrations, migrate earlier or later than usual or a combination of these changes that cause a major fluctuation in migration. When a species experiences an altered migration, they can end up spending more time in one area and less time in another. This creates a scenario in which prey species experience unusually high or low predation pressure from climate-affected predators (Nagelkerken and Munday 2016). In these situations, prey species biomass may increase or decrease, or community-wide trophic cascades may occur. In marine ecosystems, top predators are often more mobile and are more likely to migrate long distances.

Top predator species are thought to heavily influence ecosystems by exerting top-down pressure, making them a particularly important species to understand spatially. Predators occupying high trophic levels are often considered mediators of ecosystem changes resulting from shifting environmental conditions (Okey et al. 2007). Large marine predators and migratory, high-level consumers often move between different habitats and ecosystems (Heupel et al. 2015). These predators have been called mobile link species because they connect different ecosystems with their trophic interactions (Lundberg and Moberg 2003). These predators, therefore, affect multiple ecosystems and can contribute disproportionately to ecosystem structure and stability (Heupel et al. 2015). It is assumed that sharks will fulfill this role as regulators of ecosystem function, structure, and health in marine communities (Speed et al. 2010; Birkmanis et al. 2020). Sharks are particularly vulnerable to rising ocean temperatures because, as ectotherms, their body temperatures increase to match ambient conditions (Birkmanis et al. 2020). This vulnerability of sharks and similar predator species is exacerbated by their life history characteristics (slow growth, late age of maturity, long birth cycles, etc.) (O'Brien et al. 2013). Some shark species have already made observable shifts in distribution and many more are expected to make these shifts as warming continues (Okey et al. 2007; Bangley et al. 2018; Hammerschlag et al. 2022). Current research suggests that there may be many mechanisms for shifts in shark distribution, including: 1) increased SST in higher latitudes makes northern waters more tolerable for predators, 2) elevated SST similarly causes shifts in the distribution and abundance of prey species and 3) changes in interactions with fisheries (Okey et al. 2007; Hammerschlag et al. 2022). Migratory marine species often match their environmental preferences to environmental conditions by adjusting migration timing between foraging and breeding habitats. The efficacy of this process often determines an individual's condition, survival, and fecundity (Anderson et al. 2013).

Changes in shark movement patterns are frequently the result of changes in habitat specificity driven by conditions such as depth, salinity, SST, stratification, and prey availability (Speed et al. 2010; Schlaff et al. 2014). Future sea temperature changes are likely to shift the location of suitable shark habitats, consequently shifting the distribution and abundance of sharks in the global oceans (Espinoza et al. 2014; Birkmanis et al. 2020; Hammerschlag et al. 2022). Hazen et al. (2012) showed that in areas of intense SST rise, substantial northward displacement of biodiversity is expected to occur. For thermally-stressed species, including sharks and other vulnerable top predators, increased migration times and loss of pelagic habitat are expected (Hazen et al. 2012). However, few studies have quantified the extent to which warming-induced changes in migration of marine top predators may affect their prey and the entire food web.

There are at least two ways in which warming-induced changes in migration could impact ecosystems. The first is through a range shift where more biomass of the predator moves into or out of the system (range shift scenario). This occurs in most often when habitat suitability changes because of warming. In situations where the suitability of a region improves, migratory predators can move further into and spend more time in the region. A second scenario may occur warming changes the timing of migration (phenological shift scenario). Such a scenario may be probable in species with high site fidelity to spawning or feeding grounds. This phenological shift scenario represents the potential for warming to cause tolerable temperatures to occur earlier in the spring and last later into the winter. In this scenario species would migrate out earlier and return later, thus reducing annual predation rates. Many studies have documented changes in phenology, but rarely has the ecological impacts of this been assessed.

One of the challenges of a rapidly changing ocean is accurately predicting how the distribution of species will change. In some cases, we expect that species will follow local climate velocities and move proportionally as ambient conditions shift. Some species, such as endotherms, are more resistant to ambient changes and can decouple from the expectations established by climate velocities (Thorne and Nye 2021). In some predator species, spatial distributions are observed as the predator follows the distribution shift of its prey species. There have been suggestions, however, that the capacity of a species to change distribution is trait-mediated. Thorne and Nye (2021) suggest that mobility, diet specialization and thermoregulation could all be traits that determine how quickly a species might shift, explaining the dissociation between observed distribution shifts and climate velocities of some species. To further explore trait-mediated distribution shifts and the mismatch that can occur between predator and prey, we have modeled and simulated different types of spatial shifts in sharks, a group well-known for high mobility and varied diet specialization.

The purpose of this modeling exercise was to assess the relative impact of range and phenological shifts of migratory predator species (i.e. Spiny dogfish and other sharks) on their prey and the Mid-Atlantic Bight ecosystem. We developed a new model of the Mid-Atlantic Bight in Rpath that provides the framework we will use to explore these impacts and begin to understand the relationship between range and phenological shifts as well as their independent and combined effects on a continental shelf ecosystem. We investigated this impact within two contexts: 1) comparison of range and phenological shifts within a single-species and 2) assessment of ecosystem-impacts when range and phenological shifts occur in all shark species. We hypothesized that 1) prey species would experience the largest impacts because prey biomass is directly affected by predators, 2) the combined effect of the range and phenology shifts would equal the sum of the individual effects and 3) the effect of a range shift would be greater than that of a phenological shift.

Methods

We developed a mass balance food web model of the Mid-Atlantic Bight (MAB) in Rpath (Figure 1). Rpath is an implementation of Ecopath with Ecosim written in R that allows for integration between mass balance models and R packages (Lucey 2019). Our model has 50 functional groups, including: 9 lower trophic groups, 6 invertebrate groups, and 32 fish groups (Figure 2; Table 1). The functional groups featured in the model range from single-species to highly aggregated, with an emphasis on disaggregating commercially important or well-studied species. Aggregate functional groups were created by combining species that belong to the same taxa or exhibit similar diet and life history. We parameterized the model for the years 1980-1985. The biomass of most groups was estimated from the Northeast Fisheries Science Center (NEFSC) bottom trawl survey. Highly aggregated groups and those groups that are poorly represented by trawl surveys, including primary producer groups, were estimated based on values used in the Energy Modeling and Analysis eXercise (EMAX) models of the Mid-Atlantic Bight and Southern New England (Link et al. 2006).

Unlike many traditional food web modeling frameworks, Rpath includes a forcing function specifically for simulating changes in migration patterns (i.e. Forced migration function). This function is calculated as a loss term which represents emigration from the modeled ecosystem. For example, a Forced migration function value of 5.0 will cause half of the biomass of the specified functional group to leave the ecosystem. Negative values of the Forced migration function function represent migration into the system. We used monthly steps in our simulation where the forced migration function was specified in each month. This allows for the representation of seasonal migration, where a species is leaving and reentering the ecosystem within the same year basis.

In this modelling exercise, we developed several 50 yearlong scenarios that differ by the value of the forced migration function. To simulate a mismatch between predator and prey migrations, all other functional groups were given a forced migration function term of 0. All other model parameters were kept consistent with the base model and base scenario. We applied the forced migration function function to the ‘SpinyDogfish’, ‘SmoothDogfish’ and ‘Sharks’ functional groups. Forcing was not applied to any other groups to ensure that any change throughout the simulations was a result of forced migration of the target species. For the purposes of these simulations, we assume that only our predator group experiences a change in migration pattern, but that all other species in the model have not. We used 4 scenarios in this exercise: 1) the base scenario (unaffected migration pattern), 2) range shift, 3) phenological shift and 4) range and phenological shift. To achieve the goals of this study, these scenarios were repeated in two contexts: 1) forcing ‘SpinyDogfish’ migration to elucidate the independent and combined influence of range and phenological shifts of a single species and 2) simultaneously forcing the migration of all sharks (‘SpinyDogfish’, ’SmoothDogfish’, and ‘Sharks’) to investigate the potential for broad migration shifts to cause ecosystem-level changes. The scenarios and the methods used for their implementation are detailed below.

The base scenario for spiny dogfish was determined using the species’ well-known seasonal migration. Spiny dogfish typically move north in the spring and south in the fall. During the summer, their residence is primarily north of the Mid-Atlantic Bight with only a small portion of their summer distribution overlapping our modeled region. In the winter, spiny dogfish return south where their distribution overlaps heavily with our modeled region. The forced migration function terms for spiny dogfish follow this seasonal migration such that in March, April and May an emigration term of 2.6 is applied and in September, October, and November an immigration term of -2.6 is applied. This accounts for a total flux of 78% of spiny dogfish biomass emigrating in the spring and immigrating in the fall. The range shift scenario represents the potential for warming to shift the range of spiny dogfish poleward. The expected outcome of this change would be a decrease in the overlap between the summer distribution of the spiny dogfish and our modeled region. To simulate this change, the Forced migration function term for the range shift scenario is increased to 3.3 in March, April and May and -3.3 in September, October and November. This accounts for a total flux of 99% of spiny dogfish biomass rather than the 78% applied in the base scenario. The phenological shift scenario represents the potential for warming to cause tolerable temperatures to occur earlier in the spring and last later into the winter. To simulate this change, the Forced migration function term is 2.6 in February, March, and April and -2.6 in October, November and December. The range and phenological shift scenario is simulated by applying a Forced migration function term of 3.3 in February, March and April and -3.3 in October, November and December.

The smooth dogfish, which is included in our second simulation of all shark species, exhibits a similar pattern of seasonal north/south movement, but its range is nearer the southern region of the Mid-Atlantic Bight. When smooth dogfish move north in the spring, they move into our modeled region, rather than leave it. Therefore, the smooth dogfish forcing pattern is the same as the spiny dogfish pattern, but with opposite signs such that smooth dogfish migrate to the MAB in the spring and emigrate from the MAB in the fall.

The scenarios used for forcing all shark species simultaneously includes the forcing of spiny dogfish and smooth dogfish described above but involves 3 functional groups experiencing forcing at the same time. The forced migration function terms for spiny dogfish are the same as previously described. To force the aggregate 'Sharks' functional group, which contains all shark species other than spiny and smooth dogfish, the forcing terms for spiny dogfish are used. The aggregation of this functional group makes it impossible to specify one migration pattern that accurately applies to every shark in the aggregation. However, the seasonal pattern of northward movement in the spring and southward movement in the fall is perhaps the most common among migratory sharks. The biomass of the aggregate 'Sharks' group is also smaller than that of spiny or smooth dogfish. Therefore, we feel comfortable that assuming the spiny dogfish migration pattern for the aggregate group will not cause major discrepancies in the results. The final group involved in this forcing is the smooth dogfish.

To summarize the results, we examined the biomass of every individual functional group in the final year of each scenario. End state biomasses showed the largest changes in our scenarios and, in the absence of notable deviations from general trends, summarize the results of the full scenario most accurately. For use in most of our analyses, we calculated ratios for each functional group by subtracting the final year biomass of each scenario by the final year biomass of its corresponding baseline scenario and then dividing by the baseline value. In our assessment of interaction type, we determined that a comparison of the relative biomasses of the three scenarios was appropriate. The distinction between additive and non-additive was made by dividing the relative biomass change of the simultaneous scenario (ΔRP) by the sum of the range shift scenario (ΔR) and phenological shift scenario (ΔP). If the resulting quotient is equal to 1, the simulated interaction was considered additive. If the resulting quotient deviated from 1 by more than 0.1 (i.e. less than 0.9 or greater than 1.1), the simulated interaction was considered non-additive. Results that deviated from 1 by a margin smaller than 0.1 were also considered additive. We considered that non-additive interactions could be synergistic or antagonistic. Synergistic interactions occurred when the result of the simultaneous scenario (ΔRP) was greater than expected and were represented by a quotient greater than 1.1. Antagonistic interactions occurred when the result of the simultaneous scenario (ΔRP) was less than expected and were indicated by a quotient smaller than 0.9.

We explored the impact of Spiny dogfish because this trophic group produced largest changes in biomass in multiple functional groups. Functional groups were divided into two subgroups: prey, which were modeled groups that contributed to the diet matrix of Spiny dogfish, and non-prey, which were the groups that were absent from spiny dogfish diet.

Results

Fish functional groups were generally the most affected in the spiny dogfish range shift scenario. Nearly all fish groups experienced an increase in biomass except for American shad, Atlantic croaker, butterfish, mesopelagics, small pelagics and winter skate which decreased slightly (Figure 3). The most pronounced changes occurred in fourspot (increased), goosefish (increased) and other pelagics (increased). Lower trophic levels and invertebrates experienced much smaller changes to biomass. Most lower trophic groups showed little change except for gelatinous zooplankton, which increased, and megabenthos and micronekton, which decreased (Figure 4). Of the lower trophic levels, gelatinous zooplankton changed the most. All invertebrate biomass decreased at the end of the spiny dogfish range shift scenario except for Illex which increased (Figure 5). The largest change occurred in Illex (decreased). The predator functional groups experienced varied biomass changes. Odontocetes, sharks and smooth dogfish increased while the other predator groups changed negligibly or decreased slightly (Figure 6). Odontocetes experienced the largest change of the predator functional groups (increased).

Generally, a shift in spiny dogfish phenology caused a smaller response throughout the model than did the range shift scenario. Functional groups experienced varied results at a much smaller magnitude than the range shift scenario. Like the range shift scenario, fish functional groups showed the greatest biomass changes (Figure 3). Other pelagics, other demersals and southern demersals changed the most, experiencing small increases in biomass. Lower trophic levels did not change much in response to a phenological shift in spiny dogfish. Megabenthos and micronekton experienced the largest changes, increasing and decreasing, respectively. While most invertebrate groups changed only slightly, Illex did show an increase in biomass of approximately 2%. Predator trophic groups changed negligibly under the phenology shift scenario.

The biomass changes resulting from simultaneously shifting range and phenology of spiny dogfish largely reflect the trend and magnitude of the range shift scenario. The greatest responses occurred in the fish functional groups (Figure 3). Fourspot, other pelagics and goosefish were again the most affected fish groups with biomass increases of 5.4%, 5.1% and 4.9%, respectively. The response of lower trophic level groups was different than the individual scenarios (Figure 4). Gelatinous zooplankton did not experience a large increase in biomass. Megabenthos increased nearly 0.2% and micronekton decreased very slightly. All other lower trophic levels changed negligibly or not at all. Illex again experienced the largest biomass change among invertebrate groups, increasing approximately 2% (Figure 5). The predator functional groups did not change much except for smooth dogfish which experienced a small increase (Figure 6).

The ratio of simultaneously changing the range and phenological shift scenario to the sum of the range shift scenario and the phenological scenario rarely deviated from 1 (Table 2). In 45 of the 49 functional groups, this ratio was within the range considered to be additive. Of the four functional groups that were not additive, 2 were synergistic and 2 were antagonistic. There was a synergistic increase in Loligo and spiny dogfish where both trophic groups increased more than expected compared to the individual scenarios. Other cephalopods and megabenthos were antagonistic, experiencing less of a simultaneous effect than expected. There does not seem to be any correlation of life history traits or position within the model that account for these four groups having non-additive interactions under the simultaneous scenario.

A range shift of all shark species in the model caused varied effects. The most impacted were the fish functional groups (Figure 7). Most of the fish species and aggregates experienced increases in biomass. However, the small pelagics group experienced a decrease of more than 15%. All lower trophic level groups experienced declines in biomass or negligible change except for gelatinous zooplankton, which increased (Figure 8). Similarly, all invertebrate functional groups declined except for Illex which increased over 3% (Figure 9). The predator functional groups all increased except for little skate, which decreased slightly. The odontocetes and seabirds groups increased the most (Figure 10).

The phenological shift scenario for all shark species caused responses of smaller magnitude in most functional groups. Fish were, generally, the most affected groups in this scenario (Figure 7). Most fish biomass increased except for the small pelagics group which experienced a stark decline in biomass of approximately 17%. The responses of lower trophic levels to a phenological shift in all shark species was varied (Figure 8). The megabenthos group experienced the largest change of the lower trophic levels (decreased). The biomass of invertebrate groups generally did not change except for Illex which again increased (Figure 9). The predator functional groups experienced negligible biomass changes (Figure 10).

The biomass responses resulting from a simultaneous shift in range and phenology were mostly greater than those resulting from either shift independently.

Consistent with previous scenarios, fish functional groups were the most affected throughout the model. Most fish functional groups experienced an increase in biomass. The small pelagics group, however, experienced the largest change of any functional group in any scenario, decreasing over 34% (Figure 7). Lower trophic level groups exhibited varied results (Figure 8). Gelatinous zooplankton experienced the only notable increase in biomass. The micronekton group decreased slightly while all other groups changed negligibly. Most of the invertebrate groups experienced no change in biomass (Figure 9). Illex increased over 5%, remaining consistent with the previous scenario results. All predator functional groups exhibited increased biomass except for little skate (Figure 10). The odontocetes and seabirds groups showed the largest changes of the predator species.

Plotting relative change of each functional group against proportion of spiny dogfish diet (Figure 11) showed unexpected responses in both prey and non-prey species. The group that spiny dogfish eat the most, macrobenthos, did not change notably in the range + phenology shift scenario. Smooth dogfish, a group that spiny dogfish do not eat, did increase in the range + phenology shift scenario. The group that experienced the most change in the range + phenology shift scenario was Illex, which are one of the groups that contribute to the diet of spiny dogfish. There was no discernable relationship between the relative change of a group and the amount that the group contributed to spiny dogfish diet. This trend is also present when plotting the relative change of each functional group against the proportion of the diet of all shark species (Figure 12). Small pelagics, a group that is not a major component of the diet of any of our sharks species, decreased substantially when all shark species were modified in any way. Odontocetes, a group that none of our shark groups consume, increase when our shark species are reduced in the model.

Discussion

Mismatches in predator range shifts and migration phenology affected nearly all functional groups in our Mid-Atlantic food web model illustrating that changes in migration patterns are an important driver of ecosystem change under a warming climate. For most of the functional groups included in the diet of these sharks, the reduction in residence time of predators allowed gradual increases in biomass of lower trophic levels. Fish and squid functional groups were the most affected in nearly all scenarios. Invertebrates and other low trophic level groups exhibited small, varied responses, except for Illex which changed more substantially. Our comparison of the individual and combined impacts of these shifts resulted in mostly additive effects. However, in a few instances, there were non-additive effects, there was no clear correlation between any characteristics and a propensity towards unanticipated effects. Although rare, these synergistic or antagonistic responses to species range and migration shifts pose a challenge to natural resource management and conservation.

Some of the largest changes that occurred when we altered spiny dogfish migration occurred in species that spiny dogfish did not eat. These results were in direct contrast to our hypothesis that prey species would be the most affected and illustrate the importance of indirect trophic interactions. The two groups that make up the largest percentage of spiny dogfish diet, small pelagics and macrobenthos, changed negligibly or did not change at all. This is likely because these two trophic groups are common food sources for many predators such that, when consumption by one predator is reduced (e.g. our reduction in spiny dogfish residence time), other predators can feed upon those more-available prey groups. Conversely, some groups that were absent from the diet of the predator changed more than most prey species. For example, smooth dogfish increased in abundance when spiny dogfish residence time was effectively reduced. Similarly, odontocetes increased in biomass when the biomass of all shark species was reduced. In both cases, the competitor increased in biomass when the residence time of the predator was reduced without a concomitant decrease in prey as we initially hypothesized. These results not only reject our initial hypothesis that prey species would be impacted the most by changes in predator migration but also elucidate several interesting things about our model and the trophic impacts of migration. First, changes in non-prey species confirm that the model is capable of simulating complex indirect trophic interactions. Second, even though the simulations in this study are hypothetical they reflect observed changes in migrations already seen in sharks (Hammerschlag et al. 2022) and have real power in identifying potential indirect and non-additive effects that would otherwise be difficult to anticipate. Third, the structure of the model can be used to further explore and possibly explain these interactions further.

If we look closer at the diets of smooth dogfish and spiny dogfish they are not obvious competitors. There is some overlap in diet but competition is likely limited by the different feeding strategies used by these species. Spiny dogfish are generalists but smooth dogfish are benthivorous so the increases in smooth dogfish were not obviously a release from competition. However, including a third group, macrobenthos, clarifies this interaction. Macrobenthos is the second most common prey species of spiny dogfish but it does not increase in the absence of spiny dogfish. This is because macrobenthos is one of the most common prey species of smooth dogfish and is consumed by many other functional groups in the model. When spiny dogfish leave the Mid-Atlantic Bight, macrobenthos are unable to increase in biomass because smooth dogfish continue to control their population. The absence of spiny dogfish, however, does increase the availability of macrobenthos for smooth dogfish consumption, which in our model simulations, causes an increase in smooth dogfish biomass.

The example outlined above describes only one potential interaction that can be identified from our modeling exercise. That example tells us that, in the event of a large change in the distribution of spiny dogfish, macrobenthos populations might be stable and smooth dogfish populations could increase. Our modeling could similarly identify groups that may change substantially in the event of a large spiny dogfish shift. Using the same approach we have used here, any species or set of species in our model could be simulated to identify the species that are sensitive to certain perturbances and those that are more resilient. This approach can be used to highlight trophic groups that are most likely to be involved in events like trophic cascades as well as identify which functional groups are able to control others informing future monitoring and management efforts. The model also allows for identification of species that are highly connected to the rest of the food web and those that are dependent on only a few interactions.

Our simulations stress the impact that intense predator-prey mismatches might have on the entire ecosystem. It is highly unlikely that only spiny dogfish would experience a distribution shift and that none of their prey would shift. Indeed, we know that many prey species have shifted their distributions in the Mid-Atlantic specifically (Nye et al. 2009; Pinsky et al. 2013), but there is also evidence that large, highly mobile predators have shifted exceedingly faster (Thorne and Nye 2021). We chose to simulate only spiny dogfish and top predator movement to show an exaggerated mismatch where the predator experiences a drastic change to its distribution before its prey changes at all. The simulation of such an exaggerated predator-prey mismatch has identified the changes that might occur between the prey and the predators that remain in the MAB as well as how other predators might benefit from an early departure of a competing predator. Nevertheless, we have demonstrated that in the extreme and sudden absence of one of the ecosystem's top predators, the food web will likely respond in a myriad of interesting ways that would influence the way we approach further studies and management of the region.

Shifts in the distribution and movement patterns of marine species is a frequent consideration made when assessing the potential consequences of warming (Pecl et al. 2017; Melbourne-Thomas et al. 2022; Poloczanska et al. 2013). With respect to how migration extent may impact ecosystems, changes in extent and timing are often mentioned, but the extent to which such changes occur is largely unknown. Although our results suggest that shifts in the range of migrating predators may have a greater impact than an isolated shift in migration timing, changes in migration phenology still elicited food web effects. A phenological shift in all predator migrations caused over a 10% reduction in some lower trophic levels. The change in biomasses of the range shift scenario are much larger than the phenological shift scenario. In our simulations, a shift in range and a shift in phenology both reduce the overall residence time of shark functional groups in the Mid-Atlantic Bight. The functional groups affected by these predators are largely determined by the trophic interactions that drive the model.

Therefore, our simulated shifts in range and phenology affect similar functional groups in similar ways, but on different scales. The yearly output of these simulations is captured at the end of the year, which could explain why timing makes for a less impactful simulation.

It is likely that warming will impact both the extent and timing of migration patterns simultaneously (Heupel et al. 2015). However, many studies approach these changes in isolation. Our assessment suggests that shifts in range and phenology mostly interact additively. While some functional groups experienced non-additive interactions, most of them experienced additive effects. This result is consistent with the expectation that shifts in migration range and timing will combine to create proportionally greater effects. Our results suggest that range shifts may have a larger impact on food webs, which supports the most common approach taken in literature. However, several of our functional groups change more during simultaneous change, suggesting that the consideration of shifts in migration timing is important as we make predictions about warming and migrations.

In this study, we evaluated the relative importance of range and phenological shifts in the migration patterns of sharks as a potential consequence of a warming ocean. However, the simulations presented here do not explicitly consider the direct effects of warming on growth, consumption, and other physiological processes. While our model has the capacity to simulate such direct effects, we did not include it in our simulations. In future simulations, warming could be added to more closely represent the overall ecosystem impact of the changes we have described here. When temperature-dependent consumption and respiration were incorporated into a similar

Rpath model, biomass of all functional groups decreased with warming (Heinichen et al. 2022). The ability of ectothermic predators to initiate trophic cascades has been shown to be dependent of feeding rate (Shurin and Seabloom 2005). Thus, if we had included both migration changes and changes in feeding rates, stronger ecosystem effects may have been simulated. Migrations are also more complex than what was modeled here. The Mid-Atlantic Bight Rpath model is also built with 10 fishing fleets which were not active in these simulations. The addition of fishing pressure would improve the potential for these simulations to be used in ecosystem-based fisheries management.

The finding of this and many other studies that impacts of multiple stressors are often additive emphasizes the need to consider multiple factors to anticipate the effects of climate change (Nye et al. 2013; Crain et al. 2008). If we choose to exclude effects from our projections and analyses, we might underestimate the impacts that might occur as warming causing shifts in migration and distributions. Although we only simulated the migration changes in sharks, we have effectively modeled what might happen when there is a mismatch between a generalist predator and its prey. Such a mismatch is likely as large migratory predators like sharks can move more readily in response to warming waters. This has also been observed in many systems (Thorne and Nye 2021). Our results have indicated the importance of assessing range and phenology together rather than in isolation. The changes we have simulated are intended to represent the subtle consequences of a warming ocean on one group. It is possible for warming to change the spatial patterns of many species, cause large changes in community assemblages and drive ecosystems in new ways. This study shows that one facet of warming in one group can have a measurable, ecosystem-wide effect.

Supplementary methods

This model was closely developed alongside another Rpath model of the Gulf of Maine, both of which followed the procedures of the existing Georges Bank Rpath model (Lucey 2019). Many of the decisions and methods used to create the Mid-Atlantic Bight Rpath model were made to ensure future compatibility with these two models.

Functional groups and fisheries

The Mid-Atlantic Bight Rpath model includes 62 groups (Table 1). Of these groups, 49 represent fishes, invertebrates, marine mammals, sea birds and producers. These groups are divided into 26 single-species or single-genus groups and 23 aggregate groups that represent species with similar life-history or diet (See Appendix A for a list of species in each group). The model includes 2 detrital groups representing detritus and discards. There are 11 fishing fleets present in the model that represent the types of commercial gear used in the Mid-Atlantic Bight as well as a single group that represents recreational catch. These groups are connected by trophic interactions which are represented by the lines drawn between nodes in the model's food web (Figure 2).

Parameterization

The Rpath framework requires the input of biomass, fisheries catch and diet information. Rpath also requires ratios that relate production to biomass and consumption to biomass. For most groups in this model, these parameters can be obtained from existing data sources. However, some of the larger aggregate groups are not well-represented in the data sources used for parameterization and were instead given the parameters used in the EMAX models of the Mid-Atlantic Bight and Southern New England Sound (Link et al. 2006).

Biomass estimates for many species were derived from the NEFSC bottom trawl survey. Data from 1980 to 1985 were pulled from the NEFSC survey. These years were chosen for use in parameterizing the model to stay consistent with other models being developed by colleagues for use in similar projects. The rgdal and survdat packages were used together to estimate the biomass of the included functional groups across the spatial coverage of the modeled study region. There were several species that were aggregated due to low presence in NEFSC bottom trawl data in the Mid-Atlantic Bight for the years 1980 to 1985 (Table 4). The biomass per tow pulled from the NEFSC database was scaled using the catchability values from the EMAX models of the Mid-Atlantic Bight and Southern New England Sounds (Link et al. 2006). This biomass estimate was divided by the area of the modeled region to get biomass in the correct units for use in Rpath (mt km^{-2}).

Fisheries catch data for this project were provided by the NEFSC for the years 1980 to 1985. Commercial landings were pulled from NEFSC databases and discards were estimated from ratios calculated from observer data. The spatial coverage used for commercial landings was based on the statistical areas defined by the Northwest Atlantic Fisheries Organization. The statistical areas used were 526, 537, 539, 600, 612-616, 621, 622, 625, 626, 631 and 632. These statistical areas are completely inside the Mid-Atlantic Bight EPU except for 526 and 537, which also partially cover George's Bank. To account for these areas, the proportion of catch outside Georges Bank was estimated from the MS Keyrun project and considered catch within the Mid-Atlantic Bight. Recreational fishing was also considered as one of the fleets in the model. The recreational catch resulting from this fleet was estimated using observations from the Marine Recreational Information Program (MRIP).

Diet data were estimated using the NEFSC stomach content database which contains the prey items found in stomachs dating back to 1973 (Link and Almeida 2000). To ensure the most complete diet data for all species in the model, all years of the stomach content database were used. The prey items featured in the NEFSC database were assigned to the species and group labels used in the model. Any prey designated as unspecified, or unknown were excluded from our analysis of these diet data. Stomach data were converted into the percent weight of each prey type using a clustering design described by Nelson (2014). Proportions were then allocated to each functional group pairing in the model and exported as a diet matrix that was later converted into a format accepted by Rpath.

The other biological parameters needed for an Rpath model are production to biomass ratio (PB), consumption to biomass ratio (QB) and ecotrophic efficiency (EE). The mass balance framework used in Rpath only requires 2 of these 3 parameters (the other will be estimated by the model). It is most common for the PB and QB to be input and the EE to estimated, which is also the approach we used here. Due to the similarity of this model and the Georges Bank Rpath model (Lucey 2019), many of the PB and QB values for single-species groups were taken from the Georges Bank Rpath model.

Parameters from other Mid-Atlantic Bight models (Link et al. 2006; Okey et al. 2001) and models representing similar areas of the Northwest Atlantic Continental Shelf (Buchheister et al. 2017) were also compared to ensure that the parameters used in the Georges Bank Rpath model were appropriate for the Mid-Atlantic Bight. The parameters from these models were considered as a range of acceptable values for the inputs in the model.

Balancing procedures

The Mid-Atlantic Bight was predictably unbalanced when parameterization was completed. As mentioned before, the major parameters of an Rpath model are biomass, PB, QB and EE. Only 3 of these parameters must be included as inputs and the 4^{th} parameter, typically EE, is estimated by the model. EE, or ecotrophic efficiency, is a parameter that describes the amount of mortality experienced by a functional group that is explained by the model. Therefore, any EE greater than 1 is impossible and indicates that the model is unbalanced. Technically, a mass balance model is balanced when all EE values are below 1. However, Link (2010) describes an additional set of principles that ensure a model is adhering to acceptable ecological characteristics. These pre-balance diagnostics (PREBAL) can indicate troublesome functional groups that should be priority targets of balancing procedures. Therefore, we started our balancing process by evaluating the 5 following PREBAL diagnostics: 1) biomass across trophic levels, 2) biomass ratios, 3) vital rates across trophic levels, 4) vital rate ratios and 5) production and removals. The results of these PREBAL diagnostics were recalculated each time a major balancing change was made in the model. Typically, we balanced the groups in order of descending EE value. However, in some situations, PREBAL diagnostics identified implausible ecological traits occurring in some groups that were addressed regardless of the EE parameter.

Due to the definition of ecotrophic efficiency, the EE of a functional group responds intuitively. An EE greater than 1 describes a group experiencing more mortality than is possible. Therefore, increasing the biomass or productivity of the group can decrease the EE. The EE can also be reduced by decreasing the sources of mortality on the group. Within the mass balance framework, the two main sources of mortality are predators and fishing fleets. Therefore, the EE can also be reduced by decreasing the consumption or fishing pressure on the group. Consumption on a group can be lowered by reducing the biomass or QB of its predators. Consumption on a group can also be decreased by reducing the presence of the group in the diet matrix of its predators. We procedurally used the above methods, with reference to PREBAL, to decrease the highest EEs in our model until all groups had an EE lower than 1 without violating any ecological principles. The ratio of final parameters to initial parameters $\left(\frac{\mathrm{Parameter}_{\mathrm{Final}}}{\mathrm{Parameter}_{\mathrm{Initial}}}\right)$ shows the change that was made in our balancing procedures (Table 5).

Figures

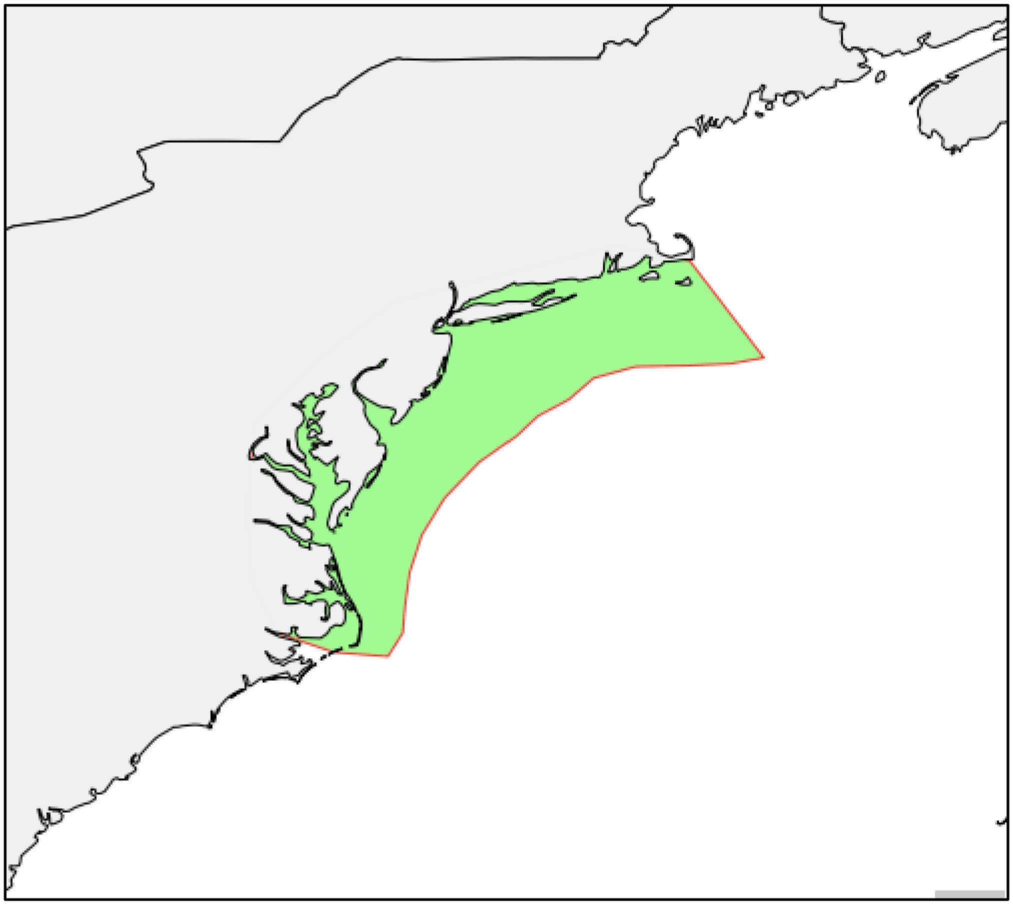

Figure 1. The Mid-Atlantic Bight relative to the Northeast US Continental Shelf. The area highlighted green approximates the modeled region.

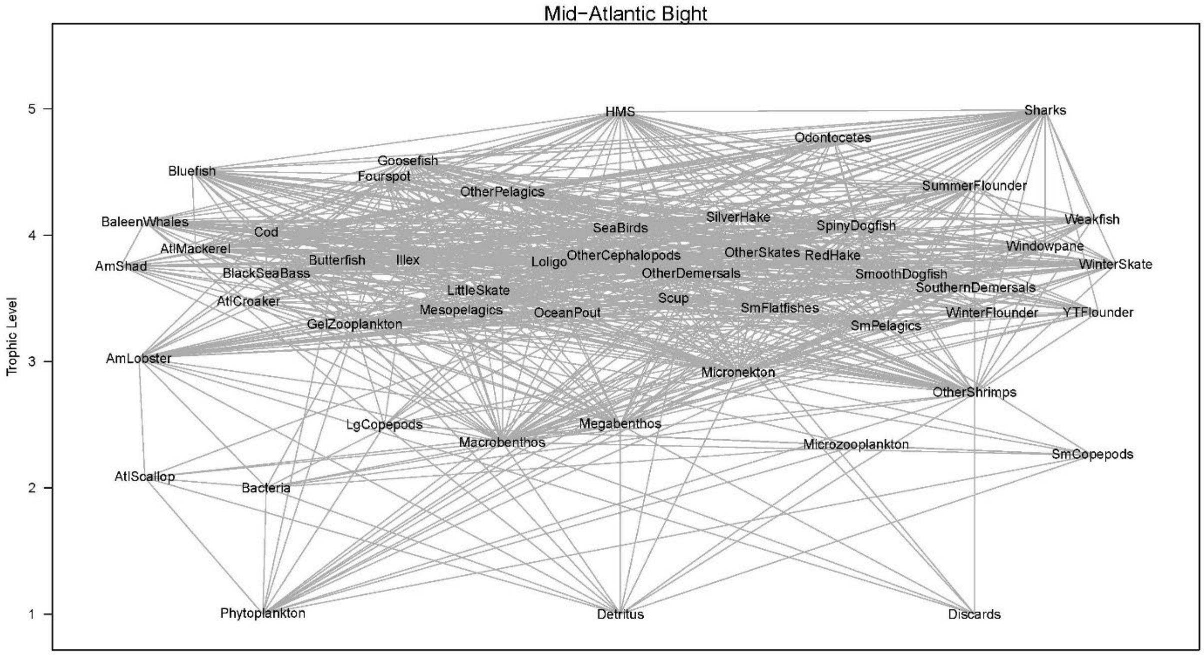

Figure 2. The Mid-Atlantic Bight Rpath model represented as a food web.

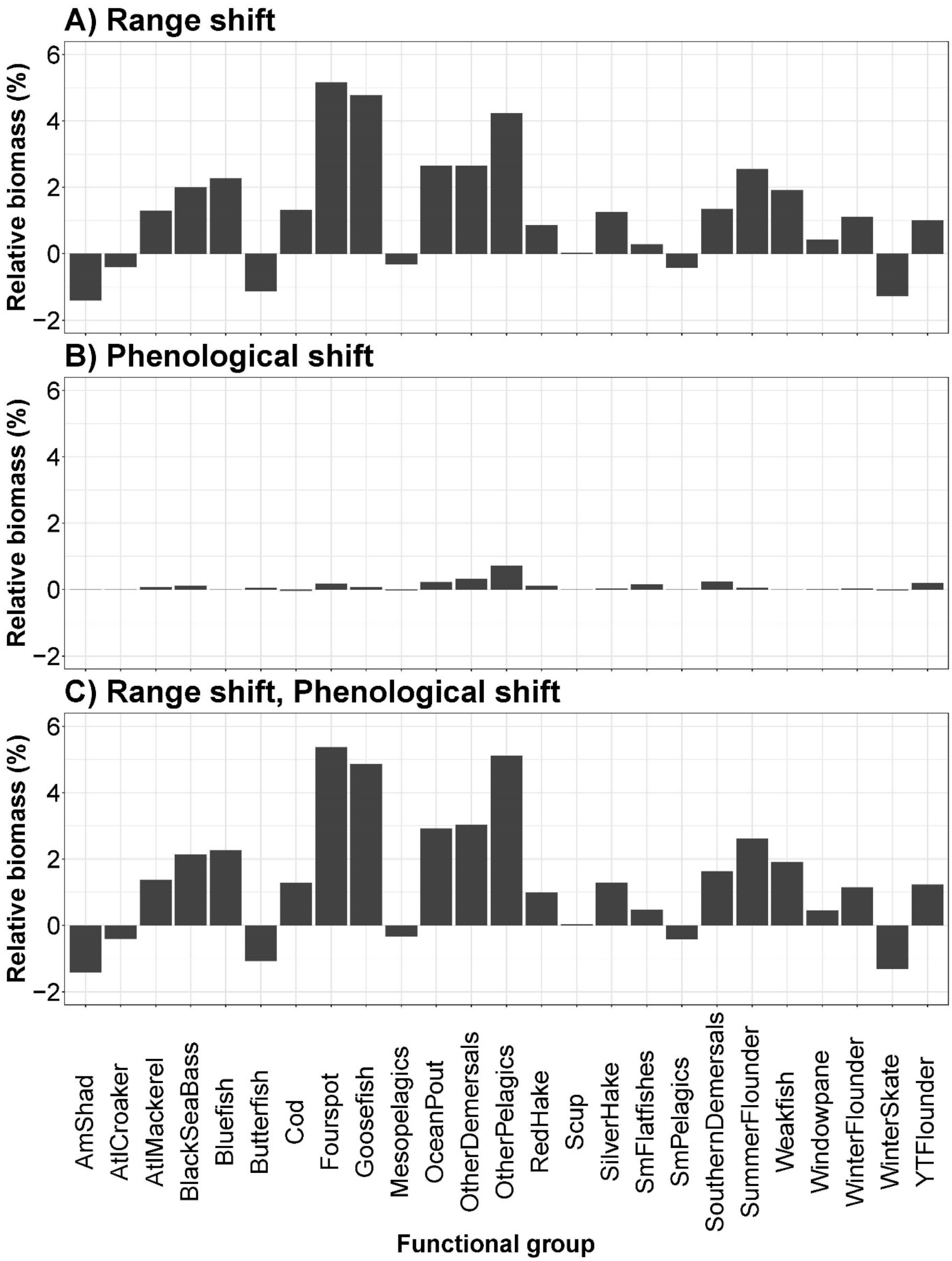

Figure 3. Final year biomass of fish functional groups relative to baseline for Spiny dogfish scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

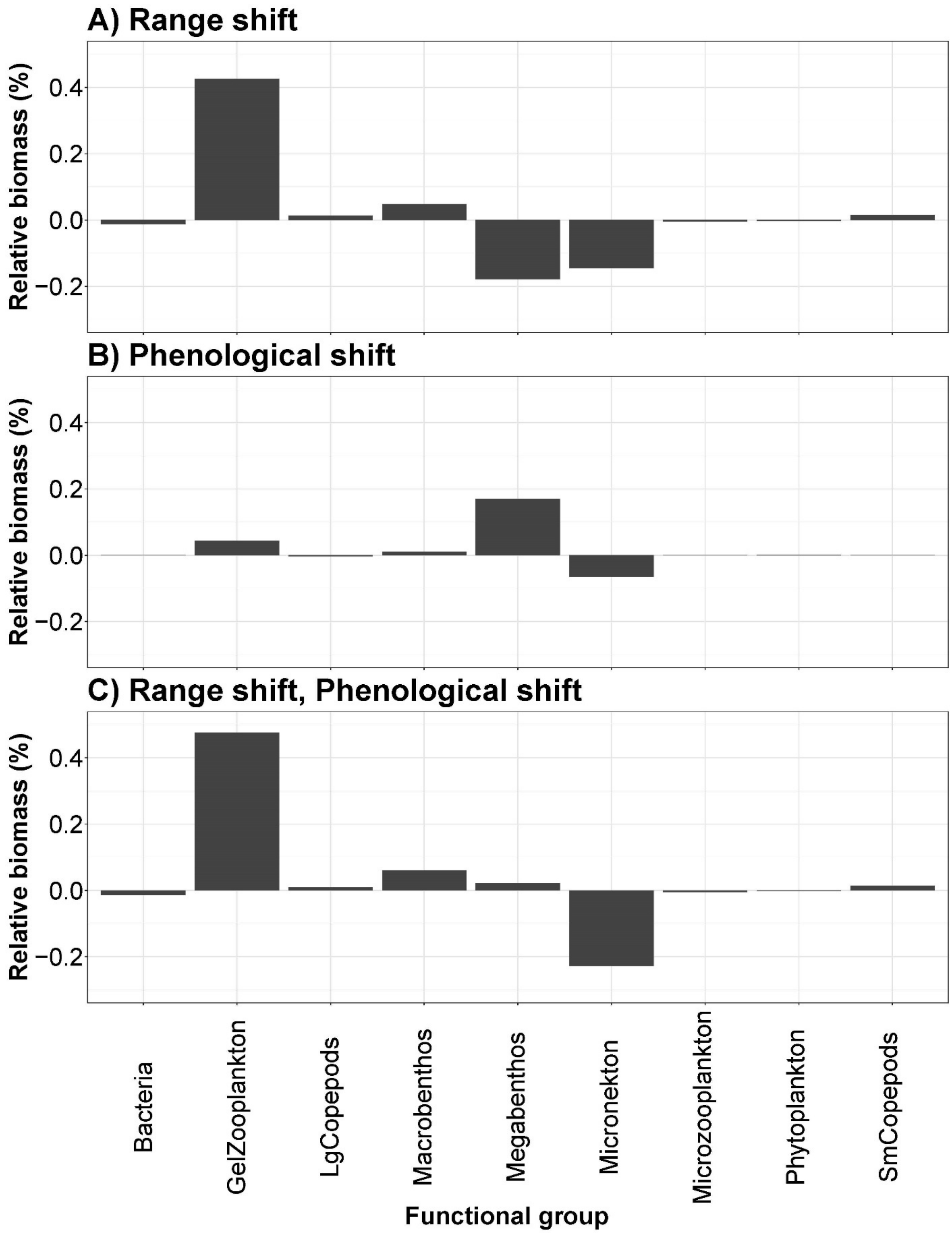

Figure 4. Final year biomass of lower trophic level functional groups relative to baseline for Spiny dogfish scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

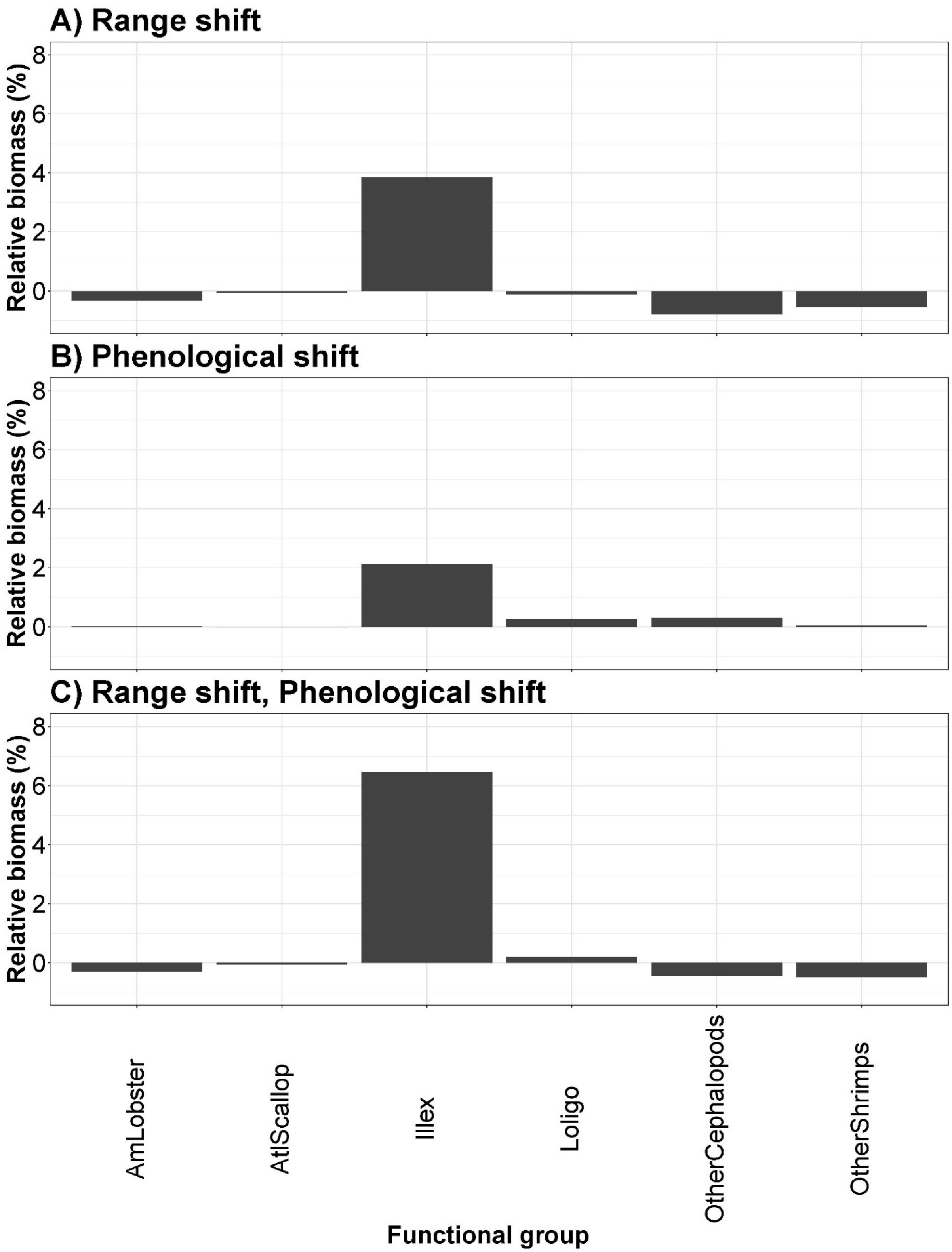

Figure 5. Final year biomass of invertebrate functional groups relative to baseline for Spiny dogfish scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

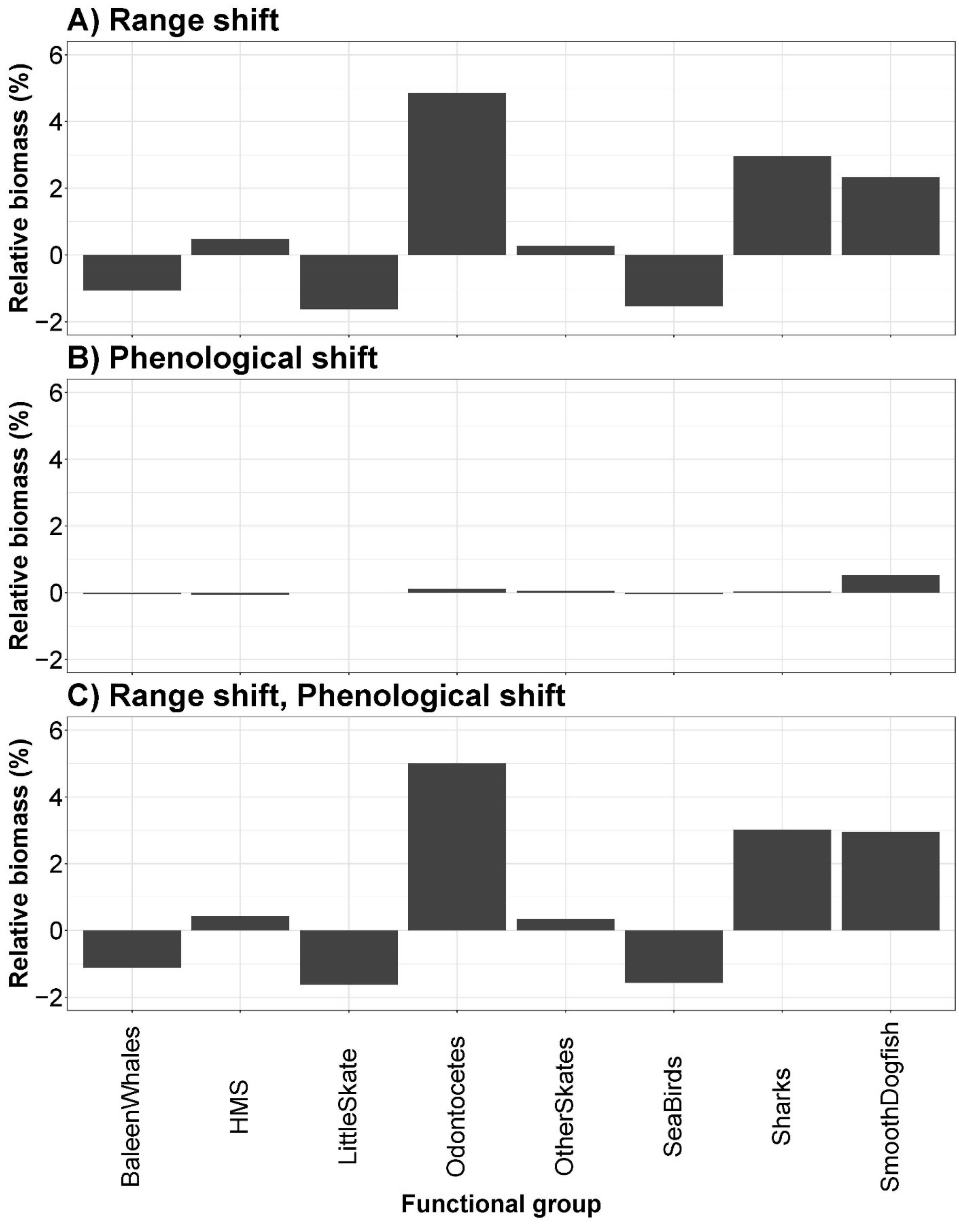

Figure 6. Final year biomass of predator functional groups relative to baseline for Spiny dogfish scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

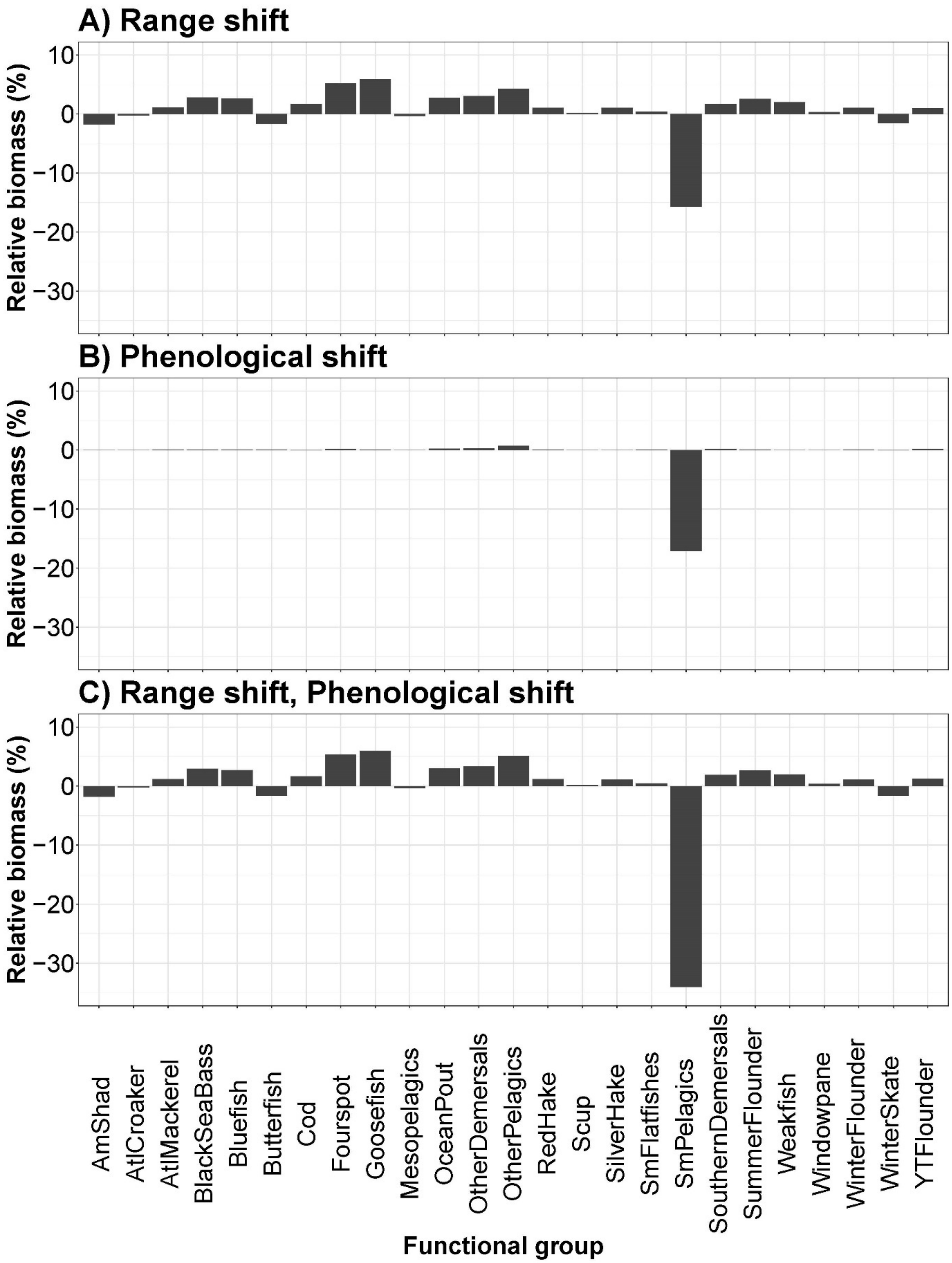

Figure 7. Final year biomass of fish functional groups relative to baseline for All Sharks scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

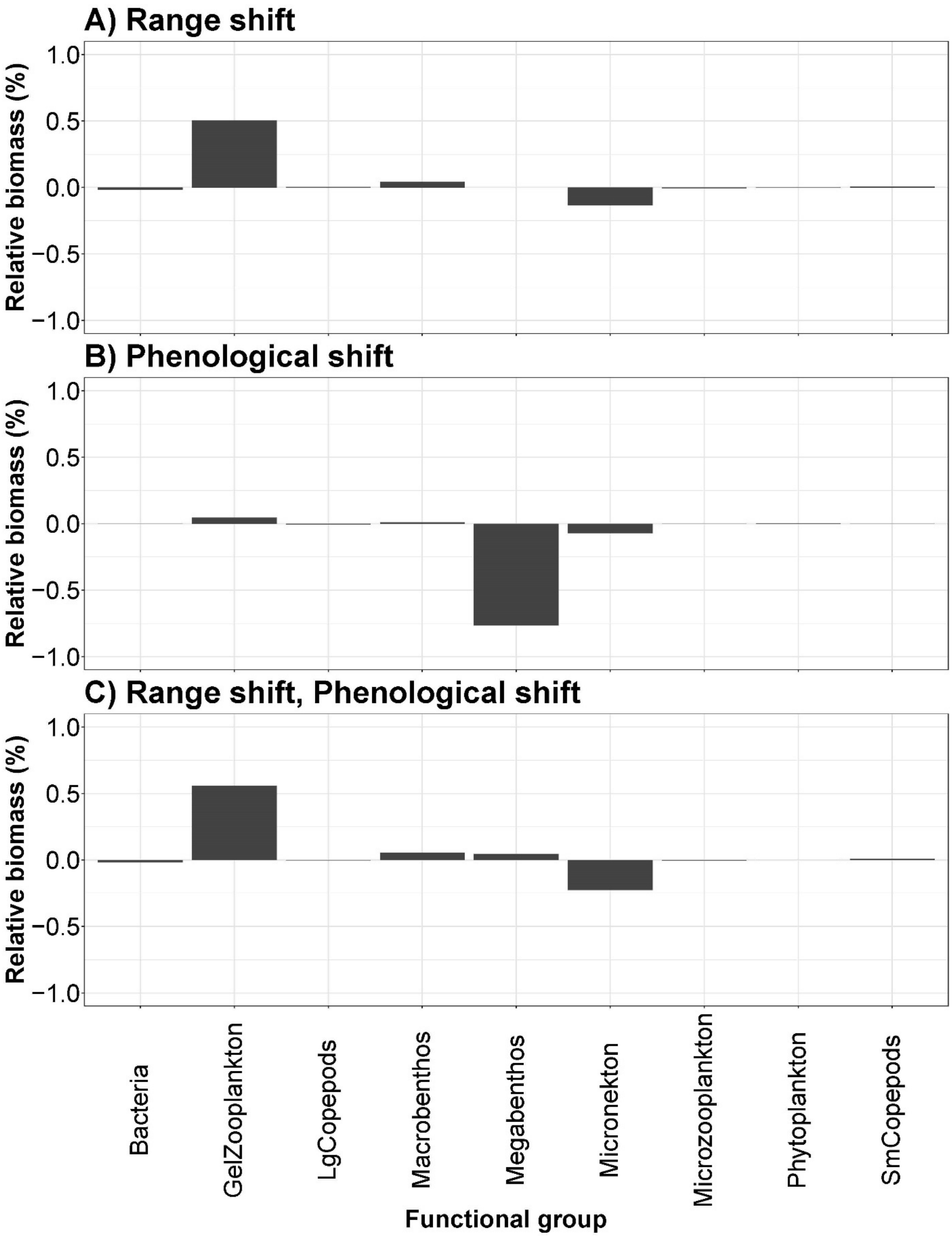

Figure 8. Final year biomass of lower trophic level functional groups relative to baseline for All Sharks scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

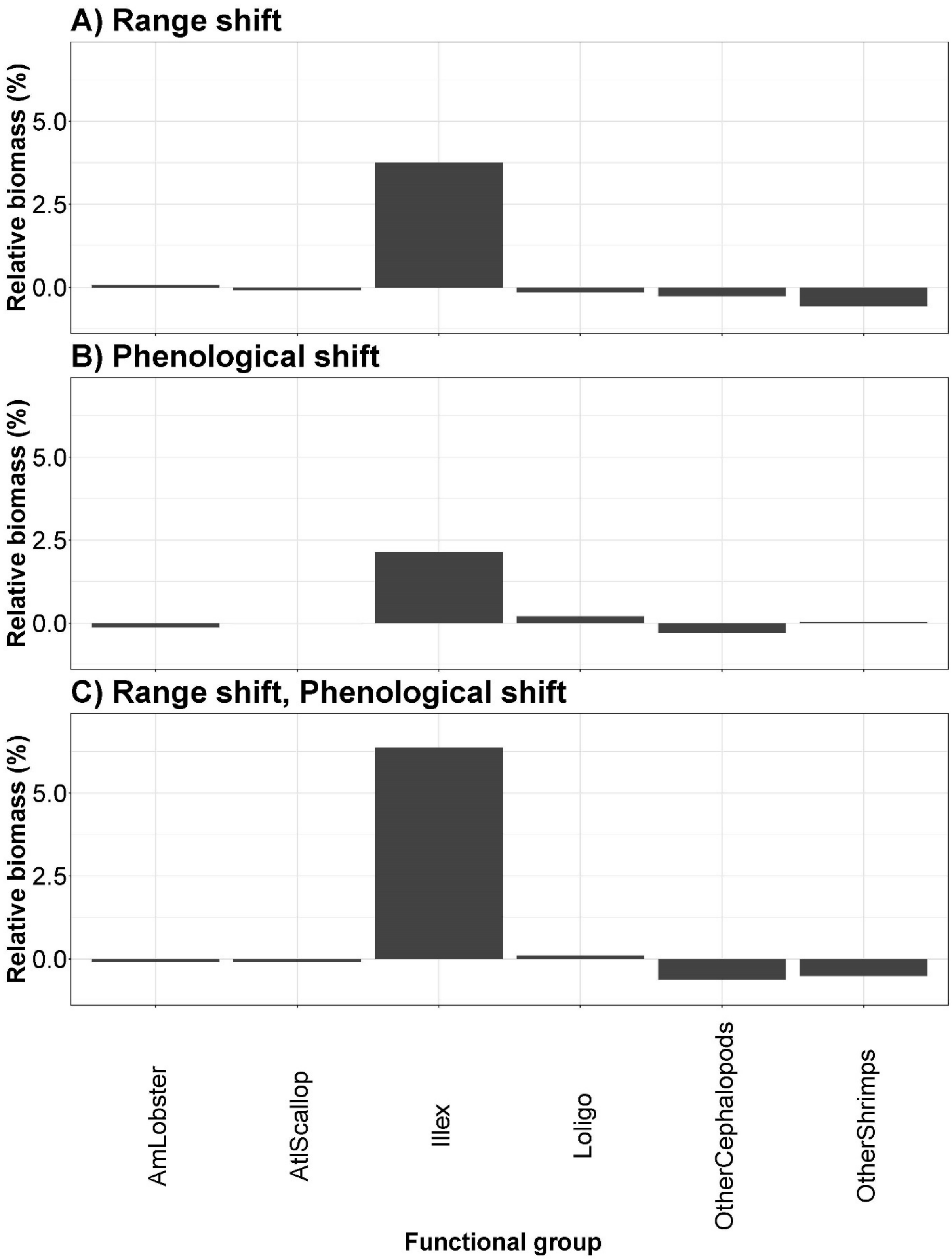

Figure 9. Final year biomass of invertebrate functional groups relative to baseline for All Sharks scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

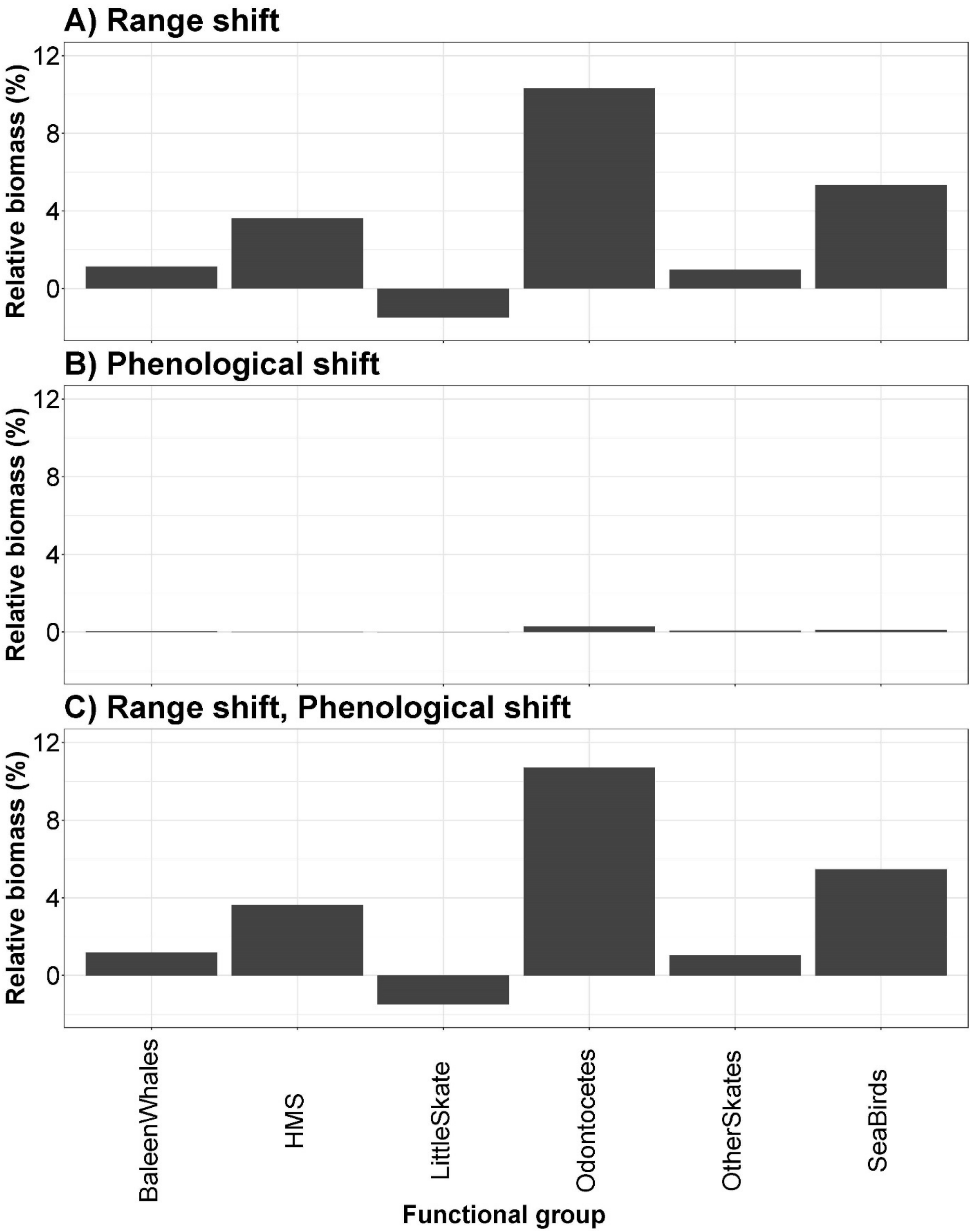

Figure 10. Final year biomass of predator functional groups relative to baseline for All Sharks scenarios: A) range shift, B) phenological shift and C) range and phenological shifts simultaneously.

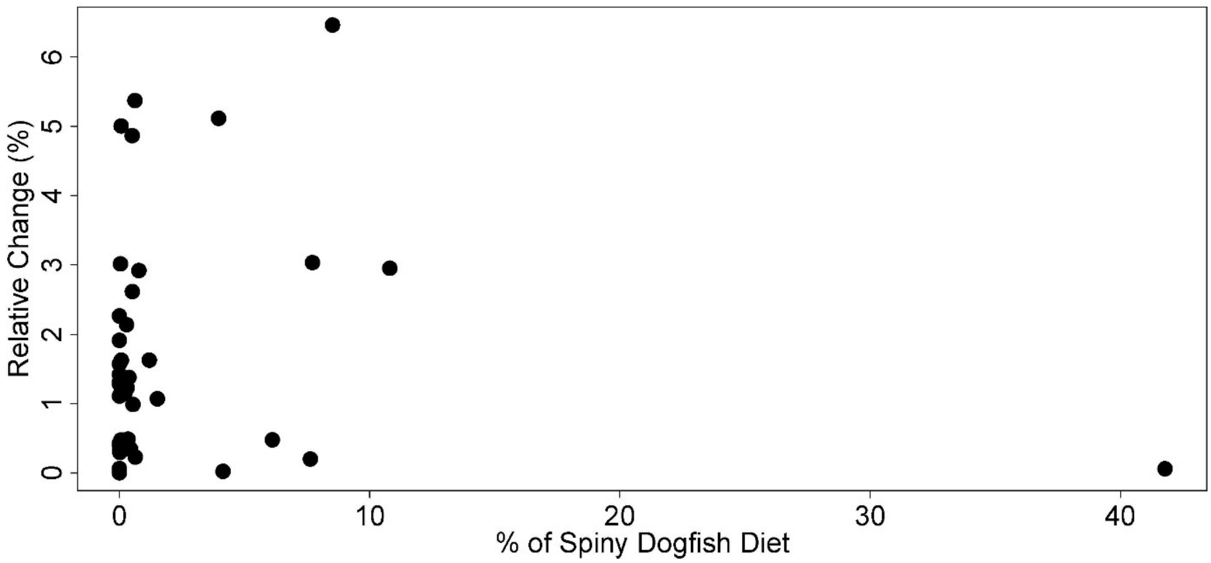

Figure 11. Relative change of each functional group plotted against the proportion of each group in the diet of spiny dogfish. The data plotted here are from the range + phenology shift scenario, chosen because it was the scenario that created the largest impacts. The change of each group relative to the baseline scenario is absolute here such that only the magnitude of change is shown.

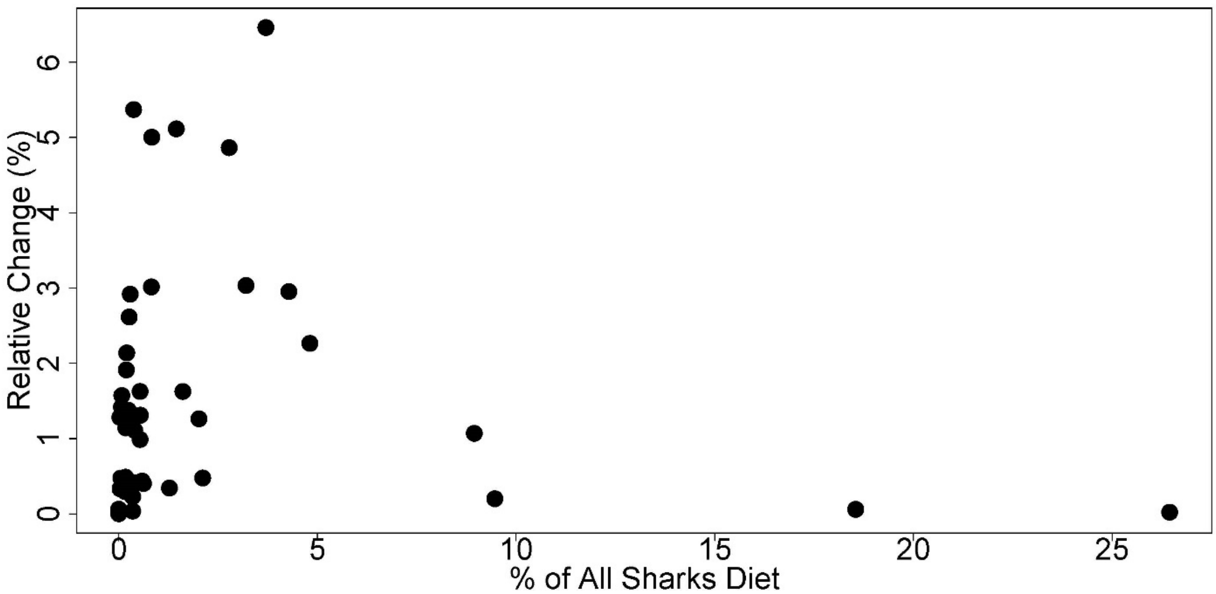

Figure 12. Relative change of each functional group plotted against the proportion of each group in the diet of all shark species. The data plotted here are from the range + phenology shift scenario, chosen because it was the scenario that created the largest impacts. The change of each group relative to the baseline scenario is absolute here such that only the magnitude of change is shown. The proportion of diet belonging to all shark species was calculated by combined the diet matrices of the three groups, spiny dogfish, smooth dogfish and sharks, that make up this analysis.

Tables

Table 1

The balanced parameters of the Mid-Atlantic Bight Rpath model. The type column designates whether the functional group is a consumer (type = 0), producer (type = 1), detrital group (type = 2) or fleet (type = 3). The abbreviations used are: TL – trophic level, B – biomass, P/B – production/biomass, Q/B – consumption/biomass, EE – ecotrophic efficiency and GE – growth efficiency.

Group	type	TL	B	P/B	Q/B	EE	GE	Removals
Phytoplankton	1	1.00	20.05	195.45	0	0.50	Inf	0
Bacteria	0	2.00	7.16	91.25	380.21	0.86	0.24	0
AtlScallop	0	2.08	0.33	1.50	6.66	0.54	0.23	0
SmCopepods	0	2.26	5.55	52.17	127.75	0.80	0.41	0
Microzooplankton	0	2.33	4.72	72.00	242.42	0.85	0.30	0
Macrobenthos	0	2.36	91.84	7.20	16.84	0.25	0.43	0.02
LgCopepods	0	2.49	4.51	68.06	109.50	0.94	0.62	0
Megabenthos	0	2.50	1.74	4.60	15.53	0.84	0.30	0.01
OtherShrimps	0	2.75	0.28	4.80	11.66	0.94	0.41	0
Micronekton	0	2.91	3.50	14.25	141.89	0.98	0.10	0
AmLobster	0	3.03	0.08	2.30	15.53	0.81	0.15	0.02
SmPelagics	0	3.27	1.60	2.00	5.39	0.98	0.37	0.04
GelZooplankton	0	3.29	0.47	40.00	109.50	0.72	0.37	0
WinterFlounder	0	3.39	0.78	0.16	0.92	0.94	0.17	0.04
OceanPout	0	3.39	0.26	0.80	7.00	0.89	0.11	0.01
YTFlounder	0	3.39	0.13	1.83	3.23	0.70	0.57	0.10
Mesopelagics	0	3.40	0.45	2.20	3.70	0.62	0.59	0.07
SmFlatfishes	0	3.43	0.03	2.42	5.39	0.51	0.45	0.00
AtlCroaker	0	3.48	0.69	1.02	3.73	0.82	0.27	0.28
Scup	0	3.49	1.96	0.45	0.92	0.81	0.49	0.55
LittleSkate	0	3.57	1.51	0.30	0.83	0.97	0.36	0.00
SmoothDogfish	0	3.64	0.58	0.50	2.44	0.27	0.20	0.03
SouthernDemersals	0	3.65	0.40	1.96	3.73	0.72	0.53	0.06
OtherDemersals	0	3.70	1.66	1.19	1.74	0.96	0.68	0.10
BlackSeaBass	0	3.70	0.19	0.65	0.83	0.68	0.78	0.02
AmShad	0	3.76	0.03	1.17	6.57	0.67	0.18	0.00
WinterSkate	0	3.77	0.52	0.15	0.90	0.90	0.17	0.00
Loligo	0	3.78	1.80	5.72	19.00	0.45	0.30	0.04
Butterfish	0	3.80	2.11	1.64	4.23	0.87	0.39	0.08
Illex	0	3.81	0.28	5.72	19.00	0.92	0.30	0.03
OtherCephalopods	0	3.81	0.05	7.15	19.00	0.96	0.38	0.01
RedHake	0	3.84	0.40	0.65	0.96	0.94	0.68	0.01
OtherSkates	0	3.87	0.59	0.90	3.00	0.72	0.30	0.03

Group	type	TL	B	P/B	Q/B	EE	GE	Removals
AtlMackerel	0	3.89	0.41	0.55	3.26	0.91	0.17	0.03
Windowpane	0	3.91	0.55	0.15	0.92	0.90	0.16	0.01
Cod	0	4.03	0.42	0.70	2.24	0.85	0.31	0.24
SeaBirds	0	4.06	0.00	0.28	40.00	0.25	0.01	0
SpinyDogfish	0	4.07	2.19	0.20	2.32	0.67	0.09	0.09
BaleenWhales	0	4.11	0.16	0.06	4.31	0.11	0.01	0
Weakfish	0	4.13	0.21	1.02	3.73	0.48	0.27	0.02
SilverHake	0	4.15	0.71	0.40	3.06	0.94	0.13	0.05
OtherPelagics	0	4.33	0.40	1.76	6.57	0.94	0.27	0.07
SummerFlounder	0	4.39	0.98	1.30	2.50	0.27	0.52	0.25
Fourspot	0	4.46	0.28	0.45	0.92	0.98	0.49	0.00
Bluefish	0	4.51	0.49	1.36	4.27	0.29	0.32	0.07
Goosefish	0	4.59	0.47	0.40	2.44	0.59	0.16	0.02
Odontocetes	0	4.78	0.12	0.07	8.21	0.80	0.01	0
HMS	0	4.98	0.02	0.29	3.40	0.12	0.09	0.00
Sharks	0	4.99	0.10	0.14	0.88	0.34	0.16	0.00
Detritus	2	1.00	10344.47	0.50	0	0.72	0	0
Discards	2	1.00	0.09	0.50	0	0.61	0	0
Clam Dredge	3	3.92	0	0	0	0	0	0
Fixed Gear	3	4.94	0	0	0	0	0	0
HMS Fleet	3	1.00	0	0	0	0	0	0
LG Mesh	3	4.83	0	0	0	0	0	0
Other	3	3.46	0	0	0	0	0	0
Other Dredge	3	3.38	0	0	0	0	0	0
Pelagic	3	5.18	0	0	0	0	0	0
Recreational	3	4.77	0	0	0	0	0	0
Recreational	3	5.00	0	0	0	0	0	0
Scallop Dredge	3	3.08	0	0	0	0	0	0
SM Mesh	3	4.84	0	0	0	0	0	0
Trap	3	4.55	0	0	0	0	0	0

Table 2

Proportion of interaction type for the simultaneous range and phenological shift scenario by trophic group.

	Additive	Synergistic	Antagonistic
Lower trophic levels	88.9	0	11.1
Invertebrates	66.6	16.7	16.7
Fish	100	0	0
Predators	88.9	11.1	0

Table 3

Diet matrices for the shark functional groups in the model. The group column indicates the prey item and values represent the proportion of the diet the prey item accounts for.

Group	Sharks	SmoothDogfish	SpinyDogfish
AmLobster	0	0.00484	0.00017
AmShad	0.00205	0	0
AtlCroaker	0.01867	0	0
AtlMackerel	0.00240	0.00101	0.00383
AtlScallop	0	0	0
Bacteria	0	0	0
BaleenWhales	0.01212	0	0
BlackSeaBass	0.00269	0.00053	0.00284
Bluefish	0.14429	0	0
Butterfish	0.25011	0.00314	0.01517
Cod	0.00088	0	0
Fourspot	0.00499	0.00011	0.00618
GelZooplankton	0.00121	0.00107	0.06112
Goosefish	0.07666	0.00161	0.00510
HMS	0.00846	0	0
Illex	0.02483	0.00108	0.08515
LgCopepods	0	0	0
LittleSkate	0.04727	0.00038	0.00077
Loligo	0.15699	0.05061	0.07631
Macrobenthos	0.02424	0.11426	0.41783
Megabenthos	0	0.75186	0.04142
Mesopelagics	0.00085	0.00004	0.00014
Micronekton	0	0.00423	0.00635
Microzooplankton	0	0	0
OceanPout	0.00071	0.00022	0.00778
Odontocetes	0.02424	0	0.00071
OtherCephalopods	0.00001	0.01504	0.00256
OtherDemersals	0.00022	0.01873	0.07715
OtherPelagics	0.00117	0.00267	0.03964
OtherShrimps	0	0.00176	0.00342
OtherSkates	0.03065	0.00320	0.00446
Phytoplankton	0	0	0.00000
RedHake	0.01068	0.00005	0.00542
Scup	0.01054	0	0
SeaBirds	0.00234	0	0
Sharks	0.02424	0	0.00042
SilverHake	0.00750	0.00246	0.00259
SmCopepods	0	0	0

Group	Sharks	SmoothDogfish	SpinyDogfish
SmFlatfishes	0.00007	0.00095	0.00057
SmoothDogfish	0.01217	0	0
SmPelagics	0.00569	0.01472	0.10804
SouthernDemersals	0.00108	0.00315	0.01193
SpinyDogfish	0.05788	0.00109	0.00162
SummerFlounder	0.00208	0.00068	0.00515
Weakfish	0.00578	0	0
Windowpane	0.00185	0	0.00088
WinterFlounder	0.00264	0.00053	0.00216
WinterSkate	0.01637	0	0
YTFlounder	0.00338	0	0.00309
Detritus	0	0	0
Discards	0	0	0

Table 4

Species that were considered for a single-species functional group but were aggregated due to low presence in the Mid-Atlantic Bight in the NEFSC bottom trawl survey 1980 – 1985 survey years used for biomass estimates.

Group	Common Name	Scientific Name
SmPelagics	Atlantic herring	Clupea harengus
OtherDemersals	Haddock	Melanogrammus aeglefinus
OtherDemersals	Offshore hake	Merluccius albidus
OtherDemersals	Pollock	Pollachius pollachius
Megabenthos	RedCrab	Chaceon quinquedens
SouthernDemersals	Tilefish	Lopholatiulus chamaeleonticeps
SmPelagics	River herring	Alosa aestivalis/Alosa pseudoharengus
OtherDemersals	WitchFlounder	Glyptocephalus cynoglossus

Table 5

Ratio of balanced parameters to initial parameters. The abbreviations used are: B – biomass, P/B – production/biomass and Q/B – consumption/biomass.

Group	B	P/B	Q/B
AmLobster	1.00	1.00	1.00
AmShad	2.00	1.00	1.00
AtlCroaker	1.00	1.00	1.00
AtlMackerel	20.00	0.20	1.50
AtlScallop	4.00	1.00	1.00
Bacteria	1.00	1.00	1.00
BaleenWhales	1.00	1.00	1.00
BlackSeaBass	11.00	1.00	1.00
Bluefish	2.00	2.00	1.00
Butterfish	1.00	1.00	1.00
Cod	10.00	1.00	1.00
Fourspot	1.50	1.00	1.00
GelZooplankton	2.00	10.00	0.75
Goosefish	2.50	1.00	1.00
HMS	0.75	0.50	0.50
Illex	1.00	1.00	1.00
LgCopepods	1.00	1.00	1.00
LittleSkate	5.00	1.00	1.00
Loligo	1.00	1.00	1.00
Macrobenthos	1.00	1.00	1.00
Megabenthos	50.00	0.50	1.00
Mesopelagics	2.50	1.00	1.00
Micronekton	1.00	1.00	1.00
Microzooplankton	1.00	1.00	1.00
OceanPout	10.00	1.00	1.00
Odontocetes	2.00	1.00	0.50
OtherCephalopods	600.00	1.00	1.00
OtherDemersals	200.00	1.00	1.00
OtherPelagics	200.00	1.00	1.00
OtherShrimps	100.00	0.60	1.75
OtherSkates	3.00	1.00	1.00
Phytoplankton	1.00	1.00	NA
RedHake	1.00	0.50	0.25
Scup	5.00	1.00	1.00
SeaBirds	1.00	1.00	0.50
Sharks	1.50	1.00	1.00
SilverHake	2.00	0.50	1.00
SmCopepods	1.00	1.00	1.00

Group	B	P/B	Q/B
SmFlatfishes	10.00	1.00	1.00
SmoothDogfish	1.00	0.25	1.00
SmPelagics	8.00	0.50	1.00
SouthernDemersals	10.00	1.00	1.00
SpinyDogfish	0.80	1.00	1.00
SummerFlounder	10.00	1.00	0.75
Weakfish	1.00	1.00	1.00
Windowpane	8.00	0.60	1.00
WinterFlounder	8.00	0.60	1.00
WinterSkate	5.00	0.60	1.00
YTFlounder	1.00	1.00	1.00

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Appendix A

Table A.1

List of species included in the Mid-Atlantic Bight Rpath model.

Group	Common Name	Scientific Name
AmLobster	American lobster	Homarus americanus
AmShad	American shad	Alosa sapidissima
AtlCroaker	Atlantic croaker	Micropogonias undulatus
AtlMackerel	Atlantic mackerel	Scomber scombrus
AtlScallop	Sea scallop	Placopecten magellanicus
BlackSeaBass	Black sea bass	Centropristis striata
Bluefish	Bluefish	Pomatomus saltatrix
Butterfish	Butterfish	Peprilus triacanthus
Cod	Atlantic cod	Gadus morhua
Fourspot	Fourspot flounder	Paralichthys oblongus
Goosefish	Goosefish	Lophius americanus
HMS	Albacore	Thunnus alalunga
HMS	Atlantic bonito	Sarda sarda
HMS	Bigeye tuna	Thunnus obesus
HMS	Black marlin	Makaira indica
HMS	Blackfin tuna	Thunnus atlanticus
HMS	Blue marlin	Makaira nigricans
HMS	Bluefin tuna	Thunnus thynnus
HMS	Longbill spearfish	Tetrapturus pfluegeri
HMS	Marlin unc	Istiophoridae
HMS	Sailfish	Istiophorus platypterus
HMS	Shortbill spearfish	Tetrapturus angustirostris
HMS	Skipjack tuna	Katsuwonus pelamis
HMS	Striped marlin	Tetrapturus audax
HMS	Swordfish	Xiphias gladius
HMS	Tuna unc	Thunnus
HMS	Wahoo	Acanthocybium solandri
HMS	White marlin	Tetrapturus albidus
HMS	Yellowfin tuna	Thunnus albacares
Illex	Northern shortfin squid	Illex illecebrosus
LittleSkate	Little skate	Leucoraja erinacea
Loligo	Longfin squid	Loligo pealeii
Macrobenthos	Astropecten	Astropecten
Macrobenthos	Atlantic seasnail	Liparis atlanticus
Macrobenthos	Bloodworms	Glycera dibranchiata
Macrobenthos	Boreal asterias	Asterias vulgaris
Macrobenthos	Calocaris templemani	Calocaris templemani
Macrobenthos	Channeled whelk	Busycotypus canaliculatus

Group	Common Name	Scientific Name
Macrobenthos	Clam blood arc	Anadara ovalis
Macrobenthos	Clam razor atlantic	Ensis directus
Macrobenthos	Clam soft	Mya arenaria
Macrobenthos	Clam stout tagelus (bamboo)	Tagelus plebeius
Macrobenthos	Clams hard	Mercenaria
Macrobenthos	Corals soft nk	Alcyonacea
Macrobenthos	Crab hermit	Pagurus
Macrobenthos	Crab japanese shore	Hemigrapsus
Macrobenthos	False quahog	Pitar morrhuanus
Macrobenthos	Galatheid uncl	Galatheidae
Macrobenthos	Hermit crab uncl	Paguroidea
Macrobenthos	Jellyfish unc	Scyphozoa
Macrobenthos	Knobbed whelk	Busycon carica
Macrobenthos	Mollusks unc	Mollusca
Macrobenthos	Moon snail shark eye and baby-ear	Naticidae
Macrobenthos	Nassarius	Nassarius
Macrobenthos	Northern moonsnail	Euspira heros
Macrobenthos	Northern quahog	Mercenaria mercenaria
Macrobenthos	Oyster eastern	Crassostrea virginica
Macrobenthos	Oyster european flat	Ostrea edulis
Macrobenthos	Periwinkles atlantic (cockles)	Littorinidae
Macrobenthos	Sand dollar uncl	Clypeasteroida
Macrobenthos	Sea cucumber	Holothuroidea
Macrobenthos	Sea star - brittle star - and baskets	Stelleroidea
Macrobenthos	Sea urchin and sand dollar uncl	Echinoidea
Macrobenthos	Sea urchins	Strongylocentrotus
Macrobenthos	Shark eye	Neverita duplicata
Macrobenthos	Snail slipper limpet	Crepidula fornicata
Macrobenthos	Snails(conchs)	Strombidae
Macrobenthos	Spider crab uncl	Majidae
Macrobenthos	Starfish	Asteroidea
Macrobenthos	Stimpson s whelk	Colus stimpsoni
Macrobenthos	Ten-ridged whelk	Neptunea decemcostata
Macrobenthos	Waved whelk	Buccinum undatum
Macrobenthos	Whelk lightning	Busycon sinistrum
Macrobenthos	Whelk true unc	Buccinidae
Megabenthos	Arctic surfclam	Mactromeris polynyma
Megabenthos	Arctic surfclam clapper	Mactromeris polynyma clapper
Megabenthos	Atlantic calico scallop	Argopecten gibbus
Megabenthos	Atlantic rock crab	Cancer irroratus
Megabenthos	Atlantic surfclam clapper	Spisula solidissima clapper
Megabenthos	Bathyal swimming crab	Bathynectes longispina

Group	Common Name	Scientific Name
Megabenthos	Bay scallop	Argopecten irradians
Megabenthos	Blotched swimming crab	Portunus spinimanus
Megabenthos	Blue crab	Callinectes sapidus
Megabenthos	Blue mussel	Mytilus edulis
Megabenthos	Box crab uncl	Calappidae
Megabenthos	Calico box crab	Hepatus epheliticus
Megabenthos	Calico crab uncl	Ovalipes
Megabenthos	Cancer crab uncl	Cancridae
Megabenthos	Caribbean spiny lobster	Panulirus argus
Megabenthos	Coarsehand lady crab	Ovalipes stephensoni
Megabenthos	Crab red deepsea	Chaceon quinquedens
Megabenthos	Crab unc	Brachyura
Megabenthos	Duck-bill shell uncl	Thracia
Megabenthos	Flame box crab	Calappa flammea
Megabenthos	Gladiator box crab	Acanthocarpus alexandri
Megabenthos	Golden deepsea crab	Geryon fenneri
Megabenthos	Green crab	Carcinus maenas
Megabenthos	Greenland cockle	Serripes groenlandicus
Megabenthos	Horseshoe crab	Limulus polyphemus
Megabenthos	Iceland scallop	Chlamys islandica
Megabenthos	Iceland scallop clapper	Chlamys islandica clapper
Megabenthos	Jonah crab	Cancer borealis
Megabenthos	Lady crab	Ovalipes ocellatus
Megabenthos	Northern cyclocardia	Cyclocardia borealis
Megabenthos	Northern horsemussel	Modiolus modiolus
Megabenthos	Northern propeller clam	Cyrtodaria siliqua
Megabenthos	Northern quahog clapper	Mercenaria mercenaria clapper
Megabenthos	Northern stone crab	Lithodes maja
Megabenthos	Ocean quahog clapper	Arctica islandica clapper
Megabenthos	Razor and jackknife clam uncl	Solenidae
Megabenthos	Ridged slipper lobster	Scyllarides nodifer
Megabenthos	Scallop unc	Pectinidae
Megabenthos	Sea scallop clapper	Placopecten magellanicus clapper
Megabenthos	Smooth astarte	Astarte castanea
Megabenthos	Snow crab	Chionoecetes opilio
Megabenthos	Southern quahog	Mercenaria campechiensis
Megabenthos	Southern quahog clapper	Mercenaria campechiensis clapper
Megabenthos	Spanish slipper lobster	Scyllarides aequinoctialis
Megabenthos	Speckled swimming crab	Arenaeus cribrarius
Megabenthos	Swimming crab uncl	Portunidae
Megabenthos	White crab	Geryon affinis
Megabenthos	Yellow box crab	Calappa sulcata

Group	Common Name	Scientific Name
Mesopelagics	Atlantic cutlassfish	Trichiurus lepturus
Mesopelagics	Atlantic soft pout	Melanostigma atlanticum
Mesopelagics	Atlantic thornyhead	Trachyscorpia cristulata
Mesopelagics	Black gemfish	Nesiarchus nasutus
Mesopelagics	Blackmouth bass	Synagrops bellus
Mesopelagics	Blackmouthed alfonsin	Hoplostethus mediterraneus
Mesopelagics	Bluntnose smoothhead	Xenodermichthys copei
Mesopelagics	Boa dragonfish	Stomias boa
Mesopelagics	Bridle cardinalfish	Apogon aurolineatus
Mesopelagics	Brown driftfish	Ariomma melanum
Mesopelagics	Careproctus ranula	Careproctus ranula
Mesopelagics	Chauliodus danae	Chauliodus danae
Mesopelagics	Chlorophthalmus	Chlorophthalmus
Mesopelagics	Epigonus pandionis	Epigonus pandionis
Mesopelagics	Escolar	Lepidocybium flavobrunneum
Mesopelagics	Glacier lanternfish	Benthosema glaciale
Mesopelagics	Gonichthys coccoi	Gonichthys coccoi
Mesopelagics	Gonostoma atlanticum	Gonostoma atlanticum
Mesopelagics	Gonostoma bathyphilum	Gonostoma bathyphilum
Mesopelagics	Greeneye uncl	Chlorophthalmidae
Mesopelagics	Grenadier uncl	Macrouridae
Mesopelagics	Hatchetfish uncl	Sternoptychidae
Mesopelagics	Headlightfish	Diaphus dumerili
Mesopelagics	Headlightfish uncl	Diaphus
Mesopelagics	Horned lanternfish	Ceratoscopelus maderensis
Mesopelagics	Houndfish	Tylosurus crocodilus
Mesopelagics	Hygophum taaningi	Hygophum taaningi
Mesopelagics	Jambeau	Parahollardia lineata
Mesopelagics	Keelcheek bass	Synagrops spinosus
Mesopelagics	Lanternfish uncl	Myctophidae
Mesopelagics	Lightfish uncl	Gonostomatidae
Mesopelagics	Longnose greeneye	Parasudis truculenta
Mesopelagics	Longnose grenadier	Caelorinchus caelorhincus carminatus
Mesopelagics	Longspine snipefish	Macrorhamphosus scolopax
Mesopelagics	Longtooth anglemouth	Gonostoma elongatum
Mesopelagics	Lumpfish snailfish uncl	Cyclopteridae
Mesopelagics	Madeira lanternfish	Lampanyctus
Mesopelagics	Marlin-spike	Nezumia bairdii
Mesopelagics	Paralepis coregonoides	Paralepis coregonoides
Mesopelagics	Patchwork lampfish	Notoscopelus resplendens
Mesopelagics	Polka-dot batfish	Ogcocephalus radiatus
Mesopelagics	Polymetme thaeocoryla	Polymetme thaeocoryla

Group	Common Name	Scientific Name
Mesopelagics	Ribbonfishes	Trachipteridae
Mesopelagics	Roughhead grenadier	Macrourus berglax
Mesopelagics	Scaly dragonfish uncl	Stomiidae
Mesopelagics	Sherborn s cardinalfish	Howella sherborni
Mesopelagics	Shortnose greeneye	Chlorophthalmus agassizi
Mesopelagics	Silver hatchetfish	Argyropelecus aculeatus
Mesopelagics	Silver rag	Ariomma bondi
Mesopelagics	Simonys frostfish	Benthodesmus simonyi
Mesopelagics	Slender lightfish	Vinciguerria attenuata
Mesopelagics	Slickheads	Alepocephalidae
Mesopelagics	Slope hatchetfish	Polyipnus clarus
Mesopelagics	Snake mackerel	Gempylus serpens
Mesopelagics	Snake mackerel uncl	Trichiuridae
Mesopelagics	Spotted driftfish	Ariomma regulus
Mesopelagics	Spotted lanternfish	Myctophum punctatum
Mesopelagics	Straightmouth tonguefishes	Symphurus
Mesopelagics	Vinciguerria	Vinciguerria
Mesopelagics	Viperfish	Chauliodus sloani
Mesopelagics	Weitzmans pearlsides	Maurolicus weitzmani
Mesopelagics	Western softhead grenadier	Malacocephalus occidentalis
Mesopelagics	White barracudina	Arctozenus risso
Mesopelagics	Yarella blackfordi	Yarella blackfordi
OceanPout	Ocean pout	Zoarces americanus
OtherCephalopods	Arrow squid	Loligo plei
OtherCephalopods	Atlantic brief squid	Lolliguncula brevis
OtherCephalopods	Bobtail uncl	Sepiolidae
OtherCephalopods	Common octopus	Octopus vulgaris
OtherCephalopods	Lesser shining bobtail	Semirossia tenera
OtherCephalopods	Longfin squid egg mops	Loligo pealeii egg mops
OtherCephalopods	Northern shortfin squid egg mops	Illex illecebrosus egg mops
OtherCephalopods	Octopus	Octopodidae
OtherCephalopods	Octopus uncl	Octopoda
OtherCephalopods	Owen s bobtail	Rossia palpebrosa
OtherCephalopods	Ruppell s abralia	Abralia veranyi
OtherCephalopods	Shield bobtail	Stoloteuthis leucoptera
OtherCephalopods	Spoonarm octopus	Bathypolypus arcticus
OtherCephalopods	Squid cuttlefish and octopod uncl	Cephalopoda
OtherCephalopods	Squids	Teuthida
OtherCephalopods	Squids loliginidae	Loliginidae
OtherCephalopods	Unicorn octopus	Scaeurgus unicirrhus
OtherCephalopods	Verrill s bobtail	Rossia megaptera
OtherDemersals	Academy eel	Apterichtus ansp

Group	Common Name	Scientific Name
OtherDemersals	Alligatorfish	Aspidophoroides monopterygius
OtherDemersals	American eel	Anguilla rostrata
OtherDemersals	American sand lance	Ammodytes americanus
OtherDemersals	Arctic eelpout	Lycodes reticulatus
OtherDemersals	Armored searobin	Peristedion miniatum
OtherDemersals	Atlantic batfish	Dibranchus atlanticus
OtherDemersals	Atlantic guitarfish	Rhinobatos lentiginosus
OtherDemersals	Atlantic hagfish	Myxine glutinosa
OtherDemersals	Atlantic midshipman	Porichthys plectrodon
OtherDemersals	Atlantic spiny lumpsucker	Eumicrotremus spinosus
OtherDemersals	Atlantic tomcod	Microgadus tomcod
OtherDemersals	Atlantic wolffish	Anarhichas lupus
OtherDemersals	Bank cusk-eel	Ophidion holbrooki
OtherDemersals	Barrelfish	Hyperoglyphe perciformis
OtherDemersals	Batfish uncl	Ogcocephalidae
OtherDemersals	Bearded brotula	Brotula barbata
OtherDemersals	Beardfish	Polymixia lowei
OtherDemersals	Beardless codling	Gadella imberbis
OtherDemersals	Blackbelly rosefish	Helicolenus dactylopterus
OtherDemersals	Blotched cusk-eel	Ophidion grayi
OtherDemersals	Blue hake	Antimora rostrata
OtherDemersals	Broadband dogfish	Etmopterus gracilispinis
OtherDemersals	Chain pipefish	Syngnathus louisianae
OtherDemersals	Cobia	Rachycentron canadum
OtherDemersals	Codlings	Urophycis
OtherDemersals	Conger eel	Conger oceanicus
OtherDemersals	Conger eel uncl	Congridae
OtherDemersals	Crested cusk-eel	Ophidion welshi
OtherDemersals	Crustaceans unc	Crustacea
OtherDemersals	Cunner	Tautogolabrus adspersus
OtherDemersals	Cusk	Brosme brosme
OtherDemersals	Cusk-eel uncl	Ophidiidae
OtherDemersals	Daubed shanny	Lumpenus maculatus
OtherDemersals	Deepbody boarfish	Antigonia capros
OtherDemersals	Dogfish unc	Squalidae
OtherDemersals	Dory nk	Zeiformes
OtherDemersals	Dusky pipefish	Syngnathus floridae
OtherDemersals	Eel cutthroat	Synaphobranchinae
OtherDemersals	Eel uncl	Anguilliformes
OtherDemersals	Eelpout uncl	Zoarcidae
OtherDemersals	Fawn cusk-eel	Lepophidium profundorum
OtherDemersals	Finless eel	Apterichtus kendalli

Group	Common Name	Scientific Name
OtherDemersals	Fish other-industrial	Osteichthyes
OtherDemersals	Gray triggerfish	Balistes capriscus
OtherDemersals	Greenland halibut	Reinhardtius hippoglossoides
OtherDemersals	Grubby	Myoxocephalus aenaeus
OtherDemersals	Hagfish	Myxinidae
OtherDemersals	Hake longfin	Phycis chesteri
OtherDemersals	Hake uncl	Gadidae
OtherDemersals	Hakes	Merluccius
OtherDemersals	Halfbeaks	Hemiramphidae
OtherDemersals	Hookear sculpins	Artediellus
OtherDemersals	Hoplostethus occidentalis	Hoplostethus occidentalis
OtherDemersals	Inquiline snailfish	Liparis inquilinus
OtherDemersals	John dory	Zenopsis ocellata
OtherDemersals	Lancetfishes unc	Alepisauridae
OtherDemersals	Largescale lizardfish	Saurida brasiliensis
OtherDemersals	Launces	Ammodytes
OtherDemersals	Leopard toadfish	Opsanus pardus
OtherDemersals	Lined seahorse	Hippocampus erectus
OtherDemersals	Lizardfish uncl	Synodontidae
OtherDemersals	Longfin hake	Urophycis chesteri
OtherDemersals	Longhorn sculpin	Myoxocephalus octodecemspinosus
OtherDemersals	Longnose batfish	Ogcocephalus corniger
OtherDemersals	Longnose lancetfish	Alepisaurus ferox
OtherDemersals	Longsnout seahorse	Hippocampus reidi
OtherDemersals	Longspine scorpionfish	Pontinus longispinis
OtherDemersals	Lumpfish	Cyclopterus lumpus
OtherDemersals	Margined snake eel	Ophichthus cruentifer
OtherDemersals	Marlinsucker	Remora osteochir
OtherDemersals	Metallic codling	Physiculus fulvus
OtherDemersals	Mora uncl	Moridae
OtherDemersals	Mottled cusk-eel	Lepophidium jeannae
OtherDemersals	Moustache sculpin	Triglops murrayi
OtherDemersals	Mummichog	Fundulus heteroclitus
OtherDemersals	Northern putter	Sphoeroides maculatus
OtherDemersals	Northern sand lance	Ammodytes dubius
OtherDemersals	Northern searobin	Prionotus carolinus
OtherDemersals	Northern stargazer	Astroscopus guttatus
OtherDemersals	Ocellated frogfish	Antennarius ocellatus
OtherDemersals	Ottshore lizardfish	Synodus poeyi
OtherDemersals	Oyster toadfish	Opsanus tau
OtherDemersals	Palespotted eel	Ophichthus puncticeps
OtherDemersals	Pancake batfish	Halieutichthys aculeatus

Group	Common Name	Scientific Name
OtherDemersals	Pearlfish	Carapus bermudensis
OtherDemersals	Pipefish seahorse uncl	Syngnathidae
OtherDemersals	Planehead filefish	Monacanthus hispidus
OtherDemersals	Polka-dot cusk-eel	Otophidium omostigmum
OtherDemersals	Putters (sea chicken)	Sphoeroides
OtherDemersals	Radiated shanny	Ulvaria subbifurcata
OtherDemersals	Red goatfish	Mullus auratus
OtherDemersals	Red lizardfish	Synodus synodus
OtherDemersals	Redfish golden	Sebastes norvegicus
OtherDemersals	Remora	Remora remora
OtherDemersals	Rock gunnel	Pholis gunnellus
OtherDemersals	Roughback batfish	Ogcocephalus parvus
OtherDemersals	Sailfin eel	Letharchus velifer
OtherDemersals	Sand diver	Synodus intermedius
OtherDemersals	Sargassumfish	Histrio histrio
OtherDemersals	Sculpin uncl	Cottidae
OtherDemersals	Sea bass nk	Centropristis
OtherDemersals	Sea raven	Hemitripterus americanus
OtherDemersals	Searobin uncl	Triglidae
OtherDemersals	Searobins north american	Prionotuw
OtherDemersals	Sharksucker	Echeneis naucrates
OtherDemersals	Sheepshead minnow	Cyprinodon variegatus
OtherDemersals	Shorthorn sculpin	Myoxocephalus scorpius
OtherDemersals	Shortjaw lizardfish	Saurida normani
OtherDemersals	Shortnose batfish	Ogcocephalus nasutus
OtherDemersals	Shorttail snake eel	Callechelys guiniensis
OtherDemersals	Shrimp eel	Ophichthus gomesi
OtherDemersals	Silversides	Atherinopsidae
OtherDemersals	Singlespot frogfish	Antennarius radiosus
OtherDemersals	Slender snipe eel	Nemichthys scolopaceus
OtherDemersals	Smooth putter	Lagocephalus laevigatus
OtherDemersals	Snake eel uncl	Ophichthidae
OtherDemersals	Snakeblenny	Lumpenus lumpretaeformis
OtherDemersals	Snakefish	Trachinocephalus myops
OtherDemersals	Snubnose eel	Simenchelys parasitica
OtherDemersals	Spearfish remora	Remora brachyptera
OtherDemersals	Speckled worm eel	Myrophis punctatus
OtherDemersals	Spoon-nose eel uncl	Echiophis
OtherDemersals	Spotted hake	Urophycis regia
OtherDemersals	Spotted spoon-nose eel	Echiophis intertinctus
OtherDemersals	Stout beardfish	Polymixia nobilis
OtherDemersals	Striated frogfish	Antennarius striatus

Group	Common Name	Scientific Name
OtherDemersals	Striped burrfish	Chilomycterus schoepfi
OtherDemersals	Striped cusk-eel	Ophidion marginatum
OtherDemersals	Striped killifish	Fundulus majalis
OtherDemersals	Striped searobin	Prionotus evolans
OtherDemersals	Tautog	Tautoga onitis
OtherDemersals	Threebeard rockling	Gaidropsarus ensis
OtherDemersals	Threespine stickleback	Gasterosteus aculeatus
OtherDemersals	Tidewater silverside	Menidia beryllina
OtherDemersals	Toadfishes	Batrachoididae
OtherDemersals	Walleye	Sander vitreus
OtherDemersals	Whitenose pipefish	Cosmocampus albirostris
OtherDemersals	Wolf eelpout	Lycenchelys verrilli
OtherDemersals	Wolffish northern	Anarhichas denticulatus
OtherDemersals	Wolffish spotted	Anarhichas minor
OtherDemersals	Wrymouth	Cryptacanthodes maculatus
OtherPelagics	Alewife	Alosa pseudoharengus
OtherPelagics	Amberjack	Seriola
OtherPelagics	Atlantic bumper	Chloroscombrus chrysurus
OtherPelagics	Atlantic flyingfish	Cypselurus melanurus
OtherPelagics	Atlantic needlefish	Strongylura marina
OtherPelagics	Atlantic salmon	Salmo salar
OtherPelagics	Atlantic saury	Scomberesox saurus
OtherPelagics	Atlantic thread herring	Opisthonema oglinum
OtherPelagics	Ballyhoo	Hemiramphus brasiliensis
OtherPelagics	Bar jack	Caranx ruber
OtherPelagics	Barracuda	Sphyraenidae
OtherPelagics	Barracudas	Sphyraena
OtherPelagics	Barracudinas	Paralepididae
OtherPelagics	Big roughy	Gephyroberyx darwini
OtherPelagics	Bigeye cigarfish	Cubiceps pauciradiatus
OtherPelagics	Bigscale pomfret	Taractichthys longipinnis
OtherPelagics	Blue runner	Caranx crysos
OtherPelagics	Blueback herring	Alosa aestivalis
OtherPelagics	Bluespotted cornetfish	Fistularia tabacaria
OtherPelagics	Bluntnose flyingfish	Prognichthys gibbifrons
OtherPelagics	Bluntnose jack	Hemicaranx amblyrhynchus
OtherPelagics	Bullet mackerel	Auxis rochei
OtherPelagics	Butterfish gulf	Peprilus burti
OtherPelagics	Butterfish uncl	Stromateidae
OtherPelagics	Capelin	Mallotus villosus
OtherPelagics	Cardinalfish uncl	Apogonidae
OtherPelagics	Cero	Scomberomorus regalis

Group	Common Name	Scientific Name
OtherPelagics	Chub mackerel	Scomber japonicus
OtherPelagics	Conejo	Promethichthys prometheus
OtherPelagics	Cottonmouth jack	Uraspis secunda
OtherPelagics	Crevalle jack	Caranx hippos
OtherPelagics	Dolphin	Coryphaena hippurus
OtherPelagics	Dolphinfish	Coryphaena
OtherPelagics	Dwarf herring	Jenkinsia lamprotaenia
OtherPelagics	Flat needlefish	Ablennes hians
OtherPelagics	Florida pompano	Trachinotus carolinus
OtherPelagics	Flying gurnard	Dactylopterus volitans
OtherPelagics	Flying halfbeak	Euleptorhamphus velox
OtherPelagics	Fourwing flyingfish	Hirundichthys affinis
OtherPelagics	Frigate mackerel	Auxis thazard
OtherPelagics	Gizzard shad	Dorosoma cepedianum
OtherPelagics	Great barracuda	Sphyraena barracuda
OtherPelagics	Greater amberjack	Seriola dumerili
OtherPelagics	Harvestfish	Peprilus alepidotus
OtherPelagics	Harvestfishes	Peprilus
OtherPelagics	Herring river	Alosa
OtherPelagics	Herring uncl	Clupeidae
OtherPelagics	Hickory shad	Alosa mediocris
OtherPelagics	Horse-eye jack	Caranx latus
OtherPelagics	Jack bar	Carangoides ruber
OtherPelagics	Jack pompano uncl	Carangidae
OtherPelagics	King mackerel	Scomberomorus cavalla
OtherPelagics	Ladyfish	Elops saurus
OtherPelagics	Leatherjack	Oligoplites saurus
OtherPelagics	Lesser amberjack	Seriola fasciata
OtherPelagics	Little tunny	Euthynnus alletteratus
OtherPelagics	Mackerel and tuna uncl	Scombridae
OtherPelagics	Mackerel chub	Scomber colias
OtherPelagics	Margined flyingfish	Cypselurus cyanopterus
OtherPelagics	Menhaden	Brevoortia
OtherPelagics	Northern sennet	Sphyraena borealis
OtherPelagics	Ocean sunfish	Mola mola
OtherPelagics	Oceanic two-wing flyingfish	Exocoetus obtusirostris
OtherPelagics	Palometa	Trachinotus goodei
OtherPelagics	Pompano dolphin	Coryphaena equiselis
OtherPelagics	Rainbow runner	Elagatis bipinnulata
OtherPelagics	Salmon coho aquaculture	Oncorhynchus kisutch
OtherPelagics	Salmon king aquaculture	Oncorhynchus tshawytscha
OtherPelagics	Salmon pacific pink	Oncorhynchus gorbuscha

Group	Common Name	Scientific Name
OtherPelagics	Salmon unclassified	Oncorhynchus
OtherPelagics	Silverstripe halfbeak	Hyporhamphus unifasciatus
OtherPelagics	Spanish mackerel	Scomberomorus maculatus
OtherPelagics	Spotfin flyingfish	Cypselurus furcatus
OtherPelagics	Striped bass	Morone saxatilis
OtherPelagics	Striped bonito	Sarda orientalis
OtherPelagics	Tarpon	Megalops atlanticus
OtherPelagics	Trumpetfish	Aulostomus maculatus
OtherPelagics	Yellow jack	Caranx bartholomaei
OtherShrimp	Mantis shrimp uncl	Stomatopoda
OtherShrimp	Mantis shrimps	Stomatopoda
OtherShrimp	Shrimp atlantic & gulf brown	Panaeidae
OtherShrimp	Shrimp crangon	Crangonidae
OtherShrimp	Shrimp northern brown	Farfantepenaeus aztecus
OtherShrimp	Shrimp rock	Sicyonia
OtherShrimp	Shrimp scarlet	Aristaeopsis edwardsiana
OtherShrimp	Shrimp unc (caridea)	Caridea
OtherShrimps	Aesop shrimp	Pandalus montagui
OtherShrimps	Arctic eualid	Eualus fabricii
OtherShrimps	Bristled longbeak	Dichelopandalus leptocerus
OtherShrimps	Brown rock shrimp	Sicyonia brevirostris
OtherShrimps	Brown shrimp	Penaeus aztecus
OtherShrimps	Friendly blade shrimp	Spirontocaris liljeborgii
OtherShrimps	Northern shrimp	Pandalus borealis
OtherShrimps	Norwegian shrimp	Pontophilus norvegicus
OtherShrimps	Pandalus propinquus	Pandalus propinquus
OtherShrimps	Parrot shrimp	Spirontocaris spinus
OtherShrimps	Pink glass shrimp	Pasiphaea multidentata
OtherShrimps	Pink shrimp	Penaeus duorarum
OtherShrimps	Polar lebbeid	Lebbeus polaris
OtherShrimps	Punctate blade shrimp	Spirontocaris phippsii
OtherShrimps	Royal red shrimp	Pleoticus robustus
OtherShrimps	Scarlet gamba shrimp	Plesiopenaeus edwardsianus
OtherShrimps	Sevenspine bay shrimp	Crangon septemspinosa
OtherShrimps	Shrimp (pink -brown - white)	Penaeus
OtherShrimps	Shrimp uncl	Crustacea shrimp
OtherShrimps	Spiny lebbeid	Lebbeus groenlandicus
OtherShrimps	White shrimp	Penaeus setiferus
OtherSkates	Clearnose skate	Raja eglanteria
OtherSkates	Longtail skate	Breviraja plutonia
OtherSkates	Ocellate skate	Raja ackleyi
OtherSkates	Ocellate skates	Raja

Group	Common Name	Scientific Name
OtherSkates	Rosette skate	Leucoraja garmani
OtherSkates	Roundel skate	Raja texana
OtherSkates	Skate shorttail	Amblyraja jenseni
OtherSkates	Skates	Rajidae
OtherSkates	Skates little/winter mixed	Leucoraja
OtherSkates	Smooth skate	Malacoraja senta
OtherSkates	Spinytail skate	Bathyraja spinicauda
OtherSkates	Spreadfin skate	Dipturus olseni
OtherSkates	Thorny skate	Amblyraja radiata
RedHake	Red hake	Urophycis chuss
Scup	Scup	Stenotomus chrysops
Sharks	Atlantic angel shark	Squatina dumeril
Sharks	Atlantic sharpnose shark	Rhizoprionodon terraenovae
Sharks	Basking shark	Cetorhinus maximus
Sharks	Bigeye thresher shark	Alopias superciliosus
Sharks	Bignose shark	Carcharhinus altimus
Sharks	Black dogfish	Centroscyllium fabricii
Sharks	Blacknose shark	Carcharhinus acronotus
Sharks	Blacktip shark	Carcharhinus limbatus
Sharks	Blue shark	Prionace glauca
Sharks	Bonnethead shark	Sphyrna tiburo
Sharks	Bull shark	Carcharhinus leucas
Sharks	Caribbean lanternshark	Etmopterus hillianus
Sharks	Chain dogfish	Scyliorhinus retifer
Sharks	Dusky shark	Carcharhinus obscurus
Sharks	Finetooth shark	Carcharhinus isodon
Sharks	Florida smoothhound	Mustelus norrisi
Sharks	Great hammerhead shark	Sphyrna mokarran
Sharks	Lemon shark	Negaprion brevirostris
Sharks	Leopard shark	Triakis semifasciata
Sharks	Longfin mako	Isurus paucus
Sharks	Night shark	Carcharhinus signatus
Sharks	Nurse shark	Ginglymostoma cirratum
Sharks	Oceanic whitetip shark	Carcharhinus longimanus
Sharks	Porbeagle shark	Lamna nasus
Sharks	Portuguese shark	Centroscymnus coelolepis
Sharks	Reef shark	Carcharhinus perezii
Sharks	Requiem shark uncl	Carcharhinidae
Sharks	Rough sagre	Etmopterus princeps
Sharks	Sand tiger	Carcharias taurus
Sharks	Sandbar shark	Carcharhinus plumbeus
Sharks	Scalloped hammerhead shark	Sphyrna lewini

Group	Common Name	Scientific Name
Sharks	Scoophead shark	Sphyrna media
Sharks	Shark carcharhin nk	Carcharhinus
Sharks	Shark caribbean sharpnose	Rhizoprionodon porosus
Sharks	Shark greenland	Somniosus microcephalus
Sharks	Shark hammerhead	Sphyrnidae
Sharks	Shark mako unc	Isurus
Sharks	Shark pelagic nk	Laminiformes
Sharks	Shark small coastal species	Chondirchthyes
Sharks	Shark thresher unc	Alopias
Sharks	Shark unc	Chondrichthyes
Sharks	Shark uncl	Selachimorpha
Sharks	Shortfin mako	Isurus oxyrinchus
Sharks	Silky shark	Carcharhinus falciformis
Sharks	Smalleye hammerhead shark	Sphyrna tudes
Sharks	Smalltail shark	Carcharhinus porosus
Sharks	Smooth hammerhead shark	Sphyrna zygaena
Sharks	Spinner shark	Carcharhinus brevipinna
Sharks	Thresher shark	Alopias vulpinus
Sharks	Tiger shark	Galeocerdo cuvier
Sharks	White shark	Carcharodon carcharias
SilverHake	Silver hake	Merluccius bilinearis
SmallPelagics	Herring smelt	Argentinidae
SmallPelagics	Rainbow smelt	Osmerus mordax
SmallPelagics	Smelts	Osmeridae
SmFlatfishes	Blackcheek tonguefish	Symphurus plagiusa
SmFlatfishes	Gulf stream flounder	Citharichthys arctifrons
SmFlatfishes	Hogchoker	Trinectes maculatus
SmFlatfishes	Largescale tonguefish	Symphurus minor
SmFlatfishes	Naked sole	Gymnachirus melas
SmFlatfishes	Northern tonguefish	Symphurus pusillus
SmFlatfishes	Ottshore tonguefish	Symphurus civitatus
SmFlatfishes	Slender tonguefish	Symphurus marginatus
SmFlatfishes	Smallmouth flounder	Etropus microstomus
SmFlatfishes	Spottail tonguefish	Symphurus urospilus
SmFlatfishes	Spottedfin tonguefish	Symphurus diomedianus
SmoothDogfish	Smooth dogfish	Mustelus canis
SmPelagics	Anchovy uncl	Engraulidae
SmPelagics	Atlantic argentine	Argentina silus
SmPelagics	Atlantic moonfish	Selene setapinnis
SmPelagics	Atlantic silverside	Menidia menidia
SmPelagics	Bay anchovy	Anchoa mitchilli
SmPelagics	Bigeye scad	Selar crumenophthalmus

Group	Common Name	Scientific Name
SmPelagics	Cuban anchovy	Anchoa cubana
SmPelagics	Dusky anchovy	Anchoa lyolepis
SmPelagics	Flat anchovy	Anchoviella perfasciata
SmPelagics	Mackerel scad	Decapterus macarellus
SmPelagics	Rough scad	Trachurus lathami
SmPelagics	Rough silverside	Membras martinica
SmPelagics	Round herring	Etrumeus teres
SmPelagics	Round scad	Decapterus punctatus
SmPelagics	Scaled sardine	Harengula jaguana
SmPelagics	Silver anchovy	Engraulis eurystole
SmPelagics	Silverside uncl	Atherinidae
SmPelagics	Spanish sardine	Sardinella aurita
SmPelagics	Striated argentine	Argentina striata
SmPelagics	Striped anchovy	Anchoa hepsetus
SouthernDemersals	Anchor tilefish	Caulolatilus intermedius
SouthernDemersals	Atlantic pomfret	Brama brama
SouthernDemersals	Atlantic spadefish	Chaetodipterus faber
SouthernDemersals	Balloonfish	Diodon holocanthus
SouthernDemersals	Banded butterflyfish	Chaetodon striatus
SouthernDemersals	Banded drum	Larimus fasciatus
SouthernDemersals	Bandtail putter	Sphoeroides spengleri
SouthernDemersals	Bandtail searobin	Prionotus ophryas
SouthernDemersals	Bandtooth conger	Ariosoma balearicum
SouthernDemersals	Bank butterflyfish	Chaetodon aya
SouthernDemersals	Bank sea bass	Centropristis ocyurus
SouthernDemersals	Barbfish	Scorpaena brasiliensis
SouthernDemersals	Basslet uncl	Grammatidae
SouthernDemersals	Beaugregory	Pomacentrus leucostictus
SouthernDemersals	Belted sandfish	Serranus subligarius
SouthernDemersals	Bermuda chub	Kyphosus sectatrix
SouthernDemersals	Bigeye searobin	Prionotus longispinosus
SouthernDemersals	Bigeye soldierfish	Ostichthys trachypoma
SouthernDemersals	Bighead searobin	Prionotus tribulus
SouthernDemersals	Black drum	Pogonias cromis
SouthernDemersals	Black grouper	Mycteroperca bonaci
SouthernDemersals	Blackbar soldierfish	Myripristis jacobus
SouthernDemersals	Blackear bass	Serranus atrobranchus
SouthernDemersals	Blackear wrasse	Halichoeres poeyi
SouthernDemersals	Blackedge moray	Gymnothorax nigromarginatus
SouthernDemersals	Blackfin goosefish	Lophius gastrophysus
SouthernDemersals	Blackfin snapper	Lutjanus buccanella
SouthernDemersals	Blackline tilefish	Caulolatilus cyanops

Group	Common Name	Scientific Name
SouthernDemersals	Blackspotted stickleback	Gasterosteus wheatlandi
SouthernDemersals	Blackwing searobin	Prionotus rubio
SouthernDemersals	Blue angelfish	Holacanthus bermudensis
SouthernDemersals	Blue parrotfish	Scarus coeruleus
SouthernDemersals	Blue tang	Acanthurus coeruleus
SouthernDemersals	Blueline tilefish	Caulolatilus microps
SouthernDemersals	Bluelip parrotfish	Cryptotomus roseus
SouthernDemersals	Bluespotted searobin	Prionotus roseus
SouthernDemersals	Blunthead putter	Sphoeroides pachygaster
SouthernDemersals	Bonefish	Albula vulpes
SouthernDemersals	Bucktooth parrotfish	Sparisoma radians
SouthernDemersals	Bull pipefish	Syngnathus springeri
SouthernDemersals	Bulleye	Cookeolus japonicus
SouthernDemersals	Caesar grunt	Haemulon carbonarium
SouthernDemersals	Cardinal soldierfish	Plectrypops retrospinis
SouthernDemersals	Carolina hake	Urophycis earllii
SouthernDemersals	Checkered putter	Sphoeroides testudineus
SouthernDemersals	Clinid uncl	Clinidae
SouthernDemersals	Cocoa damselfish	Pomacentrus variabilis
SouthernDemersals	Combtooth blenny uncl	Blenniidae
SouthernDemersals	Common snook	Centropomus undecimalis
SouthernDemersals	Cornetfish uncl	Fistularia
SouthernDemersals	Creole wrasse	Clepticus parrae
SouthernDemersals	Creole-fish	Paranthias furcifer
SouthernDemersals	Crested blenny	Hypleurochilus geminatus
SouthernDemersals	Crimson bass	Anthias asperilinguis
SouthernDemersals	Cubbyu	Equetus umbrosus
SouthernDemersals	Damselfish uncl	Pomacentridae
SouthernDemersals	Deepwater squirrelfish	Sargocentron bullisi
SouthernDemersals	Doctorfish	Acanthurus chirurgus
SouthernDemersals	Dog snapper	Lutjanus jocu
SouthernDemersals	Dotterel filefish	Aluterus heudeloti
SouthernDemersals	Dusky squirrelfish	Sargocentron vexillarium
SouthernDemersals	Dwarf goatfish	Upeneus parvus
SouthernDemersals	Dwarf sand perch	Diplectrum bivittatum
SouthernDemersals	Emerald parrotfish	Nicholsina usta
SouthernDemersals	Fantail mullet	Mugil gyrans
SouthernDemersals	Fat sleeper	Dormitator maculatus
SouthernDemersals	Feather blenny	Hypsoblennius hentz
SouthernDemersals	Flamefish	Apogon maculatus
SouthernDemersals	Foureye butterflyfish	Chaetodon capistratus
SouthernDemersals	Fourhorn sculpin	Myoxocephalus quadricornis

Group	Common Name	Scientific Name
SouthernDemersals	Fourspine stickleback	Apeltes quadracus
SouthernDemersals	Freckled blenny	Hypsoblennius ionthas
SouthernDemersals	Freckled soapfish	Rypticus bistrispinus
SouthernDemersals	Freckled stargazer	Xenocephalus egregius
SouthernDemersals	Frillfin goby	Bathygobius soporator
SouthernDemersals	Fringed filefish	Monacanthus ciliatus
SouthernDemersals	Gag	Mycteroperca microlepis
SouthernDemersals	Glasseye snapper	Priacanthus cruentatus
SouthernDemersals	Goby flathead	Bembrops gobioides
SouthernDemersals	Goby uncl	Gobiidae
SouthernDemersals	Goldface tilefish	Caulolatilus chrysops
SouthernDemersals	Gray angelfish	Pomacanthus arcuatus
SouthernDemersals	Gray snapper	Lutjanus griseus
SouthernDemersals	Greenband wrasse	Halichoeres bathyphilus
SouthernDemersals	Grouper coney	Cephalopholis fulva
SouthernDemersals	Grunt uncl	Haemulidae
SouthernDemersals	Grunt white	Haemulon plumieri
SouthernDemersals	Guaguanche	Sphyraena guachancho
SouthernDemersals	Gulf kingfish	Menticirrhus littoralis
SouthernDemersals	Highfin scorpionfish	Pontinus rathbuni
SouthernDemersals	High-hat	Equetus acuminatus
SouthernDemersals	Hogfish	Lachnolaimus maximus
SouthernDemersals	Honeycomb cowfish	Lactophrys polygonia
SouthernDemersals	Honeycomb moray	Gymnothorax saxicola
SouthernDemersals	Horned searobin	Bellator militaris
SouthernDemersals	Hunchback scorpionfish	Scorpaena dispar
SouthernDemersals	Jackknife-fish	Equetus lanceolatus
SouthernDemersals	Jolthead porgy	Calamus bajonado
SouthernDemersals	King whiting	Menticirrhus
SouthernDemersals	Knobbed porgy	Calamus nodosus
SouthernDemersals	Laemonema barbatulum	Laemonema barbatulum
SouthernDemersals	Lancer stargazer	Kathetostoma albigutta
SouthernDemersals	Lane snapper	Lutjanus synagris
SouthernDemersals	Lantern bass	Serranus baldwini
SouthernDemersals	Leopard searobin	Prionotus scitulus
SouthernDemersals	Littlehead porgy	Calamus proridens
SouthernDemersals	Liza	Mugil liza
SouthernDemersals	Longfin scorpionfish	Scorpaena agassizi
SouthernDemersals	Longsnout butterflyfish	Prognathodes aculeatus
SouthernDemersals	Longspine squirrelfish	Holocentrus rufus
SouthernDemersals	Lophiiform uncl	Lophiiformes
SouthernDemersals	Marbled grouper	Epinephelus inermis

Group	Common Name	Scientific Name
SouthernDemersals	Marbled putter	Sphoeroides dorsalis
SouthernDemersals	Mexican searobin	Prionotus paralatus
SouthernDemersals	Misty grouper	Epinephelus mystacinus
SouthernDemersals	Mojarra uncl	Gerreidae
SouthernDemersals	Mooneye cusk-eel	Ophidion selenops
SouthernDemersals	Moray uncl	Muraenidae
SouthernDemersals	Mottled jawfish	Opistognathus maxillosus
SouthernDemersals	Moustache jawfish	Opistognathus lonchurus
SouthernDemersals	Mullet red (goatfish)	Mullidae
SouthernDemersals	Mullets	Mugilidae
SouthernDemersals	Mutton hamlet	Epinephelus afer
SouthernDemersals	Mutton snapper	Lutjanus analis
SouthernDemersals	Naked goby	Gobiosoma bosc
SouthernDemersals	Nassau grouper	Epinephelus striatus
SouthernDemersals	Ninespine stickleback	Pungitius pungitius
SouthernDemersals	Northern kingfish	Menticirrhus saxatilis
SouthernDemersals	Ocean surgeon	Acanthurus bahianus
SouthernDemersals	Ocean triggerfish	Canthidermis suffiamen
SouthernDemersals	Opah	Lampris guttatus
SouthernDemersals	Orange filefish	Aluterus schoepfi
SouthernDemersals	Orangeback bass	Serranus annularis
SouthernDemersals	Painted wrasse	Halichoeres caudalis
SouthernDemersals	Pearly razorfish	Hemipteronotus novacula
SouthernDemersals	Perch true	Perca flavescens
SouthernDemersals	Pigfish	Orthopristis chrysoptera
SouthernDemersals	Pinfish	Lagodon rhomboides
SouthernDemersals	Plumed scorpionfish	Scorpaena grandicornis
SouthernDemersals	Pomfrets	Bramidae
SouthernDemersals	Porcupinefish	Diodon hystrix
SouthernDemersals	Porgy and pinfish uncl	Sparidae
SouthernDemersals	Porgy red	Pagrus pagrus
SouthernDemersals	Porkfish	Anisotremus virginicus
SouthernDemersals	Puddingwife	Halichoeres radiatus
SouthernDemersals	Putter uncl	Tetraodontidae
SouthernDemersals	Pygmy argentine	Glossanodon pygmaeus
SouthernDemersals	Pygmy moray	Anarchias similis
SouthernDemersals	Pygmy sea bass	Serraniculus pumilio
SouthernDemersals	Queen angelfish	Holacanthus ciliaris
SouthernDemersals	Queen triggerfish	Balistes vetula
SouthernDemersals	Red barbier	Hemanthias vivanus
SouthernDemersals	Red cornetfish	Fistularia petimba
SouthernDemersals	Red dory	Cyttopsis rosea

Group	Common Name	Scientific Name
SouthernDemersals	Red drum	Sciaenops ocellatus
SouthernDemersals	Red grouper	Epinephelus morio
SouthernDemersals	Red hind	Epinephelus guttatus
SouthernDemersals	Red hogfish	Decodon puellaris
SouthernDemersals	Red porgy	Pagrus sedecim
SouthernDemersals	Red snapper	Lutjanus campechanus
SouthernDemersals	Redeye gaper	Chaunax stigmaeus
SouthernDemersals	Reef butterflyfish	Chaetodon sedentarius
SouthernDemersals	Rock beauty	Holacanthus tricolor
SouthernDemersals	Rock hind	Epinephelus adscensionis
SouthernDemersals	Rock sea bass	Centropristis philadelphica
SouthernDemersals	Roughtongue bass	Holanthias martinicensis
SouthernDemersals	Saddle bass	Serranus notospilus
SouthernDemersals	Sand perch	Diplectrum formosum
SouthernDemersals	Sand seatrout	Cynoscion arenarius
SouthernDemersals	Sand tilefish	Malacanthus plumieri
SouthernDemersals	Saucereye porgy	Calamus calamus
SouthernDemersals	Scamp	Mycteroperca phenax
SouthernDemersals	School bass	Schultzea beta
SouthernDemersals	Schoolmaster	Lutjanus apodus
SouthernDemersals	Scrawled cowfish	Lactophrys quadricornis
SouthernDemersals	Scrawled filefish	Aluterus scriptus
SouthernDemersals	Sea bass uncl	Serranidae
SouthernDemersals	Sea trout unc	Cynoscion spp
SouthernDemersals	Seaweed blenny	Parablennius marmoreus
SouthernDemersals	Sergeant major	Abudefduf saxatilis
SouthernDemersals	Sharpnose putter	Canthigaster rostrata
SouthernDemersals	Sheepshead	Archosargus probatocephalus
SouthernDemersals	Sheepshead porgy	Calamus penna
SouthernDemersals	Short bigeye	Pristigenys alta
SouthernDemersals	Shortfin searobin	Bellator brachychir
SouthernDemersals	Shortspine boarfish	Antigonia combatia
SouthernDemersals	Shortwing searobin	Prionotus stearnsi
SouthernDemersals	Silk snapper	Lutjanus vivanus
SouthernDemersals	Silver jenny	Eucinostomus gula
SouthernDemersals	Silver perch	Bairdiella chrysoura
SouthernDemersals	Silver porgy	Diplodus argenteus
SouthernDemersals	Silver seatrout	Cynoscion nothus
SouthernDemersals	Skilletfish	Gobiesox strumosus
SouthernDemersals	Slender searobin	Peristedion gracile
SouthernDemersals	Slippery dick	Halichoeres bivittatus
SouthernDemersals	Smooth trunkfish	Lactophrys triqueter

Group	Common Name	Scientific Name
SouthernDemersals	Smoothhead scorpionfish	Scorpaena calcarata
SouthernDemersals	Snakehead northern	Channa argus
SouthernDemersals	Snapper cubera	Lutjanus cyanopterus
SouthernDemersals	Snapper eel	Echiophis punctifer
SouthernDemersals	Snapper uncl	Lutjanidae
SouthernDemersals	Snowy grouper	Epinephelus niveatus
SouthernDemersals	Southern hake	Urophycis floridana
SouthernDemersals	Southern kingfish	Menticirrhus americanus
SouthernDemersals	Southern putter	Sphoeroides nephelus
SouthernDemersals	Southern stargazer	Astroscopus y-graecum
SouthernDemersals	Spadefish	Ephippidae
SouthernDemersals	Spearfish roundscale	Tetrapturus georgii
SouthernDemersals	Spearfishes	Tetrapturus
SouthernDemersals	Speckled hind	Epinephelus drummondhayi
SouthernDemersals	Spiny searobin	Prionotus alatus
SouthernDemersals	Spinycheek scorpionfish	Neomerinthe hemingwayi
SouthernDemersals	Spinycheek soldierfish	Corniger spinosus
SouthernDemersals	Spot	Leiostomus xanthurus
SouthernDemersals	Spotfin butterflyfish	Chaetodon ocellatus
SouthernDemersals	Spotfin dragonet	Foetorepus agassizi
SouthernDemersals	Spotfin hogfish	Bodianus pulchellus
SouthernDemersals	Spotfin mojarra	Eucinostomus argenteus
SouthernDemersals	Spotted burrfish	Chilomycterus atinga
SouthernDemersals	Spotted drum	Equetus punctatus
SouthernDemersals	Spotted goatfish	Pseudupeneus maculatus
SouthernDemersals	Spotted moray	Gymnothorax moringa
SouthernDemersals	Spotted scorpionfish	Scorpaena plumieri
SouthernDemersals	Spotted seatrout	Cynoscion nebulosus
SouthernDemersals	Spotted soapfish	Rypticus subbifrenatus
SouthernDemersals	Spotted tinselfish	Xenolepidichthys dalgleishi
SouthernDemersals	Spotted trunkfish	Lactophrys bicaudalis
SouthernDemersals	Squirrelfish	Holocentrus adscensionis
SouthernDemersals	Squirrelfish uncl	Holocentridae
SouthernDemersals	Star drum	Stellifer lanceolatus
SouthernDemersals	Stargazer uncl	Uranoscopidae
SouthernDemersals	Streamer bass	Hemanthias aureorubens
SouthernDemersals	Streamer searobin	Bellator egretta
SouthernDemersals	Striped blenny	Chasmodes bosquianus
SouthernDemersals	Striped grunt	Haemulon striatum
SouthernDemersals	Striped mullet	Mugil cephalus
SouthernDemersals	Sunshinefish	Chromis insolata
SouthernDemersals	Tattler	Serranus phoebe

Group	Common Name	Scientific Name
SouthernDemersals	Tilefish	Lopholatilus chamaeleonticeps
SouthernDemersals	Tilefish unc	Malacanthidae
SouthernDemersals	Tomtate	Haemulon aurolineatum
SouthernDemersals	Triggerfish filefish uncl	Balistidae
SouthernDemersals	Tripletail	Lobotes surinamensis
SouthernDemersals	Trunkfish	Lactophrys trigonus
SouthernDemersals	Twospot cardinalfish	Apogon pseudomaculatus
SouthernDemersals	Unicorn filefish	Aluterus monoceros
SouthernDemersals	Unicornfish	Eumecichthys fiski
SouthernDemersals	Vermilion snapper	Rhomboplites aurorubens
SouthernDemersals	Warsaw grouper	Epinephelus nigritus
SouthernDemersals	Web burrfish	Chilomycterus antillarum
SouthernDemersals	Wenchman	Pristipomoides aquilonaris
SouthernDemersals	White grunt	Haemulon plumieri
SouthernDemersals	White mullet	Mugil curema
SouthernDemersals	White perch	Morone americana
SouthernDemersals	Whitebone porgy	Calamus leucosteus
SouthernDemersals	Wrasse uncl	Labridae
SouthernDemersals	Wreckfish	Polyprion americanus
SouthernDemersals	Yellowedge grouper	Epinephelus flavolimbatus
SouthernDemersals	Yellowfin bass	Anthias nicholsi
SouthernDemersals	Yellowfin grouper	Mycteroperca venenosa
SouthernDemersals	Yellowmouth grouper	Mycteroperca interstitialis
SouthernDemersals	Yellowtail reeffish	Chromis enchrysurus
SouthernDemersals	Yellowtail snapper	Ocyurus chrysurus
SpinyDogfish	Spiny dogfish	Squalus acanthias
SummerFlounder	Summer flounder	Paralichthys dentatus
Weakfish	Weakfish	Cynoscion regalis
Windowpane	Windowpane	Scophthalmus aquosus
WinterFlounder	Winter flounder	Pseudopleuronectes americanus
WinterSkate	Winter skate	Leucoraja ocellata
YTFlounder	Yellowtail flounder	Limanda ferruginea