



Mid-Atlantic Fishery Management Council
800 North State Street, Suite 201, Dover, DE 19901
Phone: 302-674-2331 | FAX: 302-674-5399 | www.mafmc.org
Michael P. Luisi, Chairman | G. Warren Elliott, Vice Chairman
Christopher M. Moore, Ph.D., Executive Director

Webinar on Chub Mackerel in the Diets of Highly Migratory Species

Meeting Summary

November 9, 2017

Invited experts: Jeff Buckel (North Carolina State University), John Graves (Virginia Institute of Marine Science), Steve Poland (North Carolina Division of Marine Fisheries)

Other attendees: Fred Akers, Julia Beaty, Purcie Bennett-Nickerson, Doug Christel, Jennifer Cudney, Taylor Daley, Greg DiDomenico, Robert Leaf, Pam Lyons Gromen, Rick Robins, Dianne Stephan, Alison Verkade, Kate Wilke

Summary

On Thursday November 9, 2017, the Council hosted a webinar with three invited scientific experts to discuss the importance of Atlantic chub mackerel (*Scomber colias*) in the diets of recreationally-important highly migratory species (HMS) in the Mid-Atlantic. The objectives of the webinar were to clarify what is known about the importance of chub mackerel to HMS diets based on currently available data and to develop recommendations for future studies on this topic.

Predators examined by the researchers included blue and white marlin, roundscale spearfish, wahoo, dolphinfish, yellowfin tuna, blackfin tuna, and bigeye tuna. Samples were mostly taken from recreational fishing tournaments in Cape May, Virginia Beach, and throughout North and South Carolina. Steve Poland's research in North and South Carolina also included samples from charter vessels and the commercial fleet. Most samples across the various studies were collected in the summer; however, Steve Poland's research included some samples collected during other times of year.

Jeff Buckel's examination of stomach contents from the Big Rock Tournament in North Carolina over 18 years showed very stable prey compositions over time. On the other hand, John Graves' research over 26 years of sampling the Mid-Atlantic Tournament in Cape May, New Jersey showed notable shifts in diet across years, with squid dominating the stomach contents of most predators in some years and scombrid prey dominating in others.

Of the three researchers, only John Graves identified chub mackerel in the diet of any HMS predator. These were seen in tuna caught off Virginia Beach in recent years. Data on prey

frequencies were not formally documented. Neither Jeff Buckel nor Steve Poland documented chub mackerel in their studies. This may have been due to the time and location of sampling; however, Steve Poland's research included a variety of tournaments as well as year-round samples from charter vessels and the commercial fleet off North and South Carolina.

All three researchers recorded varying amounts of fish which were too degraded to identify to the species level as unidentified scombrids. John Graves used DNA barcoding to identify some of these fish as members of the *Auxis* genus (which includes bullet and frigate mackerel). This was a proof of concept study and not a systematic diet analysis.

Steve Poland noted that although he never identified a chub mackerel in the stomach contents of the predators he examined, chub mackerel have a similar life history and ecological niche as other prey species which were quite important for all the predators he examined. He classified this type of prey as larger schooling fish not necessarily associated with the surface (e.g. tunas, herrings, squids).

All three researchers agreed that bullet and frigate mackerel (*Auxis rochei* and *A. thazard*) were major contributors to the diets of the predators they examined, at least at the times and locations where the studies took place.

The researchers agreed that all the HMS predators they examined are generalist predators, feeding on whichever prey items are available at the time. Jeff Buckel said it appears unlikely that a commercial fishery for chub mackerel would result in HMS species moving to a different area to find prey because, based on evidence to date, chub mackerel do not appear to be a major contributor to their diets.

All three researchers agreed that genetic barcoding techniques could be used to identify scombrids to the species level. They also discussed the utility of examining physical characteristics such as fin ray counts, otoliths, and caudal peduncle shape to distinguish between *Auxis* species (bullet and frigate mackerel) and *Scomber* species (Atlantic and chub mackerel).

All three researchers agreed that a coast-wide, year-round study of HMS diets based on samples from recreational and commercial HMS fisheries would be ideal for understanding the importance of chub mackerel in the diets of HMS predators; however, such an undertaking would require a funding commitment. They also agreed that a long-term, coast-wide study would be needed to adequately assess the impact of climate change and species distribution shifts on HMS diets.

Detailed Summary

Jeff Buckel: We have been looking at the diets of four predators: blue marlin, wahoo, dolphin, and yellowfin tuna. The work is spatially limited just to the North Carolina coast, centered off Cape Lookout. It's limited within the year to just the second week in June because this is

opportunistic sampling of the Big Rock Blue Marlin Tournament. However, the work has been conducted over a long time period. Sampling started in 1998 and continued through June of 2017. We missed a couple of years, but there's a total of 18 years of data. So it's a long-term data set. That's its strength. It has the limitation of being just that one week each year and the limitation to the North Carolina coast. We published on the first ten years of the diet data. That's a paper in Transactions of the American Fisheries Society, volume 139. So if anyone wants more details, they can look at that paper. We haven't analyzed the 8 years after that publication, but just looking at that data in a cursory way, we haven't seen any major changes from what we saw in the first ten years. Over this 18-year time period things have been remarkably stable in terms of what we see in the diets of the four predators. We get prey weight. Also, whenever the prey is intact enough we get the length of the prey. In terms of sample sizes, that first ten years we had around 65 blue marlin, around 75 wahoo, and around 500 dolphin fish. There were about 250 dolphin from the Big Rock Blue Marlin Tournament but we also supplemented that from another study to bring that number up to 500. And then around 55 yellowfin tuna. Over the next 8 years we collected about 40 blue marlin, 65 wahoo, 400 dolphin, and about 30 yellowfin tuna. We have never identified a chub mackerel in the stomach contents of these predators throughout this time period. We do identify scombrids and when we get those to species they are the two *Auxis* species, bullet and frigate mackerel. When you look at the bullet and frigate mackerel and the unidentified scombrids, because sometimes we know it's a scombrid but we can't get it to species, the percent weight contribution of the total Scombridae, for marlin it's 50-99% of their diet by weight, for wahoo it's 40-100%. So for those two predators off our coast in the month of June, these scombrids are a major contributor to their diet. Then again, the ones we identify are *Auxis*. Yellowfin tuna, we have fairly low sample sizes each year but the contribution of scombrids can be as low as 0% in a year to 90%. So it can be important for yellowfin tuna. And dolphin have the lowest contribution of the scombrids at 0 to 36%. Again, for yellowfin tuna and dolphin when we can identify scombrids to species, it's those two *Auxis* species. It's never been chub mackerel. We definitely can identify the bait used in the fishery. It's either ballyhoo or occasionally some of the folks that target yellowfin tuna use live menhaden. So those are easy to identify from the stomach contents. We don't count those in the contribution of prey. We delete those from the database...It's a troll fishery for the Big Rock Blue Marlin Tournament. If they do have bait it's either ballyhoo or Spanish mackerel, for example. I've never heard of folks using chub mackerel as bait. It's possible, but we've never seen a chub mackerel where we can see the rigging marks on it, for example. But then again, we've never seen a chub mackerel.

John Graves: I really don't have a specific food habits study of HMS. But I have opened up a lot of stomachs as a fisheries geneticist working on many of these species. I've used tournaments as an opportunistic platform to sample animals. I have been the scientist at the Mid-Atlantic Tournament, which is held in Cape May, New Jersey the third week in August. This year was my 26th year doing that. I have looked into the stomachs there. It was not a food

habits study. Most of these identifications have just been by sight. I have not measured individual animals. Although in some cases we have taken the samples back and identified them genetically. We developed a bar code - before the barcode was in major use - for identifying the scombrids in the western North Atlantic. In addition to that, my students and I have attended several tournaments in the Virginia Beach area that are held typically in late June, early July, focusing primarily on tunas. We have looked in some of those stomachs as well. At the Mid-Atlantic the primary sampling that we've done has been of white marlin. Typically, less than 3-4% of the fish are actually brought to the weigh station but those that are typically in the top 5% by weight. We do look at the stomachs of all of those, as well as all of the blue marlin. They also bring in yellowfin tuna, dolphin, bigeye tuna, wahoo. Depending on how busy we are at the weigh station, we don't look at the stomachs of all of those because we aren't doing a formal food habits study, but we have looked at some of them. Generally, if they're meat fish, we don't process them. In terms of any biases by bait, this is a troll only tournament. Live baiting doesn't occur. Those that are trolling troll ballyhoo. What we have observed over the years is that there is a dramatic shift in diet composition between years. But generally, most of the fish captured in the same year have very similar dietary contributions. We can have squid-dominated years and we can have scombrid-dominated years. We have identified, visually, *Auxis* as a major contributor. But we also have seen skipjack. As Jeff noted, sometimes you're not able to easily identify the fish. In fact, we've gone to very degraded species and we just did a sort of haphazard sample of ten individuals that we couldn't identify. Some of them were very well degraded. We took them back to the lab and did the mitochondrial cytochrome oxidase gene, which is the barcode. All of those were in fact *Auxis*. So, as in Jeff's study, *Auxis* is a very major contributor to the diets of these animals. I would say that over the 26 years, where squid has been the dominant item in the food habits has been about 1 out of every three years, without any pattern to that. Again, these are animals that are taken in the third week of August. The area in which they're taken is 125 nautical miles from the Cape May sea buoy. It's a very restricted area. Very restricted time. But over 26 years it gives some ideas of what they're eating. Our examination of animals off Virginia Beach has been a little different. In the tunas there, again scombrids are a major component of the prey and we have identified chub mackerel over the last few years. Again, we don't have individual sizes, we don't have percentage composition by numbers or weight. But we were asked to look at the stomachs and we did that. Those items that could be identified by sight were done. We did not do any genetic analysis of those. That would be pretty much the state of what we've got.

Julia Beaty: Just to clarify, you said that you've only seen chub mackerel in the stomachs from Virginia Beach and it's only been in recent years that you've seen them?

John Graves: That's correct. We haven't been sampling that tournament every year, but over the last few years we have seen them there. That's also been coincident with the development of the live bait fishery using *Scomber colias* in the offshore fleet. But these were not bait. I

don't think the tuna tournament allows live baiting. But we have seen them there. Have we seen them before and we missed them because they were degraded and so were just a general scombrid? I can't say because we didn't take samples for genetic analysis.

Steve Poland: I did my thesis work at UNCW on offshore pelagic food webs. It was kind of the next step with what Jeff's lab has been doing. I looked at the diets in North Carolina and South Carolina but added in a temporal component. I evaluated the seasonal diets of the predators and also used stable isotope techniques to look at chemical markers of predators and prey to construct a general community structure of the offshore food web. All my fish were collected between Oregon Inlet and Charleston down to Edisto Island. I tried to spread out sampling across the year but inevitably a lot of the samples came from the spring and summer when there was the most activity in the fishery. So the results can be skewed a little bit towards the spring and summer but I really tried to collect representative samples from the winter and fall months to evaluate seasonal diet shifts. All these samples were collected from billfish tournaments as well as charter fleets and commercial operations. I used two methods. I opened the stomachs and identified prey to the lowest taxonomic value. I collected information on size of prey as well of weight of prey. I also looked at ontogenetic shifts in prey use by predators. I measured prey sizes, lengths, as well as body depth and morphometrics of predator mouths to help explain changes in diets that we observed due to changes in growth and morphometrics of the predators. I also used stable isotope techniques and collected tissue samples from predators and prey. Stable isotope analysis is investigating chemical markers that all predators and prey have. This is used to look at relative composition of prey groups to predator diets or look at trophic structure or the relative position of different predators and prey in the food web, or more linearly in the food chain. I opened close to 1200 stomachs. Fish were the most prevalent prey in terms of diversity and number of stomachs in which they occurred. Scombridae prey - the family Scombridae includes *Auxis*, chub mackerel, even the tunas, yellowfin and blackfin tuna - for a few of the predators it constituted a large proportion of diet. For wahoo, scombrid prey in some seasons was 50% of the diet by mass. Yellowfin tuna, in some seasons it was more prevalent than others, but it remained in the diet throughout the year. For blackfin tuna and dolphinfish it was present but very infrequently. It was usually present in large individuals. It has a lot to do with size and mouth shape and gape of those predators. From the diet analysis I identified four primary prey groups. The Sargassum-associated prey, surface associated prey, and schooling fish not necessarily associated with the surface - these are your larger fish prey such as tunas, herrings, jacks, squids - and then small aggregations of crustaceans. From stable isotope analysis we were able to construct a representative structure of this food web. A lot of the predators that I looked at fell out towards the top - blackfin, yellowfin, wahoo, and dolphinfish, as well as blue marlin. We did look at diets of blue marlin and other top predators, but the sample sizes were so low that we could not characterize their diet from stomach contents so I didn't present them on the previous slide. But we did get stable isotope samples for those animals and were able to fit them in this food web. Jeff noted that a lot of their work hasn't been presented on

since the Rudershausen et al. paper, but during the years that I was sampling, from 2010 through 2013, they did share that data with me. So the data from those blue marlin and other fish from the Big Rock are included in this analysis. I was also able to structure the community into three primary trophic levels. The prey base, mid-level predators, and top-level predators. A lot of scombrid prey fell out as a mid-level predator. They're usually primary or secondary consumers. A lot of what we observed in the stable isotope analysis for the primary predators we looked at was driven by the consumption of smaller scombrids and squid especially. So, the overall conclusions from the project; there was a lot of evidence for general foraging among all the predators. There was some evidence of specialization, but for the most part predators fed on whatever prey community was available to them at the time. But the predators that had more specialized adaptations like wahoo - large gape, sharp teeth, fast swimming speed - we did see more scombrid and *Auxis*, bullet tunas, those types of prey. Squid, flying fish, and bullet tuna really did come out towards the top. They were in all the diets. For a lot of the predator species they constituted a large proportion of the diets. We did not observe any chub mackerel in any of the diets. We did see a lot of bullet tuna, a lot of *Auxis*. There was the potential that some of the unidentified scombrids we saw were chub mackerel. I know with Jeff's work at their lab, they didn't see any chub mackerel. It doesn't seem that any of the diet work done south of here, in the South Atlantic, observed chub mackerel. If I were to expect chub mackerel in the diets of any of the predators I investigated it would probably be yellowfin tuna. A lot of my yellowfin tuna came from Oregon Inlet, north of Hatteras. But again, I did not see any chub mackerel in those... I certainly think the reason we didn't see chub mackerel down here in North Carolina and the samples I collected from South Carolina is they simply don't occur down here. They're more of a mid-Atlantic, northern seaboard species. That being said, I certainly feel like they fill the same ecological niche as *Auxis* do, frigate mackerel and bullet mackerel. I can't say this with any certainty because I haven't performed any diet work north of Hatteras, but I feel like the trends that we saw down here for bullet and frigate mackerel are probably similar north of here, in the mid-Atlantic. They are a very similar species. The habitat that they utilize, their prey - I would expect them to be just as numerous in the diets north of here as their counter parts were here and south.

Jeff Buckel: Steve, did Michelle Staudinger sample tournaments in the Mid-Atlantic? Did she see chub mackerel?

Steve Poland: I've gone back and looked at the data that she's provided me and her papers and I haven't readily identified chub mackerel. I know one of her students published a study of mid-Atlantic diets a year or so ago. I haven't had a chance to review that. I think that would be good information to pursue. Michelle and Juanes, the lab up there, they do similar diet work as we do down here. So that's another good source for diet data.

Julia Beaty: I thought that was interesting that you said that chub mackerel might be more of a mid-Atlantic, southern New England species. Because my understanding was that they are

present in the South Atlantic and Gulf of Mexico and are seasonally available in the Mid-Atlantic. But you sampled year-round and didn't see any. I was thinking of them as more of a South Atlantic species that's present in the Mid-Atlantic in the summer time.

Steve Poland: I will admit, I don't know a lot about their particular life history. That's just based on the results that I saw in my diet work. If they were here I would have expected to see them in the diets at some point.

John Graves: It could be the sampling method that we're using where we're opportunistically sampling tournaments. Julia, you're absolutely right in your characterization of the distribution. In the Mid-Atlantic there has been a shift northward of *Scomber colias* distribution. In cold years we have the Atlantic mackerel down here. Some people might not be able to separate those on a cursory level. In Virginia we have had both species that are in our waters. In addition to taking *Auxis*, we have seen animals taking the chub mackerel. Generally, when *Scomber scombrus* is present the water is so cold that people aren't going fishing for highly migratory species.

Julia Beaty: You all identified a fair amount of unidentified scombrids. John mentioned his genetic work. Do any of you have any sense of how much, if any, of the unidentified scombrids could be chub mackerel?

John Graves: We took some very degraded samples out of white marlin and blue marlin stomachs just for proof of concept. You'd need a good sample size and the right design to get any real information from that. To my knowledge it hasn't been done.

Julia Beaty: Do you think if we took a similar methodology and expanded it and were more systematic about it, that could be a way to answer this question?

John Graves: Sure. Genetic techniques are being used in all kinds of diet studies now. In this case we know all the scombrids here. It would be very easy to do.

Julia Beaty: You mean you know the genetic markers for all the scombrids?

John Graves: Right.

Jeff Buckel: I think that's the best way to go. John would have a better idea of how cost-prohibitive it would be to do those larger sample sizes. For us, this is not funded work. It's just something that we're interested in and is fairly easy to do since the tournament is right in town. We did not spend a lot of time on the unidentified Scombridae. We could spend some time, maybe do x-rays of the caudal peduncle area. It could be less expensive. The *Auxis* have a median keel on the caudal peduncle and *Scomber* does not. The *Auxis* also have 7-10 anal finlets compared to the 5 that *Scomber colias* has. That's something that we didn't spend time doing just because when we did identify the scombrids it was *Auxis*, and when it was too degraded to say it was *Auxis*, we were pretty sure it was *Auxis* but we didn't want to make that call macroscopically so we just put it in the Scombridae. But we could certainly spend more

time looking at the meristics to see if we could separate that out. It might require some x-raying. That may or may not be cheaper than the genetic route. And that's just *Auxis* vs. *Scomber*. With genetics you'd be able to get to the other species. It's another potential option.

Steve Poland: I will say, for the samples that taxonomically I assigned to the genus *Auxis*, I did spend a fair amount of time going over the meristics. So the confidence I have in those is fairly high. But the ones that you open up and it's just bones and flesh, a lot of those easily identifiable meristics are gone. Certainly, they could be chub mackerel or any number of other scombrids. I did save a lot of the samples in ethanol with the hopes that somebody else would go back and look at the samples, do some genetic barcoding or something. Those are available. As far as doing pie in the sky coast wide sampling of diets, it would be time consuming and cost prohibitive to sample the whole coast. I certainly think the genetic barcoding that Dr. Graves was discussing is the way to go if you are interested in identifying these species in the diet.

Julia Beaty: John and Jeff, are you aware of any other stored samples from past work?

John Graves: We haven't saved any samples.

Jeff Buckel: We haven't saved any from our sampling. I'm not aware of any other studies. Michelle Staudinger, north of Hatteras sampling tournaments, I'm not sure if she saved any samples, but that's the only other one I can think of that's potentially out there.

Julia Beaty: If we rely on tournaments, are we always going to have a bias because only the largest fish are brought to shore?

John Graves: Some of the tournaments don't even allow landing of billfish. Those that do have fairly high minimum sizes for the tournaments, so it's a bias. But you can get an exempted fishing permit for a specific study which would allow you to take animals below a certain size. But certainly, you're going to have a size bias and an area bias in your tournaments. You're also going to be sampling fish at the very surface in most cases.

Steve Poland: I had that issue with my work. That's why I also collected samples from the charter fleet and commercial operations. Even then, you're still restricted by the regulatory limits and the spatial coverage of the fishing fleet.

Julia Beaty: Some people have asked me, what's the relative contribution to the stock status of these predators - some of which are overfished and overfishing is occurring - of the commercial and recreational fisheries for these predators compared to any impacts of removing their prey from the ecosystem. Do any of you have any insights into that question?

John Graves: In addition to being a fishery geneticist, I've chaired the U.S. ICCAT advisory committee for the last 22 years. The animals are where the food is. In the case of the HMS species, they move to areas where there is food and they'll stay there. We saw a period in the U.S. bluefin fishery in the late 1990s, early 2000s where we were not able to catch our quota.

The fish had moved into northern waters. That coincided with an increase in the herring fishery. The disruption of some of those schools, many felt was the reason that the bluefin went right through New England into Canadian waters. There was a lot of interaction at that point with the New England Council to focus on an ecosystem level. So there are two factors that are in there. One is the actual contribution of the prey species to the diets. The other one is the congregations of the prey species actually congregate the HMS species. That makes it easier for both the commercial and recreational fishermen for the HMS species to have higher catch rates if they know that the animals are going to be congregated there because of a reliable prey source. In terms of overfishing, I don't think the prey concentrations are responsible for declines in the populations, per se. These animals are highly mobile. They'll go where they need to go to get the food. In terms of the contribution of the recreational fisheries to overfishing these fisheries, the U.S. recreational fishery and its impact, at least in the case of the marlin - well, all of these species - is better estimated than in any other country. In the case of the billfish, ICCAT limits us to 250 blue and white marlin and roundscale spearfish combined. In terms of an impact on the stock as a whole, it's *de minimis*.

Jeff Buckel: I agree with everything that John said. The link that John made between bluefin tuna and herring - bluefin tuna in that area, herring are a major contributor to the diet. Chub mackerel doesn't seem like it's a major contributor, so that's less likely to happen if there's a fishery for chub mackerel. But I think it's a good thing to keep an eye on, obviously, as the fishery develops.

John Graves: A recreational fishery has developed here out of Rudee Inlet for white marlin using chub mackerel. The evolution of that fishery was simply that there were some charter boats that were offshore deep dropping for blueline tilefish and snowy grouper. *Scomber* tends to be much deeper in the water column than *Auxis* and some of the other scombrids. As they were deep dropping on their gangions they were bringing up some *Scomber*. As the *Scomber* were coming up on the hooks, white marlin were attacking them. So the fishery developed where they go out there and they catch their live bait from the depths of the *Scomber* and they slow troll right there from where they catch them using the *Scomber* as bait. There are incredible catch rates for those boats. For the billfish tournaments along the coast, they've had to wrestle with whether they allow that type of fishing to occur in their tournament or whether they strictly make it a regular speed, 6 knot or more or whatever, troll fishery. So there seems to be a very consistent concentration, at least here off Norfolk Canyon. For the last several years there's been predictable concentrations of chub mackerel and the white marlin seem to be very aware of that.

Steve Poland: I agree with everything John just said about these fish feeding on what's available to them. That's not to say that these chub mackerel constituted an important part of their diet. He brought up the ecosystem approach to management. There's a lot of questions, or data that needs to be collected on the prey field before we move in that direction. As far as

what John said about the fish being mostly opportunistic, my work has shown that, and Jeff's work has shown that.

Rick Robins: One of the important questions on this species is trying to understand the spatial and seasonal extent of the interactions between chub mackerel and HMS species. I fish out of Virginia Beach and we have seen in recent years the evolution of the white marlin fishery that John Graves described. Those fish usually come in in some point in June in Norfolk Canyon. By July they're there pretty consistently. Through the fall there's a consistent relationship between them being in the Canyon and the presence of white marlin. They were still there a few weeks ago. They appear to have a significant ecological relationship. That connection extends south of Virginia Beach too. This year in the early season tuna fishery that was focused on the month of May, there was really good fishing off Oregon inlet from the point to just below the Virginia/North Carolina line. At that time there was a great concentration of tinker mackerel there and the yellowfin were on top of them. There were a lot of sharks down there too, duskys and sandbars and spinners. The whole ecosystem was there in a concentrated way. We've never had a systematic comprehensive diet study that looks at the interactions between the HMS fisheries and the prey species throughout the mid-Atlantic. What we've heard today is some individual studies and I think those are helpful to understand but we've never had a systematic approach. I wonder if the researchers can speak to the prospect of that. One of the things that might make that possible is HMS species are landed in the mid-Atlantic in a fairly discreet number of landings points. Oregon Inlet, Ruddee Inlet, Ocean City, Cape May. There's a limited number of ports that probably account for the large majority of HMS landings. You might be able to study stomachs at those points of landing and do it across the season when HMS are being landed, maybe May through the fall. Right now we don't have studies that get at the importance seasonally and spatially in the mid-Atlantic.

John Graves: That's very tractable. You're right that there are a limited number of sites. It would depend on the objectives of your study. If you're looking at the impact of prey species on the diets of the recreational species - there are also commercial fisheries that have limited ports. Several of the longliners are setting in the heads of canyons and areas where we know the prey concentrates. It depends on if you would want to include their importance in the commercial fisheries as well. Of course, the recreational fisheries are more seasonal than the commercial fisheries. You'd want to have good seasonal coverage, like Steve had in his study.

Steve Poland: I think if you wanted to go all in and do it coastwide, you should be as comprehensive as you can. If a management agency wants to pursue a coastwide study of diets, you'd certainly need to get as many people on board as possible and sample the fishery in all areas and all times.

Jeff Buckel: I don't have anything to add other than that it's a great idea. One of the reasons why it hasn't happened in the past is these diet studies haven't been a priority for funding agencies.

Robert Leaf: In terms of the occurrence of chub mackerel in the diets of HMS in other parts of the Atlantic, chub mackerel have a pretty wide distribution. I'm wondering if when you were doing diet work if you came across any literature on chub mackerel having a high frequency of occurrence in other studies from Spain or Portugal or western Africa.

John Graves: There may be some studies out there but I'm not aware of any. I haven't done a literature search.

Steve Poland: I did a pretty extensive literature search when I started my work. I focused mostly in the South Atlantic, but I did look at the Atlantic more generally. I don't remember chub mackerel as a specific species, but I did get the sense that in all these areas, there are representative functional groups of prey. Certainly, the functional group that would include chub mackerel, free swimming, not necessarily associated with the surface, schooling prey – there were a lot of studies out there that identified a species niche that served a very similar ecological role that you would expect chub mackerel to serve.

Jeff Buckel: As part of that paper that I mentioned before, we compared the diets of the predators off North Carolina to the published literature. We found that in other oceans around the world that Scombridae are similarly important to blue marlin and wahoo like we found off North Carolina. When we dug into the species of scombrid, it did change globally. I don't remember offhand if *Scomber colias* were in some of those studies. I do remember that *Auxis* was dominant globally, so just to underscore their importance. We found that *Auxis* was very important off North Carolina. That was certainly a dominant scombrid globally for blue marlin and wahoo.

Taylor Daley: I have a question about some of the samples you saved. You said you could use genetics. Another suggestion I have is the otoliths. From my experience, the otoliths from *Scomber colias* are pretty distinct from other species. So if you could get those, you could tell the difference.

Steve Poland: I did look at hard structures that I pulled out of the stomachs. For the most part I could get them to genus. I'd have to look back at my lab sheets, but I don't remember anything that I assigned to the *Scomber* genus. As far as the tissue samples, those are certainly available to anybody who has interest in them. They were preserved in denatured ethanol so that shouldn't have any effect on the genetic material.

Taylor Daley: I have quite a few images of otoliths from *Scomber colias*. If anyone wants them, I'd be happy to provide them.

Pam Lyons Gromen: In one of the presentations you mentioned distribution shifts. I'm thinking about climate change and how many fish species in the mid-Atlantic are shifting their distributions. Is it a concern that the overlap of predator and prey might be changing because of climate change so species that were maybe not as important in the diet of some of these predators might become more important? If so, how do we monitor that?

John Graves: You'd have to have some baseline information, which we don't really have. We have some good studies that are over a short period or short regions, but we don't have anything that's coast wide. So we don't have a baseline to look at shifts yet. The first thing you would have to do is look at diets now and then have comparable studies in the future. That's the challenge with a lot of our climate change studies is we often don't have very good baseline studies to start with.

Jeff Buckel: John Manderson who works with NMFS has been working with the squid and butterfish industry to examine spatial shifts in distribution. I don't know if his work may be helpful with looking at this shift in chub mackerel or if he's come across chub mackerel in some of his work.

Julia Beaty: He's very involved in this amendment.

Jeff Buckel: [Our study, despite 18 years of data] has that spatial restriction and just the one week within the year. But I do think if there were major changes in forage off North Carolina that we would be able to pick that up. As John mentioned, in his area you can have squid years and finfish prey years, but we haven't seen that off North Carolina. Things have been fairly stable year to year. I think if there was a major change in forage for the four predators we're examining, we would pick that up. We haven't seen any indication of that.

Julia Beaty: Is it planned for your research to keep going into the foreseeable future?

Jeff Buckel: Yes. For the exact reason that we're talking about. As Steve mentioned, the costs, it's difficult to do monitoring. But sampling opportunistically from fishing tournaments is fairly inexpensive. We think we would get an indication if there is a change in the diets. That's why we've continued our sampling. Just to add, there's been quite a bit of work in the Mid-Atlantic Bight that have shown distribution shifts. Groups like Malin Pinsky's at Rutgers have looked at that in the Mid-Atlantic Bight and in the South Atlantic and haven't seen those shifts in the South Atlantic Bight like there have been in the Mid-Atlantic Bight.