



PARTICIPATORY MODELING OF DOLPHIN AND WAHOO FISHERIES IN THE U.S. SOUTH ATLANTIC: FINAL REPORT FROM A WORKSHOP SERIES

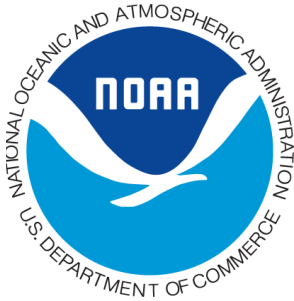
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Participatory modeling of dolphin and wahoo fisheries in the U.S. South
Atlantic: final report from a workshop series

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Contents

List of Tables	v
List of Figures	vi
Introduction and Goals.....	1
Methods.....	2
Results.....	5
Heavy emphasis on social and economic dimensions and limited knowledge of biological stock drivers	6
Dolphin versus wahoo	7
High variation in dolphin fishery at local levels	7
Importance of seasonality and fish size for dolphin and wahoo fisheries.....	10
Impact of dolphin bag limits on consumer satisfaction in the recreational fishery.....	11
Importance of imports and foreign catch on commercial prices and demand	12
Perceived conflicts at local and sub-regional levels.....	13
Increased private recreational effort and accountability concerns	15
Conclusions and Recommendations	15
Acknowledgements.....	16
References.....	18

List of Tables

Table 1 Workshop dates, locations and background of workshop participants.....	3
Table 2. Perceptions of change in abundance over time according to the workshop participants in each area.....	7
Table 3. Dolphin targeting trip characteristics based on MRIP intercept surveys.....	12
Table 4. Differences in opinions and perceived impacts of regulations by subregion.....	14

List of Figures

Figure 1. Example of a conceptual model built from combined stakeholder perceptions for South Florida for-hire (eight individuals) and private (four individuals) recreational fishermen. Yellow boxes denote physical drivers, orange boxes denote biological drivers, green boxes denote dolphin and wahoo population dynamics, pink boxes denote social factors, blue boxes denote regulatory factors, and white boxes denote economic factors. 4

Figure 2 Monthly dependence values averaged across charter fishermen ± 1 S.E. Shown are species where there were at least two independent trend lines drawn (with the exception of dolphin for Virginia Beach which was only drawn by one participant but shown regardless). 9

Figure 3. Monthly dependence values averaged across commercial fishermen ± 1 S.E., for historical dependency (top) and present day dependency (bottom). Shown are species where there were at least two independent trend lines drawn. 10

Introduction and Goals

In 2020 and 2021, the Southeast Fisheries Science Center (SEFSC) and the South Atlantic Fishery Management Council (SAFMC) collaborated on an initiative to apply a participatory modeling method to the dolphin and wahoo fishery, with the goal of better understanding the physical, biological, social, economic, and institutional aspects of the fishery in the Southeast U.S. Information gathered in this process was intended to support decision-making related to Amendment 10 and future amendments to the Fishery Management Plan for the Dolphin and Wahoo Fishery. During the workshops, SEFSC and SAFMC staff documented the perspectives of industry participants engaged in the fishery and built a conceptual model that represents the different internal and external factors impacting the fishery and how they are related. Representatives from the SAFMC and SEFSC traveled to three fishing communities (Beaufort NC, Wanchese NC, and Virginia Beach VA) in March 2020 to carry out facilitated workshops. Workshops were also planned for Southeastern Florida and the Florida Keys, but due to COVID-19 travel restrictions, a decision was made to move to a virtual format so that input from fishing industry members could be collected in a timely manner.

Several attributes of the dolphin and wahoo fisheries necessitated this work. The SAFMC manages dolphin and wahoo along the entire U.S. Atlantic coast, and there are different perceptions on the state of the fishery sub-regionally. Both of the species are data-poor, and no stock assessments are available with which to guide management advice. There is no other federal (i.e. the Gulf of Mexico or U.S. Caribbean) or international management of either species (such as International Commission for the Conservation of Atlantic Tunas) despite their extensive migratory range. Finally, the two species support very important fisheries, particularly within the recreational sector, which holds the majority of the quota allocation. The participatory modeling effort was undertaken for the purpose of understanding potential causes of varying perceptions on the state of the fishery, filling in gaps in data availability, and understanding the preferred objectives and values of the recreational and commercial sector and how these vary across the region.

The stated goals of the workshops were to:

- Map key factors in the fishery (including socio-economic, physical, biological, and regulatory factors).
- Identify the major concerns, values, and preferred objectives related to the fishery.
- Develop hypotheses on how changes in the ecosystem affect the fishery, businesses, and communities.
- Identify key questions and information gaps regarding the species.

More broadly, the participatory modeling approach is useful for giving stakeholders an opportunity within a neutral forum to voice concerns and perspectives, and to allow researchers to document these perspectives systematically. The approach is also useful for fostering a

common understanding of the stocks and their roles in the ecosystem, and putting fishermen's local ecological knowledge in a common currency with scientific research. Merging these two viewpoints is useful for identifying information and data gaps and prioritizing future research. Finally, gaining a better understanding of how the species are used and how they are valued should foster improved fisheries management, as end-goals are better aligned with stakeholder objectives.

Methods

The participatory modeling methods used in this project are broadly related to a class of methods often referred to as Participatory Modeling (Jones et al. 2009) or Community Based System Dynamics (Hovmand 2014). The methods are often applied to decision-making in natural resource management contexts, and broadly involve engaging stakeholders to work together to develop conceptual or dynamic models of a system. The process of jointly developing the model leverages local knowledge, promotes mutual learning, and helps identify the critical factors, causal relationships and drivers within a given system, which can then be used for strategy development and planning. The participatory modeling approach can be used to produce conceptual models, which provide static visual representations of a given system, or system dynamic models that can facilitate joint learning about the behavior of a system by running simulations.

The participatory modeling in the workshops involved developing static conceptual models of the dolphin and wahoo fisheries. In particular, the models focused on identifying the major physical, biological, socio-economic, and regulatory factors affecting dolphin and wahoo population abundance and the causal relationships among those factors. The final model explicitly shows the relationships among the main factors that directly or indirectly influence the abundance of the dolphin and/or wahoo populations.

Our preferred method for developing the participatory models was to use a facilitated workshop approach with approximately 8 to 12 key stakeholders (private recreational, for-hire, commercial fishermen, and dealers or processors; Table 1). We acknowledge that these focus groups do not necessarily constitute a representative sample of all participants of the fishery, but inputs from these groups does provide us a basis for formulating various hypotheses on how the fishery functions. This facilitated group approach was used in the three sessions that occurred in North Carolina and Virginia. In these meetings, index cards were used to develop the model on a sticky board. The facilitators initiated the modeling exercise by writing "dolphin-wahoo abundance" on an index card and placing it in the center of the board. The participants were then asked to brainstorm major factors that affected dolphin and/or wahoo abundance with each factor being written on a separate index card. Once a sufficient number of factors had been identified to start the process, the facilitators worked with the participants to begin to organize the model. This required discussing each one of the factors and its causal relationship with dolphin and/or wahoo abundance and the other factors. Some factors, like commercial fishing, directly affect

dolphin abundance. However, the majority of factors indirectly affect abundance through their influence on other factors (e.g., fish prices or regulations). The causal relationships between factors were illustrated in the model by drawing arrows between factors. Once the modeling process had started, the group continued developing the model through an iterative process; rearranging, adding, deleting and combining cards, and redirecting arrows as needed. This process ended when the group agreed that the model presented a reasonably complete picture of all of the major factors affecting dolphin and wahoo abundance (e.g., Fig. 1).

Table 1 Workshop dates, locations and background of workshop participants

		commercial	for-hire	private
March 9, 2020	Beaufort, NC		X	X
March 10, 2020	Wanchese, NC	X	X	
March 11, 2020	Virginia Beach, VA		X	X
March 2021	Florida (one-on-one)		X	X
April 12, 2021	Florida (group webinar)		X	X

Although we also hoped to conduct the in-person group meetings in South Florida, COVID-19 restrictions made that impossible. Instead, we conducted phone calls with key stakeholders to discuss their observations of the current status of the dolphin and wahoo fisheries and the main factors influencing dolphin and wahoo populations in South Florida. The facilitators then used these discussion results to create a draft conceptual model. To finalize the model, a group webinar was held with the individuals that had been consulted to review and make needed corrections.

Once the conceptual models were considered complete, they were used as the basis of further discussion regarding which components were perceived to be most important, drivers that were considered cause for concern, and components or outcomes that were perceived as the most valuable to the fisheries and businesses. This allowed us to clarify the major risks, values, and fishery objectives from the perspectives of the participants present. Additionally, for the in-person workshops, we conducted graphing exercises where participants were asked to draw trends over time (e.g., yearly changes in abundance) or over seasonal cycles (e.g., the importance of different species during months of the year).

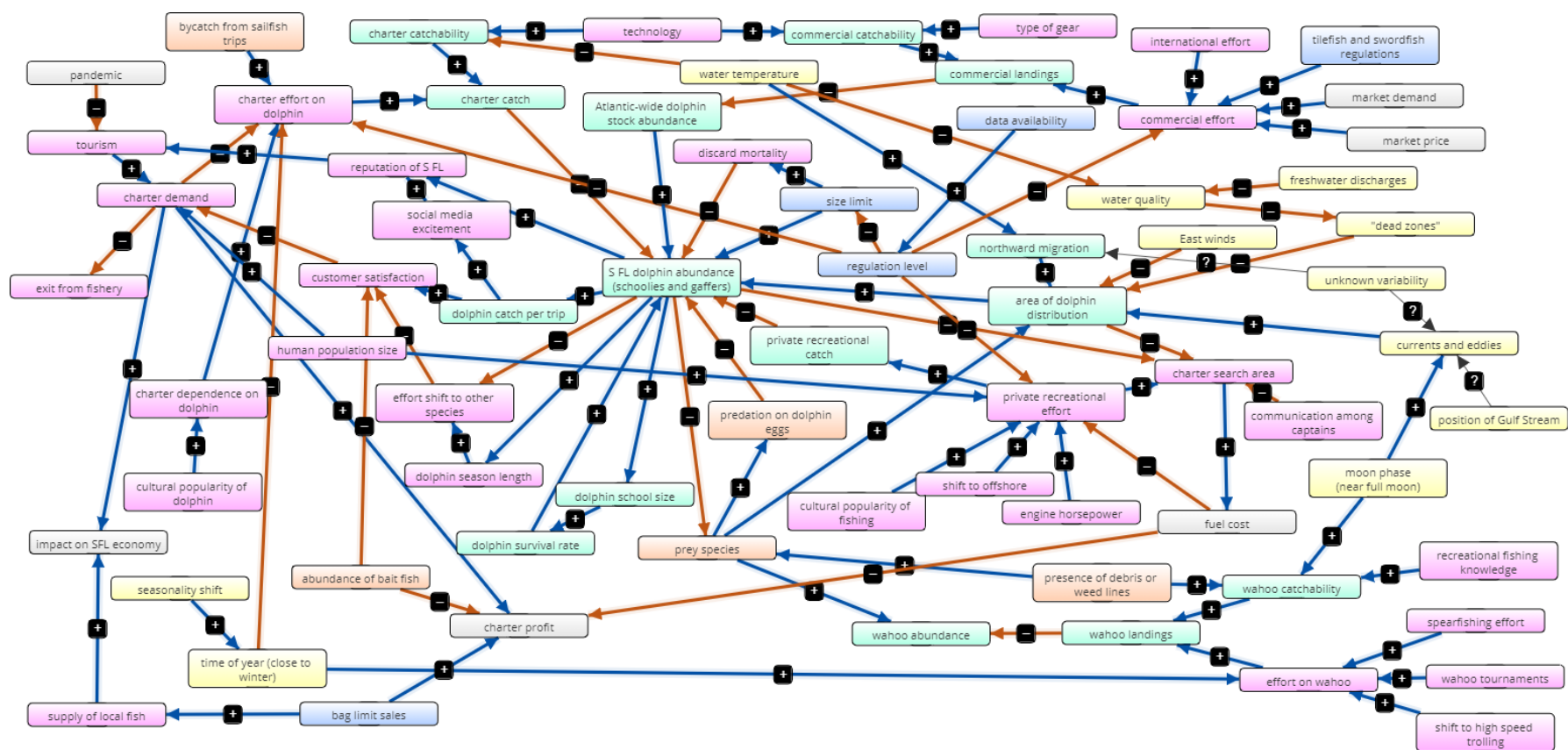


Figure 1. Example of a conceptual model built from combined stakeholder perceptions for South Florida for-hire (eight individuals) and private (four individuals) recreational fishermen. Yellow boxes denote physical drivers, orange boxes denote biological drivers, green boxes denote dolphin and wahoo population dynamics, pink boxes denote social factors, blue boxes denote regulatory factors, and white boxes denote economic factors.

Detailed notes were taken for both the group and individual meetings to document the discussions, which provided a rich body of information that could be compared across subregions about the local context, the importance of particular factors, the causal relationships between factors, points of agreement and disagreement and information gaps. The major findings from each subregion are summarized below. More detailed descriptions of the findings can also be found online in the interactive conceptual models for [South Florida](#) and [North Carolina/Virginia](#).

Results

The conceptual models in both subregions were heavily focused on the concept of local abundance of dolphin, or the portion of the stock that was available to the fishery as it was migrating through the area. Factors that influenced this local abundance generally fell into six categories: (1) the overall Atlantic dolphin stock abundance, (2) environmental factors impacting migratory patterns, (3) local habitat features/environmental conditions driving the area of distribution, (4) local and foreign commercial fishing pressure, (5) regulations on other species, and (6) local charter and private recreational effort (Figure 1). In turn, the local abundance of dolphin (or lack thereof) had downstream effects on the charter businesses, local economies, and effort shifts to other species. Though the models differed among sub-regions with regard to the specific drivers and impacts, the overall model structure was largely similar.

The major themes that emerged from the workshop findings are as follows; each of these is expanded on in further detail below.

- There was a heavy emphasis on social and economic dimensions of the fishery and relatively little knowledge of biological stock drivers.
- There were some shared drivers of dolphin and wahoo, but the two species play different roles in the fisheries and were modeled separately.
- There was considerable variation among the sub-regions with regard to the role of dolphin in fishing portfolios and effort shifts among the local fisheries.
- Seasonality in the availability of different size classes is important for dolphin and wahoo fisheries.
- There are sub-regional impacts of dolphin bag limits on consumer satisfaction in the recreational fishery (meat vs. sport fishing differences).
- Imports and foreign catch levels are important for driving prices and demand in the commercial fishery.
- There are perceived conflicts at local (e.g., Wanchese, NC) and regional (e.g., Florida vs. North Carolina) levels.
- There are widespread concerns regarding private recreational effort and accountability.

Heavy emphasis on social and economic dimensions and limited knowledge of biological stock drivers

Workshop participants spent relatively little time discussing physical and biological drivers of the stock; the conceptual models were largely focused on the social and economic elements of the fishery. This reflects not only the high importance of the species to the local businesses and economies, but also the migratory nature of the stock and the general lack of knowledge on what happens to the portion of the stock that migrates out of the SAFMC jurisdiction. Workshop participants identified international fishing pressure and unknown environmental variability as drivers of the overall Atlantic-wide stock, and noted that there are large fluctuations in the availability of dolphin from year to year; however, there was little speculation on what exactly causes these fluctuations. In contrast, with respect to drivers of local distribution, workshop participants across the region agreed on a key set of factors: temperature breaks, Gulf stream eddies, *Sargassum* or “weedlines”, and the presence of bait fish.

There was more elaborate discussion of these localized factors in Florida, particularly with respect to a perceived absence of large dolphin in recent years. Many participants agreed that while the physical and biological conditions were still ripe for dolphin, the fish were simply absent; i.e., there were many weedlines filled with baitfish but absent of dolphin. Many Florida fishermen noted that weedlines had excessive amounts of prey and surmised that this was due to a lack of dolphin and reduced predation. Several fishermen hypothesized that temperature or other physical factors were a driver behind the recent paucity of dolphin in these otherwise suitable habitats. Most participants in South Florida also noted that this decrease in large dolphin abundance is a relatively recent phenomenon that occurred approximately within the last 5 to 10 years (Table 2).

The observations regarding the sudden disappearance of large dolphin were unique to Florida; participants in North Carolina and Virginia noted some more subtle changes in migration patterns. Some fishermen in the Beaufort area perceived a gradual decrease in abundance, and fishermen in Wanchese perceived changes in seasonal availability; participants perceived that dolphin were migrating to the area earlier and hanging around for longer in the year, which led to increased availability of dolphin in the fall in recent years. Some participants in North Carolina also noted an anomalous pulse of smaller “bailer” size dolphin in recent years, but had no explanation for this phenomenon. Florida fishermen also discussed changing seasonality of dolphin in their area, noting that months of elevated abundance were shifting from summer to fall.

Table 2. Perceptions of change in abundance over time according to the workshop participants in each area.

Area ¹	Dolphin	Wahoo
Virginia Beach, VA	No change	No change
Beaufort, NC	Gradual decrease in this area, but large dolphin appearing north of Cape Hatteras in the last 5-6 years	Increasing
South FL and FL Keys	Major decrease in abundance and size starting 5-10 years ago	No change

¹ Observations from Wanchese, NC are not available as workshop time was spent on discussion of other topics of interest.

Dolphin versus wahoo

Although the workshops were intended to be focused on both dolphin and wahoo, the vast majority of the discussion revolved around dolphin. Wahoo was not linked to most of the dolphin conceptual models, except that there was some overlap in participants targeting both species. Wahoo was described by recreational fishermen as a trophy species with a small niche requiring specialized gear and high levels of experience in order to target. In North Carolina and Virginia, wahoo is primarily important in the shoulder seasons (spring and fall) when other primary target species are largely unavailable. In Beaufort and Virginia Beach it was noted that during some parts of the year, wahoo are exclusively targeted, and there were concerns that any reductions in trip limits would impact charter fishermen at this time of year as customers would be hesitant to spend money for only a single wahoo per person. It is also important to note that at the time the workshops were conducted, the Council was not considering reducing the bag limits on wahoo; had this consideration been made earlier, it is possible workshop participants would have been more vocal on the issue. In Florida, there was concern expressed by fishermen regarding increasing levels of spearfishing activity, as well as an increase in high-speed trolling, both of which were hypothesized to negatively impact the wahoo stock. The species was perceived to be of little to no importance to the commercial sector, although in recent years the fleet has gotten closer to reaching the annual catch limit.

High variation in dolphin fishery at local levels

Our participatory modeling method revealed a wide variation in dependence on dolphin over a limited geographic range. Based on the initial project conception, we had expected significant differences between Florida and North Carolina/Virginia; however, we found some striking differences in the roles of the species even within these sub-regions. Dependence on

both dolphin and wahoo, as well as the seasonality in the dependence, differs across the three locations studied in North Carolina/Virginia (Figure 2). Dolphin is an important species in the for-hire sector across the entire area, but it is a keystone species in Wanchese and Beaufort and a secondary species in Virginia Beach. In Virginia Beach and Wanchese, there was the perception that the availability of tuna (in particular yellowfin tuna) affects overall effort on dolphin. Virginia Beach for-hire captains indicated that dolphin were not customers' primary target species for most trips, but catching dolphin during the trip led to higher customer satisfaction, particularly when tuna and billfishes were not available. On the Florida mainland, the charter fishery was described as targeting a diverse portfolio with dolphin being targeted opportunistically, whereas in the Florida Keys many trips were targeting dolphin as a primary species. Commercial fisheries for dolphin were present in Beaufort and Wanchese but not Virginia Beach, and in Florida only a small-scale local commercial fishery exists. We note that we had relatively little representation from the private recreational sector, particularly in North Carolina and Virginia; more representation from this sector could have influenced the results.

Dolphin (and wahoo to a lesser extent) are part of a diverse portfolio for both commercial and for-hire sectors, but its specific role varies significantly across the region. In South Florida, dolphin plays both a direct and indirect economic role in local communities from Palm Beach to Key West. Although a wide diversity of species are targeted, dolphin or "mahi mahi" has become a unique symbol of the region. Images of colorful, jumping dolphin are a ubiquitous presence on t-shirts, license plates, and marketing materials for the region. Not coincidentally, there is also high tourist demand to catch and eat dolphin as part of the regional experience but typically not to fill freezers at home with large quantities of harvested fish. In contrast, in North Carolina tourists tend to be more local and the dolphin fishery is often considered to be more of a meat fishery than a sport fishery.

In Florida, workshop participants reported that there has been a recent scarcity of dolphin that has resulted in effort increases by recreational fishermen on other species, particularly snapper-grouper species. In North Carolina and Virginia, there are also perceived effort shifts vis-a-vis dolphin that vary across the sub-region. In Beaufort, a decline in tuna availability is perceived to have led to increased targeting of dolphin and wahoo and participants felt that any restrictions on dolphin and wahoo would lead to effort shifting onto snapper-grouper species; notably this complex is targeted at a similar time of year as dolphin (Figure 2). Further north, the main targeted species offshore are tunas, billfish and sharks, and dolphin are caught more opportunistically. There is high dependence on dolphin in Wanchese as compared to other areas, which is partially a function of the ocean dynamics and the mix of species available.

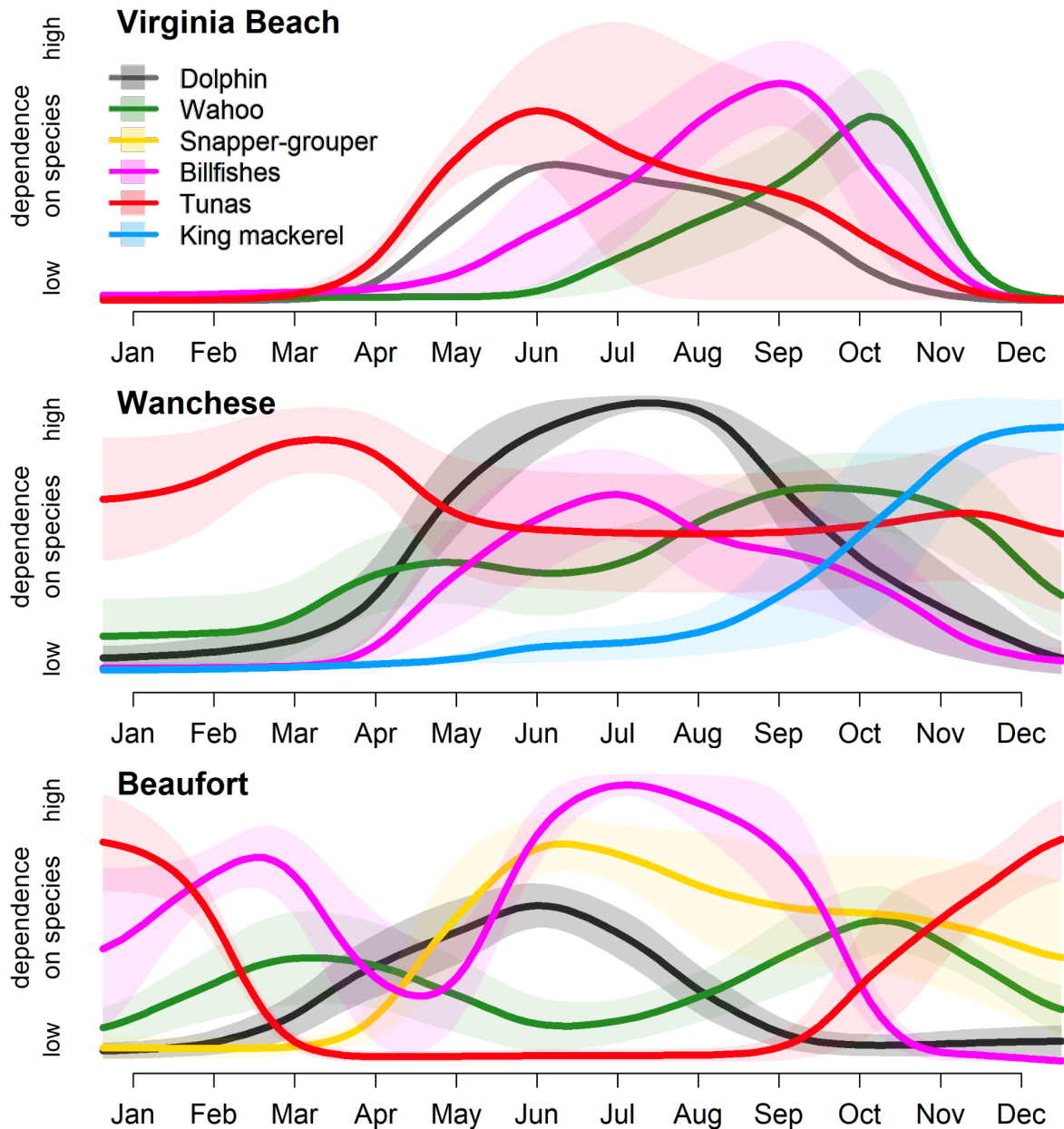


Figure 2. Monthly dependence values averaged across charter fishermen ± 1 S.E. Shown are species where there were at least two independent trend lines drawn (with the exception of dolphin for Virginia Beach which was only drawn by one participant but shown regardless).

Comparing historical and present-day commercial dependency elucidates some of the shifts that have occurred. In North Carolina, workshop participants felt that targeting of dolphin by the commercial sector has increased due to increased restrictions on blueline tilefish, tunas being less available in the region due primarily to increases in international effort, and increased

restrictions on sharks. According to workshop participant input, tilefishes, tunas, and sharks were the 3 major species being targeted by the commercial fleet 10 years ago, and when these species became less available some of the effort shifted to dolphin (Figure 3). The present day commercial sector is now focused on fewer species compared to 10 years ago, suggesting these shifts may be part of a trend where regulatory effects are leading to increased concentration within the commercial sector.

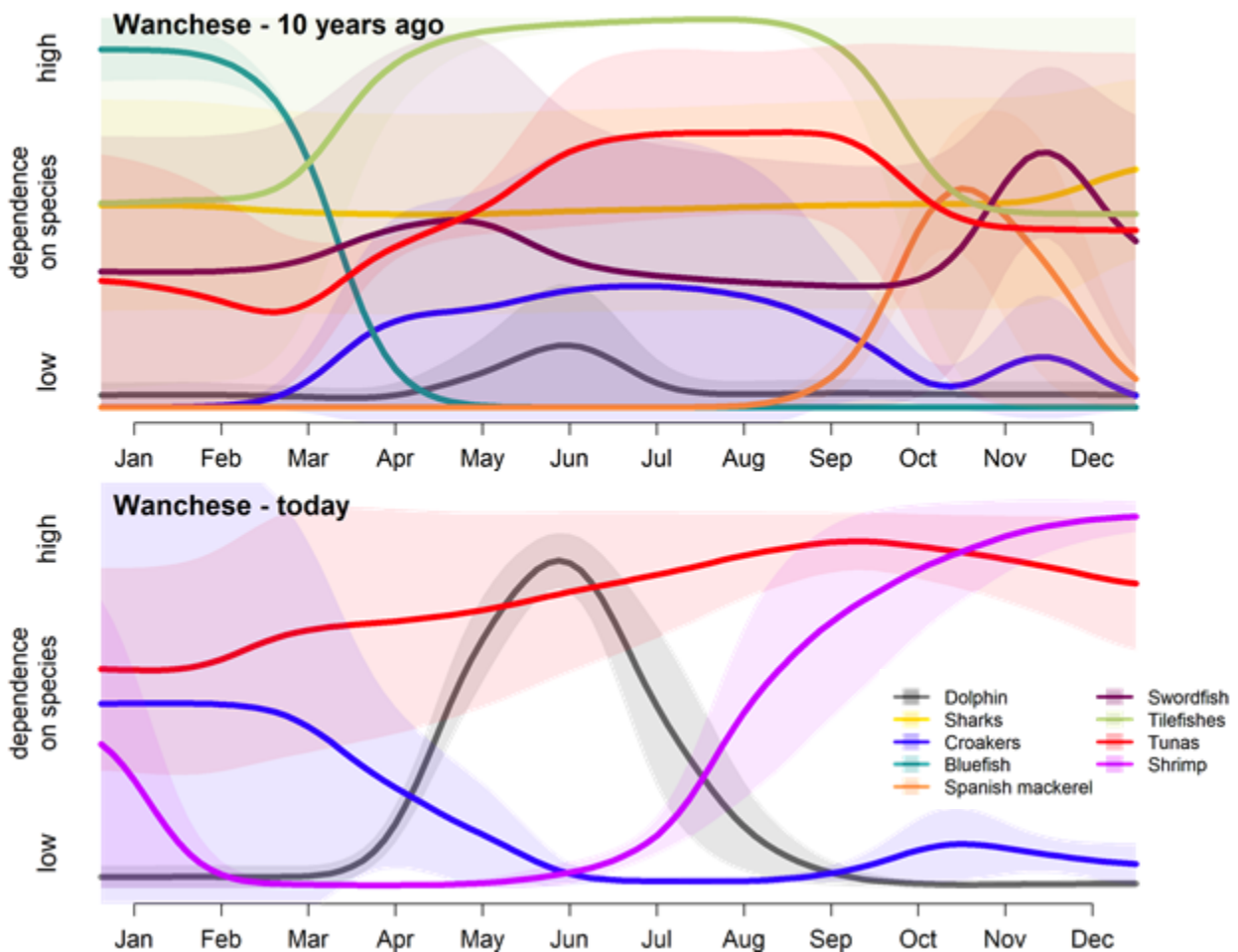


Figure 3. Monthly dependence values averaged across commercial fishermen ± 1 S.E., for historical dependency (top) and present day dependency (bottom). Shown are species where there were at least two independent trend lines drawn.

Importance of seasonality and fish size for dolphin and wahoo fisheries

Dolphin and wahoo migrate through the region at different times of the year and the seasonality is a very important factor for optimizing catch and profits. Large “gaffer” dolphin

tend to migrate through in the late spring and early summer, and wahoo are more available during the shoulder seasons (spring and fall; Figure 2). For dolphin, there is thus a relationship between the seasonality and the size of the fish that are available. In Beaufort, there was some concern over size limits due to the seasonal availability of dolphin of certain size classes; essentially a size limit would amount to a reduced season. In Wanchese, the migration of large dolphin through the area was perceived to be important to the charter fishery, as they are targeted and increase customer satisfaction. Size limits would impact the ability of for-hire captains to satisfy the expectations of their clients to bring home a reasonable number of fish, particularly later in the season when smaller dolphin are typically present.

In Florida, recreational fishermen noted a paucity of large dolphin in recent years, but small dolphin can be found throughout much of the year. Many captains were in favor of increasing the size limit with the thinking that some of the smaller dolphin would be allowed to grow and then be available to the fishery later in the year. Given the recent scarcity of dolphin, there was also the mindset that the spawning stock needed protection and that the size limit should be increased to allow smaller fish to contribute eggs to the population. However, not all fishermen were in agreement; some felt that size limits would make little difference to the population and noted that the discard mortality of dolphin is very high.

Impact of dolphin bag limits on consumer satisfaction in the recreational fishery

There were major perceived differences regarding the impact of dolphin bag limits in North Carolina and Virginia versus Florida, and this seemed to be attributed primarily to differences in the nature of tourism in these areas. In North Carolina, the recreational fishery was described as a “meat fishery.” Tourists are more frequently from the area, they arrive in vehicles with coolers, and have an expectation of taking home large amounts of catch. This expectation may also partially stem from the fact that fishing grounds are relatively far from shore, and thus trips tend to be longer and more expensive (Table 3). In North Carolina, for-hire fishermen in particular were very averse to a decrease in vessel and bag limits, noting that while the current bag limits were not usually caught, simply marketing the possibility of large catches was important to their businesses.

On the other hand, Florida tourism was described as being more of a sport fishery; customers are more frequently from outside of the region, they arrive in airplanes, and stay in hotels. Most Florida for-hire customers therefore are not typically expecting to keep more catch than what they can eat directly after the trip. The expectation of lower harvest is also made acceptable by the fact that fishing grounds are generally much closer to the coast and many fishing trips are relatively short ($\frac{1}{2}$ day) and inexpensive in comparison to those taken farther north. Consequently, many Florida for-hire fishermen were supportive of stricter vessel and bag limits, noting that they were rarely (if ever) attained and citing serious concerns about the scarcity of dolphin in recent years.

Table 3. Dolphin targeting trip characteristics based on MRIP intercept surveys.

	Florida	North Carolina
Average charter trip duration	(Not reported)	10.26 hours
Average hours fished	4.7 hours	6.7 hours
% of trips >3mi offshore	78%	99%

Importance of imports and foreign catch on commercial prices and demand

The workshops highlighted the fact that there is a commercial dolphin fishery off the coast of North Carolina. This dolphin fishery is relatively small by global standards and it is not one of the major commercial fisheries in the South Atlantic region. However, workshop participants in North Carolina emphasized the economic importance of the species particularly at the local and sub-regional scales. The fishery is highly seasonal, with the vast majority of landings taking place by longliners in May and June. The overall catch of dolphin in the U.S. Atlantic Exclusive Economic Zone (EEZ) is minimal relative to overall imports, the vast majority of which come from the Pacific Ocean. The market price for dolphin is therefore highly dependent on global supply and the import price. Workshop participants in Wanchese expressed the concern that the import price for dolphin depressed the price for local fish. There was considerable debate in the North Carolina workshops about the impact of foreign fleet landings; in particular, participants expressed a concern that increased commercial effort in the wider Caribbean and Atlantic off the northern coast of South America could be impacting local dolphin abundance and prices. However, the workshop highlighted that local stakeholders have relatively little information about both how the global markets for dolphin function and trends related to recreational and commercial effort for dolphin outside of the EEZ.

In comparison to North Carolina, South Florida only has a very small local commercial dolphin fishery. In the past, the commercial fishery in this area largely depended on the sales of excess catch from dolphin charter trips to restaurants but this practice was prohibited approximately 10 years ago. Some workshop participants noted that this prohibition has had a negative economic impact on the local charter fleet since these sales were an important additional source of income. Furthermore, they expressed concern that the quality of dolphin in local restaurants had decreased since these restaurants now have to sell largely imported dolphin. Currently, locally landed dolphin continue to be sold in a sporadic fashion in small amounts to local dealers. Some suggested that there may still be informal sales of excess fish by some charter captains. There are also some commercial fishermen that catch dolphin opportunistically and sell to local dealers. Many South Florida modeling participants expressed a strong concern that increased commercial effort in the Caribbean as well as in North Carolina could be impacting local abundance of dolphin. However, as in North Carolina these comments were

more speculative, and stakeholders had little specific information about trends in effort outside of their local area.

Perceived conflicts at local and sub-regional levels

Multiple conflicts emerged in the course of the participatory modeling process, mostly in relation to the use of the species and perceived depletion of the locally available stock by one sector or subregion. Concerns regarding the impacts of longlining on the dolphin population emerged and were most prominent in Beaufort and Wanchese, as well as Florida. In North Carolina the conflicts appeared to stem from localized usage over particular size classes; for example, there was the sentiment that targeting of large dolphin by longliners made them less available to the for-hire industry and impacted the charter businesses. There was the sentiment that these conflicts had worsened in recent years. Additionally there was conflict between commercial fishermen with different permit types. Vessels that only have a commercial dolphin-wahoo permit but not an Highly Migratory Species (HMS) Pelagic Longline permit (i.e. “Council boats”) are allowed to fish longline gear in the same areas as the HMS permitted vessels but do not have to abide by the extensive HMS regulations (e.g., minimum hook size, mandated use of circle hooks and non-stainless steel hooks, minimum ganglion length, maximum longline length, and protected resource related training requirements). There were also concerns expressed about the lack of regulations and open access nature of the dolphin-wahoo permit fishery.

The perception that longlining was causing depletion of the dolphin stock is difficult to reconcile with the overall decline in longline boats in the South Atlantic and the commercial catch as a whole being a relatively small proportion of the total (~5% of total catch in the SAFMC jurisdiction from 2000-2020). There were several factors highlighted that could contribute to a perceived increase in localized effort, or a constriction of fishing areas. These factors include: 1) changes in the Gulf Stream and/or *Sargassum* habitat, which changes the distribution of pelagics within the region, 2) an increase in shark abundance, which compresses the area where longline gear can feasibly be set, 3) shifting effort in some parts of the commercial fleet as a result of blueline tilefish regulations, reduction in tuna availability, and increasing market price for dolphin, and 4) the open access nature of the “Council boat” fishery which could allow for new entrants. Because the factors influencing commercial and recreational usage of dolphin are highly variable in space and time, it is possible that there has been an increased concentration of effort and local depletion of dolphin at small scales that is not reflected in the overall effort or catch for the South Atlantic region.

In Florida, the major conflict appeared to stem from the apparent scarcity of dolphin in the sub-region, which was perceived to have worsened in approximately the last 5 - 10 years. South Florida and Florida Keys fishermen presented a number of competing (but not mutually exclusive) hypotheses to explain these perceived declines, including: environmentally driven changes in the migratory patterns, increases in recreational catch, increased impacts from non-

local longlining activity, lack of regulations, and international effort (upstream in the Caribbean and Central America). There was a widespread perception that the effort and cost required to catch dolphin was increasing in Florida, and major concerns were expressed regarding the impacts of reduced dolphin abundance on South Florida's charter industry. For this reason, fishermen in this sub-region tended to be highly in favor of additional restrictions on the dolphin fishery in particular (Table 4).

Table 4. Differences in opinions and perceived impacts of regulations by sub-region.

Type of regulation	South Florida	North Carolina / Virginia
Bag and vessel limits	Individual bag limit OK, could live with reduction. Tend to support much smaller vessel limit.	Reductions in bag/vessel limit linked to reduced customer satisfaction and decrease in charter demand (Wanchese / Beaufort).
Size limits	Widespread support to increase size limit to increase spawning biomass (some individuals thought size limits would have no impact).	Size limits could shorten season because of availability of size classes and effort would shift to triggerfish and vermilion (Beaufort); no impacts noted in Wanchese or Virginia Beach.
Level of regulation	Generally low regulation levels have allowed increasing effort in private recreational, charter, and commercial sectors.	Lack of data and few regulations have led to unconstrained effort increases in private recreational and commercial sectors.
Effort shifts – commercial	Decrease in local commercial sales of dolphin due to regulations restricting sales by charters.	Increase in pressure on dolphin due to bluefin tilefish and shark regulations, and tuna availability.
Effort shifts – recreational	Effort may be shifting to snapper grouper species due to declines in dolphin population, not regulations.	Reduction in seasonal availability for yellowfin tuna has increased pressure on dolphin and wahoo (Beaufort); availability of tunas affects effort on dolphin (Wanchese / Virginia Beach).

Increased private recreational effort and accountability concerns

Concerns regarding increased recreational effort were apparent throughout the Southeast U.S. region (Table 4). In particular, there were concerns about expansion of private recreational fishing and a lack of regulation, enforcement, and data collection for this sector. Participants expressed concerns not only about a growth in the number of fishermen, but in the power, efficiency, and level of information transfer that makes the realized power of the private recreational fleet even greater. For wahoo, there were concerns in Florida regarding an increase in spearfishing effort. In North Carolina and Virginia, recreational fishing pressure was thought to be shaped by factors such as the level of development, which drives accessibility to the coast, as well as distance from the coast to the fishing grounds. In Florida, the drivers of recreational effort (distance from shore and coastal development) are more homogeneous and fishing pressure is consistently high across the entire region. Rapidly increasing populations in the region also underlie increases in recreational fishing pressure.

Conclusions and Recommendations

The workshops brought to light a number of competing hypotheses regarding the factors driving the overall stock abundance and availability of dolphin to the SAFMC's managed region. Hypotheses were developed regarding a potential shift in physical ocean conditions in the South Florida subregion that could be linked to the sudden perceived absence of large "gaffer" dolphin. Questions were also raised regarding the effects of a potential increase in international commercial fishing effort, in response to the increasing market demand and/or effort shifts from restrictions on other species. Finally, there were widespread concerns regarding the realized effort of the recreational sector, particularly the private recreational sector with respect to increased technology, ability to move offshore, and information transfer. These are examples of priority research questions identified through the participatory method, and are currently being investigated by the SEFSC and its collaborators.

Workshops also elucidated some of the personal values of stakeholders and how this influences the differing roles of the two species in the fisheries. In Florida, dolphin (and to a lesser extent wahoo) are highly prized, charismatic sport fish species, and captains tended to support higher levels of regulations. In North Carolina and Virginia, dolphin are regarded as an important meat fishery and sending customers home with full coolers is an important aspect of the fishery, particularly during times of the year when other species (e.g. tunas) are unavailable. The fact that individual fishermen have different values presents a challenge for management, as there are divergent end goals across the region. Furthermore, any given management action will have different impacts depending on the area; this scenario presents a need to consider the impacts of management at the subregional level.

The conceptual models were largely focused on the issue of localized dolphin abundance and highlighted the fact that many of the factors impacting the overall Atlantic stock abundance

(environment, international fishing pressure) are out of SAFMC management control. The focus of recent management actions, and discussions over setting annual catch limits are largely carried out with the intention of protecting spawning stock and ensuring sustainable harvest. However, the conceptual models indicated that the focus and sources of conflict in the fishery relate to usage at small spatial scales, competition between sectors and/or within sectors, and the potential for localized depletion. Resolving conflict at local scales is well within the SAFMC's power but requires a separate set of tools and thought processes, in contrast to maintaining a viable population through non-spatial annual catch limits. Therefore it would be beneficial if management measures make a clear distinction between actions intended to ensure sustainable harvest at the overall stock level and actions intended to address local conflicts within the SAFMC managed region. Clarifying these end goals would help align stakeholder expectations with management outcomes.

There are several unique aspects to dolphin and wahoo fisheries discussed above: stakeholder values differ across the region, many impacts on the stock are out of management control, and the species are not amenable to traditional stock assessment, given the limited data, rapid growth, and lack of a spawner-recruit relationship for the region or the larger stock. Such a situation necessitates the use of alternative tools, such as Management Strategy Evaluation (MSE), to determine viable management actions. MSEs are simulation approaches designed to build or test management procedures (MPs) that maximize management objectives and are robust to a suite of current and future biological, environmental, fishery, and any other relevant uncertainties. Stakeholder input is considered best practice within MSEs to develop fishery-specific management objectives and to identify the full scope of uncertainties about the population and fishery dynamics. Accordingly, these participatory workshops highlighted the uncertainties regarding stock drivers and the diverse sub-regionally variable end goals within the dolphin and wahoo fishery. For short-lived species whose productivity is largely environmentally driven, empirical (or indicator-based) MPs may be a more appropriate mechanism to generate catch advice compared to more traditional model-based (e.g., stock assessment-based) MPs. Empirical MPs rely on an indicator of stock status (e.g., index of abundance) to adjust total allowable catch advice, and have the flexibility to incorporate climatic or environmental drivers of regional abundance and/or local availability. However, empirical MPs require thorough testing prior to application in practice. We recommend that an MSE exercise be carried out to create and explore the performance of an empirical MP for management of dolphin and wahoo within the SAFMC's management region.

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References

- Hovmand, Peter S. (2014). Community based system dynamics. Springer, NY. 104 pp.
- Jones, N. A., Perez, P., Measham, T. G., Kelly, G. J., d'Aquino, P., et al. (2009). Evaluating participatory modeling: developing a framework for cross-case analysis. Environmental Management, Springer Verlag (Germany), 44 (6), pp.1180-1195.