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Local ecological knowledge outlining severe red tide events between 2000 – 2019 on the West Florida Shelf

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Introduction

During a series of summer 2018 workshops led by the Southeast Fisheries Science Center with stakeholders on the southwest Florida coast, serious concerns were highlighted regarding the multifaceted impacts of red tide (also referred to as harmful algal blooms or HAB). In addition to the obvious fish kills and water quality issues, stakeholders have observed extensive habitat damage related to red tide and have noted that recovery of fish populations has been increasingly delayed following recent and frequent red tides. Red tides are impacting not only the fish populations that commercial and for-hire fishing businesses are dependent upon, but other aspects of the fishing communities such as aquaculture activities, private recreational fishing, tourism visitation, local seafood markets, and real estate values. Through these additive and potentially synergistic effects, red tides can have far-reaching impacts on coastal communities.

In response to these concerns, an initiative was put into place to systematically explore local ecological knowledge (LEK) regarding red tides with individual fishermen, using oral history and participatory mapping approaches. Goals of the LEK were to: 1) document red tide locations, frequency and severity over time and space, 2) document impressions of how red tides/blooms develop and their impact on different fish populations and habitats in the short and long-term, 3) identify possible ecological signals and stakeholder-driven hypotheses of red tide event occurrence and severity, and 4) document the adaptation strategies fishermen have employed in the face of red tide events over time and any changes to those strategies. Relevant information was extracted from each of the oral histories and was quantified to compare the recent 2017-2018 event to previous events in terms of severity, recovery time, temporal extent and species killed. This working paper is an update to a working paper submitted for SEDAR 61 (Karnauskas et al. 2019). The major difference between working papers is this paper includes the complete notes from all interviews, as well as interviews from the panhandle of Florida.

Methods

Oral history and participatory mapping process

We identified key fishing communities along the southern Gulf Coast of Florida that had historically experienced relatively high commercial landings or for-hire fishing activities as well as red tide events. We reached out to community members and other stakeholders to identify key informants from these communities to participate in red tide oral history interviews. Key informants are current or retired commercial and for-hire fishermen with extensive time and experience fishing in state and federal waters along the Florida Gulf Coast. In the oral history interviews, these fishermen were asked to discuss the major red tide events that they had experienced during their fishing careers and how these had affected their fishing activities, livelihoods and the marine environment. During the interviews, fishermen also discussed the history of their own fishing practices and fishing communities and how these have changed over time.

An important subcomponent of the oral histories was a participatory mapping activity in which the fishermen were asked to draw the spatial extent of red tide events they had witnessed on nautical charts. They were also asked to describe, based on their best recollection, the biological and socio-economic impacts of each red tide event they identified on the maps including the following: 1) the exact year (or approximate dates) in which the event occurred; 2) the impacts on fish and marine life they witnessed; 3) the duration and severity of the event; 4) the recuperation time of the affected fisheries and habitat; 5) the ways that these events affected their fishing practices and livelihoods; 6) survival strategies; 7) health impacts and 8) impacts on overall community well-being.

Scientists from both the Southeast Fisheries Science Center and the Southeast Regional Office conducted the interviews. The interviews were conducted by a social scientist working in tandem with a fisheries biologist or ecologist. The interdisciplinary approach ensured the full breadth of questions and clarifications were asked to obtain relevant information on both biological and socio-economic impacts and helped generate observations about the interconnections between natural and socio-economic systems. Using two interviewers also allowed for a division of labor, with one asking questions and the other taking notes. All of the interviews were recorded, and waivers were obtained from fishermen so that the recordings can eventually be added to the NMFS Voices from the Fisheries oral history collection (https://www.voices.nmfs.noaa.gov).

Researchers did not identify a specific number of interviews to be conducted in each community during the planning phase of the project. Rather, interviews in each community continued until researchers felt each subsequent interview was providing largely redundant information regarding major red tide events in that area.

Derivation of information from oral history recordings

Information relevant to the severity of the red tide events was extracted from the interviews, via notes taken during the interview process and, when necessary, going back to the interview recordings to clarify remarks. The information was put into a spreadsheet format, where each row represents a specific red tide event in a particular year, by a given individual. When approximate dates were given to describe the timing of an event, a best estimate was used (e.g., “about 50 years ago” was assumed to be the year 1969 for the purposes of plotting and analysis). References to extended periods or cyclical trends (e.g., “every two to four years,” “getting worse over the last ten years”) were excluded from the analysis. For each individual event, we made note of commentaries concerning the overall scale of the event, how long the event lasted, the spatial scale of the event, species affected by the event, species and fishing areas not affected by the event, and recovery time after the event. Descriptions of temporal aspects of the blooms, in terms of how long the event lasted, and the recovery of the system after the event, were typically given in months or years and were standardized to a common unit. Species affected by different red tide events were typically given in extensive lists which were analyzed by categorizing species mentioned into commercially or ecologically relevant species groups. Due to the uncertain nature of common names broad categories were used in the analyses (e.g., the grouper category includes all species of grouper). Additionally, we grouped taxa such as barnacles, clam, conch, coral, gorgonian, mussels, sponge, whelk, sea fan, and seagrass into a benthic category. And the bait fish category includes taxa such as threadfin herring, Spanish sardine, needlefish, and pilchards. The audio from all the interviews were transcribed and turned into a searchable database. The key words “grouper” and “gag” were used to extract segments of the transcripts.

Results

A total of 64 oral history interviews had been transcribed in communities located on the southwest Florida coast (Figure 1). The 57 interviewees identified and described a combined 214 notable red tide events, 205 of which were tied to specific years (or specific time periods, in the case of blooms spanning multiple years in duration).

Across interviews, three exceptional red tide events were consistently identified by fishermen in the past 20 years: 2005, 2014, and 2018 (Figure 2). During the interviews, the 2005 event was mentioned 20 times (23 times +/- one year), 2014 was mentioned 10 times (22 times +/- one year), and 2018 was mentioned 55 times (58 times +/- one year). Some leeway for misremembering years of events was taken into account by including the number of mentions plus or minus one year. These three years were the most memorable across all interviews conducted. Other consistently identified events included the early 1970s, mid-1980s, and the late 1990s. However, these earlier events were identified by fewer numbers of participants, and for the purpose of summary and analysis in the present paper, events prior to 2000 were not included. Generally, patterns of the three exceptional events did not differ among the home residence of the interviewee, and descriptions of the timing of events were consistent across the different communities, however, there were notable differences. Bay County interviews only mentioned the 2018 event, Taylor County interviewees did not mention the 2018 event, and Sarasota interviewees did not mention the 2014 event (Figure 3).

Overall event intensity was categorized on a 3-part scale (minor, major, devastating) based on general descriptions or terms used to describe the events, as specified in Table 1. For the 2018 event, the vast majority of interviewees (85%) described the event as "devastating" or "major." This is in contrast to lower percentages (60%) of "major" or "devastating" designations for both 2005 and 2014 events (Figure 2). However, the overall severity designations for all bloom events do not differ based on the county of residence of the interviewee (Figure 4), and there do not appear to be regional trends in the rankings of severity across time (Figure 5). The 2005 and 2018 red tide events have similar spatial footprints based on the Florida's Fish and Wildlife Research Institute (FWRI) HAB database, with many high cell counts stretching from Marco Island up to the Tampa Bay area for a significant period. This spatial domain has been extensively covered by the interviews, which should allow for robust comparisons between the 2005 and 2018 events as they would not be biased by the locations of the interviews. By contrast, the 2014 was more limited in geographic scope with the majority of the red tide bloom concentrated offshore between Tampa Bay and the Big Bend region according to the HAB database. The interviewees reported the 2014 event affecting the offshore region more often (30% of the responses) compared to either 2005 (20%) or 2018 (14%), but the 2018 event was more frequently described as affecting both the inshore and offshore (Figure 6). When considered by county, the offshore regions were more likely to be affected in the Big Bend area extending toward Tampa Bay, while the inshore was more likely to be affected from Tampa Bay extending southward (Figure 7). This regional perspective is supported by the HAB database, but it is unknown to what extent this is biased by interviewee participation, preferred fishing locations, or the HAB sampling methods.

Of the 214 events described, 157 had accounts of species-specific fish kills, and grouper had the greatest number of mentions (53 times). Drums and crabs were the next most commonly mentioned species (48 and 27 times, respectively, Table 2). Most frequently, fishermen used the general family name "grouper" in their indications of fish species killed; where specific species names were used, goliath grouper was the most commonly cited (18 events), followed by gag and red grouper (11 mentions each) and black grouper (3 mentions). The highest proportion of grouper mentions occurred in the 2014 event (20% of all species-specific fish kill mentions), followed by the 2018 event (13%, Figure 8). Of the 17 species-specific mortality descriptions for the 2005 event, just less than one-third (5) mentioned seeing mortalities of grouper species. Other economically important species were mentioned six times or less and were not included in Table 2 or Figure 8. These included flounders mentioned 6 times only in 2018, shrimp mentioned 5 times only in 2018, cobia and mackerel, both mentioned once in 2014 and again in 2018, and triggerfish only mentioned once in 2014.

Overall, the most recent 2018 event was perceived to have lasted longer than previous events (Figure 9). On average, the estimated temporal extent of the 2018 event was 9.7 months (standard deviation 5.9), compared to less than 1.7 months (standard deviation 1.3) for the 2014 event and 6.3 months (standard deviation 5.8) for the 2005 event. Additionally, interviewees in some cases described the recovery time of the ecosystem following an exceptional red tide event (Figure 10). Of note, some individuals felt that the ecosystem had still not recovered following the 2005 and 2014 red tide events. The vast majority (89%) of interviewees felt that the ecosystem had not recovered following the 2018 red tide event.

The interview transcripts were searched for mentions of major changes to the fishery including changes to catchability. One fisher out of Madeira Beach described gear configuration changes around 2003-4 and how it affected their landings: "*I'd be gone for 10 or 12 days, I'd have 3500 pounds of red grouper and 1000 or 1200 [lbs.] gags. … I switched to the long leaders… and then I was coming home with 4000 [lbs.] gags and 3000 [lbs.] red groupers. And I wasn't the only one doing it."* This was part of a bigger discussion about the apparent decrease in gag landings in the later part of the 2000s.

Another fisher out of Steinhatchee, Florida talked about how the 2014 red tide event affected the grouper-snapper fishery and catchability. The red tide moved from the north near the Middle Grounds and pushed multiple species of groupers and snappers southward. *"…It appeared that the [red] tide was moving from the north. So I started actually working to the north on various spots of structure that I normally have fished for years. … But this was just like, wait a minute, there's not supposed to be this many red grouper on a spot."* Aggregations of fishes likely appeared as displaced fishes escaping the red tide encountered resident fishes allowing the interviewee to catch much of their quota in a short amount of time. *"But when we moved into that 2014 red tide… the fish were so stacked up on the bottom… by, say, eleven o'clock in the morning on the second day, I had three thousand pounds of fish in the box… now, mind you, I averaged about five thousand [lbs.] a year."* The fisher continued to fish like this for 3-4 more trips over three weeks before bad weather caused them to remain in port. When the weather cleared and they returned to the Middle Grounds, other fishers had heard about the increased catch per unit effort and had then started to fish the area.

Discussion

Red tide severity has previously been quantified and used in the assessment framework (Walter et al. 2013). This index is currently being updated and will provide insights as to the severity of the red tide events in different time periods (Sagarese et al. 2018). However, the LEK approach lends additional insights into the impacts of red tides on fish populations that may not be fully represented in the satellite data. The satellite-derived index is tuned to *Karenia brevis* count data compiled by FWRI, which are generally collected onshore and have limited coverage in offshore areas. Thus, the satellite index may not be fully representative of offshore blooms, and the satellite imagery is of limited use in nearshore waters due to confounding with land-based inputs. Additionally, the satellite data and the FWRI count data can only give instantaneous snapshots of the bloom status, but do not inform the larger ecosystem impacts of the bloom, such as species mortality, habitat loss, or ecosystem recovery. Finally, there are potential side effects of red tide that may have a significant influence on the ecosystem but that would not be reflected in the satellite data or cell count data. For example, there is evidence that some years of severe red tide are associated with hypoxia (Driggers et al. 2016, Turley et al, 2021), which may in itself contribute to fish mortality.

Besides the question of red tide severity, the LEK approach can yield additional insights useful for assessment and management. A major information gap from the stock assessment perspective is understanding the species and age composition of red tide-induced mortality. Generally, fishermen conveyed the perception that red tide effects on grouper populations are not discriminatory and that all age classes of the stocks are affected equally. These insights help to validate the current assumption and methods employed for the stock assessment, in which episodic mortality is applied equally to all age classes. Additionally, to date, red tide mortality has been modeled in stock assessments as an immediate effect (i.e., mortality is assumed to occur in the year of the red tide event with no lagged effects.) However, local observations point toward potential habitat loss and slowing recovery rates of populations subsequent to red tide events, which has potential implications for assessment and rebuilding plans.

The LEK approach also provides information related to how fishermen shift their effort in response to red tide events. Fishermen generally reported that in the past, red tides were regular occurrences in the region and that they were able to fish through and around shorter and/or patchier events. However, to survive the more recent severe events, fishermen often have to shift their fishing locations to avoid red tide, frequently having to make costly trips to areas that are distant from their normal fishing grounds. They may try to target different species or shift into charter fishing. Many reported having to stop fishing to find alternative employment or quit fishing all together, and these reports were particularly prevalent for the 2018 event -- a number of interviewees had very recently gone out of business. The interviews suggest that managers may be able to increase the resilience of the fishing industry by facilitating access to appropriate substitute species and adopting other strategies that can help fishermen stay in business during severe red tide events.

Oral histories rely heavily on memory and thus the accuracy of individual interviews may be affected by factors like subject recall limitation and recency bias. Studies indicate that requesting information in chronological sequence can help facilitate informants' memories of events. Furthermore, the kinds of events that are likely to endure in memory are those that are highly emotional at the time, perceived as turning points or relatively unique (Hoffman and Hoffman 1994). Asking our informants to recall red tide events in chronological order and associate their memories with impacts on their fishing businesses and families provided cues to help them remember important details. For example, interviewees could easily recall years in which they had to change business practices, shift industries, or seek alternative employment, in response to major red tide events or other shocks. Furthermore, using multiple interviews in each location allowed the researchers to identify commonalities and validate the information provided by different informants. As this research continues, we will continue to refine our history of red tides in west Florida by cross referencing oral history information with other sources such as newspaper articles and historical reports and datasets.

Acknowledgements

We greatly appreciate the time and effort of the many fishermen who participated in the red tide oral history project. We also thank the large number of community members who assisted in this research for their help in identifying key informants, spreading the word locally about the project, and providing working space in which to conduct the interviews.

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Table 1: Descriptors included within the three-level scale categories for severity of red tide events.

Category	Minor	Major	Devastating
Descriptors	Medium/minor	Bad	Nine point five out of a ten
	Minor	Extensive	Ten out of a ten
	Normal	Intense	Devastating
	Not bad	Major	The worst I've ever seen
	Patchy	Miserable	Extreme
	Small	Pretty bad	Biggest I remember
	Didn't have a big effect	Really bad	Worst
	Spotty	Severe	Sticking in my mind
	Three out of a ten	Terrible	Terrifying
		Very bad	Awful
		Significant	Catastrophic

Table 2: Species-specific kill mentions enumerated from interviews. Other commercially important species were mentioned but were only referred to six times or less across the three identified events. The category benthic includes taxa such as barnacles, clam, conch, coral, gorgonian, mussels, sponge, whelk, sea fan, and seagrass. The category bait fish includes taxa such as threadfin herring, Spanish sardine, needlefish, and pilchards.

	Events			
Species	2005	2014	2018	Total
grouper	6	10	37	53
drum	14	3	31	48
crab	4	0	23	27
grunt	5	2	14	21
snook	4	2	14	20
mullet	3	5	11	19
baitfish	2	2	14	18
eel	2	7	9	18
catfish	5	3	9	17
dolphin	0	0	16	16
shark	1	0	14	15
tarpon	3	1	11	15
pinfish	3	1	10	14
turtle	0	0	14	14
snapper	1	4	8	13
benthic	0	2	10	12
jack	0	2	9	11
manatee	0	0	11	11
porgy	2	1	6	9
hogfish	1	3	4	8

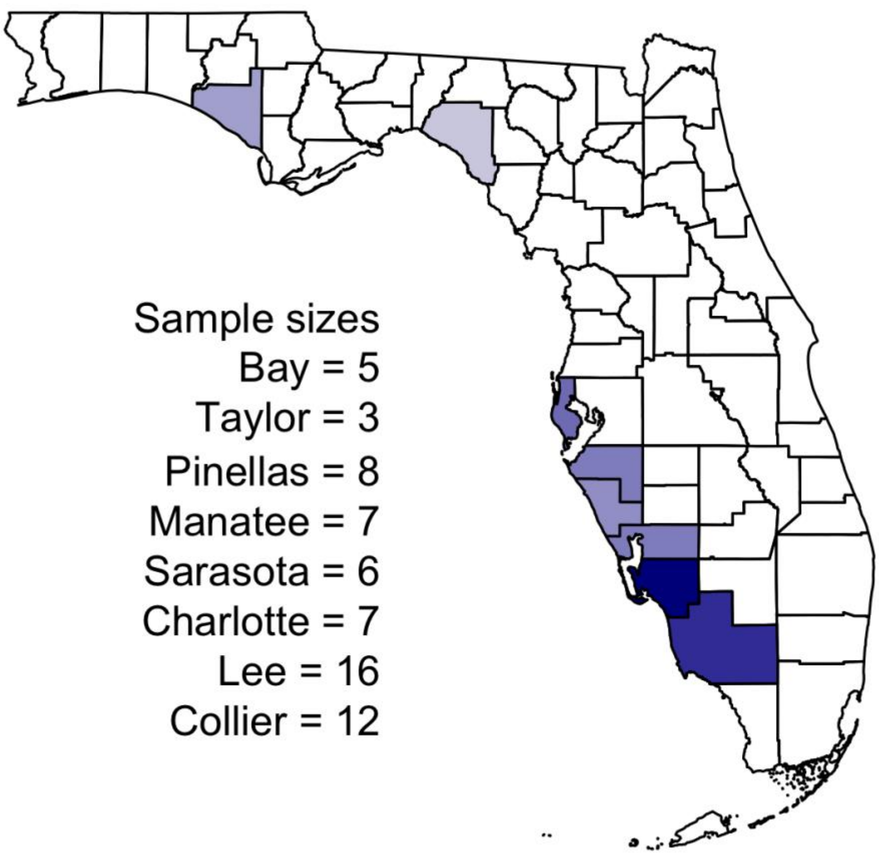

Figure 1. County map of Florida displaying the counties interviewees resided in and number of interviewees per county. The counties are listed in the order they are geographically located starting in the Florida Panhandle and moving toward the Florida Keys. The darker the shade of blue, the larger the sample size.

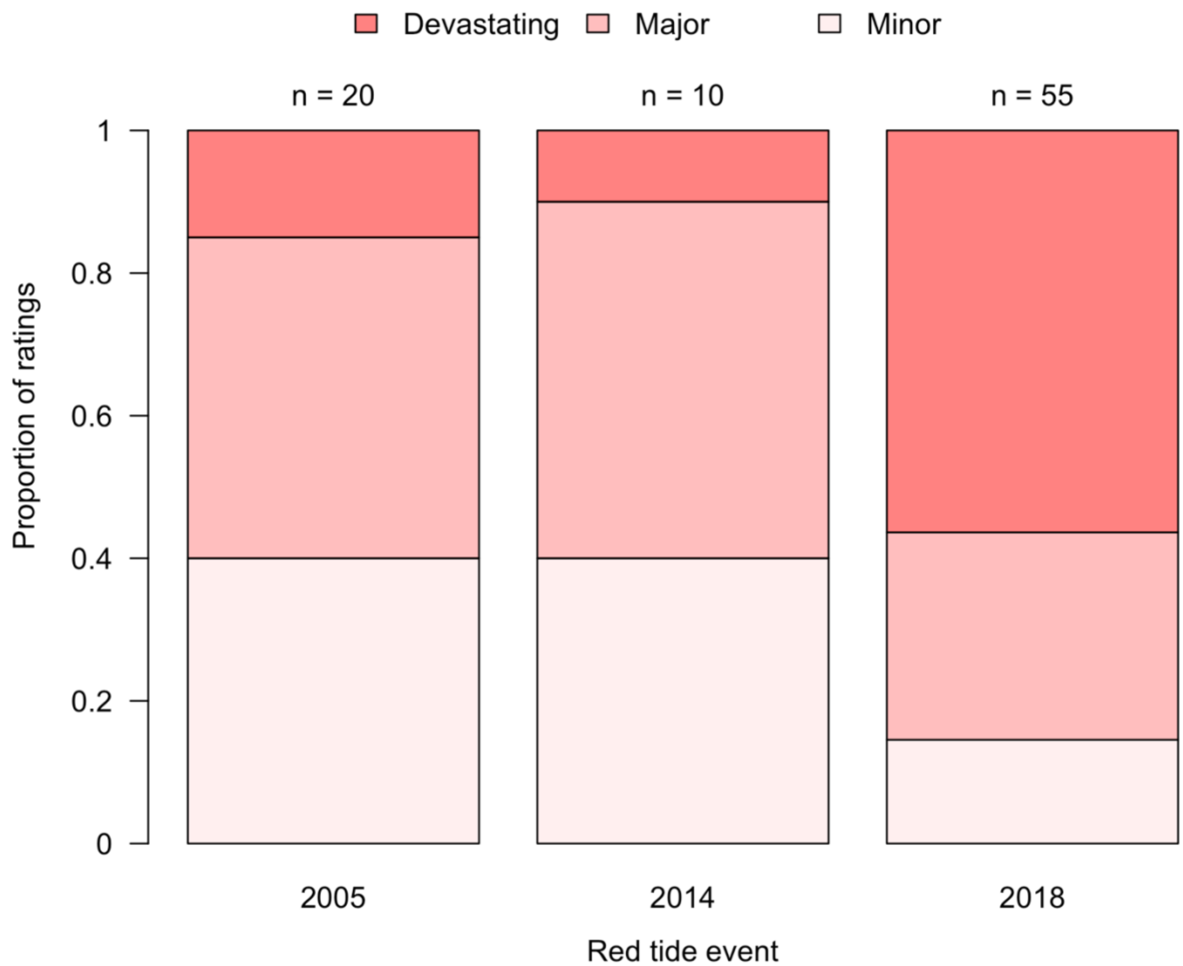

Figure 2. Categorized severity rating of the three exceptional red tide events since 2000 as given by individual interviewees. Sample sizes are the number of mentions and are displayed above each bar.

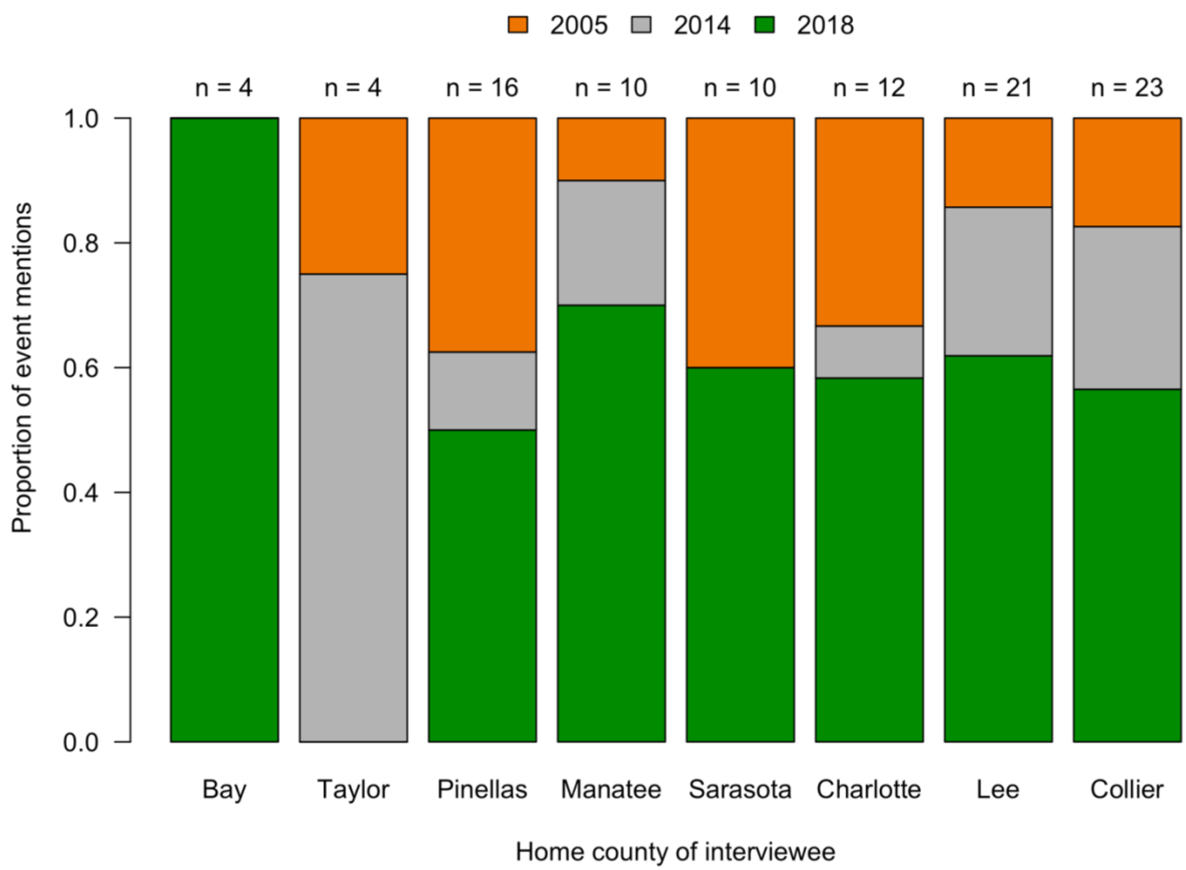

Figure 3. Proportion of red tide event mentions by interviewees per county. Sample sizes are the number of mentions and are displayed above each bar.

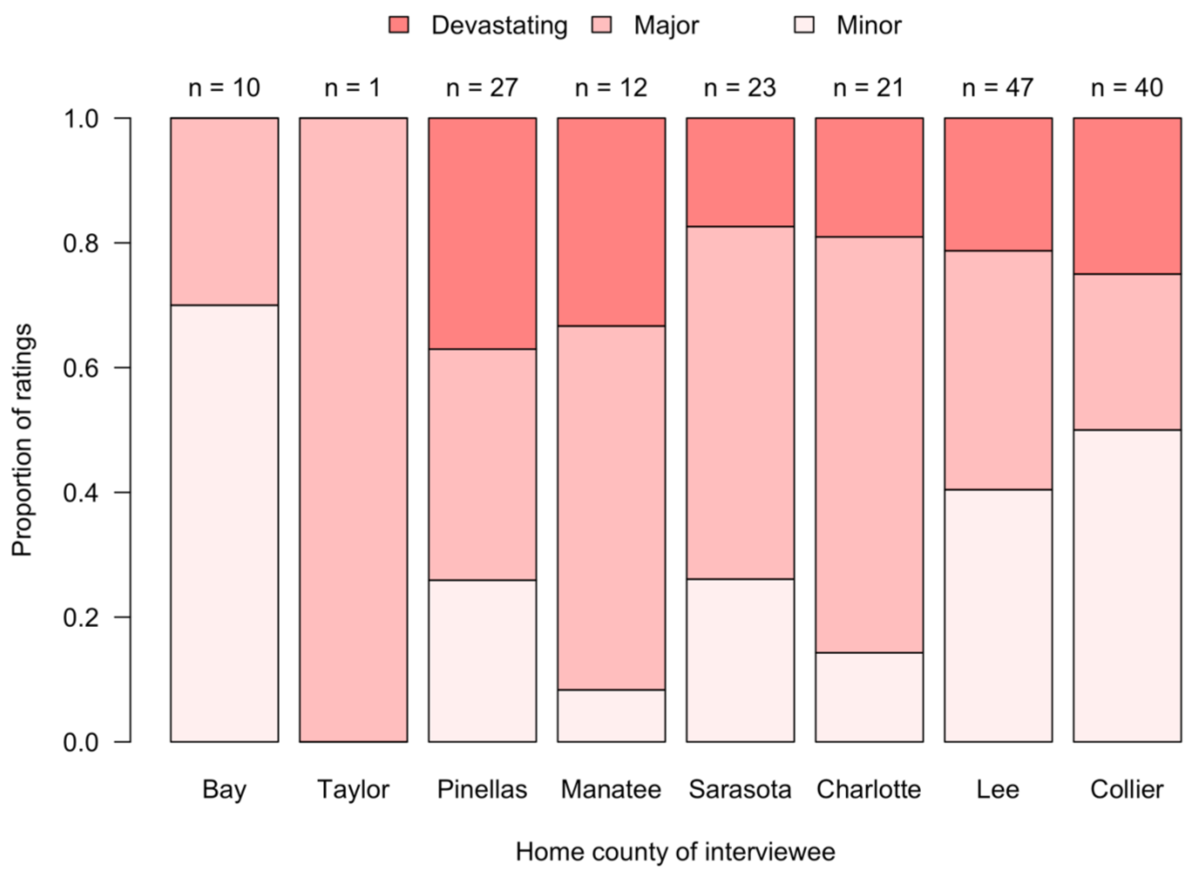

Figure 4. Categorized severity rating of red tide events since 2000 reported per county. Sample sizes are the number of mentions and are displayed above each bar.

Figure 5. Individual severity ratings for described red tide events, plotted by the identified year of the event. Each point represents an individual event described by an interviewee; some jitter was used on the y-axis to highlight the density of overlapping points. Shapes denote the region of residence of the interviewee.

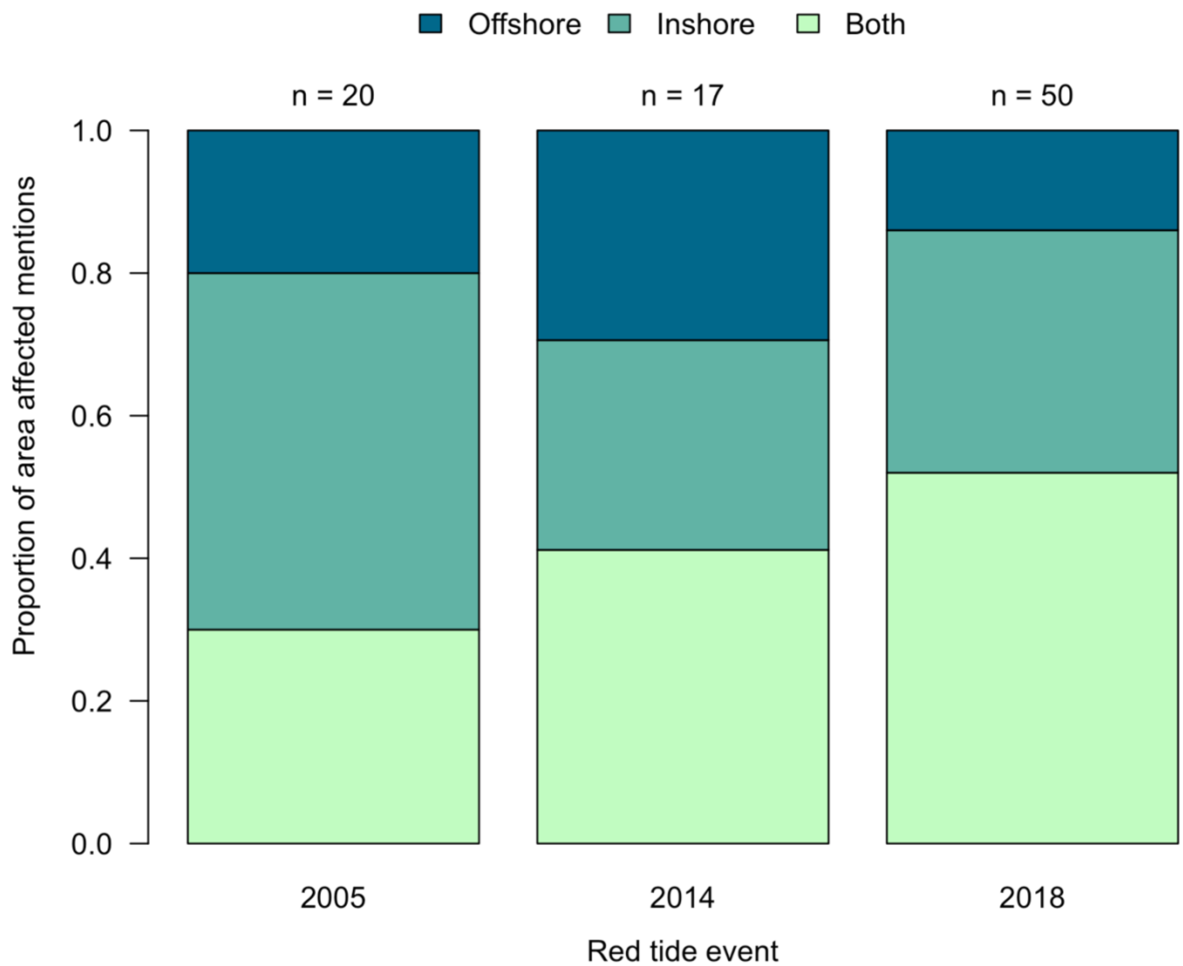

Figure 6. Inshore versus offshore areas affected by red tide events. Sample sizes are the number of mentions and are displayed above each bar.

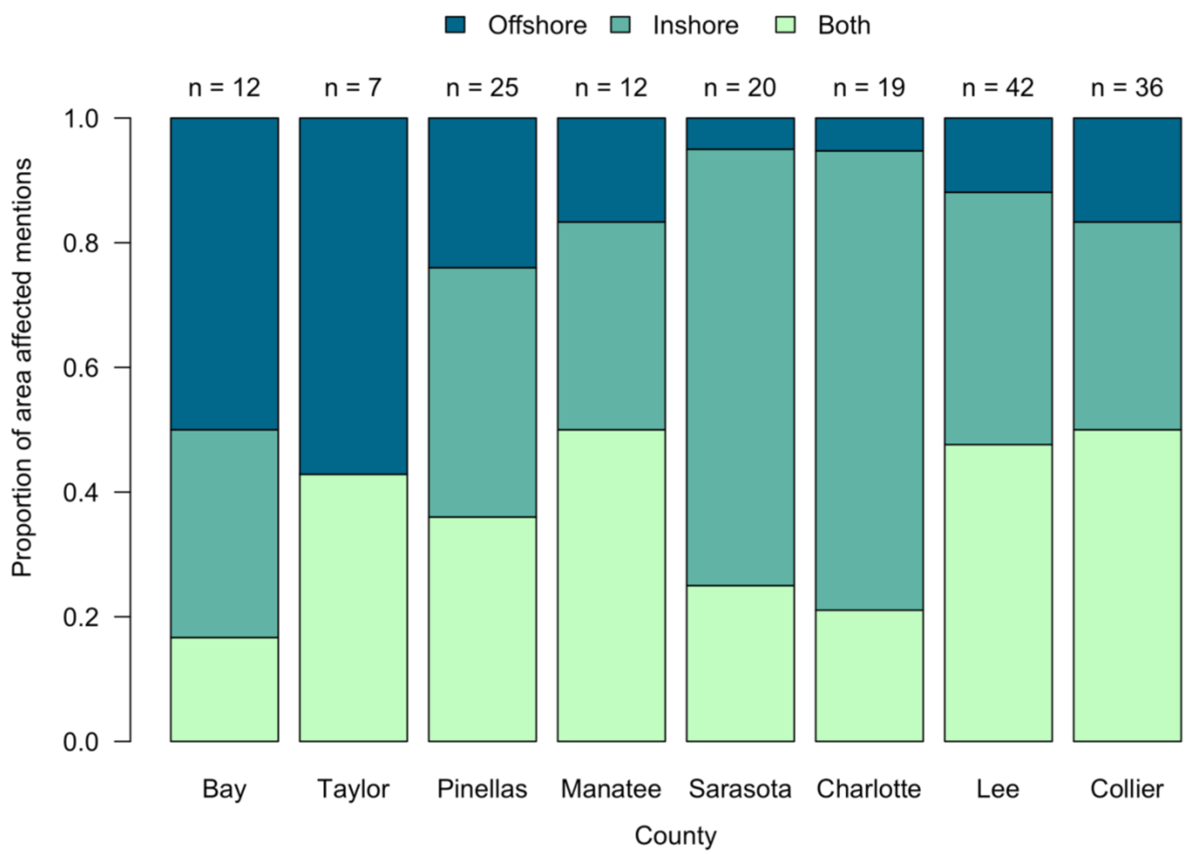

Figure 7. Inshore versus offshore areas affected by red tide events since 2000 as reported by interviewee county of residence. Sample sizes are the number of mentions and are displayed above each bar.

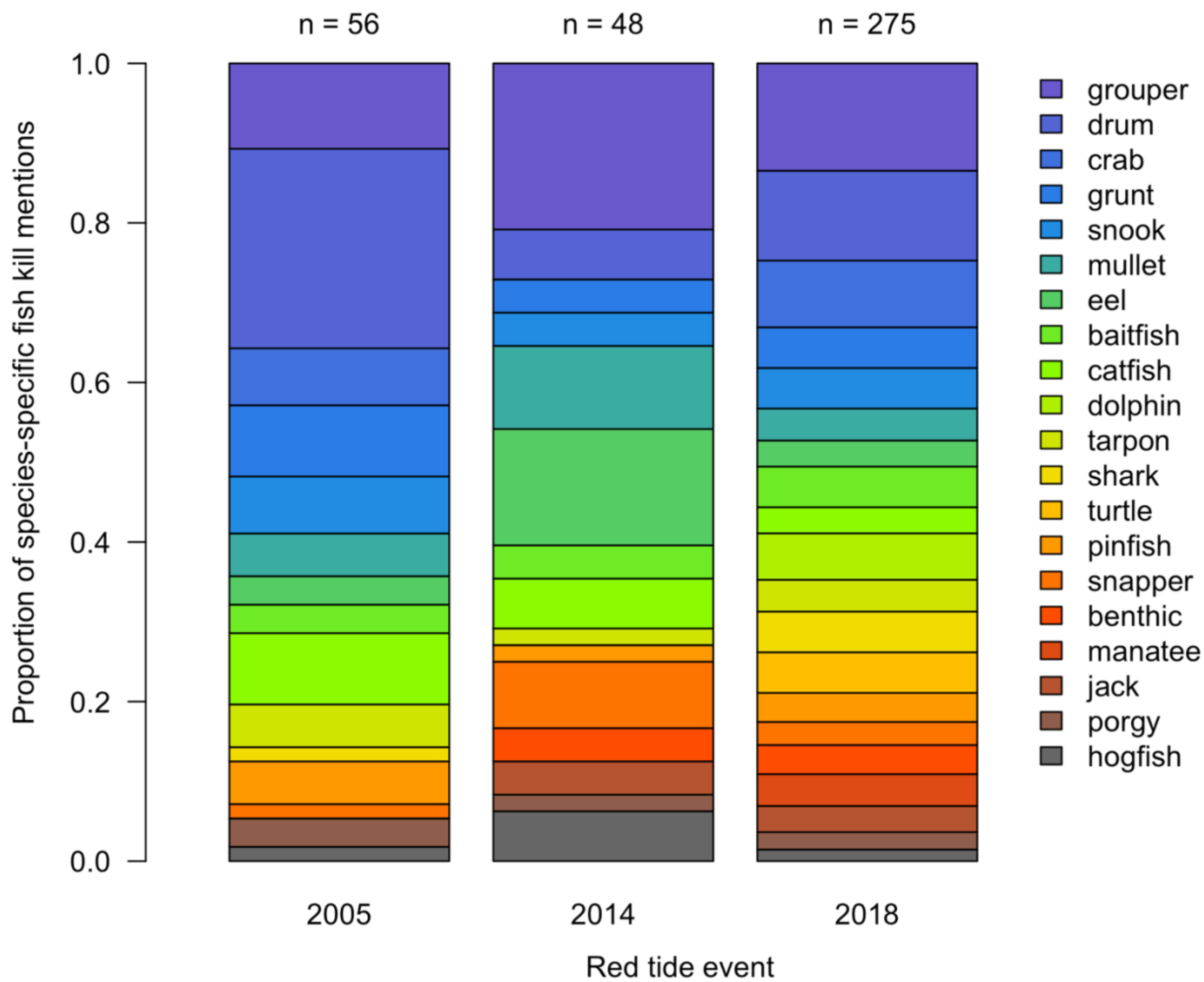

Figure 8. Species-specific kill mentions reported by red tide event grouped into generalized species categories. Sample sizes are the number of mentions and are displayed above each bar. The species list was sorted by the total number of mentions across events with the greatest number of mentions listed at the top.

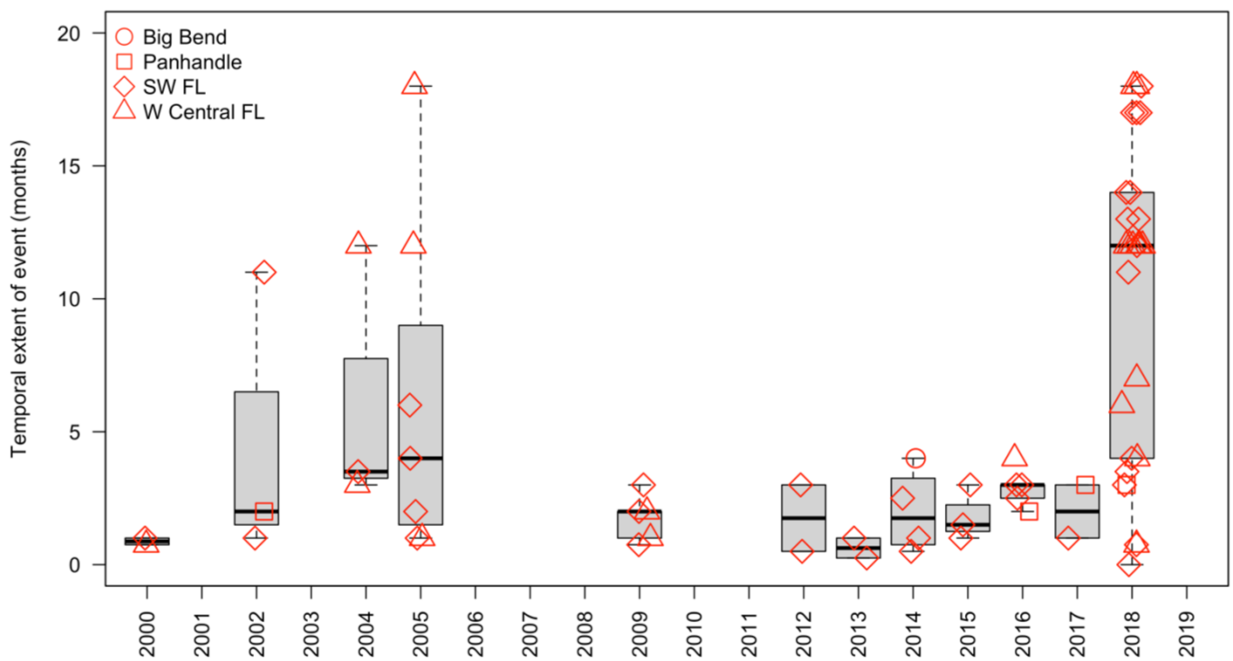

Figure 9. Temporal extent as described for individual red tide events, plotted by the identified year of the event. Each point represents an individual event described by an interviewee; some jitter was used on the x-axis to highlight the density of overlapping points. Boxplots per year indicate median value of temporal extent with dark black line. The upper and lower extent of the box are the 75th and 25th percentiles, and the whiskers are 1.5 times the interquartile range. Shapes denote area of residence of the interviewee.

Figure 10. System recovery time as described for individual red tide events, plotted by the identified year of the event. Each point represents an individual event described by an interviewee; some jitter was used on the x-axis to highlight the density of overlapping points. Shapes denote area of residence of the interviewee.