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Timeline of severe red tide events on the West Florida Shelf: insights from oral histories

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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. 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.

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 (Table 1). 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. At the time of writing, interviews were still being completed in some south Florida communities and plans were being made to conduct interviews in communities north of Clearwater, Florida and in the Panhandle during the summer of 2019.

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 on: 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 for mentions of "groupers" and/or specific grouper species.

Results

At the time of writing, 42 oral history interviews had been transcribed in communities located on the southwest Florida coast (Table 1). The 42 interviewees identified and described a combined 112 significant red tide events, 97 of which were tied to specific years (or specific time periods, in the case of blooms spanning multiple years in duration).

Across interviews, three significant recent red tide event periods were consistently identified by fishermen: years 2004-2005, 2013-2015, and 2017-2018 (Figure 1). There were only two mentions of significant events occurring outside these three ranges, in the period 2003 to present (one mention each in 2010 and 2012). Other consistently identified events included the early 1970s, mid-1980s, and the late 1990s. However these latter events were identified by fewer numbers of participants, and for the purpose of summary and analysis in the present paper, events prior to 2003 were grouped together into a single bin. Generally these patterns did not differ among the home residence of the interviewee, and descriptions of the timing of events were consistent across the different communities; however, interviewees from Charlotte County did not describe the 2004-2005 or 2013-2015 events.

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 2. A distinction between "devastating" and "major" events was deemed important, given that the specific term "devastating" was used a total of 17 times, while mentions of a "bad event" also occurred 17 times. For the 2018 event, the vast majority of interviewees (94%) described the event as "devastating" or "major." This is in contrast to lower percentages (37% - 57%) of "major" or "devastating" designations for prior events (Figure 2). These results may be partly driven by the areas that have been covered in the LEK assessment to date (all south of Clearwater), as the 2014 event is known to have occurred generally north of the Clearwater area with particularly severe effects in the Middle Grounds. However, the overall severity designations for all bloom events do not differ based on the county of residence of the interviewee (Figure 3), and there do not appear to be regional trends in the rankings of severity across time (Figure 4). The 2005 and 2018 red tide events have similar spatial footprints based on the 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 accomplished to date, which should allow for robust comparisons between the 2005 and 2018 events as they

would not biased by the locations of the interviews. Comparisons with the 2013-2015 period should be made with caution, as the communities north of Clearwater thought to be most heavily impacted by that event have not yet been interviewed.

Of the 112 events described, 99 had accounts of species-specific fish kills, and there were 33 mentions of grouper fish kills. 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 (14 events), followed by gag and red grouper (6 mentions each) and black grouper (2). The highest proportion of grouper mentions occurred in the 2014 event (50% of all species-specific fish kill mentions), followed by the 2005 event (45%); note however these are based on relatively low sample sizes (Figure 5). Of the 34 species-specific mortality descriptions for the 2018 event, just over one-third mentioned seeing mortalities of grouper species.

Overall, the most recent 2018 event was perceived to have lasted longer than previous events (Figure 6). On average, the estimated temporal extent of the 2017-2018 event was 9.5 months, compared to less than 1 month for the 2013-2015 period and 6.6 months for the 2004-2005 period. Additionally, interviewees in some cases described the recovery time of the ecosystem following a significant red tide event (Figure 7). Of note, some individuals felt that the ecosystem had still not recovered following the 2004-2005 and 2013-2015 red tide event periods. At the time the interviews were conducted (November 2018 to May 2019), the vast majority (92%) of interviewees felt that the ecosystem had not recovered following the 2017-2018 red tide event.

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. 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 has limited coverage in offshore areas. Thus, the satellite index may not be fully representative of offshore blooms; also, the satellite imagery is of limited use in nearshore waters due to confounding with land-based inputs. Also, 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 significant influence on the ecosystem but that would not be reflected in the satellite data or cell count data. For example, there is emerging evidence that some years of severe red tide are

associated with hypoxia (Diggers et al. 2016, Kelble pers.comm.), 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 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 report 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. Community of residence of interviewees, and number of interviews per community.

Community	Number of interviews
Boca Grande	3
Cape Haze	1
Chokoloskee	2
Clearwater	2
Cortez	6
Everglades City	2
Fort Myers Beach	5
Goodland	1
Madeira Beach	2
Naples	7
Pine Island	6
Placida	2
Plantation Island	1
St. Petersburg	1
Tarpon Springs	1

Table 2. Descriptors included within the three-level scale categories for severity of red tide events.

Category	minor	major	devastating
Descriptors	3/10	bad	9.5/10
	fairly significant	extensive	10/10
	medium/minor	intense	devastating
	minor	major	
	minor - strong	miserable	
	normal	pretty bad	
	not bad	really bad	
	patchy	severe	
	significant	terrible	
	small	very bad	
	small events	worst	

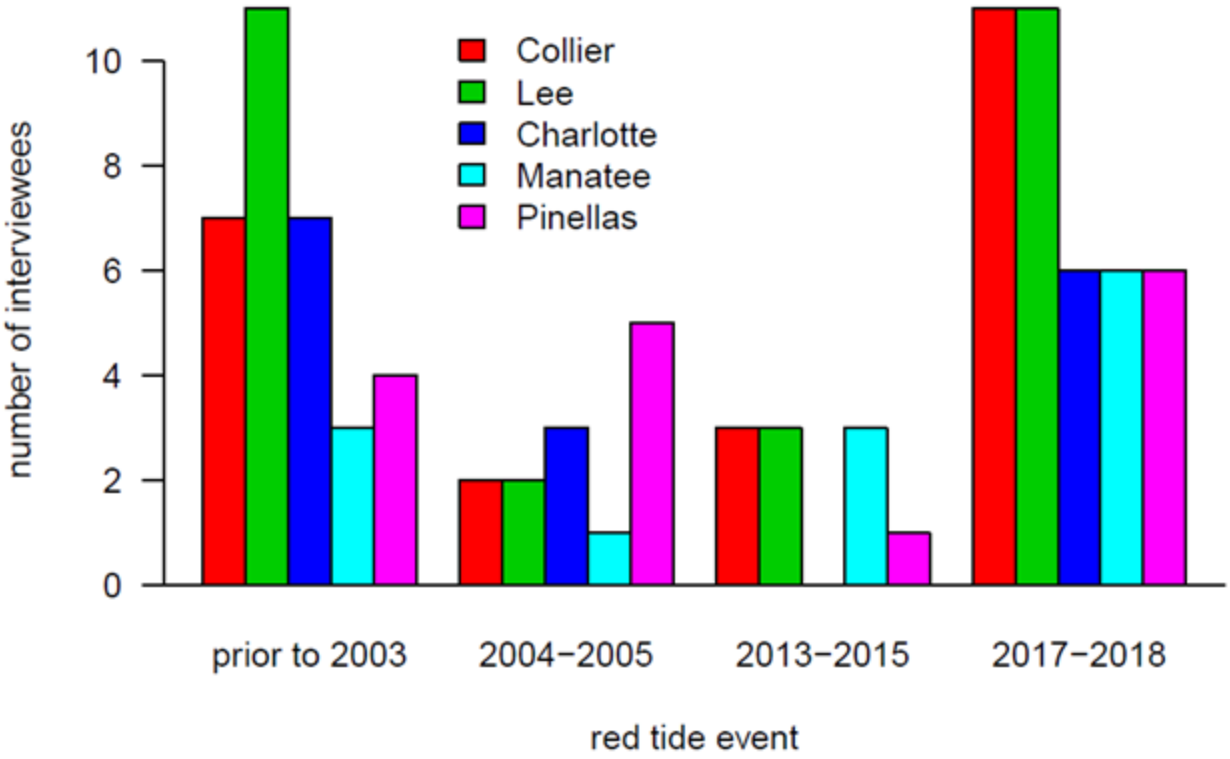

Figure 1. Number of mentions of significant red tide events, categorized by the home residence county of the interviewee.

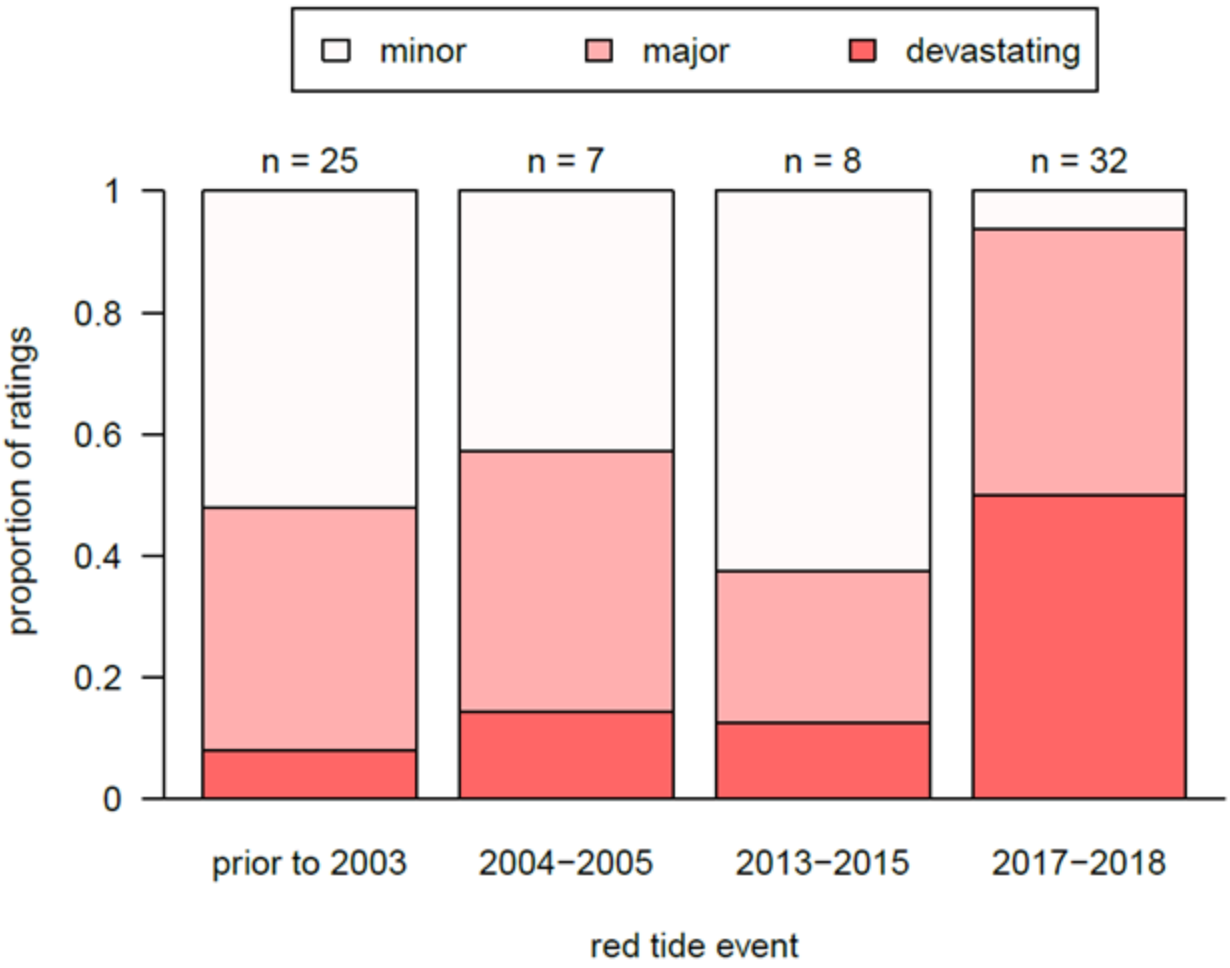

Figure 2. Categorized severity ratings of recent and past red tide events as given by individual interviewees.

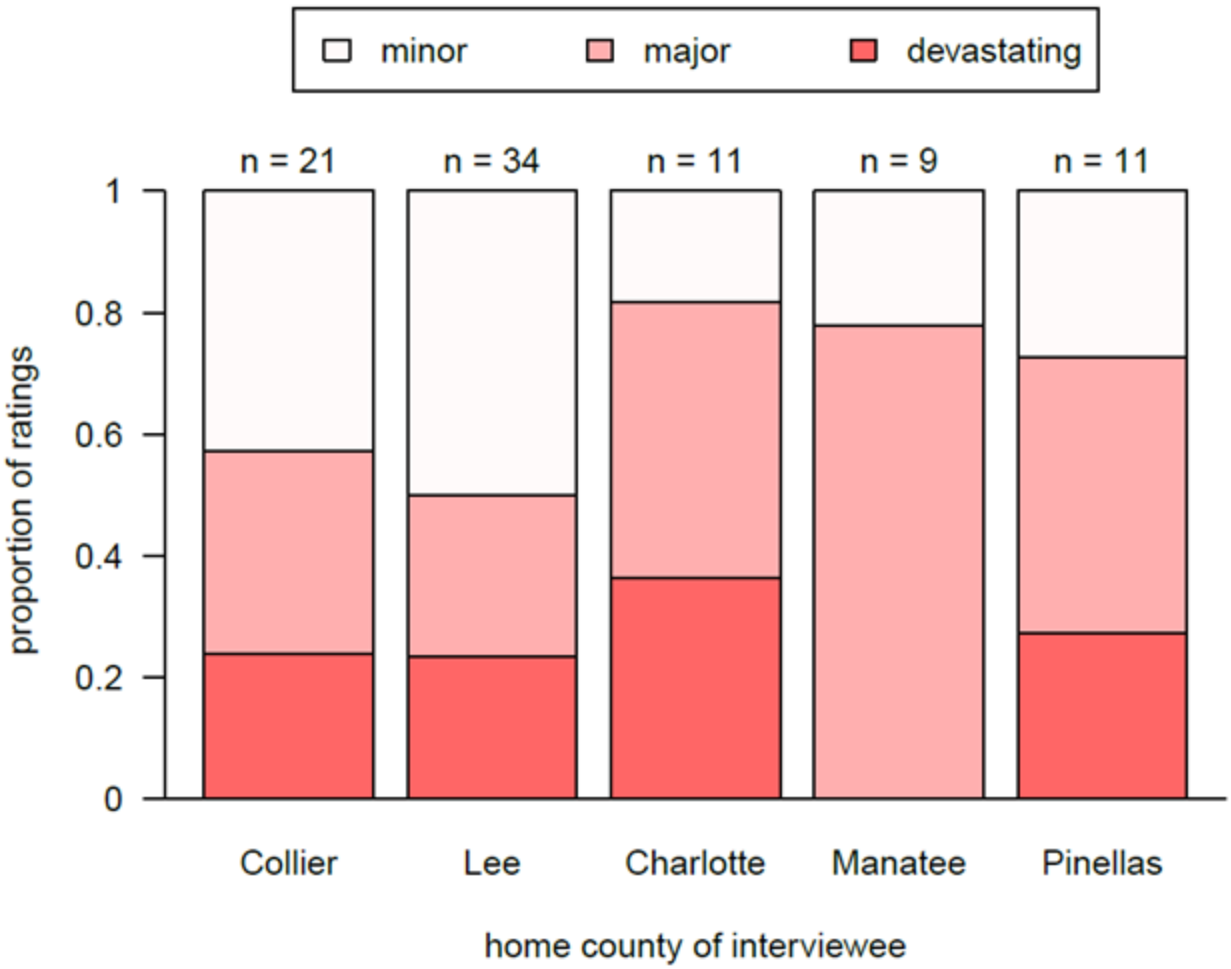

Figure 3. Categorized severity ratings for all described red tide events documented, grouped by the county of the home residence of the interviewees.

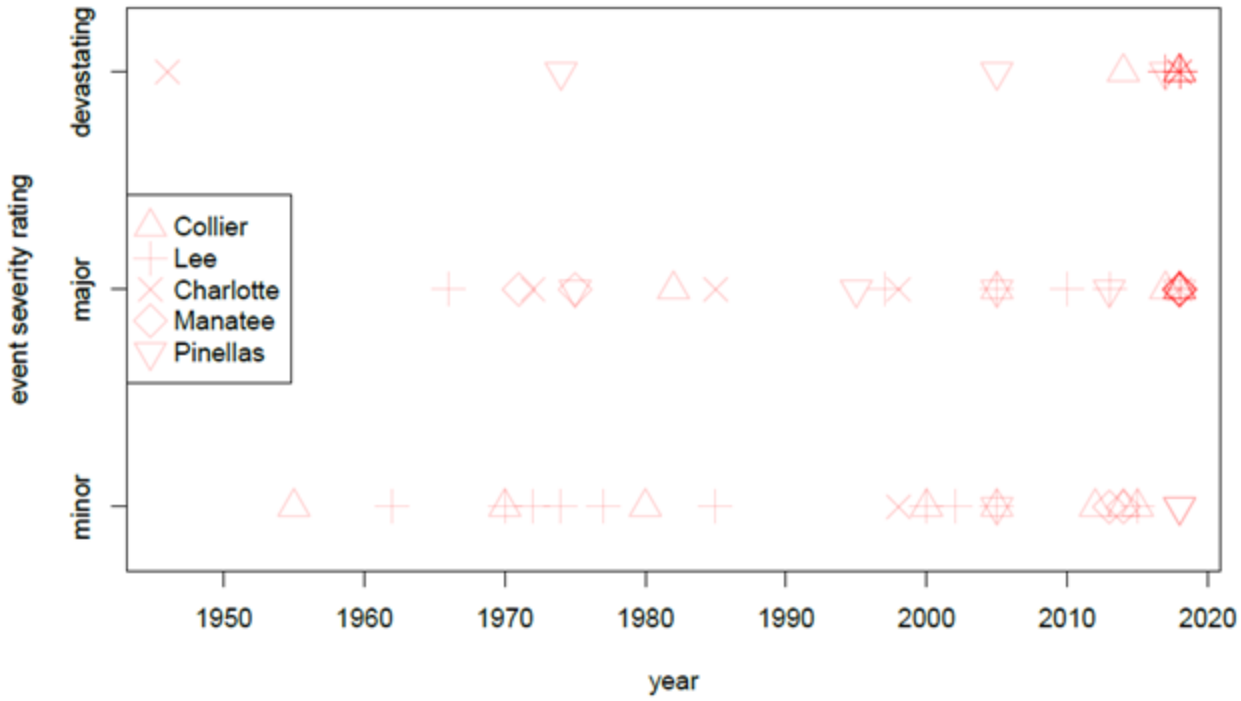

Figure 4. Individual severity ratings for described red tide events, plotted by the identified year of the event. Each point represents an individual event described by an interviewee; darker colors indicate overlying points. Shapes denote the county of residence of the interviewee.

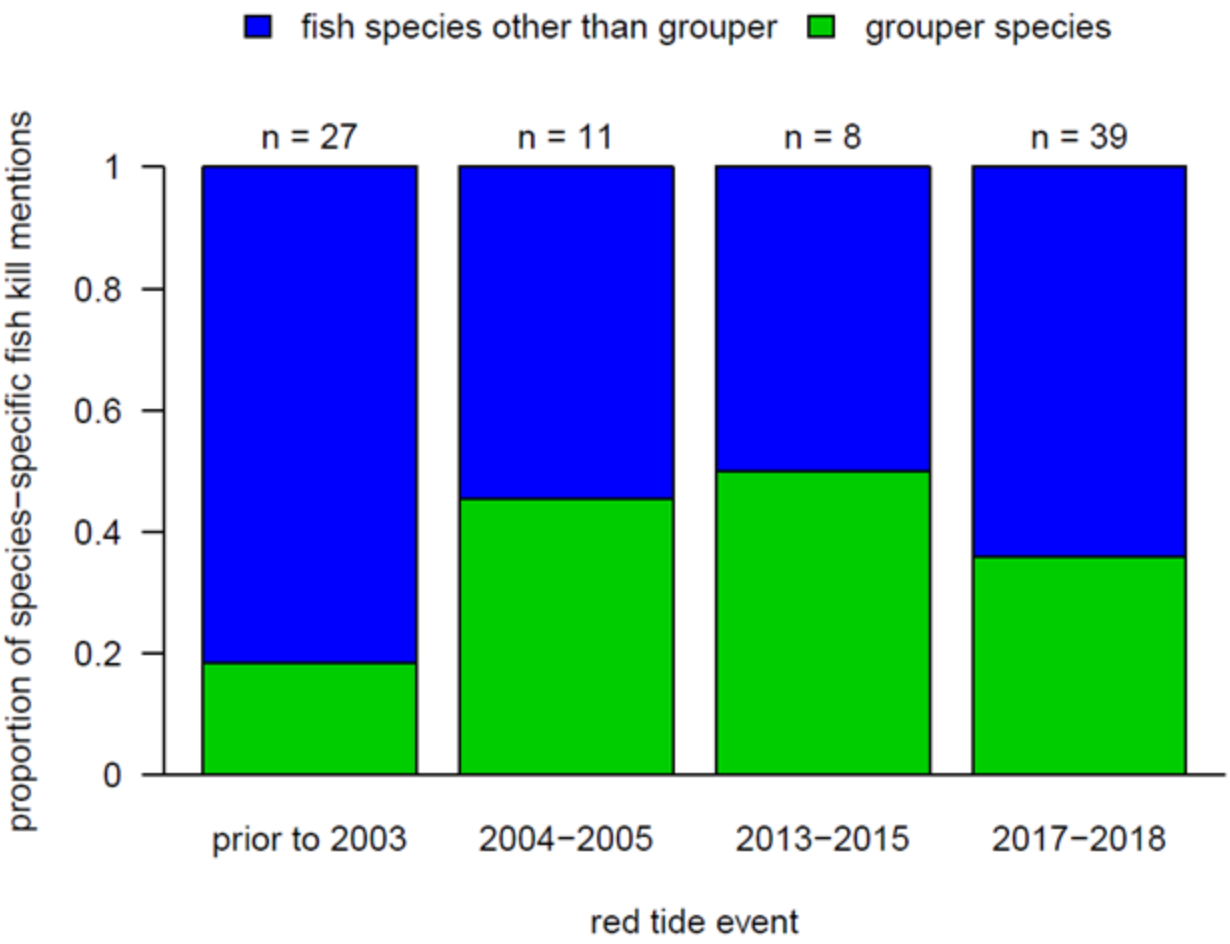

Figure 5. Summary of each red tide event in which interviewees described species that were affected by red tide, plotted to show the proportion in which grouper species were mentioned. Events are categorized by the major red tide periods.

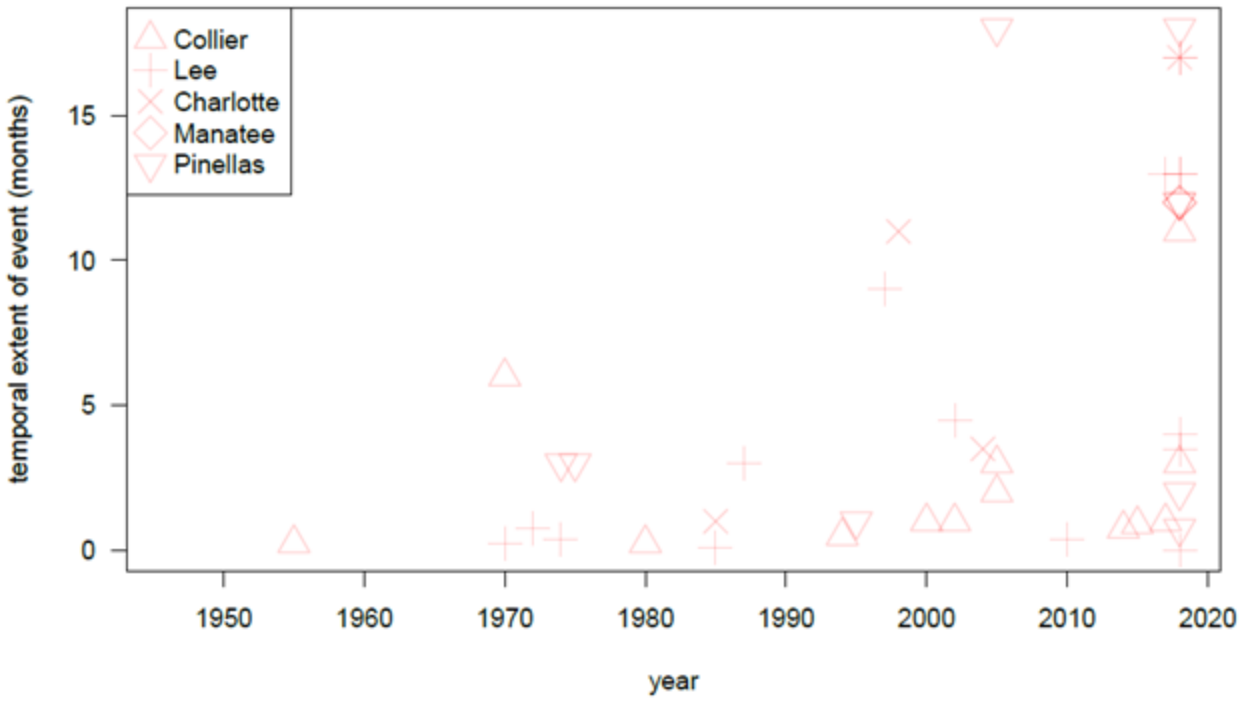

Figure 6. Temporal extent as described for individual red tide events, plotted by the identified year of the event. Each point represents an individual event described by an interviewee; darker colors indicate overlying points. Shapes denote the county of residence of the interviewee.

Figure 7. 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; darker colors indicate overlying points. Shapes denote the county of residence of the interviewee.