Draft Pilot Fishery Ecosystem Issue – Red Tide

FEI Description

From descriptions of draft Fishery Ecosystem Issues[1] compiled by SEFSC staff based on expert knowledge and stakeholder outreach and presented to the Ecosystem Technical Committee (ETC) in April 2023.

Description of the management issue: Red tide events tend to occur off the west coast of Florida. Depending on the spatio-temporal scale of these events, mass mortalities of marine organisms can occur including forage fishes, pelagic fishes, reef fishes, invertebrates, elasmobranchs, marine mammals, marine turtles, and birds. Additionally, essential fish habitat can be affected due to the mortality of structure-formatting species like seagrasses, corals, and sponges. Hypoxia has also been observed with red tide events, likely exacerbating impacts to affected ecosystems. Declines in indices of abundance and commercial and recreational catches have been observed for gag and red grouper, and have been at least partially attributed to red tide events. There are also concerns about fishermen having to travel further to escape impacted areas or limited ability to diversify the target species portfolio in response to red tide events.

Fisheries involved: forage/bait fish, reef fish, pelagic fish, protected species, essential fish habitat, coral

Geographic area of focus including habitats: West Florida Shelf out to the 200 m isobath; estuarine and nearshore essential fish habitats; seagrass meadows; coral reefs, live hardbottom

Key actors and institutions and their interests: Commercial and recreational fishermen; Gulf Council - management of fisheries in federal waters; FL FWC - red tide monitoring and management of fisheries in state waters; NOAA - management of protected marine species, federal fisheries, and aquaculture in federal waters; FL Department of Agriculture and Consumer Services - management of aquaculture and shellfish harvesting in state waters; FL Department of Environmental Protection - water management districts and water quality; US Army Corps of Engineers - manages water discharges from Lake Okeechobee

Data or information gaps: Long-term effects of red tides on biomass, spatial distribution, and age distribution of exploited reef fishes and their prey; numbers and species composition of fish in fish kills; length and age composition data from fish kills are needed to determine lengths and ages susceptible to red tide severity; movement and avoidance of species to red tide events; relationship between the spatio-temporal scale and toxicity of an event to mortality and habitat destruction; changes to ecosystem diversity and community structure including possible redistribution or colonization by competing species; effects on IFQ lease availability and price or

[1] https://gulfcouncil.org/wp-content/uploads/05.-Background_FINAL_FEIs.pdf

ex-vessel prices; how do fishermen change their behaviors to adapt to events; spatio-temporal index of red tide

Vision of success: Better quantification of fishery impacts can be used to advise other management bodies on improving nearshore water quality. Continued incorporation of red tide impacts in stock assessment, quota setting, and consideration of indirect impacts (e.g., strong red snapper recruitment events possibly caused by colonization post-red tide). Consideration of tradeoffs between maximizing catch and precautionary buffers or harvest control rules to account for future red tide events. Management that is nimbler and more reactive to extreme events (e.g., additional permit flexibilities to help industry adapt to severe events by switching gears, target species, allocation flexibilities and changes to recreational regulations).

FEI Loop

FEI Scoping: Where are we now?

Stakeholder involvement

In lieu of holding formal stakeholder engagements specific to the Red Tide Pilot Fishery Ecosystem Issue, we leveraged information gathered from existing NOAA SEFSC workshops and interviews relevant to red tide. Products from these stakeholder engagement efforts were evaluated to synthesize stakeholder values, concerns, and suggestions for addressing red tide. The SEFSC conducted stakeholder workshops in southwest Florida in 2018 focused on engaging with fishermen and coastal community members about issues affecting snapper-grouper fisheries in the region[2]. While these workshops were not centered around red tide, the impacts of red tide were commonly referenced by workshop participants given the recent 2017-2018 red tide event in the region. Participatory models summarizing the viewpoints of stakeholders frequently linked red tide with the abundance of reef fish, red drum, bait fish, and juvenile fish, as well as to changes in fishing effort, fishing location, and fish migration patterns. Stakeholders thought that water quality, pollution, and temperature, as well as oceanographic features like currents, winds, loop current intrusion, and the thermocline, may contribute to red tide occurrences.

In response to the interest in red tide highlighted during the 2018 stakeholder workshops in southwest Florida, the SEFSC subsequently launched an effort to interview stakeholders to gather local ecological knowledge about historic and recent red tide events, and to continue the dialogue surrounding the impacts of red tide to the region. These conversations took place from December 2018 through December 2019 and are documented under the 'A History of Red Tide Events on the West Coast of Florida' collection in the NOAA Voices Oral History Archives[3]. Formal analysis of interviews was conducted to identify historic red tides and evaluate

[2] https://www.fisheries.noaa.gov/feature-story/noaa-listens-fishermen-share-stories-devastation-after-florida-red-tide-hits
[3] https://voices.nmfs.noaa.gov/collection/history-red-tide-events-west-coast-florida

stakeholder sentiments regarding red tide event severity, location, resilience, and species impacts (Blake et al. 2022). Interviewees perceived that the severity and duration of red tide events on the Florida Gulf Coast has been increasing through time. Stakeholders proposed methods for improving fisheries management around red tide events, including increasing industry resilience by facilitating access to substitute species, making allowances to remove fishing limits when mortality from red tide is inevitable, flexibility in gear and permits during red tide events, and making economic provisions for the recovery period following a red tide such as waiving permit fees. Interviewees also expressed interest in helping to close the data gaps in red tide sampling and proposed employing fishermen in data collection as well as clean-up efforts (Blake et al. 2022).

Additional themes were gathered from reviews of interview summaries and transcripts. Participants consistently identified water quality issues as exacerbating red tide and contributing to extreme events, including problems caused by nutrient runoff, water diversion, coastal development, and beach renourishment. Another common concern was mass mortality on forage fish and the implications for managed species. Stakeholders frequently described lengthy recovery periods for habitat following red tides, which suggests that red tide impacts to fisheries may not be contained within the event year (current stock assessment models incorporate red tide mortality with no lags). Finally, many stakeholders expressed frustration with sensationalized media coverage of red tide events which unnecessarily drive clients away from unaffected areas, resulting in lost economic opportunity.

Red tide was also a topic of interest during public testimony at the January 2025 Gulf Council Meeting. Stakeholders mentioned that at the time of the meeting, red tide was severe in some locations and has resulted in fish leaving the area. Stakeholders also suggested that season start dates could be adjusted to account for the time that fishing would be paused due to red tide.

Prospective additional stakeholder engagements - Options for incorporating contemporary stakeholder input on red tide include data from the FWRI Fish Kill Hotline, which collects information on the location of dead or injured animals and safety-related concerns relevant to harmful algal blooms, or using the Council's Fisherman Feedback Tool, which could be launched to request information from anglers about impacts to fishing practices and to better quantify offshore blooms.

Key questions and goals

A large body of work already exists surrounding red tide on the West Florida Shelf and beyond, and there are many interdisciplinary research groups continuing to study various aspects of red tide ranging from public health and safety to identifying environmental drivers of red tide and forecasting blooms to effects on marine organisms. Key questions here will be focused on the impacts of red tide to federally managed fisheries in the Gulf.

- How do red tides affect federally managed fish stocks?

- In addition to gag and red grouper, what other Gulf stocks need red tide episodic mortality consideration in stock assessments?
- Do impacts of red tide to managed fish stocks extend beyond episodic mortality during the bloom event (i.e., sublethal effects, redistribution, habitat destruction and recovery, changes in community structure, impacts to forage base)?
- Are current methods for determining harvest limits robust to potential changes in the frequency and severity of red tides in the future?
- How can management approaches be adapted to improve resilience to red tides?
- How do social and economic impacts to fishing communities differ during severe localized red tide events versus widespread red tide events?

Dimensions of the problem

Red tide events are common on the west coast of Florida, occurring nearly annually to varying degrees of spatial extent and duration. Severe red tide events can result in mass mortality of marine organisms and are known to impact Gulf gag and red grouper stocks, although effects on other federally managed Gulf stocks are less well quantified. Presently, red tide is incorporated into single species management for gag and red grouper but there is need for a more holistic ecosystem approach to red tide, with consideration for other species, social and economic tradeoffs, and interjurisdictional cooperation.

Data availability

Relevant data sources and products:

Red tide

- *Karenia brevis* cell count data from the Florida Fish and Wildlife Research Institute (FWRI) Harmful Algal Bloom (HAB) monitoring program[4]. Data are available from 1953 to present. Routine monitoring began in 1998, prior to which sampling efforts were reactive and conducted in response to bloom events. Over 100 locations around the Florida Gulf coast are monitored on a weekly to monthly basis, with sampling concentrated in southwest Florida. Most sampling sites are coastal (< 1 mile from shore), but offshore sites are also routinely sampled (>1 mile from shore). Cell concentration thresholds[5] and possible effects are defined by FWRI as follows:
    - Not present-background: <1,000 cells/L (no effects anticipated)
    - Very Low: >1,000 – 10,000 cells/L (possible respiratory irritation, shellfish harvesting closures > 5,000 cells/L)
    - Low: >10,000 – 100,000 cells/L (respiratory irritation, shellfish harvesting closures, possible fish kills)

[4] https://myfwc.com/research/redtide/monitoring/database/
[5] https://myfwc.com/research/redtide/statewide/

    - Medium: >100,000 – 1,000,000 cells/L (respiratory irritation, shellfish harvesting closures, probable fish kills)
    - High: >1,000,000 cells/L (as above, plus water discoloration)
- Remote sensing data – MODIS-Aqua satellite (2002-present) derived chlorophyll-a fluorescence anomalies have been used to identify the spatial extent of HABs but cannot differentiate among algal species (Hu et al. 2005).
- Monthly red tide maps from the West Florida Shelf Ecosystem Model (Vilas et al. 2023), which are derived from FWRI-HAB *K. brevis* cell concentration data interpolated over the West Florida Shelf, with bloom spatial extent and duration defined with MODIS-Aqua satellite data.
- Indices of red tide severity:
    - Satellite-derived index of red tide severity (1998-2010) for the West Florida Shelf developed for the gag stock assessment (SEDAR 33). Multiple index configurations were tested, but the final index was binary, consisting of a time series of all zeros except for 2005, which had a value of 1 (Walter et al. 2013).
    - An updated satellite-derived index of red tide severity was calculated for select years (2004, 2005, 2007, 2014) in response to the Gulf SSC's request for additional analyses from the SEFSC to assess the impact of the July 2014 severe red tide event, to inform ABC recommendations following the red grouper stock assessment (SEDAR 42). Calculations were made using MODIS satellite data, and comparisons were made to index estimates made using SeaWiFS satellite data (Walter et al. 2015).
    - Updated satellite-derived index of red tide severity (2003-2017) for the West Florida Shelf developed for the shallow-water grouper complex (Sagarese et al. 2018) using the same methods as Walter et al. (2013), but with a change in satellite data sources from SeaWIFS to MODIS. This index was not recommended for use in the red grouper stock assessment due to concerns with calibration between satellite sources (SEDAR 61).
    - Monthly and annual bloom severity index for nearshore (<5 km) Southwest Florida based on FWRI-HAB *K. brevis* cell counts (1953-2018). The index accounts for extent of latitudinal distribution as well as cell concentration intensity category (Stumpf et al. 2022).

Fisheries data

- Commercial landings by fleet
- Recreational landings by mode
- Standardized indices of relative abundance
    - Fishery dependent
    - Fishery independent (e.g., trawl surveys, video surveys)

Environmental data sources

- Sea level, sea surface temperature (National Data Buoy Center)

- Loop current position (HYCOM)
- Riverine discharges and nitrogen concentrations (USGS Streamflow Monitoring)
- Submarine groundwater discharge (USGS)
- Hurricane track data (NHC)

Stock assessments, management action, and relevant previous work:

Stock assessments – Red tide mortality has been estimated within stock assessment models for Gulf gag and red grouper since 2009, in recognition of the likely influence of episodic mortality from the 2005 red tide event on population abundance. Early efforts estimated excess natural mortality due to red tide, which improved model fits and accounted for declines in abundance in 2005 relative to base models that did not consider red tide (SEDAR 10 Update, SEDAR 12 Update). In subsequent stock assessments, red tide mortality has been incorporated as a discard-only bycatch fleet operating in years with strong red tide (SEDAR 33, SEDAR 42). Informed by the West Florida Shelf Ecosystem Model (Vilas et al. 2023), indices of red tide mortality have been developed for gag (SEDAR 72) and red grouper (SEDAR 88) using spatially explicit approaches that consider the location and severity of red tide blooms and age-specific species distribution patterns, allowing for incorporation of age-based red tide selectivity.

Management action – The Council's Science and Statistical Committee (SSC) has considered the implications of red tide episodic mortality and uncertainty around mortality estimates when recommending the acceptable biological catch (ABC) for gag and red grouper. Buffers between the overfishing limit (OFL) and ABC have previously been increased to account for red grouper red tide mortality concerns (GMFMC 2010; 2019) and decreased following assessments that provide evidence of minimal red tide impacts (GMFMC 2016). Red tide estimates from the West Florida Shelf ecosystem model were used to inform stock projections for setting gag catch limits, with SSC recommendations based on assumptions of a 'medium' red tide scenario[6].

Commercial fleet dynamics – Red tide effects on commercial reef fish fisheries were evaluated by analyzing bottom longline and vertical line fisheries metrics (from vessel monitoring systems and logbook data) relative to maps of red tide severity (Perruso et al. 2023). Red tide did not influence the number of vessels, trips, fishing effort, or revenue. However, monthly fishing effort was displaced from red tide areas, with increased probability that sites remained unfished with increasing intensity of red tide. It remains unknown whether fishers are avoiding red tide blooms or whether the change in spatial fishing behavior results from redistribution of the resources.

Recreational revenue – A survey of charter for-hire operators indicated significant impacts following the 2018 red tide event in Southwest Florida[7]. Average sales revenue across trip types

[6] https://gulfcouncil.org/wp-content/uploads/Gulf-SSC-Summary-Nov-2021-12072021.pdf
[7] https://fred.ifas.ufl.edu/media/fredifasufledu/economic-impact-analysis/reports/FRE_WCIND_SWFMIA_Harmful_Algal_Bloom_Report_2018.pdf

decreased by 61% when red tide was present locally, and by 10% when red tide was not present locally. A 28% decrease in revenue continued through the remainder of the 2019 season after the red tide event subsided.

Hypoxia – Red tide events can be associated with hypoxia, and in recent years it has been found that red tides occurred concurrently with hypoxic events in 2005, 2014, and 2018 (Turley et al. 2022). These red tide-hypoxia events had common characteristics, including timing of bloom initiation (early summer persisting into fall) and strong water column stratification driven by changes in salinity. Large red tide blooms that did not result in hypoxia were less likely to be identified as damaging to fisheries resources based on local ecological knowledge, suggesting that hypoxia plays a large role the severity of red tide impacts.

Council authority

Red tide is often viewed as a water quality issue that is outside of the Council's purview. Attempts to mitigate red tide events themselves would require response from other agencies to manage the land-use changes and discharge of nutrients that are thought to contribute to blooms, although many of the complex and dynamic factors that initiate and sustain blooms are natural processes that fall outside of agency control such as Loop Current position (Maze et al. 2015), coastal upwelling (Stumpf et al. 2008), and water column stratification (Turley et al. 2022). However, the Council has the authority to adjust catch, size, and bag limits for affected fisheries, change risk tolerance to account for uncertainty around red tide episodic mortality events, or establish seasonal or spatial closures to allow for recovery from red tides.

FEI Workplan: Where are we going?

Objectives, workplan, timeline

A. Continue incorporation of red tide impacts into stock assessments for relevant species, including ongoing projects to **(1)** update and operationalize the West Florida Shelf Ecosystem model for stock assessments and management and **(2)** evaluate the impacts of climate-driven red tide uncertainty on biological reference points. Projects are detailed below in the 'Execution of Workplan' section, each with a timeframe for project completion. Timelines specific to the FEI Workplan could incorporate schedules for results and products to be considered by the SSC.

B. Develop an updated red tide severity index for evaluation of red tide impacts on landings of Gulf stocks, including stocks with less information on red tide mortality. Exploratory analyses will be presented to the ETC for discussion at its May 2025 meeting.

Indicators and performance metrics

A. To be determined

B. To be determined

Data and research needs

A. To be determined

B. To be determined

Execution of Workplan

(A1) *Red Tide and Reef Fish Modeling (Chagaris RESTORE, 2024-2028)* – Operationalizing the West Florida Shelf ecosystem model and application to red tides, stock assessments, and catch advice for Gulf reef fish. The project team will 1) develop red tide maps using NOAA's VIIRS satellite instrument; 2) incorporate oxygen and red tide dynamics into a physical biogeochemical model; 3) update and calibrate the West Florida Shelf (WFS) Ecospace model; and 4) operationalize the WFS ecosystem model for routine stock assessment and management. The project team will also develop an online questionnaire to facilitate collection of local ecological knowledge from fishers and complement model predictions with on-the-water accounts of red tide impacts. The project is expected to support acceptable biological catch determination for multiple species under the Gulf reef fish fishery management plan that will undergo stock assessments from 2023-2028. This project will also help inform fishery management plan amendments and contribute to the implementation of the Gulf of Mexico Fishery Ecosystem Plan process as it works through its first Fishery Ecosystem Issue.

(A2) *Accounting for episodic mortality in stock assessments under a changing climate (SEFSC, 2025-2026)* – The SEFSC is conducting a project to evaluate how to best account for climate-driven episodic mortality within stock assessments and projections used to determine stock status, using Florida red tides and groupers in the Gulf as a case study. Red tide mortality has been a key source of episodic mortality for groupers in the Gulf. However, there is considerable uncertainty surrounding how climate change will affect Florida red tides. This project will first evaluate how reference points are affected by episodic events of severe red tides causing mass mortality and help us understand how we can best manage these fisheries in light of the uncertainties associated with a changing climate. The remainder of this project will focus on simulation testing the inclusion of climate-driven episodic mortality in stock assessments. This analysis will address questions such as what is the risk of inclusion/exclusion in the assessment model, and what if we are wrong about the mechanism?

(B) *Updated red tide severity index for comparison with landings and environmental variables (Council staff)* – Preliminary red tide severity indices were developed using red tide maps from the West Florida Shelf Ecosystem model (Vilas et al. 2023). Several variations of annual indices were developed, each at multiple *K. brevis* cell concentration thresholds: (1) annual cumulative area of red tide presence, (2) annual cumulative area of red tide presence scaled by bloom duration, and (3) annual cumulative gridded bins of red tide occurrence. Red tide indices were used to evaluate trends in landings for red grouper, gag, gray snapper, lane snapper, and the other shallow water grouper complex, as well as patterns in environmental variables associated with red tide.

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