# Coastal Acidification Network Stakeholder Feedback Project

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A Report to the NOAA Ocean Acidification Program
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This report was reviewed and guidance was given by Kimberly K. Yates, Senior Research Oceanographer, United States Geologic Survey

## EXECUTIVE SUMMARY

This project is a result of a Southeast Ocean and Coastal Acidification Network (SOCAN) and Gulf of Mexico Coastal Acidification Network (GCAN) collaboration across the Southeast and Gulf of Mexico regions to support efforts of the Interagency Working Group on Ocean Acidification (IWGOA) Monitoring and Prioritization plan. SOCAN and GCAN were funded by the NOAA Ocean Acidification Program to create a stakeholder feedback survey to inform the acidification community on stakeholder monitoring needs. Monitoring includes information on the state of acidification, its chemical and environmental causes, and impacts on the environment and economy. Presentations that were provided to the Coastal & Heartland National Estuary Partnership Technical Advisory and its Citizen Advisory Committees were aimed at non-acidification experts and concerned stakeholders. A "primer" on acidification, what causes it, and current knowledge of acidification in the Southeast USA and Gulf of Mexico regions, was provided to all participants. After the presentations, committee members were asked a series of questions on their understanding of acidification, their perception of the impacts of acidification on the environment, and where they think future research and monitoring should focus. A survey was also made available through an online polling system, made available through the SOCAN and GCAN websites, social media, at multiple meetings, and through emails.

## BACKGROUND

US Southeast

The Southeast region, North Carolina, South Carolina, Georgia, the east coast of Florida, and the Florida Keys, spans sub-tropical to tropical climate zones and encompasses diverse ecosystems and environmental conditions. While much of the Southeast and Caribbean region has higher seawater temperature and salinity, which act to decrease acidity, and lower carbon dioxide levels than in other regions, many coastal areas are experiencing higher rates of acidification than in the open-ocean. The Southeast includes diverse habitats and ecosystems such as shallow and deep coral reefs, mangroves, seagrass beds, salt marshes, open water pelagic zones, and other carbonate dominated environments. Impacts of acidification to corals include decreased growth rates and other physiological effects, and dissolution of carbonate seafloor sediments. Coral reefs provide important coastal resistance to dangerous waves, support a large tourism industry, and provide social value for communities in the Southeast. The Southeast also has one of the largest recreational fishing industries and a growing aquaculture industry. The Southeast represents a wide range of communities and cultures, and many have important ties to the marine environment. Fishing, shellfish collection, and coral reefs are economically important, and provide cultural value including heritage, sense of place, identity, and pride. At present, many stakeholders in the Southeast are less concerned about ocean and coastal acidification compared to other co-stressors, such as low oxygen events and harmful algal blooms (HABs).

Gulf of Mexico

The Gulf of Mexico is home to highly diverse marine, coastal, and estuarine environments including ecosystems that contribute significantly to the U.S. Blue Economy. These systems contain several habitats and species including shellfish, coral reefs, and carbonate seafloor environments that are vulnerable to acidification. Gulf of Mexico seawater chemistry is highly complex but remains relatively under-observed with respect to acidification and poses critical knowledge, research, and monitoring gaps that limit our current understanding of environmental, ecological, and socioeconomic impacts. The habitat diversity over multiple climate zones makes international collaboration key to understanding the influence of acidification causes and changes in the Gulf of Mexico. In addition to the $CO_2$ from the atmosphere, acidification in the region is influenced by a complex interplay of processes and multiple stressors such as increasing water temperature, ocean circulation, river water, excess nutrient input, HABs, low oxygen conditions, storms, and oil seeps and spills. Similar to the Southeast, many industry stakeholders in the Gulf of Mexico are also more concerned with low oxygen or HABs than ocean and coastal acidification; however, these environmental stressors often interact, and little research has been conducted to evaluate these co-stressors.

The following sections provide a summary of research and monitoring gaps identified in the 2022 Ocean Chemistry Coastal Community Vulnerability Assessment of the Interagency Working Group on Ocean Acidification as mandated by the 2020 Coordinated Ocean Observations and Research Act.

### Social Vulnerability Gaps Identified in the *Ocean Chemistry Coastal Community Vulnerability Assessment*[1]

[1] "*Ocean Chemistry Coastal Community Vulnerability Assessment*" (May 2023) A report by the Subcommittee on Ocean Science and Technology to the White House.

US Southeast

Ecosystems at risk from ocean and coastal acidification are closely linked to coastal communities, but there are severe gaps in evaluating societal understanding of its own vulnerability to acidification. How chemical and biological changes resulting from increased acidification translate into social and economic impacts is not well understood; additional research on this will direct effective management practices, mitigation efforts, and community adaptation strategies. Commercial and recreational fisheries have important economic value in the Southeast, with total combined sales value at over $31 Billion, the employment income generated was over $7 Billion, and there were 194,000 jobs within this sector in 2019. **Figure 1** shows the number of jobs, gross sales, and employment income by state. Major Southeast fisheries include oysters, clams, lobster, shrimp, blue crab, stone crab, and finfish (flounders, groupers, king mackerels, snappers, swordfish, and tunas); there is relatively low diversity of commercially harvested species in the Southeast. Acidification reduced larval survival of blue crab, stone crab, hard clams, and eastern oysters in lab experiments and some species such as blue crab and shrimp populations have already shown declines in the last decade, though the cause has not yet been identified. Key gaps in information also include:

1. Valuation and quantification of the growing aquaculture industry and potential economic loss
2. Quantification of social and economic impacts from structural reef loss and related impacts to the fishing industry and other sectors of the economy
3. More research is needed to couple valuations with ecosystem forecasts that predict the effects of ocean and coastal acidification on ecosystems

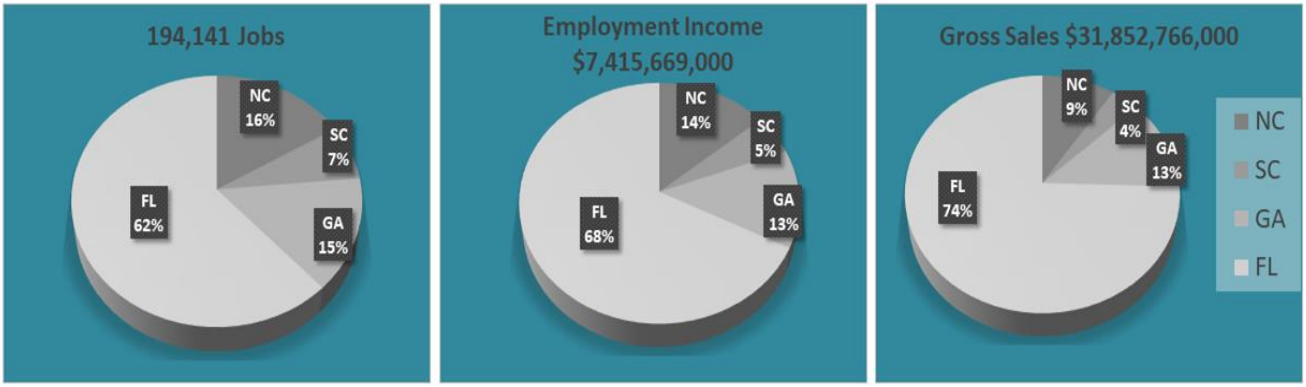



**Figure 1**. 2019 U.S. jobs and economic revenue from the recreational and commercial fishing industry in the US Southeast.

Gulf of Mexico

The seafood industry in the Gulf of Mexico generated nearly $6 Billion of income in 2019 and supported over 160,000 jobs. Recreational fishing activity, which generated over $1 Billion in income in 2019 has supported over 40,000 jobs. **Figure 2** shows the number of jobs, gross sales, and employment income by state throughout the Gulf of Mexico. Some of the most important species for commercial fisheries include blue crab, shrimp, oysters, tuna, red snapper, spiny lobster, menhaden, mullet, and grouper. Species of importance for recreational fisheries include Atlantic croaker, Gulf and Southern kingfish, sand and silver seatrout, sheepshead, red snapper,

southern mackerel, and striped mullet. However, in this region, gaps remain in our understanding of the processes that directly influence ocean and coastal water chemistry, species, and ecosystem, which inhibits our ability to directly link species response to ocean and coastal acidification. These gaps make it difficult to estimate how commercial and recreational stocks will respond and the resulting economic impacts. There are also gaps in assessing how ocean and coastal acidification will affect marine resources that hold social or cultural values. Synthesis of socioeconomic data on potentially impacted species, ecosystems, industries, and resources is extremely limited in the region. Other key gaps of information also include:

1. Economic and acidification data at smaller geographic scales
2. Understanding what increases sensitivity of communities to economic declines in fisheries that are driven by acidification
3. Development of social indicators specific to acidification to evaluate the vulnerability of coastal communities.

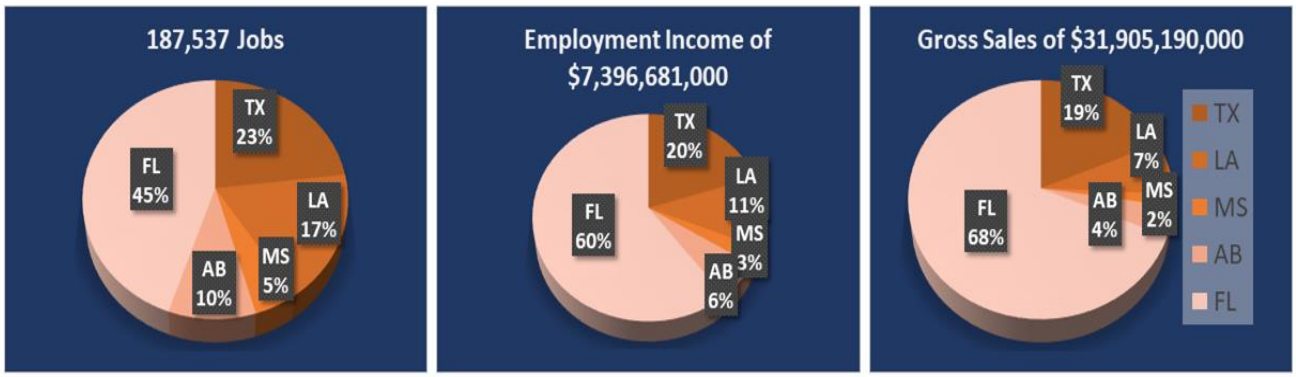



**Figure 2.** 2019 U.S. jobs and economic revenue from the recreational and commercial fishing industry in the Gulf of Mexico.

**Exposure Gaps**

US Southeast

Monitoring is key for understanding the current levels and spatial coverage and tidal, daily, seasonal, and yearly variability in ocean and coastal acidification in the Southeast. Monitoring various marine environments allows managers to determine the exposure level a species or ecosystem has to acidic conditions. Monitoring also provides information on the causes of acidifications and co-stressors (river water, low oxygen, excess nutrients, currents, atmospheric $CO_2$, biological usage of $CO_2$), and data for predictive models. Monitoring sites can include buoys, fixed sites on piers, and samples taken during cruises, however, continuous high-quality measurements are still limited. Key monitoring gaps for organism and ecosystem include:

1. Shelf water monitoring, both within the water column and in deep water ecosystems
2. Monitoring how biological processes and river discharge affect changes in $CO_2$ water chemistry
3. Monitoring of multiple acidification parameters in estuaries, wetlands, mangroves, and marshes that provide important ecosystem services (fisheries, tourism, recreation, essential fish habitat, coastal hazards protection)

Gulf of Mexico

Although conditions are highly variable and long-term sustained data are limited, pairing modeling approaches with the available data is a valuable strategy for filling monitoring gaps in the Gulf of Mexico. However, sustained and additional monitoring is needed to track the progression and understand the causes of acidification across the region due to the diversity of environments and high degree of habitat and tidal, daily, seasonal, and yearly variability in carbonate chemistry. Due to limited observational data, impacts of acidification on coastal and seafloor habitats and species are poorly understood. Seasonal changes have not been well defined in the Gulf due to limited collection of data during winter and fall seasons. Targeted subsurface observations are critical for supporting research to understand vulnerable seafloor communities
that are already exposed to more acidic waters, such as deep, cold-water coral habitats. A rigorous synthesis of existing historical and modern data relevant to acidification observations and research has not been conducted in the Gulf of Mexico. Other key gaps in information also include:

1. Examining when acidification conditions occur and how long they persist to aid decision making for monitoring areas of interest
2. Informing habitat restoration and acidification mitigation strategies
3. Improving ocean biogeochemical models that can also inform sampling and monitoring strategies
4. Modeling past and future changes in acidification.

**Biological Exposure Gaps**

US Southeast

More research is needed to fully understand how most of the economically important species' populations will be impacted, which will inform how fisheries and tourism will be financially impacted. Trickle-down effects from harmful biological effects to social and economic impacts
are not well understood. Biological exposure to acidification also impacts living habitats such as coral reefs, mangroves, and sea grasses directly, though how habitats respond to multiple environmental stressors is still not well defined. In addition to impacts to species and habitats,
acidification may also result in a shift in plankton communities towards an increase in HABs, such as Florida red tide (*Karenia brevis*), which affects human health, the survival of marine organisms, and can ultimately disrupt coastal economies. Species survival, habitat health, and water quality are all impacted by acidification. **Figure 3** shows which species have been studied and of those species, which have been commercially evaluated and impacted by acidification in the US Southeast. Ultimately, very little is understood about the impacts of acidification on biological organisms:

1. Species specific studies are very limited, especially for commercially important species
2. Determination of the effects of timing of acidification events with other environmental stressors
3. Data that does exist has not yet been combined throughout the Southeast to better understand biological responses
4. Acidification impacts on various different life stages of organism is unknown

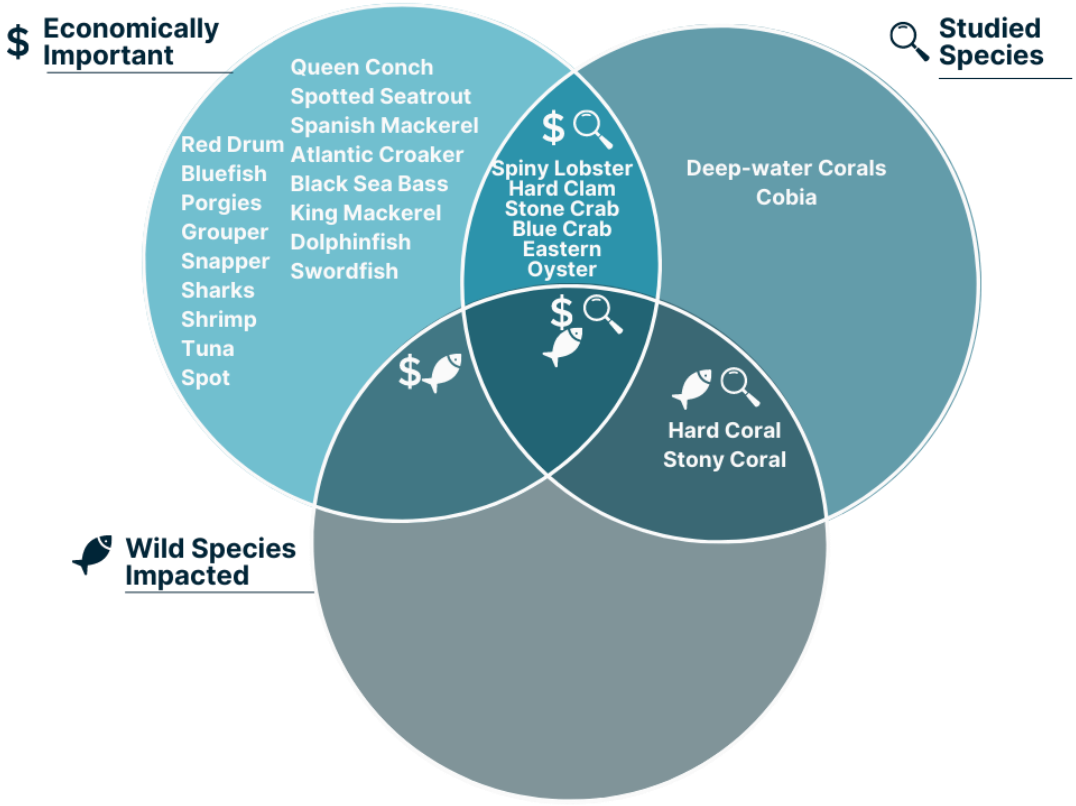



**Figure 3.** A visualization of known biological impacts in the US Southeast with three general classifications: economically important species, species that have been studied in the lab, and species that are known to have been impacted by acidification in the wild. Note that there are no species within the center of the three circles.

Gulf of Mexico

The Gulf of Mexico is home to a range of marine habitats including salt marshes, seagrass and shellfish beds, mangroves, oyster reefs, and coral reefs that host economically, ecologically, and recreationally important marine species that are vulnerable to acidification. However, studies on impacts of acidification to Gulf species have been limited and mostly focused on a few economically important shellfish species including Eastern oysters, Bay scallops, Hard clams, Queen conch, Gulf shrimp, and Florida stone crab (Osborne et al., 2022). While the Gulf of Mexico has over 1,443 finfish species, studies of acidification-impacts on fish are also limited to only a few species. **Figure 4** shows which species have been studied and of those species have been commercially evaluated and impacted by acidification within the Gulf of Mexico region. The cascading indirect impacts of ocean and coastal acidification across the marine food web is not yet known. Little is known of how co-stressors interact with each other and with acidification, including impacts of these co-stressors to coastal and marine species and harmful algal blooms. Estuarine, coastal, and open marine habitats in the Gulf of Mexico provide a variety of ecosystem

services that support food security, recreation, tourism, industry, and coastal hazards protection. Additional knowledge gaps include:

1. Assessing the impacts of acidification on chemical erosion of the seafloor, elevation loss, relative sea level rise, and coastal hazards
2. Identifying resistant ecosystems and species
3. Conducting research to develop acidification reduction strategies
4. Monitoring trickle-down effects of multi-stressor impacts on marine species to ecosystem function and services.

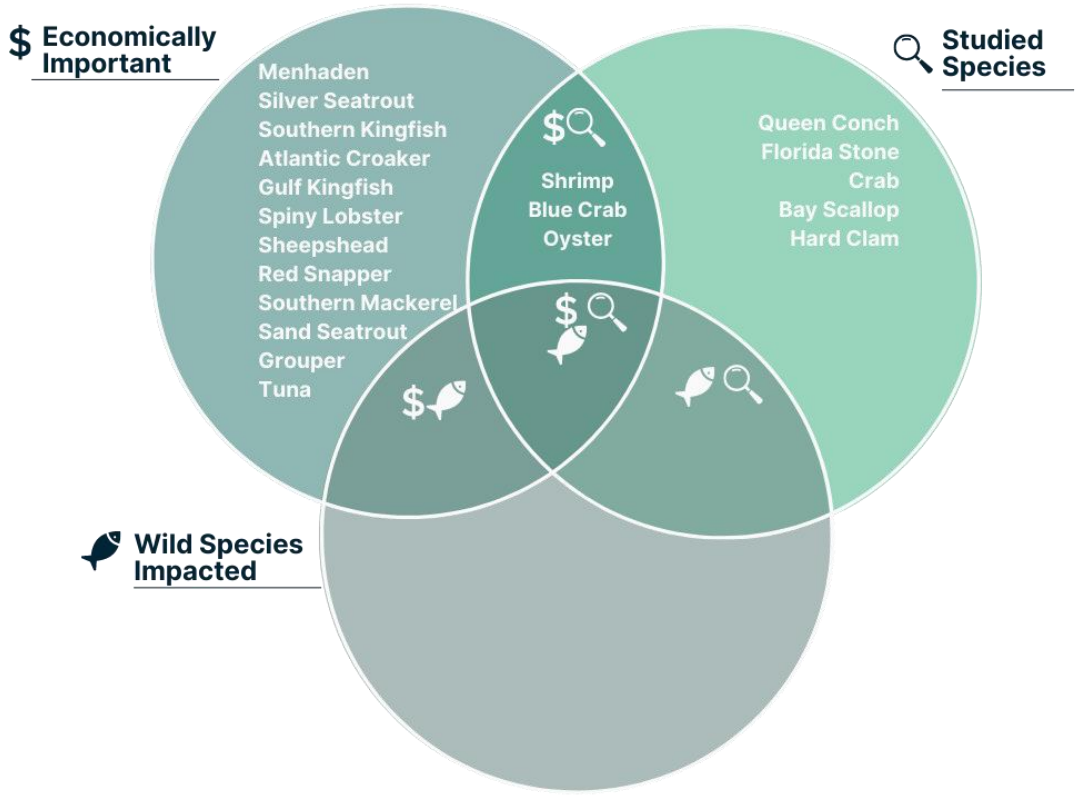



**Figure 4.** A visualization of known biological impacts in the Gulf of Mexico with three general classifications: economically important species, species that have been studied in the lab, and species that are known to have been impacted by acidification in the wild. Note that there are no species within the center of the three circles.

## PROJECT METHODS

Prior to this study, SOCAN and GCAN collected information on social and environmental vulnerabilities in the US Southeast and Gulf of Mexico in response to the IWGOA's request for Coastal Acidification Network (CAN) engagement in identifying Ocean Acidification (OA) vulnerabilities and research and monitoring priorities. In 2021, SOCAN hosted a workshop, and generated a report[2], to bring researchers and stakeholders together to broadly discuss sources of

[2] Reimer, J.J., E.R. Hall, L. Korman (2022). SOCAN Workshop Report: Coastal Vulnerability in the Southeast

vulnerability in Florida, Georgia, South Carolina, and North Carolina (Reimer and Hall, 2022). In 2021, GCAN's Science Working Group and colleagues from Cuba and Mexico participated in a trinational workshop to discuss the state of OA science in the Gulf of Mexico to identify research and monitoring needs in areas that could benefit from international collaboration. Due to geographic and membership overlap, SOCAN and GCAN collaborate on proposal writing, social media, stakeholder engagement, and regional strategic planning. Based on those previous efforts, SOCAN and GCAN proposed to create a question-and-answer survey to engage US Southeast and Gulf of Mexico stakeholders. This survey asked stakeholders to prioritize research and monitoring needs across both regions based on identified gaps in the draft IWGOA US Southeast and Gulf of Mexico Coastal Communities Vulnerability Assessment. The surveys were presented in two different manners with 19 questions total:

1. Live MentiMeter questions at in-person meetings (at a number of National Estuary Program Technical (TAC) and Citizen Advisory Committee (CAC) meetings)
2. Online Google Form questions (via email and posted on the SOCAN and GCAN websites)

Prior to the survey, SOCAN/GCAN collaboratively wrote a key findings Executive Summary of research and monitoring gaps identified in the draft IWGOA Vulnerability Assessment Report. The Executive Summary was distributed to SOCAN/GCAN members/stakeholders (over 350 people). No personally identifiable information (PII) was collected during the survey process with the exception of identifying their state of residence and job sector. This information will be used in future stakeholder outreach efforts by both SOCAN and GCAN. Results of the survey have been synthesized here for contribution towards the development of the IWGOA Research and Monitoring Priorities Reports for the US Southeast and the Gulf of Mexico. Results of this survey were also presented to the Coastal & Heartland National Estuary Partnership (CHNEP) at the 2023 CHNEP Watershed Summit.

## RESULTS

Efforts were made to connect with all of the NEPs within the two regions to provide a summary, in-person or virtual presentation, and presentation of the survey as a MentiMeter poll. The survey was presented in person to four NEP TACs and CACs including: the Tampa Bay Estuary Program (TBEP) TAC and CAC, the Sarasota Bay Estuary Program (SBEP) TAC, the Coastal & Heartland National Estuary Partnership (CHNEP) TAC and CAC, and the Albemarle-Pamlico National Estuary Partnership (APNEP) TAC. The Google Form was posted on the SOCAN and GCAN

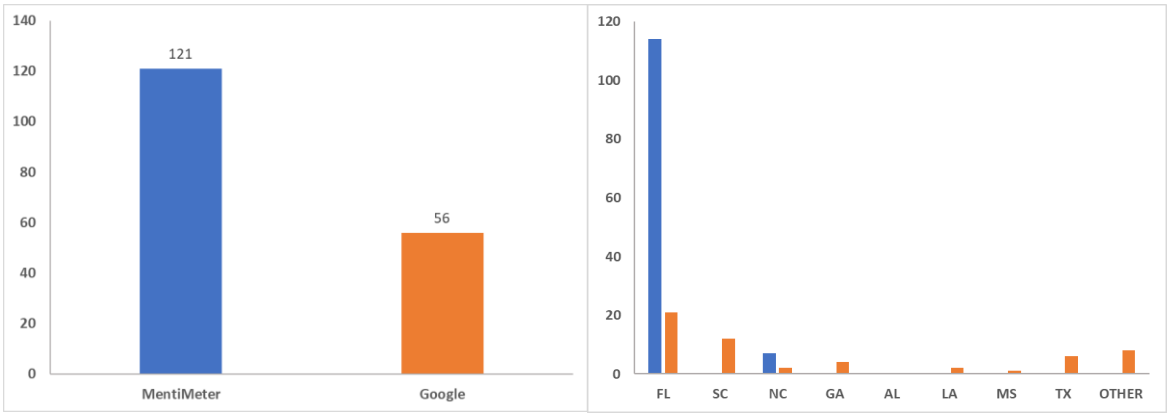



**Figure 5.** Responses from the (a) MentiMeter Poll and Google Form surveys, and (b) total responses from each state.

websites and was emailed to a number of contacts throughout both regions including the SOCAN and GCAN Science and Stakeholder Working Groups, Steering Committees, and members. There was a total of 177 responses with 121 of those responses from the MentiMeter polls and 56 from the Google Form (**Figure 5**). Within the MentiMeter poll, 114 were from Florida and 7 were from North Carolina. Within the Google Form, 21 responses were from Florida, 12 from South Carolina, 2 from North Carolina, 4 from Georgia, 2 from Louisiana, 1 from Mississippi, 6 from Texas and 8 from other locations (including Pennsylvania, Europe, and Guam).

The following figures show summaries of results of each question that was asked in the MentiMeter and Google Forms.

1. **Do you have any knowledge on this topic prior to today? If so, how would you classify your level of knowledge on ocean acidification?**

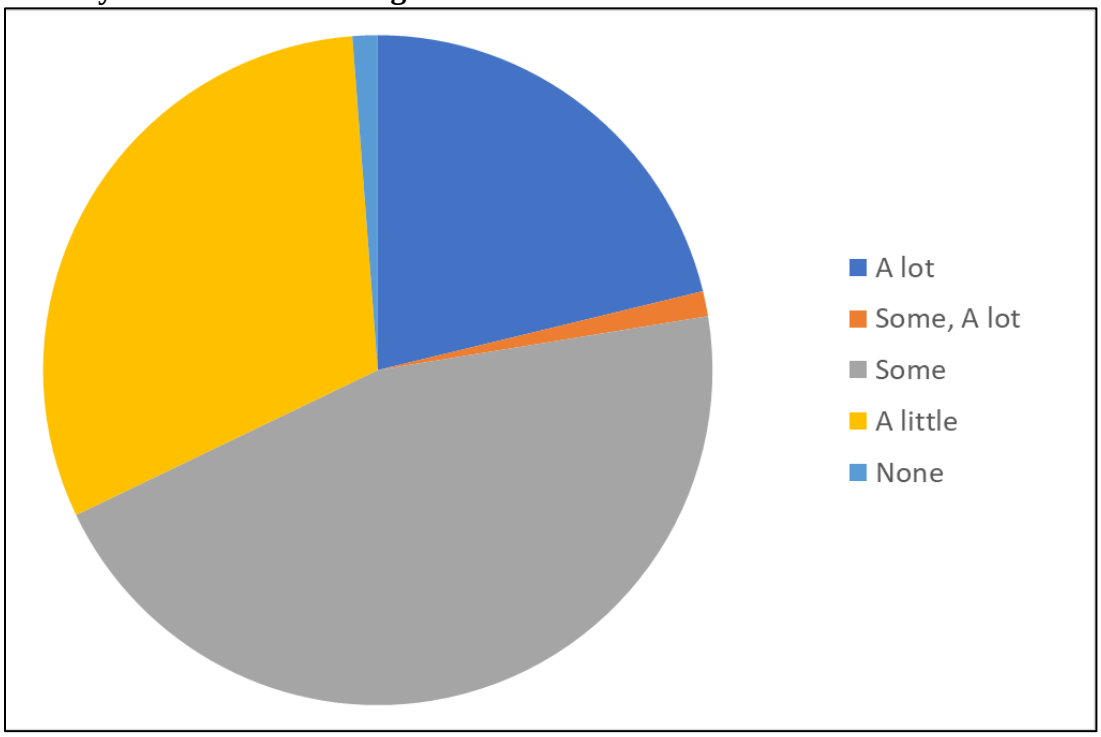



Fig. 6 Results: The number one answer was “Some”, followed by “A little” and “A lot”.

2. **How would you describe your main source for information about acidification?**

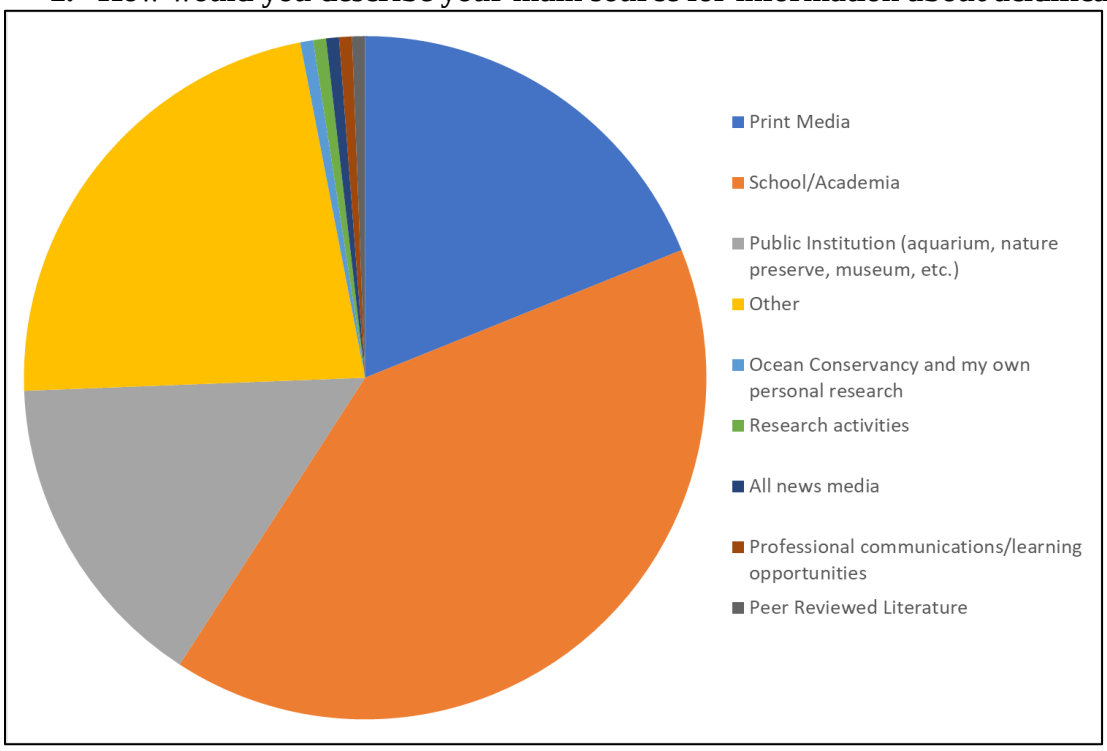



Fig. 7 Results: The number one answer was "School/Academia" followed by "Other (undefined)" and "Print Media".

3. **Which of the following processes are you familiar with?**

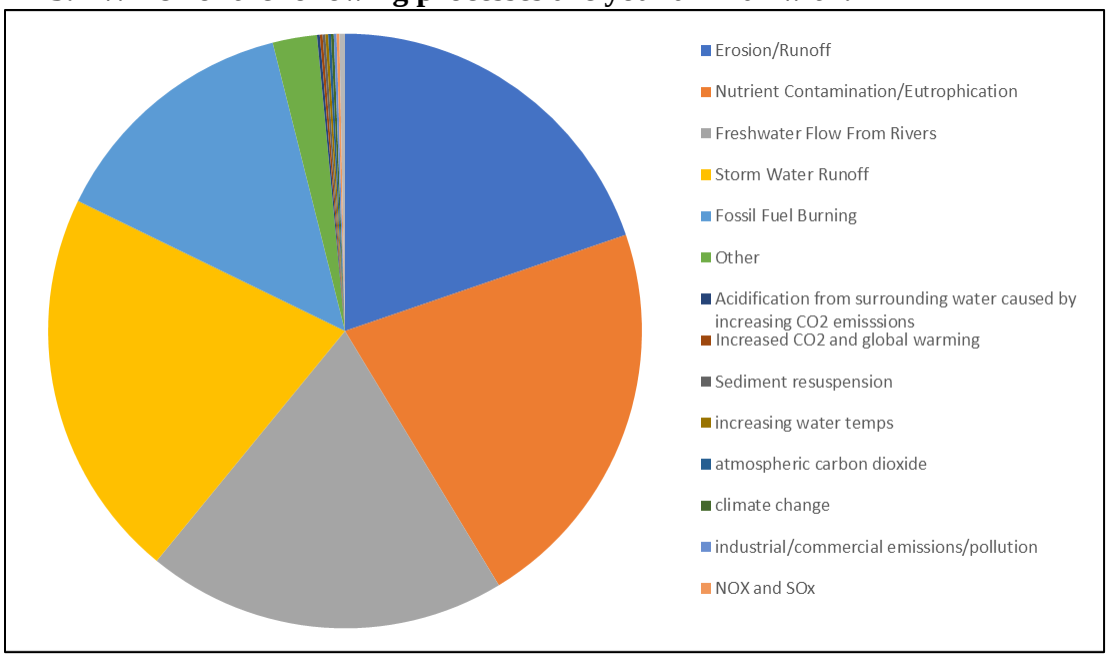
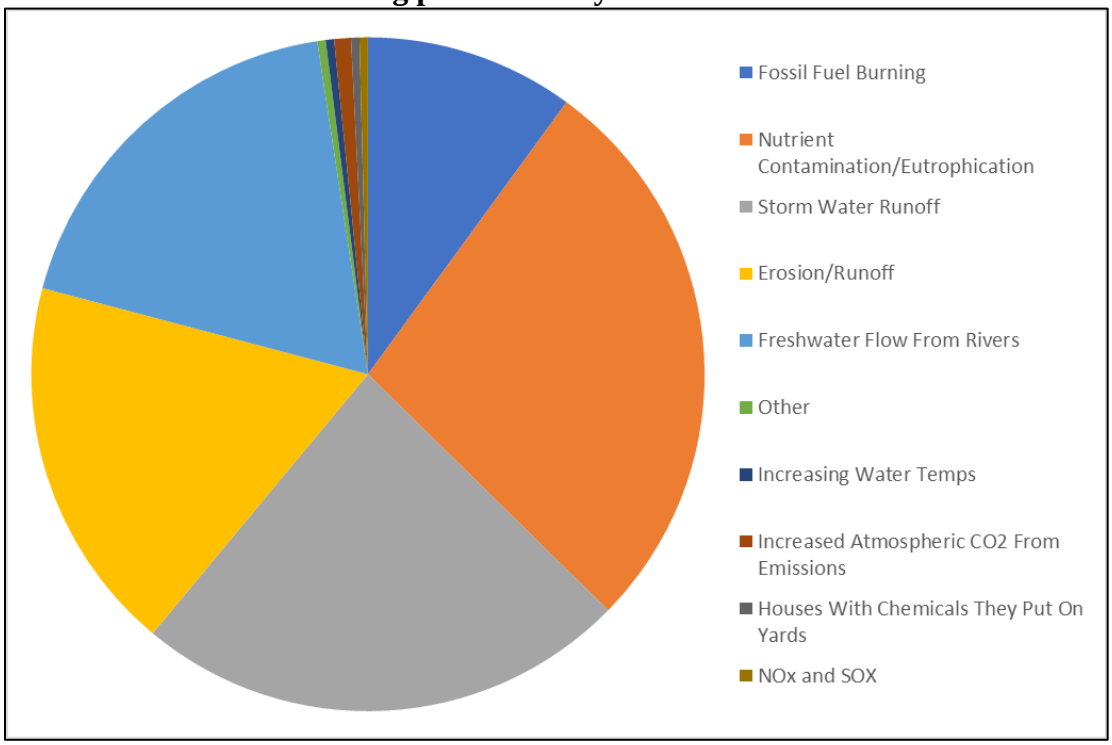


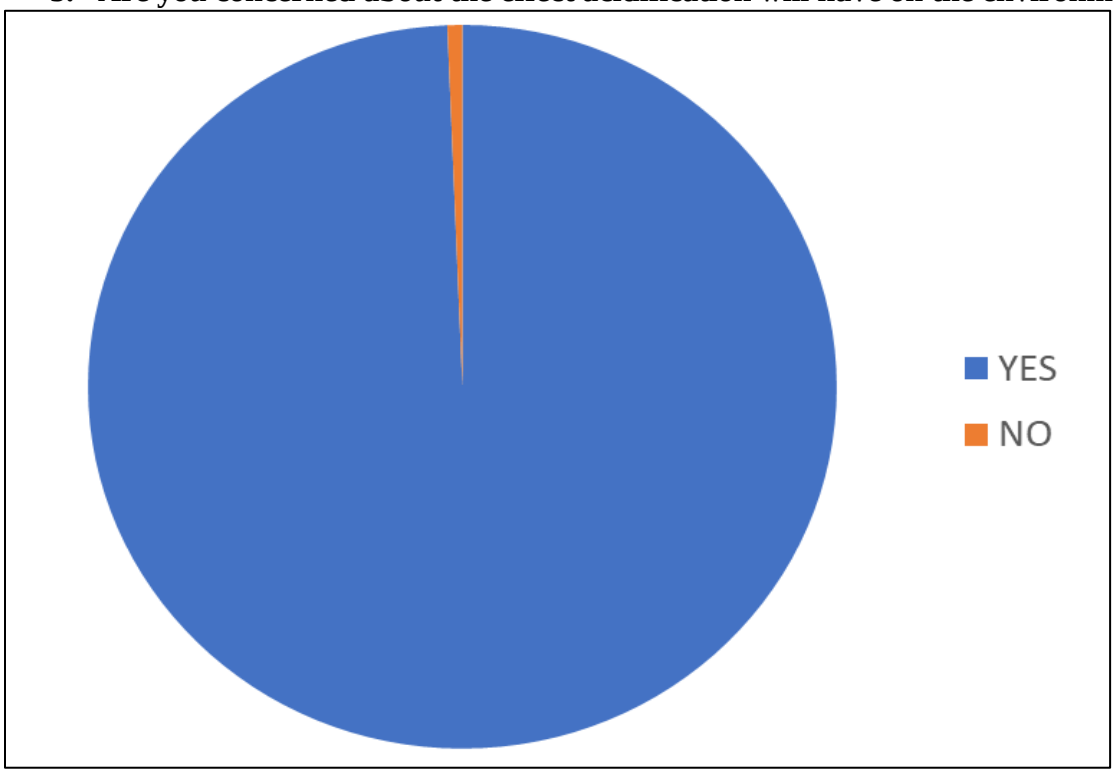

Fig. 8 Results: The number one answer was "Nutrient Contamination/Eutrophication" followed by "Stormwater Runoff" and "Erosion/Runoff".

4. **Which of the following processes do you think could lead to or worsen acidification?**



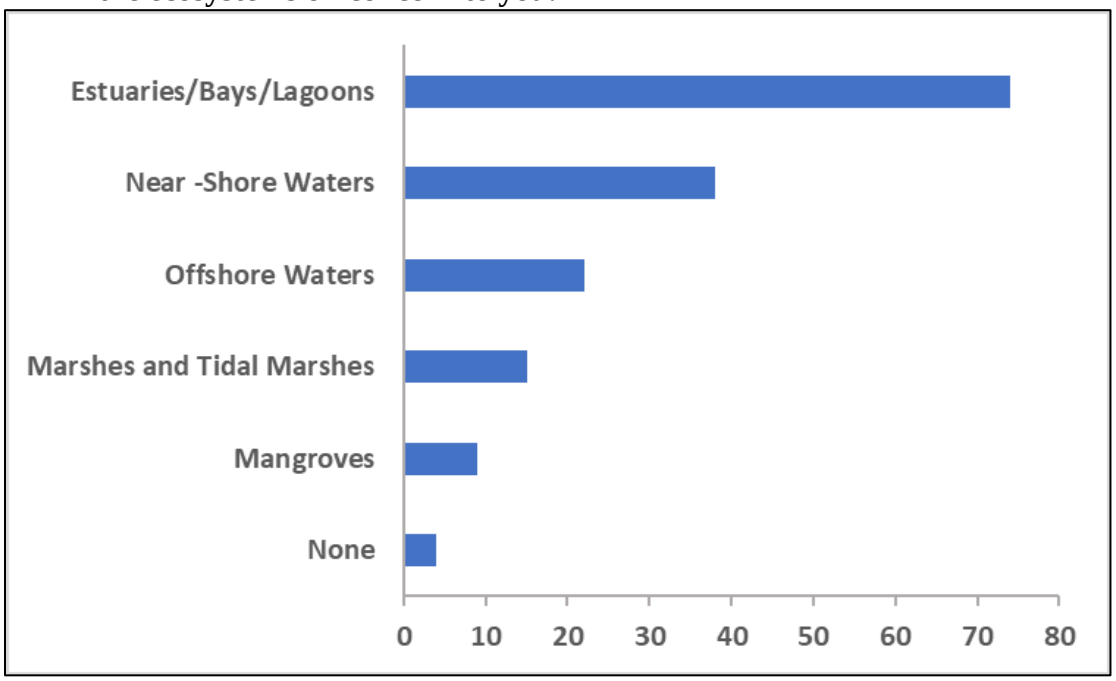

The number one answer was “Nutrient Contamination/Eutrophication” followed by “Storm Water Runoff” and “Freshwater Flow from Rivers”.

5. **Are you concerned about the effect acidification will have on the environment?**



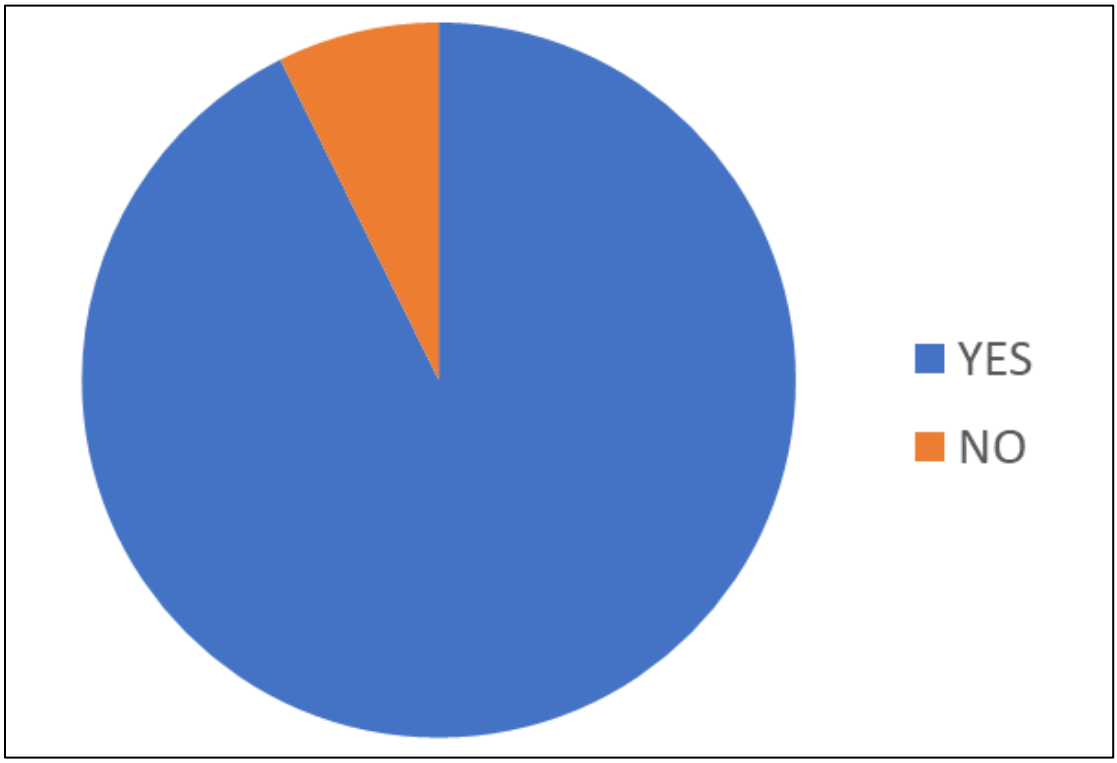

The overwhelming number one answer was "Yes". Only one person selected "No".

6. **If you are concerned about the effects of acidification on the environment, please rank the ecosystems on concern to you.**

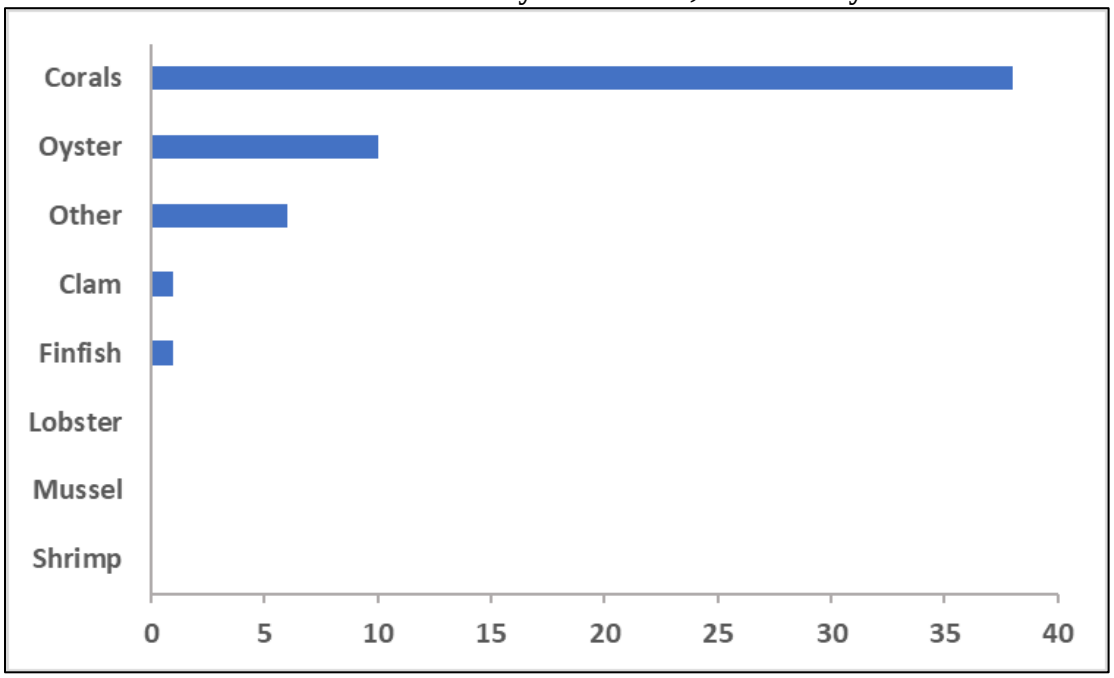



The number one answer was "Estuaries/Bays/Lagoons" followed by "Near-Shore Waters" and "Offshore Waters".

7. **Are you aware of the potential effects of coastal or ocean acidification on marine animals?**

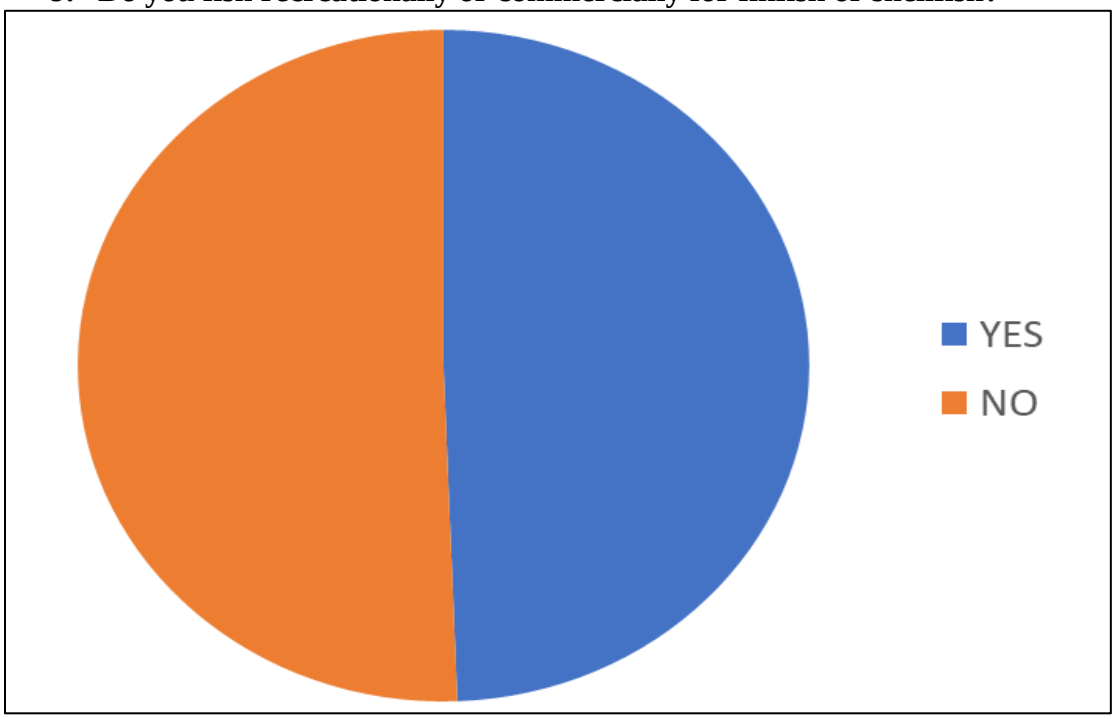



8. **Of the marine animals that may be affected, which are you most concerned about?**



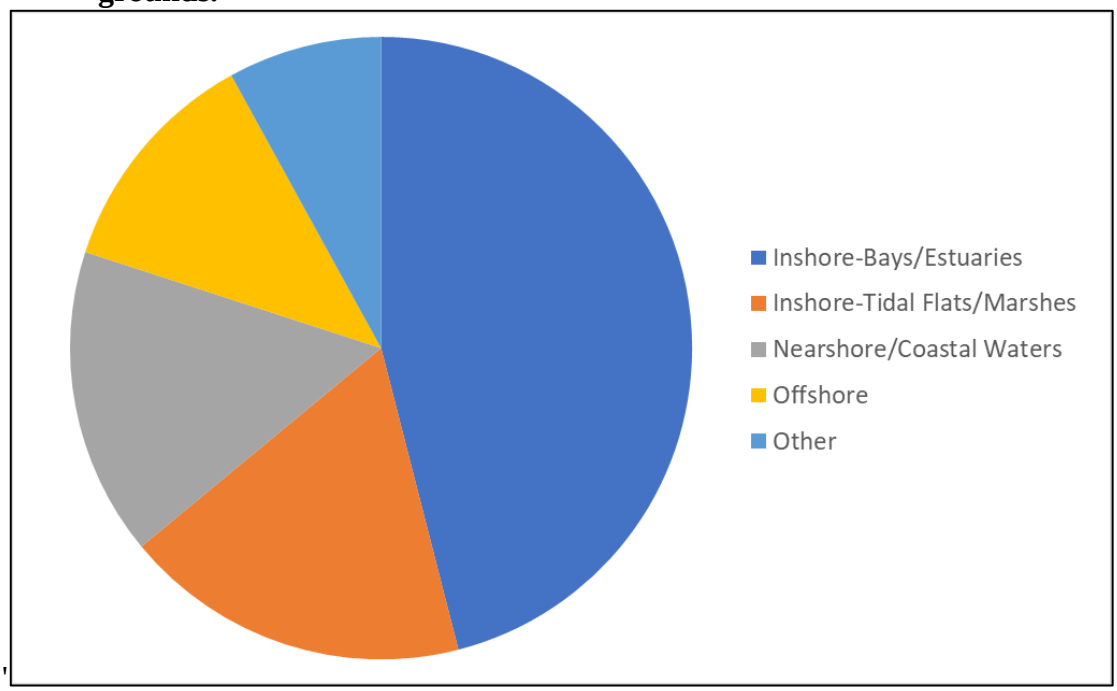

The number one answer was "Corals" followed by "Oysters" and "Other" (with write in answers including: crabs, everything else, all species, coccolithophores, pteropods, phytoplankton, shorebirds).

9. **Do you fish recreationally or commercially for finfish or shellfish?**




100% of the responses were recreational fisheries people. There were no commercial fisheries people who responded to the poll (though there were attempts to reach commercial fishery groups).

10. **If yes (to question number 9), please specify which zone best describes your fishing grounds.**

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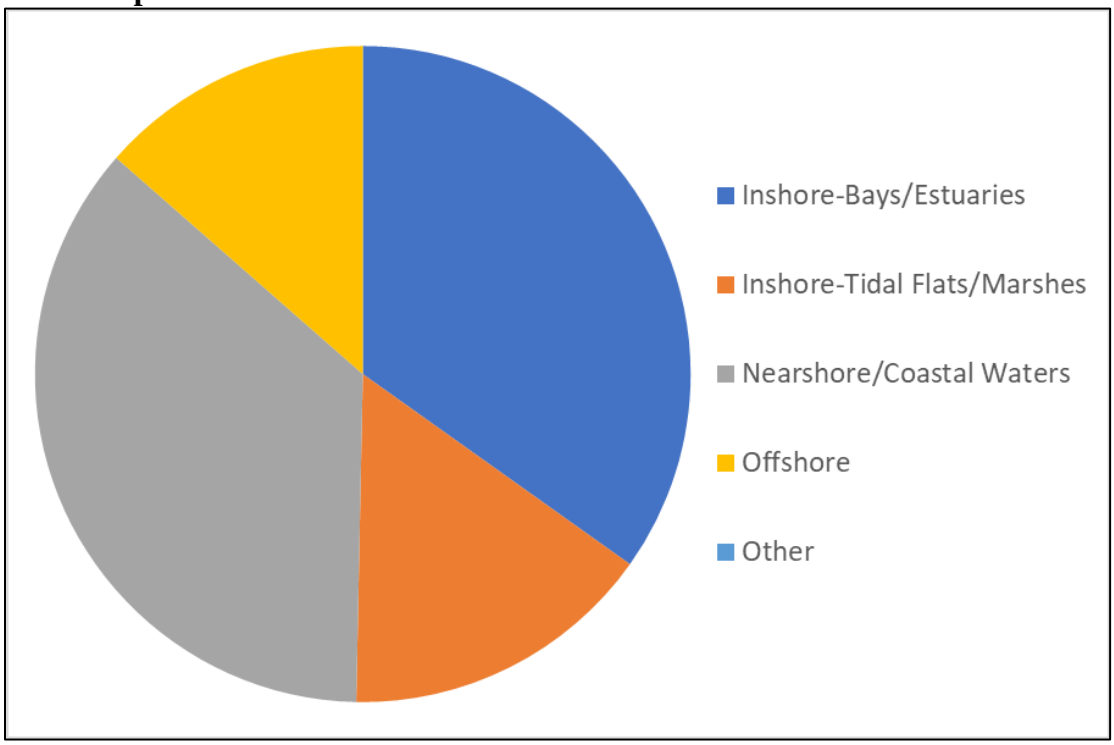
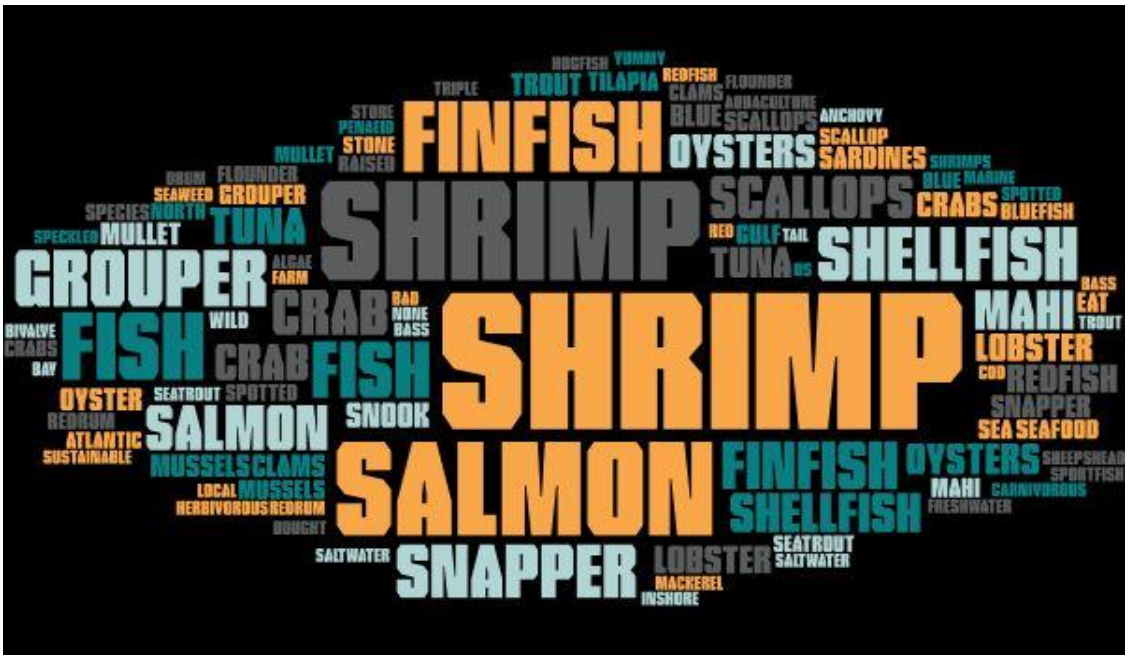
The number one answer was "Inshore - Bays/Estuaries" followed by "Inshore – Tidal Flats/Marshes" and "Nearshore/Coastal Waters".

**11. If these ecosystems are affected by acidification, which, in your opinion, is most important to focus on?**



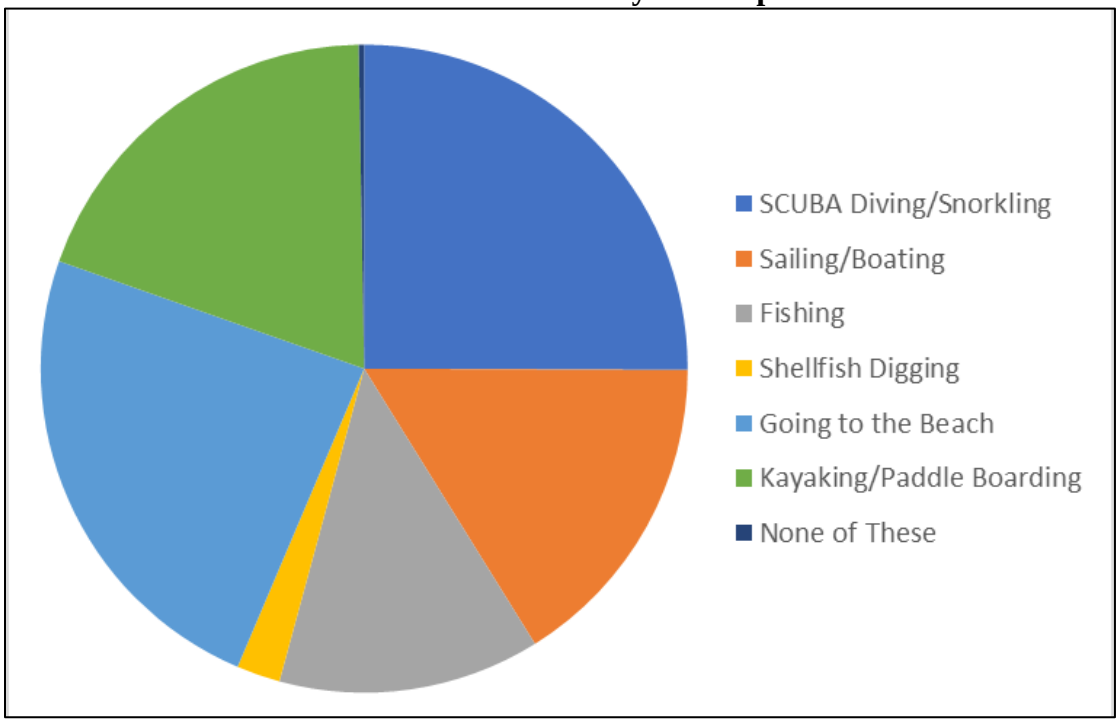

The number one answer was "Nearshore/Coastal Waters" followed by "Inshore - Bays/Estuaries" and "Inshore – Tidal Flats/Marshes".

**12. What describes the top 3 types of seafood you fish for or consume at home?**



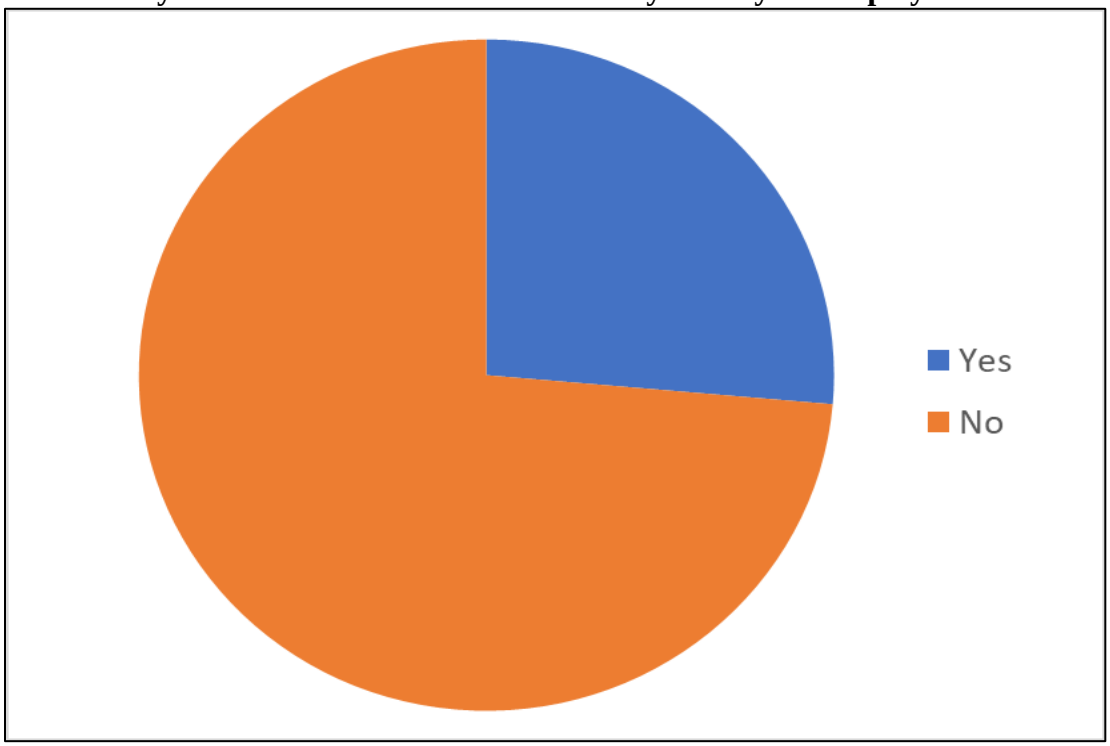

The top three answers are as follows: Number 1: Shrimp, Number 2: Salmon and Number 3: Finfish

**13. What recreational marine activities do you take part in?**

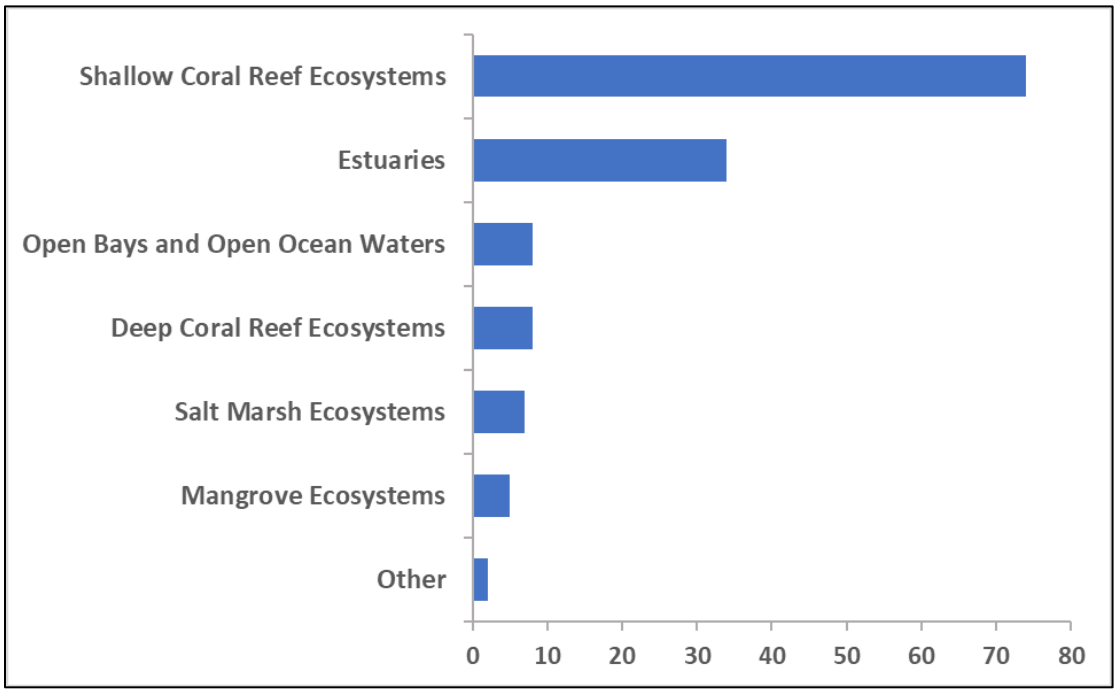



The number one answer was “SCUBA Diving/Snorkeling” followed by “Going to the Beach” and “Kayaking/Paddle Boarding”.

**14. Are you concerned that acidification may affect your employment in the future?**

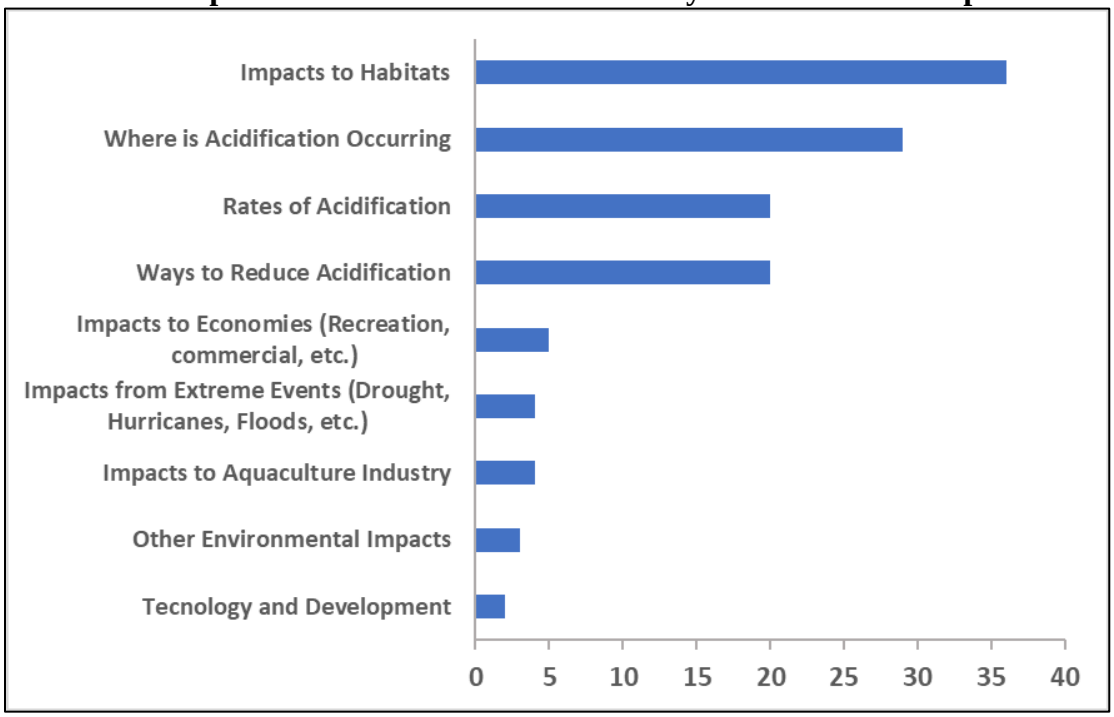


**15. The following locations could be affected by acidification. Rank your concern about the potential effects of acidification?**




The number one answer was "Shallow Coral Reef Ecosystems" followed by "Estuaries" and "Open Bays and Open Ocean Waters".

**16. Rank aspects of acidification research that you think should be prioritized.**

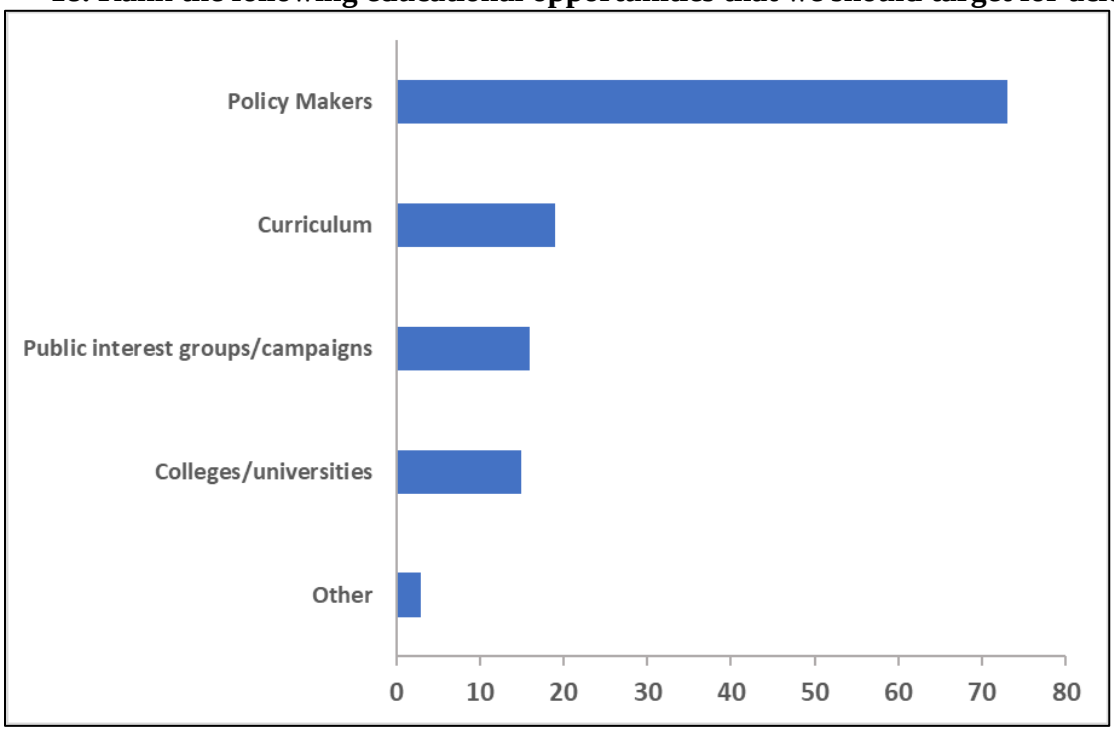



The number one answer was "Impacts to Habitats" followed by "Where is Acidification Occurring" and "Rates of Acidification".

## 17. Are there any research areas we left out in the above question?

1. Better understanding the relative role of global climate chance and atmospheric co2 levels versus nutrient inputs
2. Acidification from air pollution, human health and plant impacts
3. Impacts on wildlife
4. Behavioral changes to reduce causes
5. Social surveys to understand what the public and decision makers know about this topic.
6. sediment/erosion
7. Buffering capacity of ecosystems/estuaries
8. Micro flagellates, food chain base
9. Larval recruitment
10. food web impacts
11. critical planktonic food webs
12. Trend analysis of acidification over time
13. chemical erosion of carbonate sediments
14. Acidification contributing factors in our area
15. Florida aquifer
16. where impacts come from most
17. How ocean acidification affects prevalence and toxicity of harmful algal blooms.
18. Compiling existing water quality data to help understand trends in areas across Florida
19. How to best educate the public and policy
20. Modeling of acidification for future impacts
21. Measurement tech improvements
22. Would like to see more studies done on the slowly rising alkalinity levels vs acidification
23. Impacts to subsistence fishing communities
24. Research promoting non-carbon fuels
25. Public education on what OA is and how people can be proactive to mitigate
26. Impacts on cultural resources- overlap with habitat and economy

**18. Rank the following educational opportunities that we should target for acidification.**




The number one answer was "Policy Makers" followed by "Curriculum" and "Public Interest Groups/Campaigns".

**19. What type of communication would be helpful for conveying information about acidification?**


The number one answer was "Social Media" followed by "Restaurants/Retailers".

## SUMMARY

This was the first attempt at this survey method for SOCAN and GCAN in response to requests from the IWGOA to inform the Research and Monitoring Priorities Reports for the US Southeast and the Gulf of Mexico. This information will be provided to the IWGOA and NOAA OAP to inform a nation-wide survey for decision making on prioritizing Ocean Acidification monitoring and assessment.

This report presents raw response data. SOCAN and GCAN have not included conclusions or discussion within this report. Additional data analysis, interpretation, and discussion of lessons learned are anticipated for inclusion into a summary manuscript.

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