

**SPATIAL ANALYSIS OF CRUISE LINES AND  
CRITICAL BENTHIC HABITATS**

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Masters project submitted in partial fulfillment of the  
requirements for the Master of Environmental Management degree in  
the Nicholas School of the Environment and Earth Sciences of  
Duke University  
2007

## **Abstract**

Due to concerns regarding the proximity of cruise line discharge to critical marine benthic habitats (i.e. corals and seagrasses), a science panel for the International Council of Cruise Lines (ICCL) has recently updated recommendations for the improvement of discharge practices. No previous spatial component exists to assess the distance relationship of cruise liners to critical benthic habitats. Duke University and Conservation International have collaborated on a pilot project to create a series of GIS (Geographic Information Systems) maps, indicating cruise ship track density and discharge locations with respect to “sensitive marine habitats”, Marine Protected Areas (MPAs), and the 20-meter depth contour in the southeastern Florida cruise line corridor from Fort Lauderdale to the Dry Tortugas. The pilot project will be used as a future reference point for mapping other high-density cruise line corridors in the Caribbean Sea.

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## **Introduction**

Modern cruise lines are the equivalent of small floating cities, which generate a considerable amount of marine pollution. Cruise line effluent dumping practices are insufficiently monitored and regulated under existing marine sanctuary management plans, policies, and environmental laws. The U.S. Coast Guard's limited detection and enforcement capabilities have allowed many discharge incidents to go undetected. The largest cruise lines, with a carrying capacity of 5000-plus passengers and crew, generate more than one million gallons of waste water everyday [1]. A one-week voyage can produce 210,000 gallons of sewage, fifty tons of garbage, one million gallons of graywater, and 35,000 gallons of oil-contaminated water[1].

A Science Panel for the International Council of Cruise Lines (ICCL), along with Conservation International, have recently updated recommendations to commission a global mapping project to “identify and integrate into navigational charts the sensitive marine areas where discharge should be avoided” [2]. Duke University and Conservation International have proposed a pilot study to evaluate the relationship between “sensitive marine areas” (coral reefs, seagrass beds, shellfish habitats, hard-bottom habitats, etc.) and cruise ship track density and discharge locations, by evaluating the relative distances and positions of cruise ship traffic to important benthic habitats. The pilot project will hopefully lead to reproducible methods for the assessment of regional and local concentrations of cruise ship traffic and potential discharge patterns relative to protected areas and marine habitats.

## **Background**

There are no current regulations prohibiting cruise liners from discharging treated and untreated sewage, sewage sludge, or treated and untreated graywater in the National Marine Sanctuary System in the United States [1]. Cruise liners are not sufficiently regulated because the Clean Water Act provisions that apply to cruise ships were written over 30 years ago, which precede today's growing fleet of large luxury liners. When the Clean Water Act was drafted, Congress never considered the current vast quantities of waste produced by cruise liners. Furthermore, cruise line discharges are exempt from regulations governing land-based wastewater dischargers.

### *Legal Mandates Regarding Ocean Dumping Policies*

There are four policies that relate to marine dumping: the Marine Protection, Research, and Sanctuaries Act (MPRSA); Coastal Zone Management Act (CZMA); the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78); and the Clean Water Act (CWA).

The Marine Protection, Research, and Sanctuaries Act (MPRSA) was created in 1972 to regulate ocean dumping and the transportation of materials [3]. Specifically, the act recognized that unregulated dumping of material into ocean waters endangers human health, welfare, and amenities, and the marine environment, ecological systems, and economic potentialities. Congress declared that this act regulates the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would "adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities." The act also regulates the transportation of material in the United States, which includes

national or international vessels, aircraft, or agencies that discharge material in the U.S. territorial sea or the contiguous zone.

In December 1988, Reagan issued the Presidential Proclamation 5928, which increased the territorial sea from three to twelve miles for the United States (comprising Puerto Rico, Guam, American Samoa, the U.S. Virgin Island, and the Northern Mariana Islands) [4, 5]. Although the extension of the territorial sea was inspired by national security concerns, this proclamation allowed the United States to theoretically protect a larger area of ocean water. The Contiguous Zone is twelve nautical miles out to sea from the edge of the Territorial Sea.

The Coastal Zone Management Act (CZMA), enacted in October 1972, was created to encourage coastal states to develop comprehensive programs to manage and balance competing uses of and impacts to coastal resources [5]. This act emphasizes the primacy of state decision-making regarding the coastal zone. Section 307 (16 USC § 1456) specifically called for the federal consistency provision. This provision was a major incentive for states to join the national coastal management program.

The 1954 OILPOL Convention inspired the Marine Pollution Conferences of 1973 and 1978 (MARPOL 73/78) [6]. The OILPOL Convention, which entered into force in July 1958, attempted to tackle the problem of pollution of the seas by oil—defined as crude oil, fuel oil, heavy diesel oil, and lubricating oil—in two main ways: The act established “prohibited zones” extending at least 50 miles from the nearest land in which the discharge of oil or of mixtures containing more than 100 parts per million was forbidden; and required Contracting Parties to take all appropriate steps to promote the provision of facilities for the reception of oily water and residues.

The 1973 International Conference adopted the International Convention for the Prevention of Pollution from Ships [6]. This act recognized that operational pollution was a bigger threat than accidental oil spills, based on the frequency of occurrences of operational pollution. MARPOL incorporated much of OILPOL 1954 and its amendments into Annex I, which covers oil pollution. The act intended to address other forms of pollution from ships and other annexes covered chemicals, harmful substances carried in packaged form, sewage, and garbage. The 1973 Convention also included two Protocols dealing with *Reports on Incidents involving Harmful Substances* and *Arbitration*. The convention required ratification by fifteen states, with a combined merchant fleet of not less than 50 percent of world shipping by gross tonnage, to enter into force. By 1976, it had only received three ratifications—Jordan, Kenya, and Tunisia—representing less than one percent of the world’s merchant shipping fleet. States could become Party to the Convention by only ratifying Annexes I (oil) and II (Chemicals). Annexes III and V, covering harmful goods in packaged form, sewage and garbage, were optional.

In 1978 the International Maritime Organization (IMO) held a conference on Tanker Safety and Pollution Prevention [6]. This conference adopted measures affecting tanker design and operation, which were incorporated into both the Protocol of 1978 relating to the 1974 Convention on the Safety of Life at Sea (1978 SOLAS Protocol) and the Protocol of 1978, relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol). The 1978 MARPOL Protocol allowed states to become Party to the Convention by first implementing Annex I (oil), as it was decided that Annex II (chemicals) would not become binding until three years after the

Protocol entered into force. This gave states time to overcome technical problems in Annex II, which for some had been a major obstacle in ratifying the Convention. The Convention finally entered into force in October 1983 (for Annexes I and II). Annex V (garbage) achieved sufficient ratifications to enter into force in December 1988, while Annex III (harmful substances carried in packaged form) entered into force in July 1992. Annex IV (sewage) did not enter the force until September 2003.

Annex IV (sewage) describes the proper procedure for sewage treatment or storage aboard ship and the circumstances in which sea discharge would be allowed [7]. This Annex requires Parties to the Convention to provide adequate storage facilities for sewage and contains a model International Sewage Pollution Prevention Certificate to be issued by national shipping administrations to ships under their jurisdiction. Annex IV will be applicable to ships traveling internationally. All new ships of 400 gross tonnage and above and new ships less than 400 gross tonnage will be affected by the Annex immediately after entry into force. Five years after the entry into force, the Annex will apply to existing ships of 400 gross tonnage and above and of less than 400 gross tonnage and above but certified to carry more than fifteen persons. In other words, all cruise lines should adhere to the standards set forth by Annex IV and MARPOL 73/78.

The Federal Water Pollution Control Act Amendments of 1972 were amended in 1977, and this law became commonly known as the Clean Water Act (CWA) [8]. When the CWA was drafted, Congress never considered the current vast quantities of waste produced by cruise liners. Cruise liner discharges are exempt from regulations governing land-based wastewater discharges. On land, the CWA requires a permit under the National Pollutant Discharge Elimination System (NPDES) to discharge any pollutant



from a point source into United States waters. On water, sewage discharges from vessels, effluent from properly functioning marine engines, shower, laundry, and sink galley wastes (“graywater”), or any other discharge “incidental to the normal operation of a vessel” are exempt from NPDES permits. The Clean Water Act is a powerful tool that states can use to manage coastal uses and resources and also to facilitate cooperation and coordination with federal agencies. However, there are no specific guidelines for cruise lines to dump their effluent.

In 2002, Florida Governor Jeb Bush and the EPA declared the state waters of the Florida Keys National Marine Sanctuary (FKNMS) a No Discharge Zone (NDZ) under Section 312 of the Clean Water Act [9]. A No Discharge Zone is a geographic area where it is illegal for vessels to discharge treated or untreated sewage (black water)[9]. Florida state waters extend three miles into the Atlantic Ocean and nine miles into the Gulf of Mexico. Approximately 65 percent of the FKNMS is located in state waters. Although the Dry Tortugas National Park is not part of the FKNMS, vessels are prohibited from discharging any kind of waste within the Park. The FKNMS is now in the process of declaring its federal waters an NDZ for all vessels, including cruise liners. The City of Key West has also declared an NDZ for city waters, which comprise 3.8 square miles.

With the increase of cruise ship traffic adjacent to the Florida Keys National Marine Sanctuary, the city of Key West is attempting to have stricter enforcement on pollution by raising berth fees to pay for environmental monitoring and control [10]. Reef Relief, a non-profit agency in Key West that is committed to protecting local reefs, recommends that all cruise lines install onboard advanced nutrient-removal wastewater

treatment or have the sewage storage capacity to pump-out upon return to Key West and other ports of call in Florida. The City of Key West requires all cruise lines to have black water pumped out by facilities upon entering the port. The Gulf Stream and other currents distribute nutrients and sewage discharge to the Florida Keys and greatly impact coastal waters. In 2004, Reef Relief urged congress to require cruise line discharge to be treated to tertiary nutrient-free levels and restrict discharge to international waters [10].

The Cruise Lines International Association (CLIA) is a non-profit organization that represents the interests of 21 passenger cruise lines that call on major ports in the United States and abroad [11, 12]. Within the United States, CLIA concentrates efforts towards safety, public health, environmental responsibility, security, medical facilities, passenger protection, and legislative activities. For environmental responsibility, CLIA has integrated comprehensive waste management programs to meet national and international laws. CLIA also works closely with the International Maritime Organization (IMO), the U.S. Coast Guard, and the Environmental Protection Agency, to strictly adhere to federal and international environmental standards. As for legislative activities, CLIA monitors all U.S. regulatory and legislative matters that impact the cruise industry. CLIA also informs Congress and the Administration of the cruise industry's current practices and policy positions on a wide variety of issues, as well as educates Washington leaders on the important economic contribution that the cruise industry makes in the United States.

Internationally, CLIA coordinates with the IMO, Safety of Life at Sea (SOLAS), Standards of Training, Certification, and Watchkeeping (STCW), MARPOL, and International Shipping Organizations (ISO) [12]. The IMO is a United Nations agency

that reviews current maritime issues and sets international law by adopting conventions and treaties that become international law. CLIA functions as a non-governmental consultative organization to the IMO. CLIA and the ISO work together with leading flag and port state administrations, international shipping associations and classification societies on environmental and safety issues.

In 2003, the International Council of Cruise Lines (ICCL, now part of CLIA) and Conservation International joined forces in order to “protect biodiversity in top cruise destinations and promote industry practices that minimize the cruise industry’s environmental impact” [11, 13]. The two organizations set up four priority areas: improving best practices for wastewater management; collaborating with local governments and communities to protect natural and cultural assets of cruise line destinations; promoting environmental education for tourists and crew; and decreasing supplier/vendor environmental impacts.

In 2006, a science panel for the ICCL made several recommendations to improve cruise liner dumping practices. Previous recommendations for good discharge practices suggested discharging at least four Nautical Miles from 20-meter depth contour and at least four Nautical Miles from “Sensitive Marine Areas” [2]. The council recommends the treatment and discharge of blackwater (wastewater from toilets and medical sinks) and graywater (wastewater from sinks, showers, laundries, and kitchens). They further recommend there should be continued installation and monitoring of advanced wastewater purification systems (AWPS), and independent evaluation of AWPS through the EPA’s Environmental Technology Verification Program. The ICCL suggests that there should be protocols for sewage bio-residues (sludge). Cruise lines should

encourage passengers to use biodegradable soaps, shampoos, detergents and cleaning agents. Cruise lines should also provide passenger education about environmental stewardship and pre-boarding and onboard literature about waste management practices.

The Science Panel Recommendation report proposes that for blackwater that has been treated with an MSD Type II (Marine Sanitation Device), there should be a minimum distance of four nautical miles from a 20-meter depth contour and the recommended improved practice distance is twelve nautical miles from 20 meter depth contour and four nautical miles from sensitive marine habitats [2]. The 20-meter depth contour is recommended to incorporate the larger ship drafts, which are approximately nine meters and the ship mixing zone is twice the draft, around eighteen meters [14]. The science panel recommends limiting discharges in shallow waters and/ or near sensitive marine habitats, to reduce the impact of chlorinated and brominated compounds from water and sewage treatment; freshwater, which will dilute the ocean water salinity; nutrients (nitrogen, phosphorus), which promote algal growth; viruses, particularly from human stomach bacteria; metals; and other chemical constituents, such as pharmaceuticals (i.e. high blood pressure medication, birth control, etc...).

#### Definition of “Sensitive Marine Areas”

“Sensitive Marine Areas” take the form of seamounts, shellfish beds, corals and coral reefs, mangroves, seagrasses, kelp beds, and Marine Protected Areas (MPAs). The primary areas located on the southeastern coast of Florida include shellfish beds, corals and coral reefs, mangroves, seagrasses, and Marine Protected Areas (MPAs).

Seamounts (undersea mountains) are “prominent features of the world's underwater topography” [15]. Scientists estimate there are over 100,000 seamounts

worldwide. Seamounts are biodiversity hotspots that are ecologically and economically important for offshore commercial fishing and seabed mining [15].

Shellfish in Florida include mussels, oysters, and clams, and generally live in the brackish water of estuaries [16]. Shellfish are filter feeders (e.g. pump up to 40 gallons of water per day across their gills to obtain oxygen and nutrients) and tend to take in bacteria, viruses, and chemical contaminants from sewage. These contaminants concentrate in the shellfish tissues over 100 times the levels in water [16].

Corals and coral reefs are located all along Florida's southeastern coast. Corals can be located as deep as 19,700 feet below the surface, but reef-building corals are typically found where sunlight can penetrate, or depths of 150 feet or less [17]. Deepwater corals are located within strong water currents in order to gather food and remove sediments to prevent coral polyps from being smothered [18]. As some of the oldest structures on the earth, corals provide a home for more than 25% of all marine wildlife species [19]. These structures prevent storms and erosion from depleting coastlines, as well as support tourism and fishing industries to increase revenues for local, state, and regional economies. Untreated sewage increases the amount of nutrients in the water, such as nitrogen and phosphorus, which promote the growth of algae. High concentrations of solid sewage and algae cover the corals and block essential sunlight for the zooxanthellae (a microscopic algae with a symbiotic relationship with corals), thus preventing coral growth and survival [20]. Raw or partially treated sewage also weakens corals, making them more susceptible to disease and other infections (such as yellow band disease) [21]. Coral reefs also depend heavily on nearby seagrass and mangrove ecosystems [22].

Seagrasses and mangroves filter out some nutrients from sewage and runoff from the land [23]. Destruction of mangrove and seagrass habitats will have a negative impact on corals and coral reef ecosystems, since these two ecosystems also provide nursing and feeding grounds for several reef dwellers. Excessive nutrients from sewage promote algal growth, which weaken seagrass root systems and block out essential light for photosynthesis [24].

Marine Protected Areas (MPAs) are state and federally government designated. Marine Protected Areas (MPAs) include National Marine Sanctuaries, Ecological Reserves, National Marine Parks, State Marine Parks, and Wildlife Refuges. In Southeastern Florida, there are two main Marine Protected Areas the Florida Keys National Marine Sanctuary and the Dry Tortugas Ecological Reserve. These areas have been created to protect areas of Natural Heritage (i.e. natural ecosystems, habitats, communities, populations, and biodiversity in national marine sanctuaries, parks, and wildlife refuges); Cultural Heritage (i.e. U.S. maritime and submerged resources and traditional cultural connections to the ocean); and Sustainable Production (i.e. support removal of fish, plants, mammals, shellfish, or birds that live within the MPA or organisms that depend on the area for nursery grounds, mating, spawning, and/or feeding) [25]. Each MPA has a different level of protection (listed here least to greatest): Uniform Multiple-Use, Zoned Multiple-Use, Zoned Multiple-Use with No-Take Area, No-Take, No Impact, or No Access. MPAs can be permanent, conditional, or temporary and may be year-round, seasonal, or rotating. National Marine Sanctuaries (such as the Florida Keys National Marine Sanctuary) and Ecological Reserves (such as the Dry Tortugas Ecological Reserve) are designated and regulated by NOAA (National Oceanic

and Atmospheric Administration). National Marine Parks are regulated by the National Park System. State Marine Parks are designated and regulated by individual State Park Systems. Wildlife Refuges are designated and regulated by U.S. Fish & Wildlife Services.

## **Materials and Methods**

Conservation International (CI) coordinated with Dr. Pat Halpin and me from the Marine Geospatial Ecology Lab at Duke, on this project. In late 2003 and early 2004, CI conducted a study to determine areas of cruise line discharge. If cruise lines were traveling in a two-day window around four dates during this time, they were asked to take coordinates (latitude and longitude) and time when they discharged sewage. From these studies, CI realized that cruise lines were leaving the discharge valve open while cruising around, and closing the valve just before coming back into port. Although sewage was not necessarily constantly coming out of the valve, if left open, there was a possibility of sewage discharging in close proximity to sensitive marine habitats and MPAs. The data obtained from this study was also very sensitive, so I changed my maps only to show distances from the discharge recommendation criteria. I created these maps to provide a visual image of the new recommendations promote better effort of cruise line discharge practices.

During the initial phase of my research, I used ArcGIS 9.2 to analyze geospatial data on bathymetry, sensitive marine habitats, ports (Fort Lauderdale and Miami), and marine protected area management. I downloaded benthic habitat data from the Fish and Wildlife Research Institute (FWRI) and bathymetry data from the General bathymetric Chart of the Oceans (GEBCO). I buffered four and twelve nautical mile distances from the 20-meter contour and then buffered four nautical miles from both the sensitive marine areas and Marine Protected Areas (MPAs).

On March 15, 2007, I attended the Seatrade Cruise Shipping Convention at the Miami Beach Convention Center, with three representatives from Conservation



International. We held a closed-door meeting with cruise line representatives to determine if the industry was interested in these maps to eventually integrate with NOAA navigational charts and for us to continue to map out the rest of the major Caribbean cruise line corridors.

## **Results**

Using the above methods, I created the following maps: 1) 20-meter depth regions with four- and twelve-Nautical Mile Distances; 2) a four-Nautical Mile buffer area around “Sensitive Marine Areas” (primarily seagrasses and corals); 3) a four-Nautical Mile buffer area around Marine Protected Areas (including the Florida Keys National Marine Sanctuary and the Dry Tortugas Ecological Reserve); and 4) a combined map of Proposed Areas of Wastewater Discharge Avoidance.

The first map depicts the 20-meter depth contour, with four and twelve Nautical Mile distances (Fig. One). The lighter blue areas represent regions that are zero to twenty meters deep. The area where the light blue and red regions meet represents the 20-meter contour, or where it is consistently twenty meters deep. The red area represents the distances up to four Nautical Miles from 20-meter depth contour and where the ICCL science panel recommends cruise lines not discharging here. The yellow area represents the distances between four and twelve Nautical Miles from 20-meter depth contour. The ICCL science panel recommends cruise lines discharge in this area with caution, and preferably discharging outside of yellow area (beyond twelve Nautical Miles).

The second map depicts the “sensitive marine areas” with a four-Nautical Mile buffer zone (Fig. Two). In Florida ecosystems, the majority of sensitive marine habitats include corals and seagrasses, which surround mangroves. Mangroves grow on the edge the land. Seagrasses grow in shallow waters up to five meters deep, with shallow water corals growing in the deeper ranges of the seagrass beds and beyond [24]. The seagrasses and corals are indicated in green with an orange outline. The red buffered area

represents up to four Nautical Miles from these sensitive marine habitats. The science panel recommends cruise lines avoid discharging in the red area.

The third map depicts the Marine Protected Areas (MPAs) with a four-Nautical Mile buffer zone (Fig. Three). MPAs in southeastern Florida include the Florida Keys National Marine Sanctuary and the Dry Tortugas Ecological Reserve. The red buffered area represents distances up to four Nautical Miles from MPAs, and where the science panel recommends avoiding discharge.

The final map shows a combination of all of the ICCL science panel discharge recommendations (Fig. Four). The red buffered area represents where the science panel recommends avoiding discharge (includes the MPAs, sensitive marine areas, depths up to 20 meters, four Nautical Miles from the 20-meter contour, four Nautical Miles from sensitive marine habitats, and four Nautical Miles from MPAs). The yellow buffered area represents four- to twelve- Nautical Mile distances from the 20-meter contour, and where cruise lines should discharge with caution. The science panel recommends discharging outside of the twelve-Nautical Mile region (represented by the darker blue area).

## **Discussion and Conclusions**

When the representatives from Conservation International and I spoke to the cruise line representatives, they had three concerns: 1) What if they had to reroute their vessel to discharge? 2) What if all vessels started to discharge in the same location? 3) What about cases, such as off the coast of California, where there were MPAs, but the water depth was 1000m+, could they still discharge?

For questions one and two, I suggested that cruise lines could coordinate with each other on discharge locations, like airline or trucker communication. The impact of many cruise lines discharging in one location has not been researched, but would probably depend on the speed and direction of the local currents, which would affect the effluent dispersal rate. As for the third question, MPAs not only protect the sea floor, but also the organisms residing within the area. Although discharging within the MPA would not directly affect the sea floor at such great depths, organisms residing within the entire water column of the protected area could be affected. These deep water MPAs are globally important hotspots for organisms.

In general, cruise lines voluntarily comply with these new recommendations, since they want to be respected by other cruise lines and customers by being a more eco-friendly business. The cruise line representatives said the maps were clear and concise and would like to see them implemented as soon as possible in NOAA navigational charts.

Cruise lines on the west coast of the United States have also agreed to comply with improved discharged recommendations. In Washington State in 2004, an agreement was made among the Department of Ecology, the U.S. Coast Guard, the Northwest

Cruise Ship Association (NWCA), the Port of Seattle, Holland-America cruise lines, Norwegian cruise lines, and Princess lines, which produced a draft Memorandum of Understanding (MOU) to improve management of wastewater discharge from cruise lines [26]. Each of the cruise lines has agreed to perform above standards of waste discharge requirements of Washington State and federal laws.

During the 1990s, several wastewater violations and cruise ship fines in Alaska, along with the increase of cruise line density and size within Alaskan waters, provoked public concerns of cruise line waste management practices [27]. The Alaska Cruise Ship Initiative was created in 1999 in conjunction with the discussion between the U.S. Coast Guard, U.S. Environmental Protection Agency, Southeast Alaska communities and Tribes, concerned Alaskans, environmental groups, and industry representatives. In 2000, voluntary sampling located malfunctioning marine sanitation devices and high levels of fecal coliform in wastewater samples. To regulate cruise line wastewater discharges within Alaskan waters, the state passed a law in 2001, to establish the Commercial Passenger Vessel Environment Compliance (CPVEC) Program with the Alaska Department of Environmental Conservation (ADEC). To further progress in the on the United States west coast, Conservation International and Duke plan to map out the new science panel recommendations for improved discharge practices and determine relative distances from cruise line discharge to sensitive marine habitats, marine protected areas, and 20-meter contours.

In summer 2007, the Alaskan state program will implement up to sixty rangers on cruise lines with more than 250 passengers, traveling in state waters [28]. These rangers will monitor the vessel to inspect cruise line waste disposal methods and ensure the

vessels are not discharging in Alaskan waters. The program costs (\$4/person) will assist in paying for satellite transponders that track ships' movements through state waters.

Currently, Conservation International and Duke University will continue to work together to map out sensitive marine areas, 20-meter contours, and MPAs (Marine Protected Areas) in other major cruise line tracks throughout the Caribbean (including the second corridor in southern Florida from Fort Lauderdale east to Nassau; Puerto Rico to the US Virgin Islands; the Mesoamerican reef from Cozumel to Belize; and the Cayman Islands. This study does not take currents into account, so future studies should also focus on direction of prevailing currents.

## **Acknowledgements**

I would like to thank the following people: my advisor, Dr. Pat Halpin, for his endless patience and assistance; Conservation International representatives Jamie Sweeting, Dr. Emily Pidgeon, and Rebecca Rogers, for all of their guidance and assistance; my wonderful family and Carter and Duncan Watterson for their love and support; the Duke Marine Lab 3 am GIS team for their help and support; my roommates, Melissa Stephens, Kim Collini, Andy, Teeter, and O.J., for putting up with me coming home at all hours of the night; and my fellow amazing CEMs for their support☺

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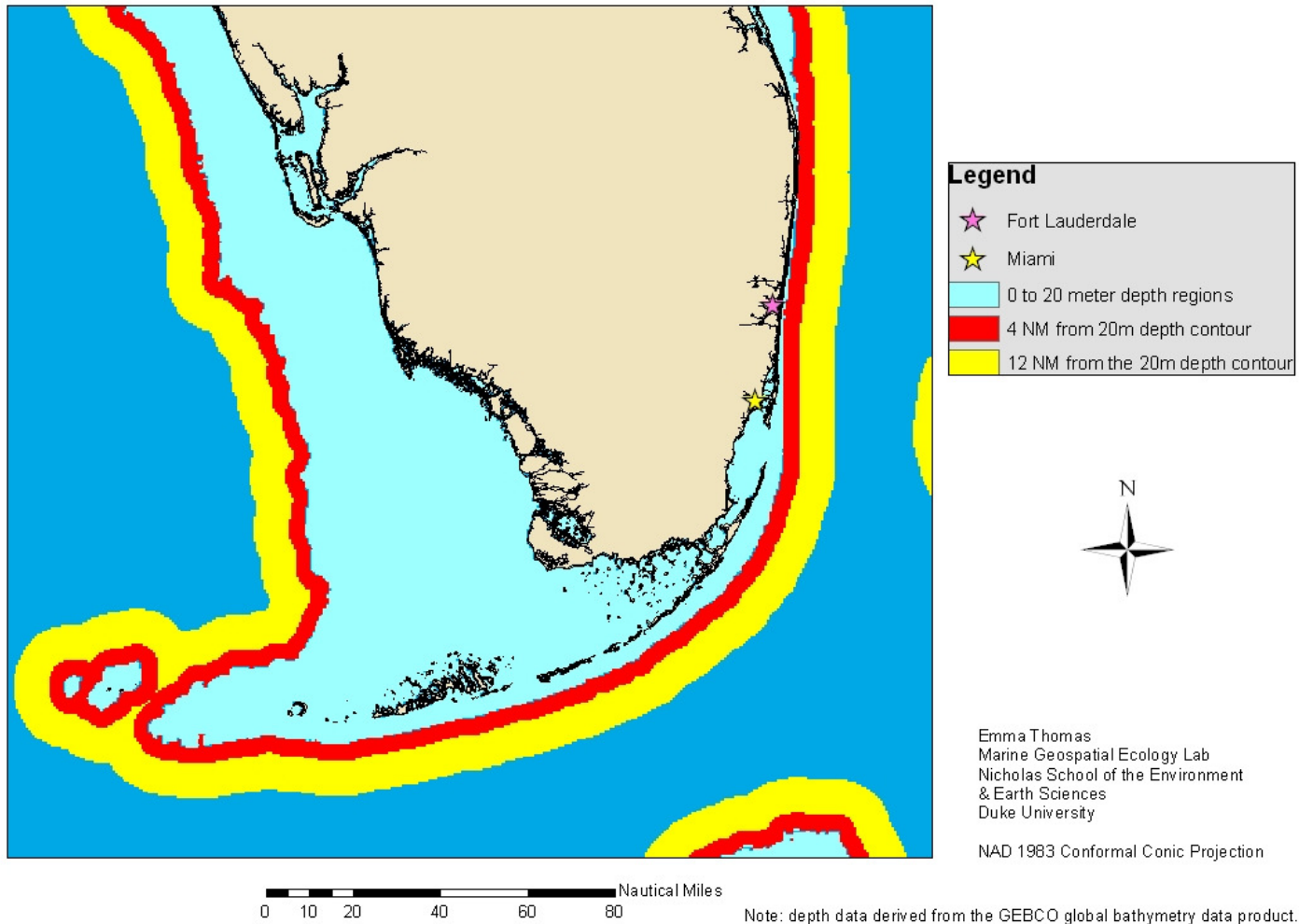
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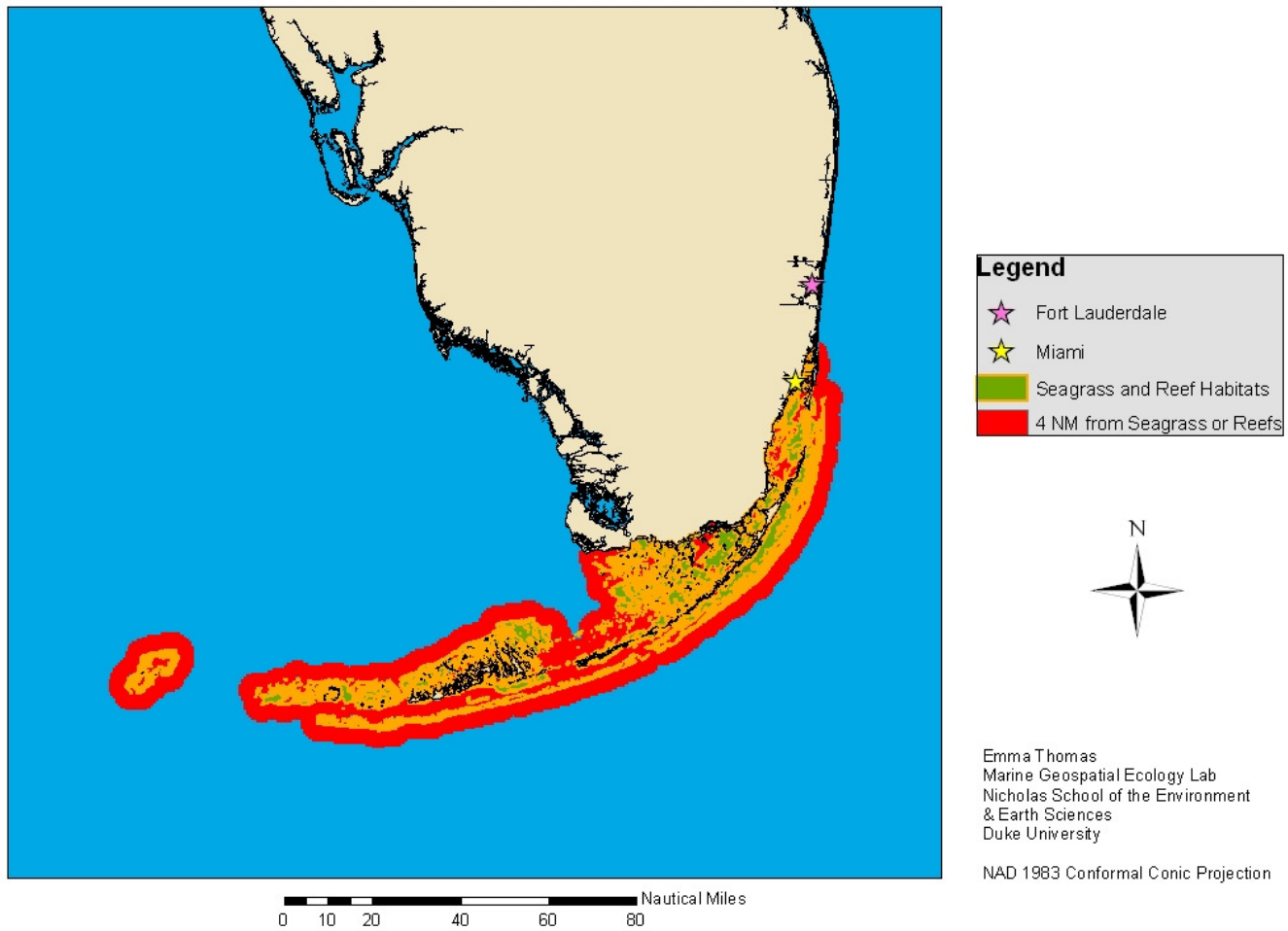
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## Distances from 20-Meter Depth Contour



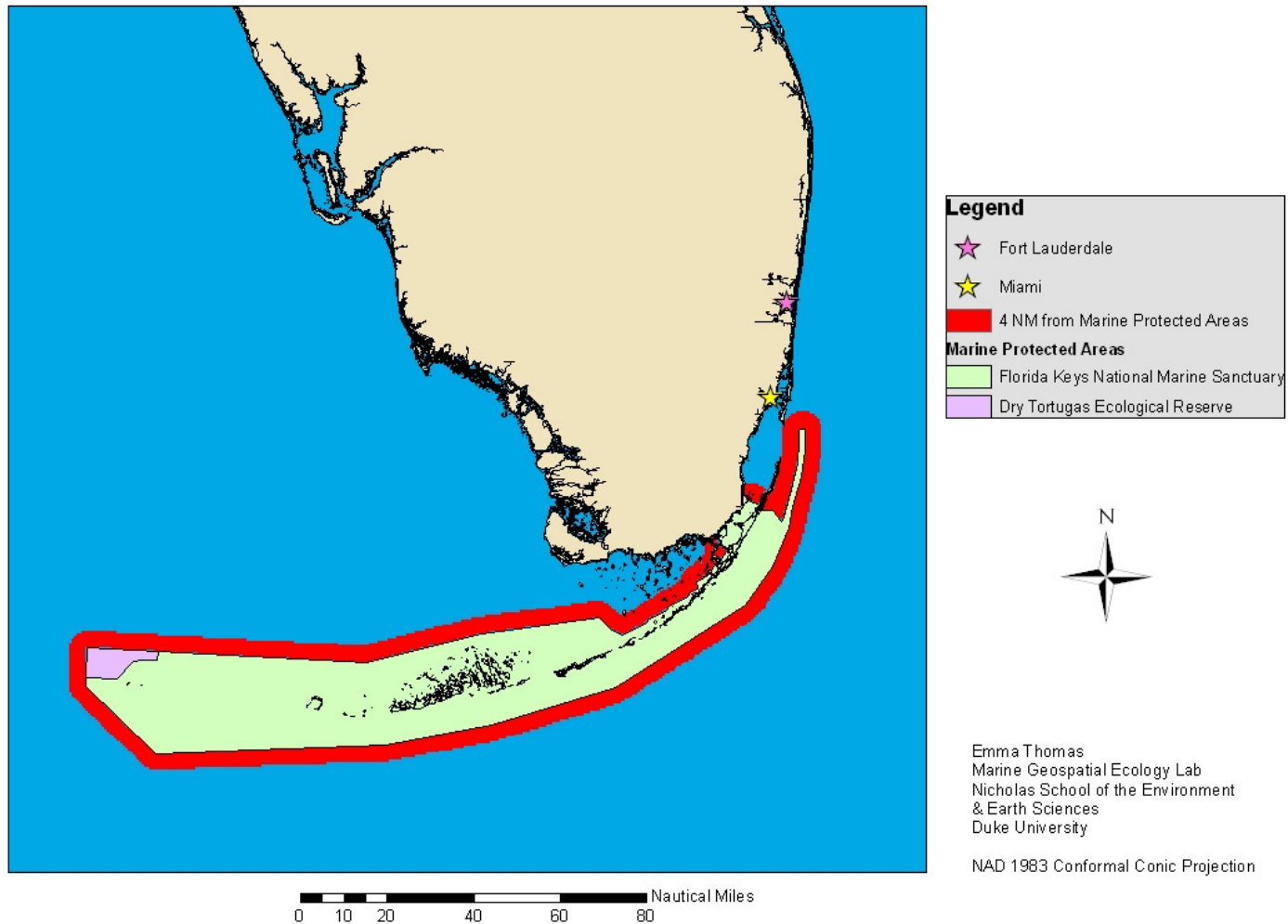
**Figure One:** Four- and Twelve- Nautical Mile Distances from the 20-Meter Contour and Depth Regions

## 4 Nautical Miles from Sensitive Marine Areas



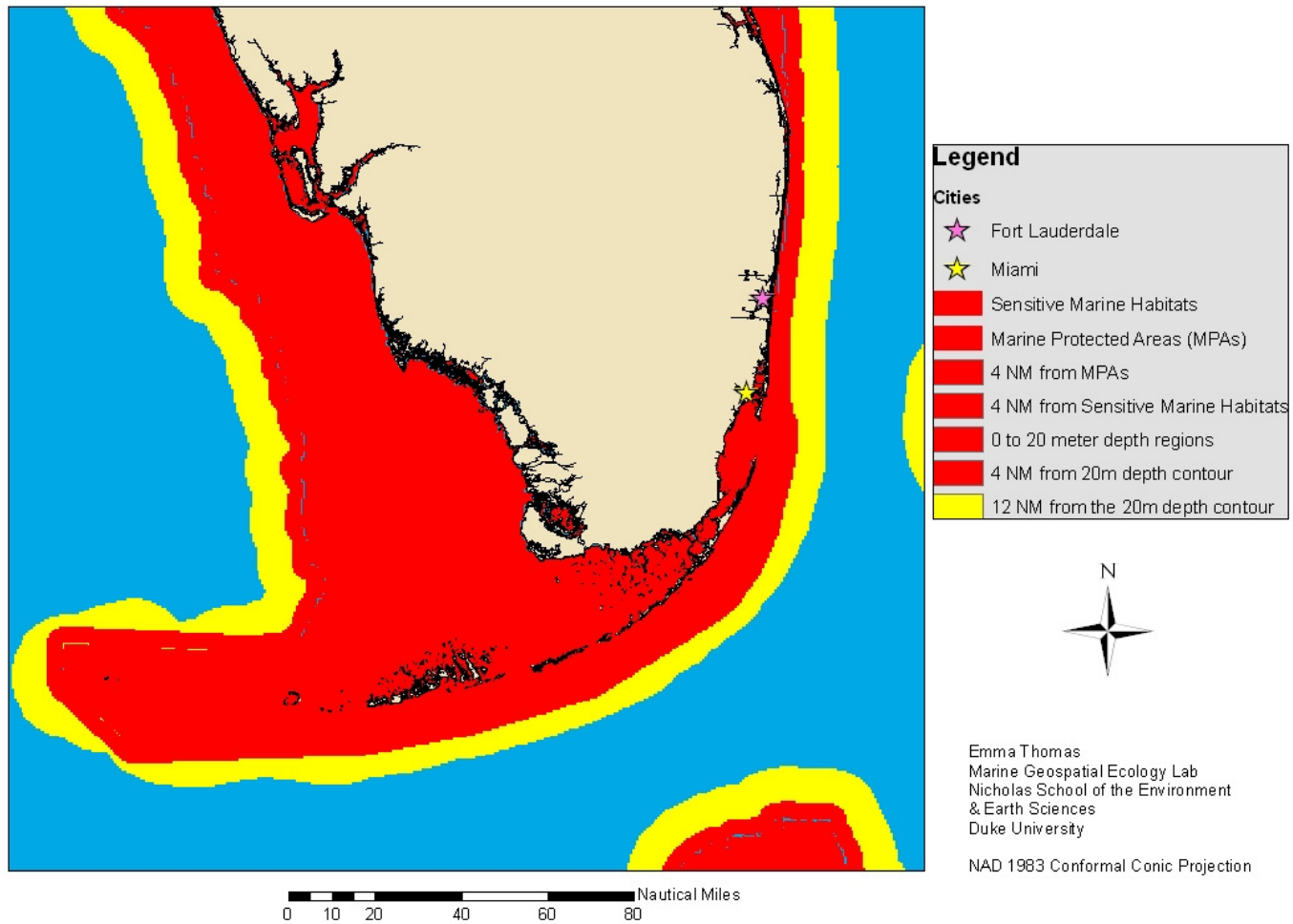
**Figure Two:** Four-Nautical Mile Distances from Sensitive Marine Areas

## 4 Nautical Miles from Marine Protected Areas



**Figure Three:** Four-Nautical Mile Distances from Marine Protected Areas (MPAs)

# Proposed Areas of Wastewater Discharge Avoidance



**Figure Four:** Combination of All Recommendations for Improved Discharge Practices for Cruise Lines