Patterns of ballast water management in US waters in the greater Caribbean during the Stony Coral Tissue Loss Disease outbreak (2014 – 2020): analyses of National Ballast Information Clearinghouse data

I. Effect of USCG Marine Safety Information Bulletin

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ACRONYMS AND DEFINITIONS

BW – Ballast Water
BWE – Ballast Water Exchange
BWM – Ballast Water Management
BWMS – Ballast Water Management System
C.F.R. – Code of Federal Regulations
FRT – Florida Reef Tract
GOM – Gulf of Mexico
IMO – International Maritime Organization
MSIB – Marine Safety Information Bulletin
NBIC – National Ballast Information Clearinghouse
Nm – Nautical Mile
NOAA – National Oceanographic and Atmospheric Administration
SCTLD – Stony Coral Tissue Loss Disease
U.S.C. – United States Code
USCG – United States Coast Guard

EXECUTIVE SUMMARY

Stony coral tissue loss disease was first detected in the vicinity of Miami, FL, in 2014 and has since spread throughout the greater Caribbean region. The disease has had a devastating impact on many species of stony coral in the region, including some considered threatened. While there is no definitive identification of a causal agent, evidence suggests one or more bacteria may be involved. The disease can be transmitted through water, as well as through direct contact between corals. Ballast water of ships has been suggested as one possible mechanism for spread of the disease. The United States Coast Guard (USCG) and Environmental Protection Agency (EPA), as participants of the Caribbean Coral Reef Partnership, were provided information regarding the rapid spread of SCTLD in 2019. On September 06, 2019, at the request of the National Oceanic and Atmospheric Administration, the USCG issued Marine Safety Information Bulletin OES-MSIB: 07-19, advising mariners of the disease outbreak, reminding them of ballast water management regulations, and recommending voluntary ballast water exchange practices that would help reduce the potential for spreading the disease via ballast water. Following release of the MSIB, the National Ballast Information Clearinghouse conducted an analysis of ballast water management reports submitted by vessels arriving to ports in the region before and after the MSIB to see if there was a change in vessel ballast water management that might be attributed to the MSIB. Over the 12 months following the MSIB, the number of vessels discharging unmanaged BW within 12 Nm was ***lower*** than the average number doing so for the 6 years prior to the MSIB. However, it is not possible to determine whether this resulted from ships following the guidance in the MSIB. In particular, there was not a compensatory increase in the number or proportion of BWE events which would have been expected if recommendations in the MSIB were being followed. The increase in the number of vessels using ballast water management systems over the same time period may account for some of the decrease in the number of vessels

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discharging unmanaged BW. Additionally, the global Covid-19 pandemic resulted in a noticeable decline in the numbers of vessel arrivals in the region during the year following issuance of the MSIB.

INTRODUCTION

Stony coral tissue loss disease (SCTLD) is a lethal coral disease that was first reported off the coast of Miami-Dade County, Florida in September 2014. Since then, the disease has spread across the entire Florida Reef Tract (FRT), infecting more than 350 miles of corals from the northern most extent of the reef at the St. Lucie Inlet in Martin County, FL, all the way south and west of Key West and, as of this writing, to the greater Caribbean region (Precht et al., 2016; Walton et al., 2018). The term "greater Caribbean" as used throughout this report (**Fig. 1A**) refers to the Caribbean Sea as well as SW Atlantic/Gulf of Mexico (GOM) regions with coral, and is largely encompassed within the IUCN Caribbean Marine Bioregions, excluding CAR-VI and CAR-VII, of Hewitt et al. (2004) after Kelleher et al. (1995), and the Tropical Northwestern Atlantic Marine Ecoregion of Spalding et al. (2007). The disease is known to affect at least 24 species of scleractinian corals, including species such as pillar corals (*Dendrogyra spp*.) listed as threatened (NOAA, 2018; Chan et al., 2019). The disease has resulted in massive die-offs of several reef-building coral species along the FRT (Precht et al., 2016; Walton et al., 2018). Once a coral colony becomes afflicted, the disease progresses rapidly and often results in whole colony mortality within days to months (Precht et al., 2016; Walton et al., 2018; Rippe et al., 2019). The etiological agent(s) of SCTLD has not yet been identified, but it can be transmitted through water as well as by coral-to-coral contact (Aeby et al., 2019). Furthermore, the spatio-temporal dynamics of its spread along the Florida coast suggest that this is a highly contagious disease (Muller et al., 2020). Bacteria in the orders Flavobacteriales (Meyer et al. 2019), Rhodobacterales, and Rhizobiales (Rosales et al. 2020), among others, have documented associations with SCTLD-afflicted coral tissue. These groups of bacteria have all been associated with other tissue loss diseases of corals, including white plague disease (Roder et al., 2014) and white band disease (Gignoux-Wolfsohn and Vollmer 2015). SCTLD is unique among tissue loss diseases with respect to the number of species it infects and its pattern of spread within and between reefs.

As of October 2020, outbreaks of SCTLD have been confirmed in 16 countries/territories throughout the greater Caribbean. Dates of first detection of SCTLD across the greater Caribbean are shown in **Table 1** and **Figure 1B**. Because timing and location of infections are a function of human discovery, the dates in Table 1 are likely not reflective of the order in which SCTLD actually spread. Currents have been invoked as one potential mode by which SCTLD spread along the FRT (Aeby et al., 2019; Muller et al., 2020), but ocean currents alone do not explain the disease's unique spatio-temporal pattern of spread across the greater Caribbean, inviting the exploration of other potential modes of transmission (**Fig. 1B**).

A potential anthropogenic mechanism of spread is vessel-related transport. Biota of all sorts are known to be transported in, or on, vessels via ballast water (BW), biofouling of exterior (e.g., hull) and internal (e.g., seawater piping) surfaces exposed to the sea, water in bilges and fish holds, and water and solids entrained in fishing gear and anchor chains (Fofonoff et al., 2003). Of these various transport modes, BW and biofouling are the largest potential vectors in terms of magnitude (i.e., volume of BW discharged, surface area of potentially fouled hulls, etc.) and frequency (number of vessel arrivals, number of discharges). While no definitive connection between any transport mode and coral disease outbreaks has been positively identified, it is reasonable to recognize BW and ship biofouling as potential vectors for transmission of SCTLD. Here we focus on BW transport, delivery, and management, using the comprehensive database of BW discharges in U.S. waters compiled by the National Ballast Information Clearinghouse (NBIC), a partnership of the United States Coast Guard (USCG) and the Smithsonian Environmental Research Center established in 1997 under the National Invasive Species Act of 1996.

In using the NBIC data, we have focused on the following two distinct questions related to BW as a potential mechanism for the transport of SCTLD:

I. Was there a detectable change in the pattern of discharges of unmanaged BW in U.S. waters of the greater Caribbean after the USCG issued a bulletin to mariners on September 06, 2019, advising of the SCTLD problem (USCG, 2019) and recommending voluntary practices to minimize potential transport of SCTLD via BW; and

II. Is there a correlation between the temporal or spatial pattern of BW transport from areas with SCTLD and the appearance of SCTLD in US waters in the greater Caribbean?

Below, we report on the first of these questions using an analysis of vessel-reported BW management information before and after the bulletin was issued. A separate analysis (in prep) will address the second question by elucidating the spatial and temporal patterns of BW transport and the appearance of SCTLD in U.S. waters.

Ballast Water Management Regulations

In support of efforts to reduce possible ship-borne spread of SCTLD, the USCG, at the request of the National Oceanic and Atmospheric Administration (NOAA), published a Marine Safety Information Bulletin (MSIB) entitled "Ballast Water Best Management Practices to Reduce the Likelihood of Transporting Pathogens that May Spread Stony Coral Tissue Loss Disease" (USCG, 2019). The September 6, 2019 MSIB was distributed electronically to all mariners operating in U.S. waters and conversations were held with major vessel associations to assist in distribution of the bulletin.

The MSIB added to already-existing USCG ballast water management (BWM) regulations, which require ships with ballast tanks to conduct BWM using one or more approved methods prior to discharge of BW in U.S. waters (i.e., Ballast water management for control of nonindigenous species in waters of the U.S., 2012). The approved methods since 2012 (Title 33 C.F.R. § 151 Subpart D) include (1) use of an on-board, USCG-approved or accepted, ballast water management system (BWMS) to treat BW prior to discharge, (2) ballast water exchange (BWE) greater than 200 nautical miles (Nm) from shore, (3) use of water from U.S. Public Water Supplies, and (4) discharge to a reception facility permitted to accept and treat ships' BW.

Currently, the majority of vessels operating in the region affected by SCTLD use BWE as the method of BWM, although an increasing number of vessels are using BWMS (**Fig. 2**). This transition away from BWE is likely because U.S. regulations require vessels to switch from BWE to one of the other methods in accordance with a schedule established in the USCG regulations. BWE entails taking on BW in a port, and then exchanging that port water for open ocean water while the vessel transits to its next port of call. BWE proportionally reduces the concentration of the pre-exchange organisms in ballast tanks, but it does not completely remove them (NRC, 2011). BWE is conducted either by continuously pumping three full tank volumes of open ocean water through each tank (flow-through exchange) or by pumping out the original water until the pump loses suction, and then refilling the tank with open ocean water (empty-refill exchange).

The USCG regulations allow vessels using BWE as their method of BWM to forgo conducting BWE if their route does not take them outside of 200 Nm for long enough to conduct an exchange. The regulations do not require vessels to divert or delay their voyages for the purpose of conducting BWE. The regulations also include exemptions from conducting BWE if the practice would be unsafe due to vessel design or sea conditions. The MSIB informed the maritime industry of the SCTLD issue; reminded vessel owners/operators of the requirements under current regulations; and advised vessel owners/operators of voluntary BWM practices that could be used to reduce the potential for transfer of SCTLD pathogens. For the latter, vessels could voluntarily elect to conduct BWE between 50 and 200 Nm of any shore prior to discharge of the water in the U.S. Importantly, conducting BWE >50 Nm aligns with the International convention for the control and management of ships' ballast water and sediments (BWM Convention; International Maritime Organization (IMO), 2018)). Although the U.S. is not a party to the BWM Convention, many countries are, binding their ships to abide by the convention's BWM requirements, wherever they operate. Thus, ships of Parties to the BWM convention transiting to places in the greater Caribbean should be conducting BWE >50 Nm of shore whenever possible. Note, however, that as under

US regulations, the BWM Convention does not require ships to divert or delay their voyage in order to conduct a proper BWE (i.e., beyond 50 Nm).

Under USCG regulations, all vessels with ballast tanks bound for ports or places in the U.S. are required to submit a ballast water management report to the NBIC for each arrival. These reports identify, for every tank of BW discharged, the source location, discharge location, and method of BWM in accordance with USCG requirements. Thus, the NBIC collects and maintains a comprehensive database of information on ballast water discharged to U.S. waters and provides a tool for elucidating temporal and spatial patterns of management and transport of BW discharged into U.S. ports and places, including the U.S. territories such as Puerto Rico and the U.S. Virgin Islands. Here we analyze data reported to the NBIC on BW discharges to U.S. waters in the greater Caribbean to look for changes in the spatial pattern of BW discharges that may be attributable to vessels heeding the MSIB.

METHODS

Following the September 06, 2019 publication of the MSIB, a series of analyses was conducted by the NBIC to determine whether there were any changes in the spatial patterns of reported BW discharges. To investigate whether changes to ballasting behavior had taken place since the release of the MSIB, data from monthly intervals prior to, and after release of the bulletin were analyzed. Six years of monthly data from Sept 2013 to Aug 2019 were used as a pre-MSIB baseline for comparison with corresponding monthly data collected from Sept 2019 to Aug 2020 (i.e., post-MSIB period).

The number of discharges and discharge volumes were compiled and analyzed to determine whether changes in spatial patterns of BW discharges occurred after issuance of the MSIB. Data were partitioned according to discharge distance from shore, (i.e., <12 Nm, 12–50 Nm, and 50–200 Nm) for each one-month interval. Analyses focused on the following **three** mechanisms by which pathogens could potentially be transported in ballast water between nearshore areas:

1. **Discharge of treated BW to U.S. waters:** During the period of this analysis the USCG has required the phased in use of onboard BWMS to treat BW prior to discharge to meet the USCG's concentration-based BW discharge standards. While less likely to spread a potential pathogen, the prevalence of reported onboard BW treatment, both in frequency of arrival and volume of BW discharge that was treated in the region, was also quantified to provide context when assessing observed behavior differences in the use of BWE.

2. **Discharge of Unmanaged BW to U.S. Waters**: Unmanaged BW (i.e., BW that did not undergo any BWM - either exchange or treatment) entrained <12 Nm originating inside the greater Caribbean, which was subsequently discharged in U.S. waters (<12 Nm) in the greater Caribbean. As a first assumption, we consider unmanaged BW taken on farther from shore (i.e., beyond 12 Nm) to be less likely to carry coral pathogens than unmanaged BW taken on closer to shore (i.e., within 12 Nm).

3. **BWE Locations as Source Locations**: BW that was taken on during a BWE event in the greater Caribbean at distances of <12 Nm, 12-50 Nm, 50-200 Nm, or > 200 Nm from shore and that was subsequently discharged in U.S. waters (<12 Nm from shore) in the greater Caribbean. BW taken on during a BWE event conducted close to shore (i.e., <12 Nm) is more likely to contain coral pathogens than BW taken on at greater distances from shore

Pre- and post-MSIB data were analyzed using basic descriptive statistics, including number of discharges, mean discharge volumes, 95% confidence intervals, and ranges. Time series plots of reported BW volumes and number of reported discharges were created to identify patterns and trends. These calculations were compiled into detailed monthly reports. Key findings of these analyses are presented here.

RESULTS & INTERPRETATIONS

1. Discharge of Treated BW to U.S. Waters

This analysis focuses on the use of installed BWMS to treat BW discharged in U.S. waters (<12 Nm from shore) of the greater Caribbean, considering BW that also originated inside the greater Caribbean, before versus after issuance of the MSIB.

- The number of vessel arrivals for which the use of a BWMS to treat BW discharge was reported, and the percent of the total number of discharging arrivals that reported the use of a BWMS increased steadily over the period September 2018 – July 2020 (**Fig. 2**). This pattern reflects the continuing effect of the required schedule for compliance with the ballast water discharge standard established in the USCG's current BWM regulations. Under the regulations, ships constructed on or after December 1, 2013 are required to meet the discharge standard upon entry into service in U.S. waters. Existing ships (those constructed prior to that date), are required to come into compliance with the discharge standard in accordance with a specified schedule. Although the USCG provides extensions to this schedule for ships that are unable to comply with the schedule due to technical difficulties, such extensions are increasingly difficult to receive due to the large increase in the number and types of USCG-approved BWMS available on the market. As of October 28, 2020, there are 37 different systems, incorporating a variety of treatment processes and approved for a variety of BW capacities, with several additional systems under review for approval.

2. Discharge of Unmanaged BW to U.S. Waters

This analysis focuses on the discharge of unmanaged BW in U.S. waters (<12 Nm from shore) in the greater Caribbean that also originated inside the greater Caribbean prior to, and after issuance of the MSIB. These data provide insight into the discharge of unmanaged BW (regardless of source/distance from shore) to U.S. waters.

- The number of unmanaged BW discharges occurring <12 Nm from shore was consistently ***lower*** during post-MSIB months as compared to the average number for pre-MSIB months (**Fig. 3A**). In all months following the MSIB, except for December, the number of unmanaged discharges was lower than the lowest number in the range for the pre-MSIB period (**Table 2**).

- Overall, a relatively small proportion of vessels, both prior to (~14-16%) and after (~8-12%) issuance of the MSIB, discharged unmanaged BW (i.e., BW that did not undergo BWE or treatment with a BWMS) in U.S. waters (<12 Nm of shore) that was sourced in the greater Caribbean (**Fig. 3B)**. While these vessels represent a small percentage of all arrivals, they account for approximately half of discharging arrivals in the pre-MSIB period (41-71%) and slightly lower (33-43%) in the post-MSIB period (**Table 2**).

- It is important to consider the impact of SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) on shipping patterns during the post-MSIB period. A clear decrease in the number of dischargers is seen after March, 2020 (**Fig. 3; Table 2**), coincident with the burgeoning SARS-CoV-2 pandemic and a world-wide reduction in maritime transportation. Proportional values also were used in the analysis in an effort to reduce the impact of this underlying factor.

While the reduction in number of BW discharges is correlated with the issuance of the MSIB, it is also correlated with a) the increase in the use of onboard BWMS (**Fig. 2**) and b) the reduction in shipping due to SARS-CoV-2. Therefore, while the MSIB included a reminder of the requirement to manage BW in accordance with USCG regulations, we cannot definitively attribute the resulting reduction in discharge to the MSIB alone. For example, this pattern could also be attributed to the increase in the use of onboard BWMSs over this period (**Fig. 2**) and/or the decline in shipping, beginning in March 2020 (**Fig. 3A**), during the Covid-19 pandemic.

3. BWE Locations as <u>Source</u> Locations

This analysis views BWE as a source location where the pathogen may be brought onboard. The general assumption is that water taken on closer to shore has a greater potential for carrying the pathogen(s), and being transported to, and discharged in, nearshore U.S. waters.

We therefore only consider in this analysis vessels carrying BW that was taken on during BWE in the greater Caribbean and subsequently discharged in U.S. waters (<12 Nm from shore) in the greater Caribbean.

- The majority of vessels fulfilling these criteria conducted BWE 50–200 Nm from shore**, both prior to and after issuance of the MSIB** (**Fig. 4).** Thus, this pattern of behavior appears to be due to factors other than those recommended in the MSIB (e.g., IMO requirements). While there was a slight decrease in the numbers of vessels and the percent of vessels conducting BWE <50 Nm from shore following issuance of the MSIB (**Fig. 4A**–**D**), there was not a compensatory increase in BWE beyond 50 Nm (**Figs. 4E**–**H**).

- A relatively small number and percent of vessels fulfilling these criteria took on ballast water during BWE <12 Nm of shore during both the pre- and post-MSIB period (**Fig. 4A and B**). A slightly larger number and percent of vessels took on ballast water during BWE between 12 and 50 Nm of shore during both the pre- and post-MSIB period (**Fig. 4C and D**). It is not known why some vessels are conducting BWE within 50 Nm of shore, since this is neither required nor recommended in either U.S. or international regulations. These exchanges may be occurring as part of a ship husbandry practice to reduce the accumulation of sediments in ballast tanks. In this practice, water taken on in relatively shallow and turbid ports is exchanged as soon as possible after departing a port, thereby replacing turbid sediment-laden water with clearer offshore water, before the suspended sediments in the port water have settled to the bottom of the tanks. This exchange is thus not done to comply with the BWM regulations; however, ships may be reporting the exchanges due to incomplete understanding of BW regulations. An incomplete understanding of the regulations may also be the reason for vessels conducting BWE less than 50 Nm (the IMO recommended distance) from shore, as some vessel masters may consider that "something is better than nothing" and conduct exchanges even though their transits do not take them more than 50 Nm from shore.

SUMMARY

While the number of vessels discharging unmanaged BW within 12 Nm of shore after the issuance of the MSIB in September 2019 was ***lower*** than the average number doing so for the 6 years prior to the MSIB (**Fig. 3, Table 2**), it is not clear this resulted from ships voluntarily following the guidance in the MSIB. In particular, there was not a compensatory increase in the number or proportion of BWE events conducted between 50 Nm and 200 Nm, which would have been expected if the MSIB were being followed to an appreciable degree. The increase in the number of vessels using BWMS over the same time period may account for some of the decrease in the number of vessels discharging unmanaged BW. Ships using BWMS are not afforded the route and safety exemptions that can be used by ships using BWE as the method of BWM. Thus, ships that had transitioned from BWE to using a BWMS during this time would not be in a position to discharge unmanaged BW due to short routes or the inability to conduct BWE safely due to adverse sea conditions.

Similarly, while the number of vessels conducting BWE within 12 Nm of shore while en route to U.S. ports in the greater Caribbean in some months was ***lower*** than the average number during the pre-MSIB period, the practice was still exhibited by multiple vessels each month after MSIB issuance. Taking in BW during an exchange within 12 Nm of shore increases the probability that coral pathogens could be entrained in the BW and transported to new locations and discharged with the ballast water during cargo operations in and/or near ports.

The MSIB was chosen as a communication platform because it avoids the significant administrative efforts and timelines associated with a new regulation or change in policy; however, it has not appreciably resolved the potential increased risk of transporting coral pathogen(s) to U.S. locations in the greater Caribbean through the discharge of unmanaged BW. Further actions should be considered. The USCG could look more closely at the vessels reporting discharge of unmanaged ballast water in U.S. ports in the region, and also at vessels reporting BWE within 12 Nm of shore in the greater Caribbean while en route to

U. S. ports. The former may well be discharging unmanaged BW in compliance with the regulations, due to the exemptions for route or safety issues. Any vessels discharging unmanaged BW without the coverage of the route or safety exemption, or other dispensation from the USCG, should be the focus of attention. Vessels conducting BWE <12 Nm of shore should be identified, and, at a minimum, informed that this is contrary to the BWE requirements (> 200 Nm under U.S. regulations; > 50 Nm under the IMO BWM Convention). If an exchange is conducted within U.S. waters, the discharge of unmanaged BW during the exchange may constitute noncompliance with the regulations, depending on the circumstances, and vessels doing so should be examined closely to increase compliance. Similarly, exchange of BW <12 Nm from shore outside of U.S. water is not an accepted BWM practice under Coast Guard regulations. If geographic circumstances within the greater Caribbean limit the efficacy of voluntary practices in reducing the discharge of unmanaged ballast water (i.e., continued use of the route exemption), a more drastic potential option could be to restrict the use of the route exemption under certain circumstances to reduce the risk of spread of the pathogen(s) in the region. Such restrictions might be imposed by the U.S. Environmental Protection Agency as "emergency best management practices" under the Vessel Incidental Discharge Act of 2018 (33 U.S.C. § 1322(p)(4)(E)), or by the USCG as Captain of the Port Orders. In either case, such restrictions would need very careful consideration, as many of the inter-port distances are relatively short, and most of the imports and exports of the island populations are via ships. Requirements for vessels to divert and/or delay to conduct BWE during transits within the greater Caribbean could have significant impacts on the local economies, and on vessel traffic management within the array of relatively closely spaced ports in the greater Caribbean.

Table 1 Date of first detection of SCTLD in the greater Caribbean (ACRRA, 2020)

Year	Month	Location	Map ID
2014	September (mid)	Miami-Dade, Florida	A
2018	February 6	Jamaica	B
	July 3	Quintana Roo, Mexico	C
	November 22	Saint Maarten, Netherlands	D
2019	January 29	St. Thomas, USVI	E
	March 3	Dominican Republic	F
	March (early)	Turks & Caicos (S. Caicos)	G
	June 21	Belize	H
	August 13	Sint Eustatius, Netherlands	I
	December 23	Culebra, Puerto Rico	J
	December	Grand Bahama Island, Bahamas	K
2020	May 17	British Virgin Islands (“The Indians”)	L
	June 29	Cayman Islands	M
	June 9	Guadeloupe	N
	August 9	St. Lucia	O
	September 25	Roatan, Honduras	P

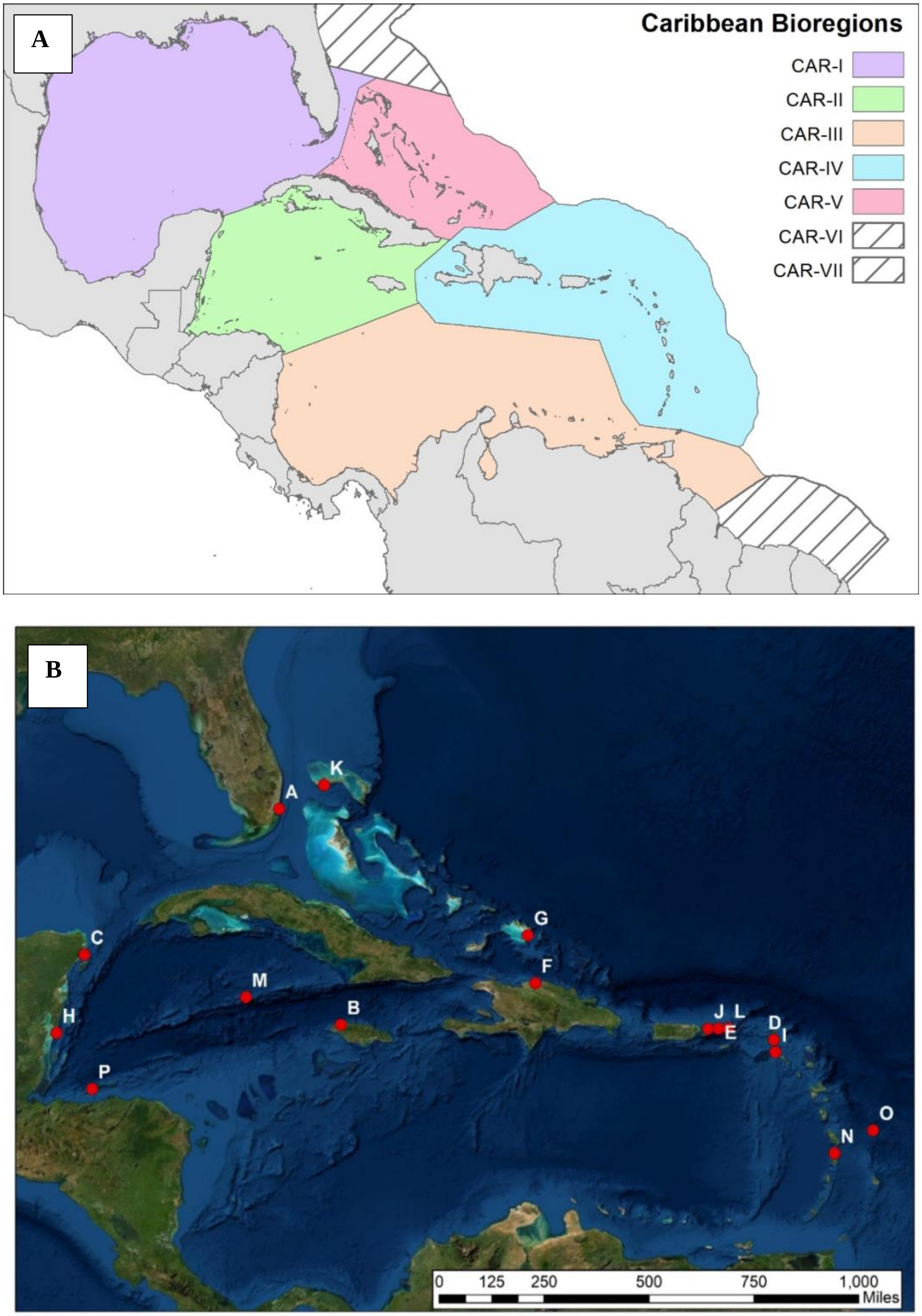

Figure 1. (A) Geographic area of the "greater Caribbean" region considered in this analysis, including IUCN Marine Bioregions (Kelleher et al., 1995); Areas in crosshatching were not included. **(B)** Spatial distribution of the SCTLD Outbreak in the greater Caribbean (AGGRA 2020); see Table 1 for details.

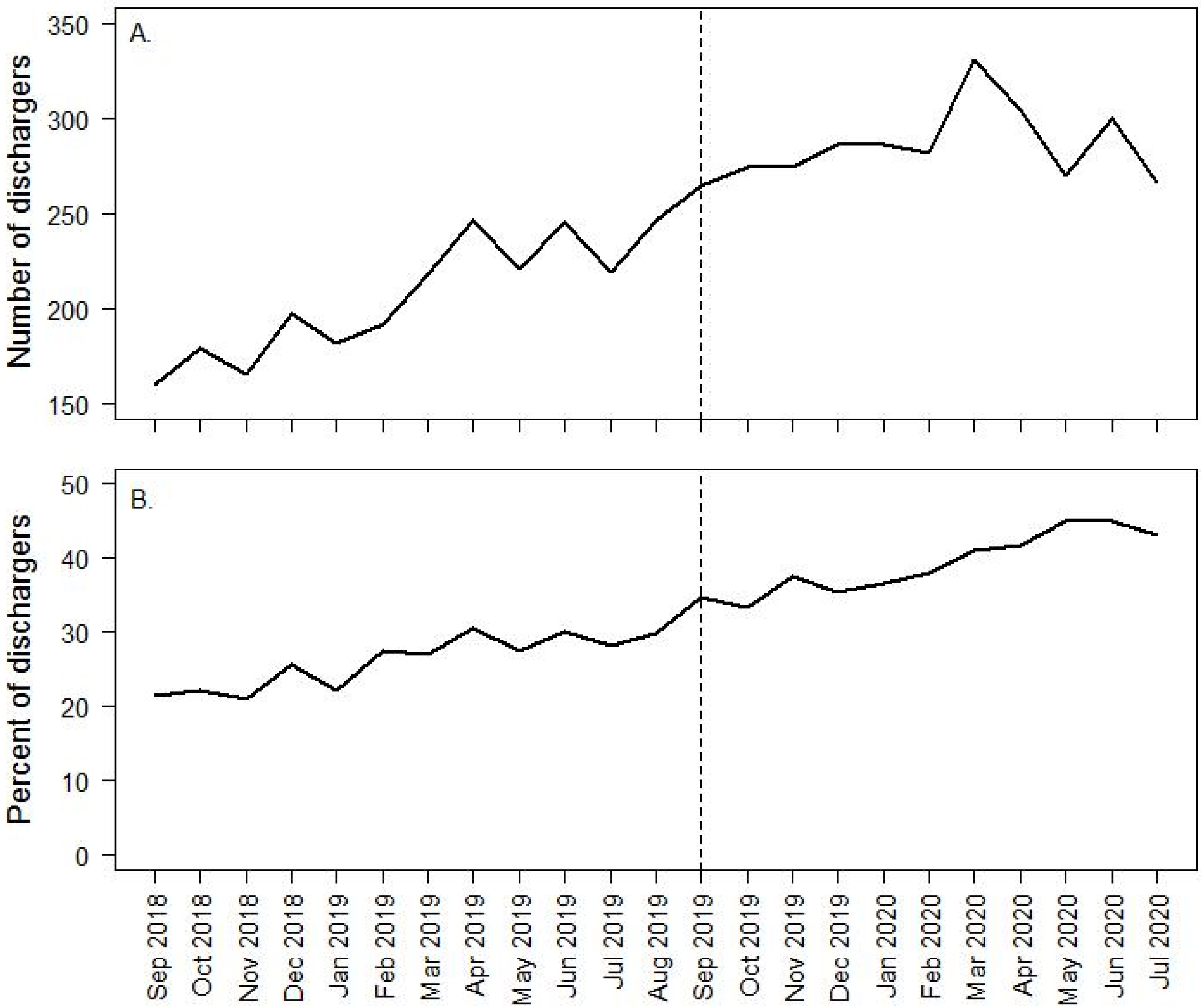

Figure 2. Treated BW discharges in US waters of the greater Caribbean: **(A)** number of discharging vessels reporting the use of a BWMS; **(B)** percent of total discharging vessels that use BWMS for the period of Sept 2018 – July 2020. The dashed vertical line indicates when the MSIB was issued.

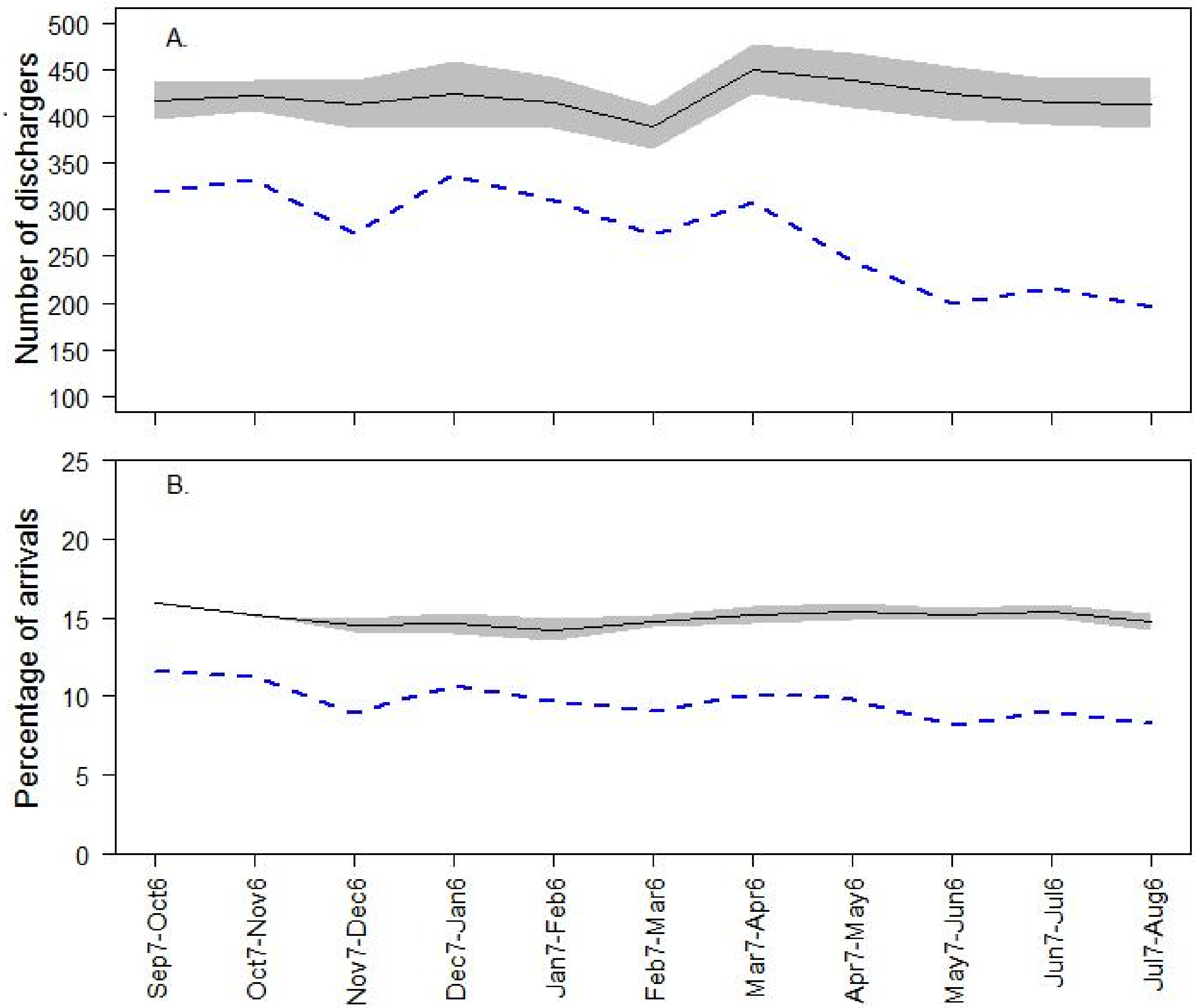

Figure 3. Vessels discharging unmanaged BW in U.S. Waters (within 12 Nm of shore) in the greater Caribbean that also originated inside the greater Caribbean prior to, and after, MSIB issuance. **(A)** Number of arrivals reporting discharge of unmanaged BW <12 Nm from shore. **(B)** Percentage of total arrivals reporting discharge of unmanaged BW <12 Nm from shore. The solid lines represent 6-year means for each monthly interval during the pre-MSIB period; shaded areas are 95% confidence limits based on the 6 years of data. The dashed lines represent the individual time periods following issuance of the MSIB. Note different y-scales.

Table 2. Total number of reported ballast water (BW) discharges (unmanaged + managed) in U.S. waters in the greater Caribbean that originated in the greater Caribbean, total number of such unmanaged BW discharges, and the percent of such discharges that were unmanaged. For the pre-MSIB periods, the mean of the 6 years of data (with range) is shown; post-MSIB, shown in boldface, represents a single month of data.

Period	Relation to MSIB Date	Total Discharges (managed + unmanaged)	Total Unmanaged Discharges	Percent Unmanaged Discharges
Sep 7-Oct 6	pre	703 (663 - 769)	421 (352 - 461)	60 (46 - 67)
Sep 7-Oct 6	**post**	**762**	**320**	**42**
Oct 7-Nov 6	pre	724 (678 - 797)	426 (372 - 469)	59 (47 - 66)
Oct 7-Nov 6	**post**	**784**	**334**	**43**
Nov 7-Dec 6	pre	727 (659 - 789)	418 (341 - 501)	58 (43 - 66)
Nov 7-Dec 6	**post**	**717**	**279**	**39**
Dec 7-Jan 6	pre	732 (676 - 769)	428 (312 - 519)	58 (42 - 68)
Dec 7-Jan 6	**post**	**801**	**337**	**42**
Jan 7-Feb 6	pre	714 (663 - 782)	418 (318 - 485)	59 (41 - 68)
Jan 7-Feb 6	**post**	**777**	**311**	**40**
Feb 7-Mar 6	pre	669 (639 - 728)	393 (307 - 449)	59 (42 - 67)
Feb 7-Mar 6	**post**	**761**	**277**	**36**
Mar 7-Apr 6	pre	758 (695 - 814)	455 (349 - 500)	60 (43 - 71)
Mar 7-Apr 6	**post**	**781**	**308**	**39**
Apr 7-May 6	pre	747 (691 - 780)	443 (327 - 528)	60 (42 - 68)
Apr 7-May 6	**post**	**690**	**250**	**36**
May 7-Jun 6	pre	737 (668 - 786)	429 (339 - 527)	58 (43 - 68)
May 7-Jun 6	**post**	**586**	**202**	**34**
Jun 7-Jul 6	pre	721 (637 - 788)	422 (340 - 489)	59 (43 - 67)
Jun 7-Jul 6	**post**	**640**	**218**	**34**
Jul 7-Aug 6	pre	733 (666 - 775)	418 (339 - 494)	57 (44 - 68)
Jul 7-Aug 6	**post**	**598**	**200**	**33**

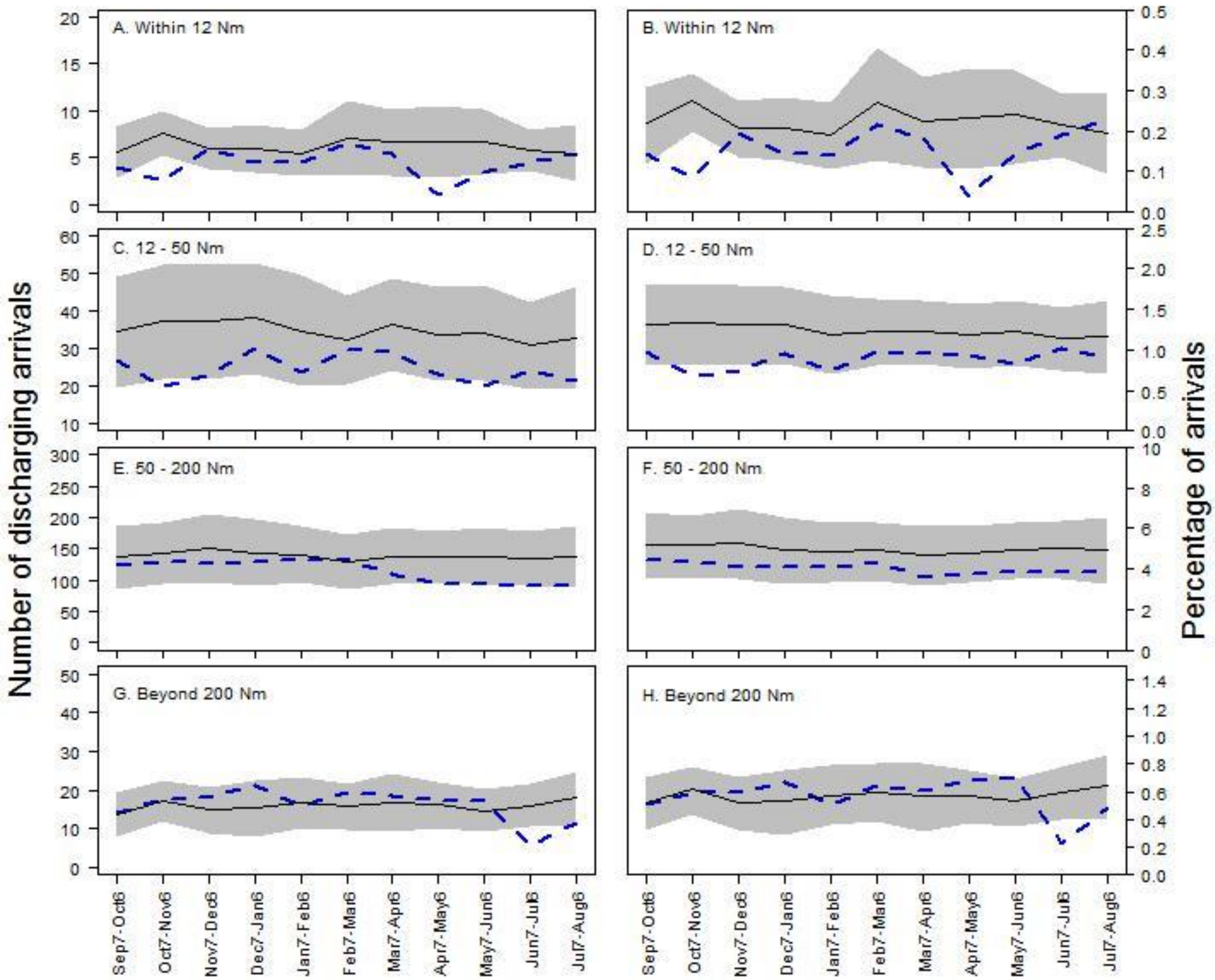

Figure 4. Number of arrivals reporting BWE as source and the percentage of all greater Caribbean arrivals that reported BWE as source, regardless of the original source (i.e., where the vessel originally took on BW prior to conducting BWE). Panels **(A), (C), (E),** and **(G)** show the number of dischargers as a function of distance from any shore in the greater Caribbean during BWE. Panels **(B), (D), (F),** and **(H)** show the percentage of greater Caribbean arrivals that conducted BWE in the greater Caribbean by distance from shore. The solid lines are the 6-year means for each monthly interval and the shaded areas are 95% confidence limits based on the 6 years of data prior to issuance of the MSIB. The dashed lines represent the individual time periods following the MSIB. Post-MSIB values are plotted at the endpoints of each time period. **Note different y-scales.**

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