A Scan of Environmental Monitoring in Top Ports Around the Globe

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A SCAN OF ENVIRONMENTAL MONITORING IN TOP PORTS AROUND THE GLOBE

by

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ABSTRACT

Ferrario, F., Archambault, P., and Templeman, N. 2021. A Scan of Environmental Monitoring in Top Ports Around the Globe. Can. Tech. Rep. Fish. Aquat. Sci. 3428: vii + 36 p.

This report provides an annotated scan of existing environmental monitoring activities occurring in domestic (i.e., in Canada) and international ports. The scan considered the top five ports, based on tonnage, per geography for North America (excluding Canada), South America, Asia, Africa, Europe, Oceania, as well as the top five Canadian (i.e., domestic) ports. Authors arbitrarily added additional ports to the scan to balance the geographic distribution of ports. Selected ports were also reviewed for the level of access to monitoring data. Data and information gathered during the port review were consolidated in accompanying datasets made publicly available via the Canadian Healthy Ocean Network Dataverse. The current report provides a synthesis of the data and an overall consideration on emerging data trends. The concurrent monitoring of biological, hydrographic and water quality variables did not occur in all the ports considered. Ports in Canada, USA, Europe and Australia were more likely to have environmental monitoring programs in place. Availability of monitoring data (e.g., open data) was higher for North America (including Canada). When monitoring data were immediately available or open, port authorities were not directly involved in the monitoring program.

RÉSUMÉ

Ferrario, F., Archambault, P., and Templeman, N. 2021. A Scan of Environmental Monitoring in Top Ports Around the Globe. Can. Tech. Rep. Fish. Aquat. Sci. 3428: vii + 36 p.

Le présent rapport contient une analyse annotée des activités de surveillance environnementale qui sont menées dans les ports nationaux (c.-à-d. au Canada) et internationaux. Cette analyse porte sur les cinq plus grands ports, selon le tonnage, en Amérique du Nord (Canada exclu), en Amérique du Sud, en Asie, en Afrique, en Europe, en Océanie, et sur les cinq plus grands ports canadiens (c.-à-d. nationaux). Pour équilibrer la répartition géographique des ports, les auteurs ont arbitrairement inclus d'autres ports dans cette analyse. Ils ont également évalué l'accessibilité des données de surveillance aux ports choisis. L'information recueillie au cours de l'examen des ports est regroupée dans des ensembles de données d'accompagnement mis à la disposition du public sur le Réseau pour des océans canadiens en santé (CHONe). Le présent rapport synthétise ces ensembles de données et analyse les tendances qui s'en dégagent. Les variables biologiques, hydrographiques et de la qualité de l'eau ne font pas toutes l'objet d'une surveillance dans tous les ports examinés. Les ports du Canada, des États-Unis, de l'Europe et de l'Australie sont ceux où les programmes de surveillance environnementale sont les plus fréquents. Les données de surveillance (p. ex. données ouvertes), quant à elles, sont davantage accessibles en Amérique du Nord (Canada compris). Dans les cas où les données de surveillance sont directement accessibles ou ouvertes, les administrations portuaires ne participent pas directement à la surveillance.

INTRODUCTION

The Canadian Healthy Oceans Network-2 (CHONe2) is a Natural Sciences and Engineering Research Council of Canada (NSERC) strategic network. The network includes researchers from universities across Canada, Fisheries and Oceans Canada (DFO), and other organizations to carry out collaborative research projects across highly applicable and interrelated research themes. In its most recent iteration (2015-2020), CHONe2 research included a component of focus related to marine ecosystem stressors, including cumulative impacts, that alter marine biodiversity and ecosystem functions and services in high use environments.

The Bay of Sept-Îles area and surroundings is among CHONe2 research sites; and a number of research projects have been conducted there in partnership with INREST (Institut Nordique de Recherche en Environnement et en Santé au Travail, representing the City of Sept-Îles and the Port of Sept-Îles) and DFO. The bay was selected for its combination of northern marine conditions, freshwater inflow, and ongoing industrial, municipal, recreational, and tourist activities, making it a prime location to study cumulative impacts in northern environments.

Following on end-of-project discussions related to outcomes and lessons learned, both scientifically and operationally, from a Port of Sept-Iles (QC) case study undertaken by CHONe2 partners, it was determined by those involved that other potential opportunities likely exist within Canada to advance future projects or collaborations related to multiple stressors and sustainable development (with a particular focus on coastal zones and ports as an important high-use environment); and that a review of the range of environmental monitoring approaches taken at ports globally could inform such scoping discussions. As such, with the objective to further understand the realm of science and management existing for multiple stressors within this subject area of interest, a scan of environmental monitoring in top ports around the globe was commissioned.

This report provides an annotated scan of existing environmental monitoring activities occurring in ports domestically (i.e., Canada) and internationally.

The scan considered the top five ports, based on tonnage for Canadian ports, as well as international ports by geography for North America (excluding Canada, i.e., USA and Mexico), South America, Asia, Africa, Europe, and Oceania (i.e., including Australasia, Melanesia, Micronesia and Polynesia). In particular, the following information was included for each port:

- The level of activity (i.e., tonnage) in the port.
- A description of the aquatic component(s) of environmental monitoring programs at the ports with a focus on hydrography (e.g. bathymetry, currents, tides), water quality (e.g. temperature, salinity, dissolved oxygen, contaminants, turbidity) and biological components (e.g. plankton, fish, benthos, vegetation).
- Knowledge of the authority responsible for environmental monitoring.
- Accessibility of monitoring data (including directly or indirectly).
- Land use of the adjacent shoreline (i.e., urbanized or rural).
- Other known uses of the marine environment around the port.

METHODS

PORT SELECTION

The American Associations of Ports Authorities (AAPA) acknowledges that ranking ports is an ambiguous task because multiple metrics can be used (e.g., number of containers, weight of cargo, ship traffic) and the appropriateness of specific metrics depends on a port business (e.g., container vs. bulk ports) (AAPA 2021). Common metrics include Total Cargo Volume (referring to the tonnage) that can be expressed either as "metric tons", "revenue tons" or "freight tons", and Container Traffic expressed as Twenty-foot Equivalent Units - TEUs; consult Annex A for details on port activity parameters.

For Canadian ports no precompiled ranking or list of summary statistics was available, therefore the most recent freight summary statistics on Total Cargo Volume expressed as metric tons were recorded for each port listed on the website of the Association of Canadian Port Authorities (ACPA 2016). Summary statistics for each port were recovered from information available on port websites (e.g., annual reports), and the top five Canadian ports were selected for review. For international ports, the selection was based on the ranking of the top 100 ports produced by the American Associations of Ports Authorities (AAPA 2016). These data were identified on the web through a Google search using the key words "world ports list" on 10/02/2020. The AAPA ranking of top 100 ports is based on 2016 port statistics according to both Total Cargo Volume (i.e., expressed either as "metric tons", "revenue tons" or "freight tons") and Container Traffic (i.e., Twenty-foot Equivalent Units - TEUs). The top five international ports for each geography were selected from the 2016 AAPA list based on Total Cargo Volume expressed as metric tons only - thus excluding freight and revenue tons, as wells as TEUs.

Total Cargo Volume as metric tons was chosen for the sake of comparability with Canadian ports. Consequently, because some renowned international ports were more appropriately ranked by different metrics (e.g., TEUs) they were not listed in our top 5 ports per geography (e.g., Los Angeles, Singapore). Since only three African ports were present in the top 100 ranking list based on the total cargo volume, the first two African ports ranked on the TEUs values were also included. Therefore, based on qualitative knowledge of some port properties such as size and/or location, the ports of Los Angeles (CA, USA), Callao (Peru), Singapore (Singapore), and Busan (South Korea) were also strategically reviewed and included in the overview to enhance the representativeness of the scan by including ports along the west coast of North and South America, and other renowned Asiatic ports outside of China. In particular, we acknowledge that the ports of Los Angeles and Long Beach are located in the same bay, and they collaborate in coordinating and supporting several environmental monitoring programs (see description of Los Angeles monitoring programs in the Appendix). Information gathered for both the selected (i.e., top five) and additional ports were included in the analyses and summarized in this report to give an overview by geography except when a specific reference is made to the "top five" ports.

PORT REVIEW

The website of each port was consulted to retrieve information on the existence of monitoring programs, data availability, and other uses in the proximity of the port area. When incomplete or no information was available on the port website, Google searches were performed using the combinations of keywords such as:

- Port name AND ("water quality" OR environmental OR pollution OR pollutant OR biota OR biolog OR biodiversity OR benth OR biota) monitoring
- Port name AND (hydrography OR bathymetry OR "multibeam" OR currents OR tides)
- Port name AND (recreation OR "commercial fisheries" OR "recreational fisheries" OR "boating" OR touris OR marina OR “fish farm” OR “aquaculture”).

Searches were extended outside of port websites in an attempt to verify the existence of monitoring programs carried out by entities other than Port Authorities. In some cases, this identified collections of relevant datasets and/or databases whose primary aim was not environmental monitoring in ports. However, these data sources were included in the scanning exercise for the sake of completeness. For some ports, more than a single monitoring program and/or environmental database was identified. Google Earth was consulted to assess the land use type of the area surrounding the port, and identify other known uses by browsing the gallery of georeferenced photographic material.

DATA ACCESSIBILITY

According to the Canadian government, “Open Data” are “defined as structured data that is machine-readable, freely shared, used and built on without restrictions” (Government of Canada 2019). For this report, “data accessibility” was assessed as more than “openness”, and following the general diagram outlined in Figure 1.

According to the diagram, data properly defined as open are those that are made available (i.e., downloadable from a website or repository without a formal request for access), with no restriction on use, accessible at no cost and in a format that is immediately machine-usable (e.g., excluding data provided as a table in a report). As per this definition “Open Data” are considered immediately available. During the scan however, in some cases raw data were made available although not all the condition for “open data” were met. In this case, the data were still considered as “immediately available” – although not “open” – because they could still be obtained by conforming to certain requirements (e.g., paying a fee) that do not include a formal request to a provider.

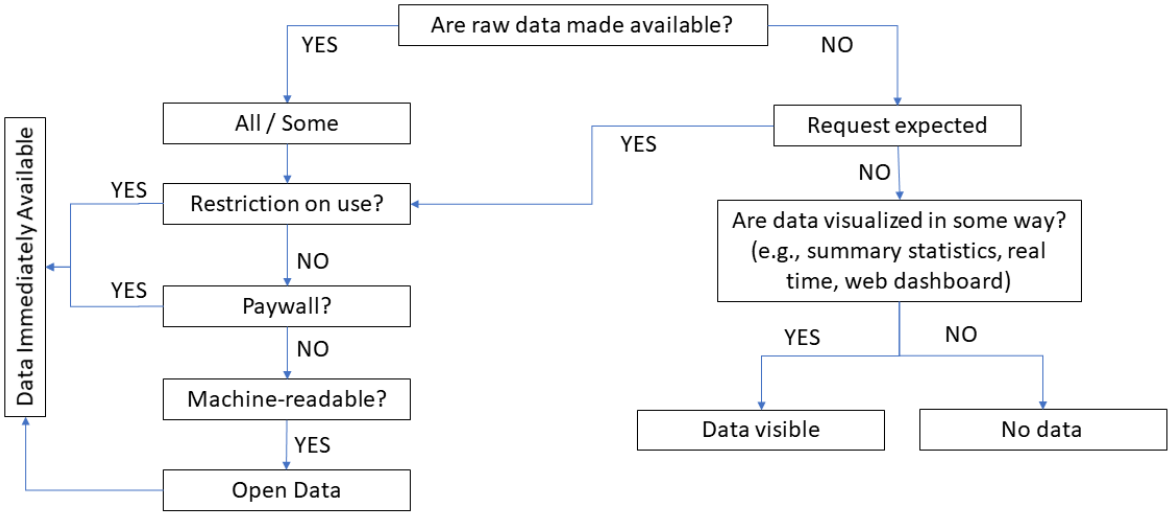

Figure 4: Data accessibility diagram. Machine-usable data for which no restriction on use or paywall is in place are considered to be “Open”.

RESULTS SUMMARY AND CONSIDERATIONS

Information gathered during the ports review were consolidated in four datasets listed in Table 1. These datasets represent the main product of the scanning activity and the information contained therein are described in Annex B.

The current report summarizes the information contained particularly in the dataset "selected_ports-env_mon_info.csv".

All the data and the R script used to analyze the data are made publicly available via the Canadian Healthy Ocean Network Dataverse at https://doi.org/10.5683/SP2/YFYOLU (Ferrario 2021) .

Table 4: Description of the datasets consolidating the port review.

Dataset name	Description
freight_data-interntl_ports.csv	Freight data for international ports
freight_data-canadian_ports.csv	Freight data and ranking for Canadian ports
selected_ports-meta.csv	List of selected international and domestic ports with data at port level: freight volume, urbanization, other known uses.
selected_ports-env_mon_info.csv	Data on identified monitoring programs.

DISTRIBUTION OF PORTS AND MONITORING ACTIVITIES PER GEOGRAPHY

The top five international ports per geography included in the scan were within a single country in all geographies considered except for Europe and Africa (Table 2). Information on the existence of monitoring programs for hydrographic, water quality and/or biological variables was more likely to be available for Canadian, Australian, European and USA ports (Figure 2a). The least amount of information pertaining to monitoring programs was available for African ports (Figure 2). In general, hydrographic and water quality monitoring programs were more common than those focusing on biological components of the ecosystem. While more than one monitoring program of the same data type was identified for some ports, the number of monitoring programs at each port was highly variable (Figure 2b). However, the concurrent monitoring of biological, hydrographic and water quality variables did not occur in all the ports. Overall, it was more common to find, at the same port, at least one monitoring program for each of the three types of variables in Europe, North America, Oceania and Canada, while only two ports monitored all the variable type in South America and none in Africa (Figure 3).

The fact that some geography was represented predominantly by one country (Table 2) was reflected by the type and availability of information and the general attitude towards monitoring and reporting. For example, ports in the same country were more likely subjected to the same administrative/legal framework so that some monitoring activities were systematically performed by the same government agency. This was the case for hydrographic variables monitored by national hydrographic or

oceanographic agencies such as NOAA in the USA, the center of Navy Hydrography in Brazil and, domestically by DFO and the Canadian Hydrographic Service.

Table 5: Represented Countries per geography. Numbers in parenthesis represent the number of ports reviewed per country.

Geography	Country or Province represented top five ports[a]	Extra ports[b]
North America[c]	United States of America (5)	United States of America (1)
South America	Brazil (5)	Peru (1)
Asia	China (5)	Singapore (1), South Korea (1)
Oceania	Australia (5)	
Europe	Netherlands (2), Germany (1), Belgium (1), Spain (1)	
Africa	South Africa (2), Egypt (2), Morocco (1)	
Canada	Quebec (3), British Columbia (1), New Brunswick (1)	

[a] International Ports identified as top five per geography according to the AAPA ranking (see methods)
[b] Additional ports included in the scan (see methods)
[c.] Intended as USA and Mexico as specified in the introduction. Canada has been considered separately.

The extent of available of information for Asian ports was affected from the fact that the majority of the ports considered in this geography were in China. Chinese port websites usually did not have sections on environmental initiatives and/or policies. Since port websites provided content also in English, we interpreted this lack of information as a real deficiency with regard to the environmental monitoring and sustainable development rather than simply a language issue. However, the language barrier was primary challenge when searching for additional information on the web for environmental monitoring initiatives around Chinese ports. Additionally, even when it was possible to find references to some monitoring activities carried out by government institutions, websites were frequently not reachable (i.e., URL address not working) and difficult to search and/or to access because of the lack of translation. The addition of the ports of Singapore and Busan (South Korea) to the scan allowed us to capture different approaches and sensitivity regarding environmental monitoring in the Asian context. Information was much more accessible for these two ports due to their use of English as the primary language. While environmental monitoring information was scarce on the Singapore and Busan port websites, clear information on environmental monitoring programs for both were identified elsewhere on the web. In particular, for Singapore, government agencies are responsible for environmental monitoring and provide clear information on existing programs. It must also be noted that the case of Singapore is peculiar in that, due to the limited geographic extent of the country, the port area and its surroundings likely represent an important portion of any nation-wide marine monitoring program. Environmental monitoring programs in Busan appear to be in their infancy with a pilot study only done recently.

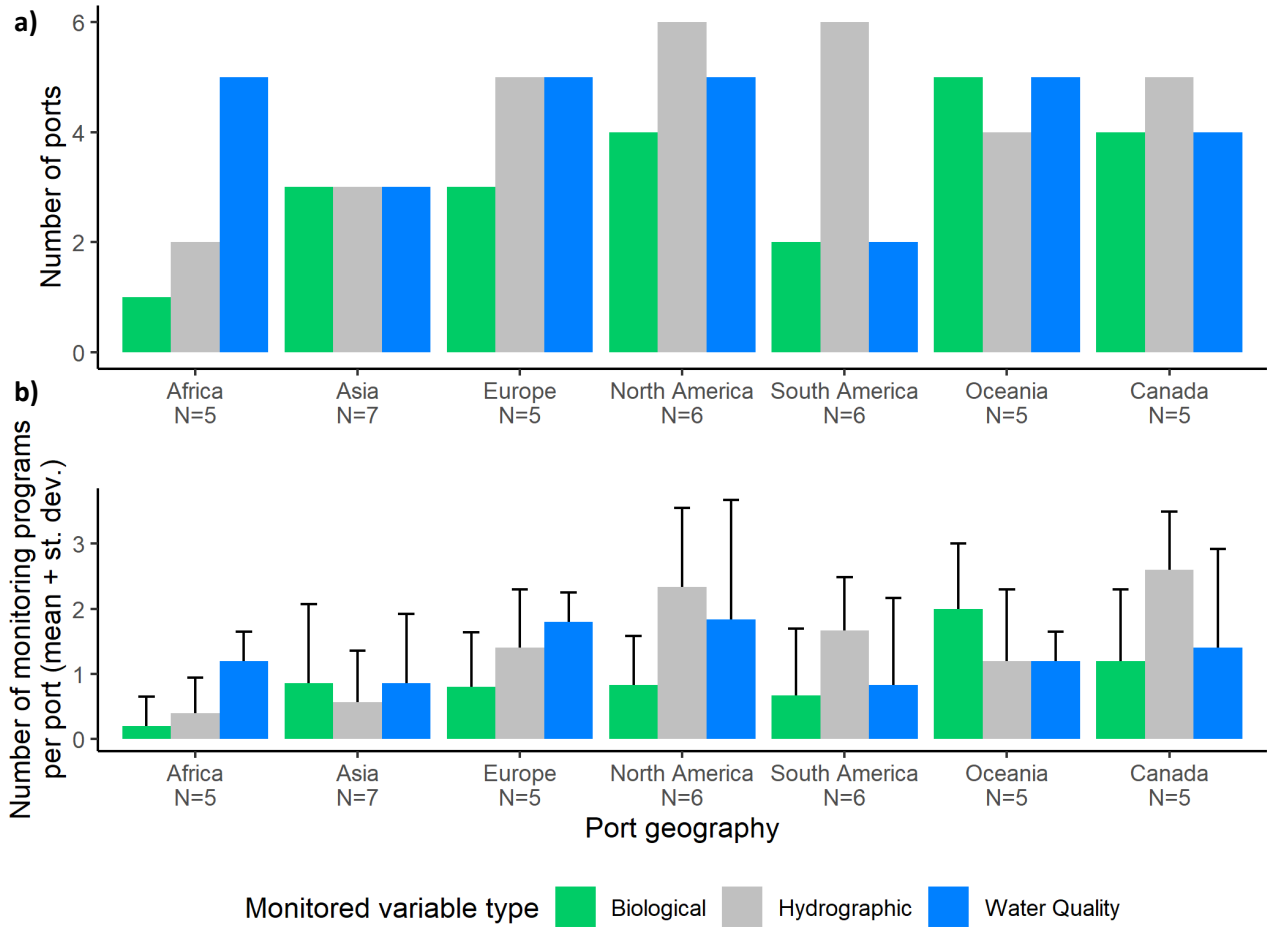

Figure 5: Distribution of monitoring programs per type of variable per geography. a) Number of ports per geography in which at least one monitoring program was identified for a specific type of variable. b) Average number of monitoring programs per port per geography and type of monitored variable, error bars show 1 standard deviation. North America does not include Canada. The number of ports considered per geography (N; i.e., top five and additional ports) is indicated below the x-axis labels.

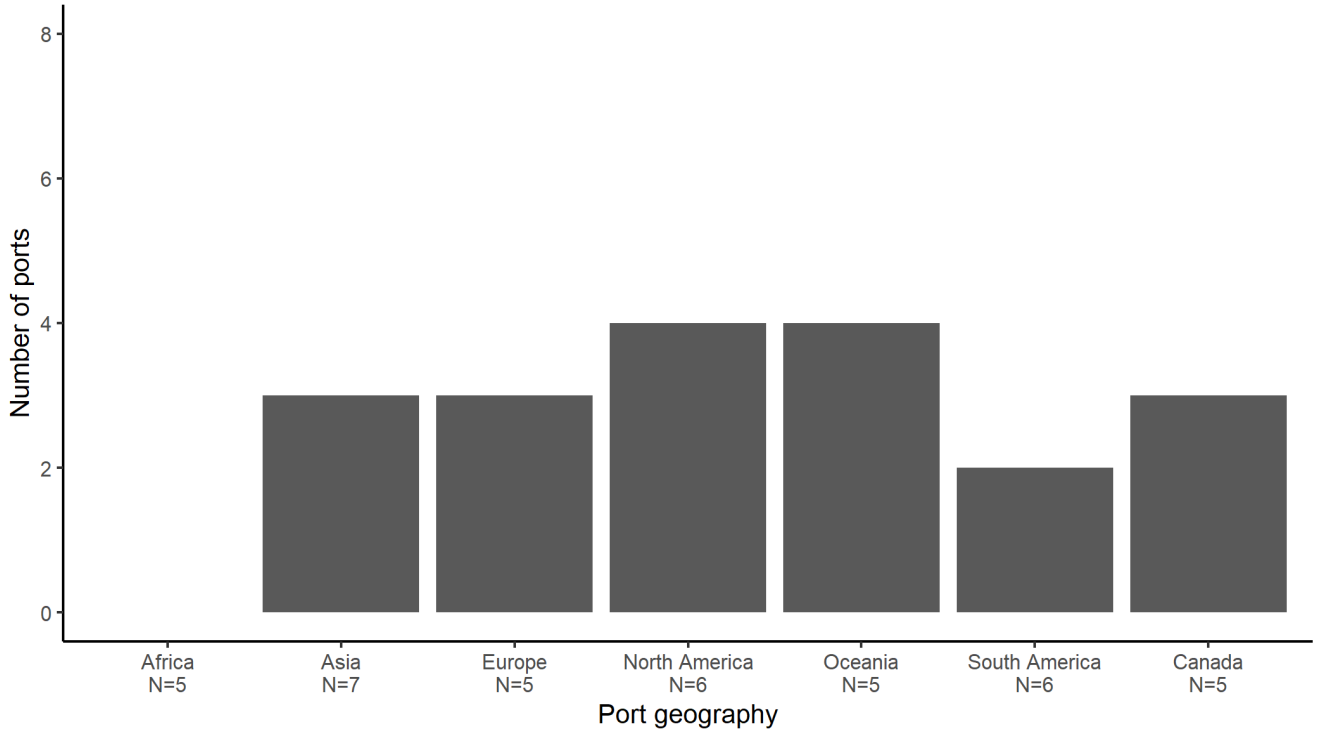

Figure 6: Number of ports per geography in which each variable type (i.e., biological, hydrographic, water quality) was monitored by at least one environmental monitoring program. North America does not include Canada. The number of ports considered per geography (N; i.e., top five and additional ports) is indicated below the x-axis labels.

CONSIDERATIONS ON HYDROGRAPHIC MONITORING PROGRAMS

Port-specific information on monitoring hydrographic variables was usually difficult to find. While ports frequently referred to dredging activities to maintain water depth, details on how depth or sediment dynamics throughout ports were monitored were virtually absent. When available, some general information was available in technical reports prepared by consulting engineering firms. These were often technical opinions based on reviews of existing information or general hydrodynamics of the area rather than outlining purpose-designed field studies.

Bathymetric surveys were usually carried out by national hydrographic services, i.e. governments, to create nautical charts. While nautical charts exist for every port, raw data were generally not simple to identify or access.

Marine currents, water levels, and other meteorological variables were usually monitored by nation-wide monitoring networks that have sensors in proximity to ports, generally to provide information on general patterns for wide areas rather than detailed portraits at the scale of specific ports.

CONSIDERATIONS ON WATER QUALITY MONITORING PROGRAMS

Water quality was monitored in the majority of ports, with many measured variables common to multiple monitoring programs. These included water temperature, salinity, dissolved oxygen, dissolved organic matter, nutrients, hydrocarbons, and bacteria (usually fecal bacteria). Sediment quality was not commonly monitored at ports, except in Africa and Oceania (monitored in four and three ports, respectively). Analysis of contaminants was occasionally performed on biota or some sentinel species (e.g., mussels).

CONSIDERATIONS ON BIOLOGICAL COMPONENTS MONITORING PROGRAMS

When biological components were monitored at ports, no details were available on which parameters were evaluated. Commonly, the jargon used to describe the focus of biological monitoring consisted only of broad categories such as benthic, planktonic, or nektonic communities.

When cetaceans or other charismatic species (e.g., turtle, seals) were mentioned as the object of monitoring activities, these actions were frequently only carried out as mitigation measures concurrent with another port activity (e.g. dredging). As such, monitoring for charismatic megafauna appeared to be largely a sporadic rather than a systematic effort and unlikely to generate more than short-term data.

DATA ACCESSIBILITY

Data availability from environmental monitoring in ports varied between geographic regions. Data were more often immediately available (e.g., raw data downloadable with some condition – such as restriction on use – conflicting with the open data definition, see Figure 1) or open in North America and Canadian ports (Table 3). In Europe, the frequency of monitoring programs with data immediately available was slightly lower than 50% while only 30% of data were open.

It is important to note that when monitoring data were immediately available or open, port authorities were not directly involved in the monitoring program (Table 3).

For monitoring programs that did not provide immediately available data, the possibility of submitting a data request – i.e., the existence of a formal and explicit procedure to access data – was given in only 25% of the cases overall but with variation between geographic areas (Table 4). In particular, submitting a data request was possible in 57% of the cases in Europe. While data requests were always possible in North America (USA) and Asia (China).

Table 6: Frequency of Data immediately available and of Open Data per geography. The frequency of data immediately available (or not) and the frequency of Open Data, are subdivided according to the involvement of Port Authority in the monitoring program. Data are presented as the percentage calculated on the total of monitoring programs (T_{mp}) in given geography. The number of ports considered per geography (N; i.e., top five and additional ports) indicated in parenthesis.

	DATA immediately available				**OPEN DATA**			
	No		**Yes**		**No**		**Yes**	
Geography	**Other**	**Port Authority**	**Other**	**Port Authority**	**Other**	**Port Authority**	**Other**	**Port Authority**
Africa (N=5, T_{mp}=7)	85.7	14.3	0.0	0.0	85.7	14.3	0.0	0.0
Asia (N=7, T_{mp}=11)	81.8	0.0	9.1	9.1	81.8	9.1	9.1	0.0
Europe (N=5, T_{mp}=13)	30.8	23.1	46.1	0.0	46.2	23.1	30.8	0.0
North America (N=6, T_{mp}=23)	4.3	17.4	73.9	4.3	4.3	17.4	73.9	4.3
South America (N=6, T_{mp}=19)	15.8	52.6	31.6	0.0	15.8	52.6	31.6	0.0
Oceania (N=5, T_{mp}=13)	0.00	100.0	0.0	0.0	0.0	100.0	0.0	0.0
Canada (N=5, T_{mp}=22)	22.7	4.5	72.7	0.0	27.3	4.5	68.2	0.0
Total	**25.9**	**29.6**	**1.8**	**42.6**	**28.7**	**30.6**	**39.8**	**0.9**

Table 7: Possibility of data request for environmental monitoring data not immediately available. Data are provided as counts of the monitoring programs for which a request was possible or not in each geography. Percent values are calculated on the total of monitoring programs without data immediately available in given geography. The number of ports considered per geography (N; i.e., top five plus additional ports) is indicated in parenthesis.

	Possibility of data request			
	Counts		**Frequency (%)**	
Geography	**no**	**yes**	**No**	**yes**
Africa (N=5)	7	0	100.0	0.0
Asia (N=7)	2	7	22.2	77.8
Europe (N=5)	3	4	42.8	57.1
North America (N=6)	4	1	80.0	20.0
South America (N=6)	13	0	100.0	0.0
Oceania (N=5)	11	2	84.6	15.4
Canada (N=5)	5	1	83.3	16.7
Total	**45**	**15**	**75**	**25**

HURDLES TO INFORMATION ACCESSIBILITY AND NAVIGATION

The time and effort required to find information on environmental monitoring programs at ports greatly depends on how websites are structured and the terminology used. Throughout the scan, no one consistent way of referring to such activities was noted even for ports within the same country. In general, when monitoring activities were presented on port websites, these were mentioned in sections dedicated to the environment or sustainability.

In the simplest cases, a port was directly involved in the monitoring and/or reports linked to dedicated pages or websites where more details or data could be found. However, the ease to navigate to monitoring program web pages is highly variable, depending on how content was organized on websites and on how many levels of nesting separate the monitoring page from the home page of the port.

In some cases, summarized information regarding monitoring initiatives that seemed were being conducted might be obtained by piecing together disparate information from official documents (e.g., policy statements, environmental management system statements) or reports (e.g. technical reports from external consultants). In these cases documents were readily available and further searches were needed to obtain them.

Finding information on monitoring initiatives or data availability requires considerable time and effort when external entities are fully or partially involved. This was typically the case for monitoring or research programs run by government agencies. In these cases, the greatest hurdle was usually related to the need to understand how organizations are structured and how to navigate the relevant agency's website and/or webtools designed to access the information (e.g., web dashboards, interactive mapping

tools). When data from government agencies were made available, there were generally two scenarios: data were accessible from a government open data portal; or data were submitted to international initiatives for data management. In the first case, the user needs to understand how the portal works and subsequently to look for data produced by a monitoring program using some filters. The common consequence was that several results, not always pertinent, were prompted to the user. For example, searching for "environmental monitoring ports" on the Canadian Open data portal (open.data.ca), the only result that was returned was the entry relative to the "Lake Simcoe/South-Eastern Georgian Bay Cleanup Fund" which is an inland area of the Lake Ontario region. Alternatively, trying to refine the search with "coastal environmental monitoring ports", 334 results were returned of which the first proposed entries were not related to port monitoring at all (e.g., list of BC Environmental Monitoring Locations, Independent Environmental Monitoring program implemented by the Canadian Nuclear Safety Commission, Marine Environmental Quality (MEQ) Dissolved Oxygen, Eelgrass and Nutrient Monitoring in Southern Gulf of St. Lawrence, The Canadian Radiological Monitoring Network – Environmental Dosimetry).

In the second scenario, understanding how information is organized and can be accessed could be complicated by the fact that the same information could be provided by several entities (e.g., research institutions, agencies, international programs). This may happen when data are collected through a shared network of sensors, such that the same data may be referenced by more than one international initiative.

In summary, information and data for environmental monitoring in ports were seldom clearly identifiable and directly available. Most often, users need to navigate their way through a variably intricate web of links, in which, it is easy to get lost.

HIGHLIGHTS AND TRENDS

- The concurrent monitoring of biological, hydrographic and water quality variables did not occur in all the ports considered.
- Port authorities tended to be sensitive to the environmental sustainability of their activity particularly in North America, Europe, Australia and Canada. In Asia different sensitivities to this theme seemed to coexist: while Singapore and Busan aligned with the above mentioned geographies, port authorities within China tended not to address the topic (judging from the English content of their websites). Sustainability and actions taken to improve environmental sustainability also usually considered the impact that port activities may have on climate change. Ports frequently mentioned efforts related to reducing or mitigating green-house gas emissions, and improving energetic and/or logistics efficiency.
- Chinese port authorities were mainly concerned with monitoring and reporting on infrastructure and economic development.
- United States monitoring programs were often initiatives led by government agencies (e.g., EPA, Texas Commission on Environmental Quality), non-governmental groups (foundations and universities), and collaborations between these two groups.
- Northern European ports are moving towards the developments of "Smart Ports", taking advantage of "Big-Data" and the "Internet-of-Things", by creating networks of sensors for managing port activities (e.g. ship traffic, logistics) and to perform automated monitoring. In particular, both

Antwerp and Rotterdam are "digitizing" their ports to create a virtual 3D copy of their ports and use Artificial Intelligence to manage their activities. In this context, monitoring is likely to be integrated into "smart" systems. At the moment, these two ports are building a network of sensors for automatic monitoring of air quality (iNose, E-Noses). Another notable trend is the use of floating drones to monitor port activities (e.g. surveillance) and acquire bathymetric data.

- In Europe, there are also advanced efforts to enhance the availability and shareability of environmental datasets collected by governments or research institutions, using common vocabulary and data management policies. The best example was the www.seadatanet.org portal. Here, metadata of datasets can be searched based on geography or keywords and a list of parameters measured is easily accessible. Data were generally open, after registration, however access to some datasets had restrictions or costs. The existence of similar data portals can offer data in port areas even when port monitoring programs are not in place or do not make data available.
- In the United states and in Canada, government (federal) Open data portals are also sources of datasets for environmental variables (e.g., satellite data and hydrographic data). However, navigating these portals and accessing metadata is less efficient than the European seadatanet example.

CONCLUSION

The majority of Canadian ports considered had monitoring programs in place for biological, hydrographic and water quality variables. This behavior is in line with ports in North America (particularly the USA), Europe and Australia. However, globally variability exists in monitoring efforts depending on the geographic area of the ports.

One commonality emerging from this scan can be found in the general lack of coordination of monitoring activities and approaches both within and between countries (except for hydrographic monitoring usually pertaining to governmental agencies). Indeed, even when monitoring programs existed for the same type of variables (e.g., biological), monitoring did not focus on a common set of parameters nor was it performed within a common framework (e.g., policy, standards). Rather, the breadth of monitoring efforts usually is determined at a local level (e.g., port authorities, non-governmental organizations). Importantly, Port Authorities were not necessarily involved in the existing monitoring programs.

Still, the heterogeneity in environmental monitoring approaches encountered through this scan could be seen as an opportunity to identify inspiring examples and good practices. For instance, following the European experience of data sharing via the SeaDataNet portal, a common repository of abiotic and biotic data in coastal areas could be proposed to share existing information and to inventory knowledge gaps for coordinated monitoring at coastal sites and ports in Canada. Drawing from the Australian example, where port authorities more frequently have a leading role in biological monitoring, Port Authorities could be more openly involved in the design and implementation of programs to monitor the biotic components of the ecosystem. On the other end, this scan highlighted that hydrographic monitoring programs are usually run by Government agencies, but mainly for the sake of navigation. Thus there is the need to enhance the concertation of all organizations invested in environmental monitoring at different levels and scales, within and around port areas, in order to ensure collecting or

accessing the information needed to safeguard the environmental sustainability of port activities is more efficient, intentional and systematic.

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ANNEX A – Notes on Port Activity Parameters

FREIGHT TON

From http://www.conversion-website.com/volume/from-ton-freight.html

The freight ton, or measurement ton, is a unit of volume or capacity equal to 1.13267386368 cubic meters (1 freight ton = 1.13267386368 m^3), the derived unit of volume in the International System of Units (SI).

The freight ton (FT) is also equal to 1,132,673.86368 cubic centimeters (cm^3), or 1,132.67386368 cubic decimeters (dm^3) or $1.13267386368 \times 10^{-3}$ cubic decameters (dam^3) (units of volume in the SI), or 11,326.7386368 deciliters (dL), or 1,132.67386368 liters (L), or 113.267386368 decaliters (daL) or 1.13267386368 kiloliters (kL), which are units of volume in the metric system.

The freight ton is defined as the volume of a freight carrier such as a truck or train.

Conversions of various tons:

- The displacement ton is equal to about 0.9911 cubic meters
- The freight ton or measurement ton is equal to about 1.13267 cubic meters
- The register ton is equal to about 2.832 cubic meters
- The water ton is equal to about 1.0183 cubic meters

METRIC TON

From https://www.aapa-ports.org/unifying/content.aspx?ItemNumber=21048
A metric ton = 2,205 pounds

REVENUE TON (RT)

From https://shipgsl.com/shipping-tools/shipping-terms/revenue-ton-rt/

A ton on which the shipment is freighted. If cargo is rated as weight or measure (W/M), whichever produces the highest revenue will be considered the revenue ton. Weights are based on metric tons and measures are based on cubic meters. RT=1 MT or 1 CBM.

TWENTY-FOOT EQUIVALENT UNIT (TEUs)

From https://en.wikipedia.org/wiki/Twenty-foot_equivalent_unit

One 20-foot-long (6.1 m) intermodal container represent 1 TEUs.
Port activity can be expressed as the number of TEUs transited through the port (arrived and left). TEUs do not provide information on whether or not Containers were loaded.

ANNEX B – Description of Datasets Accompanying this Report

Description of datasets accompanying this report and available at:

https://doi.org/10.5683/SP2/YFYOLU

freight_data-interntl_ports.csv

Column	Description
geography	Geography id
ocean	Name of the ocean/sea on which the port is located
rank	Rank of the port as from the original data source
port	Port name
country	Country of the port
measure	Unit of measure of the parameter used to assess the port activity (see Annex A)
val	Value of the parameter
data_name	Name of the data from which data have been sourced
year	The year against which the port activity was assessed.

freight_data-canadian_ports.csv

Column	Description
port	Port name
province	Province of the Port
url	url of the port website
Metric_tons	Port activity parameter expressed in Metric tons (x1000) of freight moved in the port. (see Annex A)
TEUs	Port activity parameter expressed in Twenty-foot Equivalent Unit (x1000) of containers moved in the port. (see Annex A)
year	The year against which the port activity was assessed
note	Notes on the values of activity parameter
rank	Ranking of the ports based on Metric Tons

selected_ports-meta.csv

Column	Description
rank_geography	port rank relative to geography
geography	Geography of the port
port	Port name
country	Country of the port
measure	Parameter on which the ranking is based
value	value of the parameter
url_port	url address of the port website
shoreline_urbanization	level of urbanisation of the port. Urbanized = means the area around the port is mainly developed; Rural = means that the area

	around the port is mainly farmed or undeveloped. Both values are reported when the area is mixed.
other_known_uses	List of other known uses in the proximity of the port

selected_ports-env_mon_info.csv

Column	Description
id	Sequential numerical identification of the port
geography	Geography of the port
port	Port name
country	Country of the port
monitoring_program	Name of the monitoring program if available
url_program_or_repository	url address of the monitoring program or of the data repository where environmental datasets can be found
variables-hydrography	List of hydrographic variables included in the monitoring program
variables-water_quality	List of variables included in the monitoring program of water quality. Analysis of Sediment and contaminants in animal tissues are also included.
variables_biological	List of variables included in the monitoring program biological components
DATA-immediately_available	Are data immediately available (see Figure 1) (e.g. downloadable datasets). All = data for all parameters listed in Variables; some = dataset are available only for some parameters, No= data are not immediately available (e.g. need to be requested from the data holder)
DATA-registration_needed	Does the user need to register to access data (see Figure 1). Yes/No
DATA-request_possible	Is there a procedure to submit a request to access data? (see Figure 1). Yes/No
DATA-restrictions	Type of restriction on the use of data.
DATA-visible	When data are not available, are data or summary statistics visualized in some way? (e.g. web dashboard for real time data)
DATA-cost	Free= data can be accessed at no cost; Paywall= a payment is required to access data
DATA-access_type	Method available to access data
DATA-OPEN	Are data open (see section 2.3)
environmental_monitoring_entity	Who is responsible /conduction the monitoring program
notes	Notes on the monitoring programs

ANNEX C – Annotations on Individual Ports

NORTH AMERICA

SOUTH LOUISIANA (LOUSIANA)

The South Louisiana port authority also includes the Port of South Louisiana Executive Regional Airport. There is no reference to environmental initiatives and/or programs on the South Louisiana port authority website.

Monitoring programs

Environmental monitoring: There is no clear information about the existence of environmental monitoring activities related to the port. Environmental management and monitoring activities seem to be carried out more generally by a government agency (e.g. EPA) or at the state level, not focusing on the port area but rather at the level of state. In particular, water and air quality are monitored by the EPA and Louisiana Department of Environmental Quality. The State of Louisiana, through the Coastal Protection and Restoration Authority, developed a Master Plan for a Sustainable Coast (current version released in 2017) which offers a portrait of the coastal risk (i.e., loss of land and ecosystem services) of coastal ecosystems related to coastal hazards (e.g., sea level rise, storms and hurricanes) and human impacts.

Hydrographic Monitoring: Data regarding variables such as water temperature, water levels and currents, along with other meteorological information are available in real-time through the NOAA program PORTS®. Data can be accessed via API or other web services. Type and time range of retrievable data vary by station.
NOAA is responsible for the acquisition of bathymetric data. Several datasets can be searched and downloaded from https://maps.ngdc.noaa.gov/viewers/bathymetry/.

Other uses
Unknown. Boating may be possible since the port is located on a river, however no direct evidence was found.

HOUSTON (TEXAS)

The Houston port authority website has a page dedicated to Outreach and Environment; through which information and contacts can be found for air and water quality, marsh restoration, community outreach and education, and channels development (Navigation Information and Soundings).

Monitoring programs

Environmental monitoring: Water quality of rivers and coastal waters is monitored by the Texas Commission on Environmental Quality (TCEQ). On the TCEQ website, one may see the location of past and current sampling stations, however it is not clear which parameters are/have been monitored: data seems to be station- and time period-dependent. Parameters such as water temperature, dissolved

oxygen and pH seems to be common. Additionally, some data regarding invertebrate fauna seems to be available for a subset of stations.

No monitoring program focusing on biological communities was identified.
The Gulf of Mexico Coastal Ocean Observing System (part of the Integrated Oceans Observing System) collects various data from public and private programs and makes it available. Although not strictly related to ports, it has sensors and observations in nearby areas. In particular, for the Houston area, there is a Citizen Science program led by the Galveston Bay Foundation that provides water quality data at various stations since 2011.

Hydrographic monitoring: The port authority website refers to the USACE (US Army Corp of Engineers) hydrographic surveys of navigation channels for which bathymetric data are available.

Data regarding variables such as water temperature, water levels and currents, along with other meteorological information, are available in real-time through the NOAA PORTS® program. Data may be accessed via API or other web services. Type and time range of retrievable data vary by station.
NOAA is responsible for the acquisition of bathymetric data. Several datasets can be searched and downloaded from https://maps.ngdc.noaa.gov/viewers/bathymetry/.

Other uses

Activity such as recreational boating and fishing, beach visiting as well as tourist cruises have been reported
(https://tidesandcurrents.noaa.gov/publications/EstimatingEconomicBenefitsfromNOAAPORTSInformation_Houston-Galveston.pdf, https://www.bayareahouston.com/content/Regional_Profile/maritime)

NEW YORK/NEW JERSEY (NEW YORK)

The New York-New Jersey port authority includes not only the seaport, but more generally the transportation infrastructure in the greater New York City area, including airports, bus and train terminals, and tunnels.
The port authority website has a section on Environmental Initiatives and Sustainability that mainly focuses on initiatives/goals related to clean air and energy, sustainable development of buildings and infrastructure, with a focus on resilience from climate stressors.

Monitoring programs

Environmental monitoring: The New York-New Jersey Harbor Estuary Program (HEP) is an extensive monitoring program in the New York harbor/estuary (https://www.hudsonriver.org/hep-emp/). HEP is wholly or partly funded by the Environmental Protection Agency (EPA), regrouping several monitoring activities undertaken by various government and non-governmental partners. HEP includes water quality and biological/ecological variables.

Hydrographic monitoring: Data regarding variables such as water temperature, water levels and currents, along with other meteorological information, are available in real-time through the NOAA

program PORTS®. Data can be accessed via API or other web services. Type and time range of retrievable data vary by station.
NOAA is responsible for the acquisition of bathymetric data. Several datasets can be searched and downloaded from https://maps.ngdc.noaa.gov/viewers/bathymetry/.

Other uses
Boating, tourism (e.g., cruises, waterfront, parks), transportation (i.e., ferries), recreational, beach visiting, Outdoor Education, recreational fishery, commercial fishery.

NEW ORLEANS (LOUSIANA)

The New Orleans port authority website does not refer to any Environmental monitoring activity program. It mentions Green Marine certification and a community program to make storm water drains visible through artwork.

The New Orleans port is located a few kilometers downstream of the South Louisiana Port Authority.

Monitoring programs

Environmental monitoring: The Louisiana University Marine Consortium (LUMCON) runs a monitoring program with 3 active and 3 archived stations. Active stations are on the coast of the Gulf of Mexico while the New Orleans port is located along the Mississippi River and Lake Pontchartran, a more inland position. One archived station was located in Lake Pontchartran. Variables sampled at the active stations include wind direction, wind speed, air temperature, air pressure, rainfall, relative humidity, solar radiation, water temperature, water height, salinity, conductivity, dissolved oxygen, and chlorophyll.
As mentioned for the South Louisiana Port Authority, environmental management and monitoring activities seem to be carried out more generally by national government agencies (e.g., EPA) or State-level ones, not focusing on the port area specifically, rather at the level of state. In particular, water and air quality are monitored by the EPA and Louisiana Department of Environmental Quality.
The Gulf of Mexico Coastal Ocean Observing System (part of the Integrated Oceans Observing System) collects various data from different public and private programs and makes it available. Although not strictly related to ports, it has sensors and observations in nearby areas.

No monitoring program focusing on biological communities was identified.

Hydrographic monitoring: Data regarding variables such as water temperature, water levels and currents, along with other meteorological information, are available in real-time through the NOAA program PORTS®. Data can be accessed via API or other web services. Type and time range of retrievable data vary by station.
NOAA is responsible for the acquisition of bathymetric data. Several datasets can be searched and downloaded from https://maps.ngdc.noaa.gov/viewers/bathymetry/.

Other uses
Tourism activities (e.g., cruises, venues rental), boating.

BEAUMONT (TEXAS)

No information on Environmental Initiatives is given on the Port of Beaumont website.

Monitoring programs

Environmental monitoring: Water quality of rivers and coastal waters is monitored by the Texas Commission on Environmental Quality (TCEQ). The location of past and current sampling stations may be seen on the TCEQ website, however it is not clear which parameters are/have been monitored: data seems to be station- and time period-dependent. Parameters, including water temperature, dissolved oxygen and pH, seem to be common. Additionally, some data regarding invertebrate fauna seems to be available for a subset of stations.

No monitoring program focusing on biological communities was identified.

Hydrographic monitoring: NOAA is responsible for the acquisition of bathymetric data (https://maps.ngdc.noaa.gov/viewers/bathymetry/). No information on currents and water levels was identified.

Other uses

Recreational (e.g., Sea Scouts activities, fishing charters), commercial fisheries.

ASIA

SHANGHAI (CHINA)

The port website does not provide information on any environmental initiative.

Monitoring programs

Environmental monitoring: No information identified.
The East China Sea Environmental Monitoring Center and State Oceanic Administration should be the organization responsible for monitoring water quality. Websites for this agency are not reachable (i.e., URL did not work).
The Shanghai Environmental Monitoring Center runs Air quality monitoring.

Hydrographic monitoring: No information identified.

Other uses

Recreational boating

GUANGZHOU (CHINA)

The port website does not provide information on any environmental initiative.

Monitoring programs

Environmental monitoring: No information identified. South China Sea Environmental Monitoring Center of the State Oceanic Administration appears to be the institution responsible for monitoring. Website only in Chinese (http://scs.mnr.gov.cn/).

Hydrographic monitoring: No information identified.

Other uses

Recreational boating.

NINGBO ZHOUSHAN (CHINA)

The website of the port does not provide information on any environmental initiative.

Monitoring programs

Environmental monitoring: No information was identified on water quality or biodiversity monitoring programs.

Hydrographic monitoring: No information identified.

Other uses

Not known.

QINGDAO (CHINA)

The website of the port does not provide information on any environmental initiative.

Monitoring programs

Environmental monitoring: Several authorities are conducting environmental monitoring in the area of Qingdao: 1) Qingdao Environmental Monitoring Center (QEMC), Qingdao Environmental Protection Bureau; Qingdao municipal Ocean and Fisheries Administration (QOFA); 3) North China Sea Environmental Monitoring Center, State Oceanic Administration of China; Jiaozhou Bay Marine Ecosystem Research station (JMER), Chinese Academy of Sciences. Information could not be identified for all these authorities (i.e., website URLs did not work)).

In particular, the Ocean & Fishery Administration of Qingdao and the Jiaozhou Bay Marine Ecosystem Research station (JMER), seem to have monitoring programs for both water quality and biological components with datasets on these possibly available upon request (Report on Marine Environmental Quality of Qingdao, 2017; http://jzb.cern.ac.cn/meta/metaData).

Hydrographic monitoring: No information identified. However, some Hydrographic variables may be available in the data catalog of Jiaozhou Bay Marine Ecosystem Research station.

Other uses
Recreational and touristic; fishery; aquaculture

TIANJING (CHINA)

The website of the port does not provide information on any environmental initiative.

Monitoring programs

Environmental monitoring: The State Oceanic Administration was once responsible for pollution monitoring but was integrated into the Ministry of Natural Resources in 2018. No information was found on their website.
References to other entities, such as the "Tianjin Tanggu Environmental Monitoring Station" and the "Tianjin Port Environmental Monitoring Engineering Center," were identified during the scan, although the corresponding websites were not.

Hydrographic monitoring: No information found. The Tianjin Marine Survey and Charting Center and the Tianjin Municipal Water Management Bureau should be the authority responsible for hydrographic surveys, although no related websites were identified.

Other uses
Recreational boating, fishing

EUROPE

ROTTERDAM (NEDERLANDS)

The port website has a section on sustainability and environmental initiatives (e.g. E-noses sensor network for hazardous gases in the air).

Monitoring programs

Environmental monitoring: Water quality data are collected by the Ministry of the Infrastructure and Water Management. Several datasets with information about water quality and biota for the marine areas off the Rotterdam coast are listed and available through the databases nodc.nl and the SeaDataNet. The available datasets encompass an area bigger than the port and station locations could potentially not provide data for the port area per se. Datasets have variable time and spatial resolution.

Hydrographic monitoring: Various data about currents, tidal streams (i.e. current associated with tide), water level, salinity, wind and waves are reported in real time at

https://www.portofrotterdam.com/en/shipping/operational-information/maps/hydrometeo-data.
These data are visible on a web dashboard.
Several hydrographic datasets (e.g., bathymetry, currents, salinity, wave heights) for the marine areas off the Rotterdam coast are listed and available through the nodc.nl and SeaDataNet databases. The available datasets encompass an area larger than the port and station locations may potentially not provide data for the port area per se. Datasets have variable temporal and spatial resolution.

Other uses

Recreational boating, housing, tourism. In particular, the waterfront seems to be undergoing urban renewal.

ANTWERP (BELGIUM)

The port website has a section on sustainability and publishes a sustainability report in which there are references to physico-chemical monitoring programs run by the port authority.
The port is working on a project to create a network of sensors to create a virtual 3D image of the port ("a digital twin") through which one may monitor port activities and functioning in real-time. This network includes flying and floating drones and sensors to monitor air-quality (iNoses), and bathymetry (https://www.portofantwerp.com/en/smart-port#APICA).

Monitoring programs

Environmental monitoring: According to information in the sustainability report and on the "Sustainable Port of Antwerp" website (https://www.duurzamehavenvanantwerpen.be/en/), the port seems to have a monitoring program for biota and water quality. However, no link to related data was found nor was information on data accessibility.
Several datasets with information on water quality for the marine areas off of the Antwerp coast are listed and available through the SeaDataNet database. The available datasets encompass an area bigger than the port and station locations could potentially not provide data for the port area per se. Datasets have variable temporal and spatial resolution.
No information was identified for biodiversity monitoring programs.

Hydrographic monitoring: Several hydrographic datasets (e.g., bathymetry, currents, salinity) for the marine areas off the Antwerp coast are listed and available through the SeaDataNet database. The available datasets encompass an area bigger than the port itself and station locations could potentially not provide data for the port area per se.

Other uses

Recreational fishing and use of coastal natural areas, tourism (port tours).

HAMBURG (GERMANY)

The port website does not provide information on environmental initiatives. The Port authority website (www.hamburg-port-authority.de) vaguely refer to results of water quality monitoring in past sustainability reports. The port authority refers to projects such as making the port "smart" and adopting floating drones with sounding capabilities.

Monitoring programs

Environmental monitoring: The Hamburg's Institute for Hygiene and Environment runs a water quality measurement network; related data can be downloaded by holders of a Hamburg Service account (e.g., local citizens and companies).

Several datasets with information about water quality for the marine areas off the Hamburg coast are listed and generally available through the SeaDataNet database. The available datasets encompass an area bigger than the port and station locations could potentially not provide data for the port area per se. Datasets have variable temporal and spatial resolution.
No information was identified for biodiversity monitoring programs.

Hydrographic monitoring: Several hydrographic datasets (e.g., bathymetry, currents, salinity) for the marine areas off the Hamburg coast are listed and available through the SeaDataNet database. The available datasets encompass an area bigger than the port and statios locations could potentially not provide data for the port area per se.

Other uses
Recreational boating, recreational fishing on the river Alster

ALGECIRAS - LA LINEA (SPAIN)

The port website vaguely refers to environmental policy objectives. The port produces an annual environmental report in which there are references to a water quality monitoring program and a biodiversity survey related to a specific port development project. No data are presented in the report nor is there a link to these programs.

Monitoring programs

Environmental monitoring: Several datasets with information about water quality and biota (mainly shellfish physiology data) for the marine areas off the Algeciras coast are listed and available through the SeaDataNet database. The available datasets encompass an area bigger than the port and stations location could potentially not be providing data for the port area per se. Datasets have variable time and spatial resolution.

Hydrographic monitoring: Several hydrographic datasets (mainly current, salinity and water temperature) for the marine areas off the Algeciras coast are listed and available through the SeaDataNet database. The available datasets encompass an area bigger than the port and stations location could potentially not be providing data for the port area per se.

Other uses
Recreational boating and sailing, beach visiting, transportation (ferry), fishery.

AMSTERDAM (NEDERLANDS)

The port website does not refer to environmental initiatives.

Monitoring programs

Environmental monitoring: No monitoring programs linked to the port were identified.
Water quality data are collected by the Ministry of the Infrastructure and Water Management.
Several datasets with information about water quality for the marine areas off the Amsterdam coast are listed and available through the databases nodc.nl and the SeaDataNet. The available datasets encompass an area bigger than the port and stations location could potentially not be providing data for the port area per se. Datasets have variable time and spatial resolution.

Hydrographic monitoring: No monitoring programs linked to the port were identified.
Several hydrographic datasets (e.g., bathymetry, currents, salinity and water temperature) for the marine areas off the Amsterdam coast are listed and available through the SeaDataNet database. The available datasets encompass an area bigger than the port and stations location could potentially not be providing data for the port area per se.

Other uses

Tourism (e.g., cruises), recreational open-air, boating, fishing

AFRICA

RICHARDS BAY (SOUTH AFRICA)

There is no website for this port.

Monitoring programs

Environmental monitoring: No clear existing monitoring program was identified. However, a recent uMhlathuze & Richards Bay Estuarine Management Plan assigns water quality and biodiversity monitoring to various government agencies/entities (e.g. Transnet National Ports Authority, Department of Environmental Affairs, City of uMhlathuze).

Some monitoring was done by the Council for Scientific and Industrial Research prior to port expansion projects.

Hydrographic monitoring: No clear existing monitoring programs were identified.

Other uses

Tourism (e.g. cruises), boating, fishery, beach visiting, dolphin viewing, water sports

SALDANHA BAY (SOUTH AFRICA)

There is no dedicated website for this port. Some information is reported on more general websites such as https://ports.co.za/saldanha-bay.php and https://www.transnetnationalportsauthority.net/OurPorts/Saldanha/Pages/Overview.aspx

Monitoring programs

Environmental monitoring: The Saldanha Bay Water Quality Forum Trust is conducting long-term monitoring programs which include water and sediment quality as well as biota, including benthic invertebrates, algae, fish and birds.

Hydrographic monitoring: No clear existing monitoring programs were identified.

Other uses

Fishery, aquaculture, recreational uses, boating, tourism.

ALEXANDRIA AND EL-DEKHEILA (EGYPT)

The port authority website does not report any environmental initiatives.

Monitoring programs

Environmental monitoring: The Egyptian Environmental Affairs Agency monitors coastal waters through the Environmental Information and Monitoring Programme (EIMP). Information on the EIMP website indicate that EIMP collect data about water quality and benthos.
According the Egyptian Biodiversity Strategy and Action Plan (2015 – 2030), Egypt is restructuring monitoring programs for biodiversity.

Hydrographic monitoring: Acquisition of bathymetry data is the responsibility of the Egyptian Navy Hydrographic Department, which have conducted surveys in the port of Alexandria as part of a larger Mediterranean Coast survey.

Other uses

Fishery, recreational (e.g., SCUBA diving), boating.

EAST PORT SAID PORT (EGYPT)

Port Said falls under the Suez Canal Authority. There is no website for the port. Almost no reference to environmental initiatives is reported on the Suez Canal Authority website.

Monitoring programs

The Suez Canal Authority has a Research Center that seems to be in charge of hydrographic and water quality monitoring to some extent.

The National Institute of Oceanography and Fisheries conducts Hydrographic and Benthic surveys (including sediment quality).

Environmental monitoring: The Egyptian Environmental Affairs Agency monitors coastal waters through the Environmental Information and Monitoring Programme (EIMP). Information on the EIMP website indicate that EIMP collect data about water quality and benthos. According to the Egyptian Biodiversity Strategy and Action Plan (2015 – 2030), monitoring programs for biodiversity in Egypt are being restructured.

Hydrographic monitoring: Several agencies seem to conduct hydrographic monitoring (see above).

Other uses
Fishery, aquaculture (possibly land-based), tourism, beach visiting.

TANGER (MOROCCO)

The Tanger Med port is the commercial port of Tanger, recently built and separated from the touristic port. The port website references sustainability and environmental protection but there is no reference to monitoring programs.

Monitoring programs

Environmental monitoring: The Agence Nationale des Ports (ANP) is measuring water quality and sediments in port zones and comparing them to the environmental quality standards currently in port zones. No data are provided.

Hydrographic monitoring: No clear existing monitoring programs have been identified.

Other uses
Fishery, beach visiting, tourism, boating.

SOUTH AMERICA

ITAQUI (BRAZIL)

The port authority website has a detailed section on its environmental policy and monitoring activity.

Monitoring programs

Environmental monitoring: Various monitoring programs are run by the port authority. These include water effluent monitoring, monitoring of water resources and sediments, aquatic biota monitoring, monitoring of sediment plume dispersion, and monitoring for exotic / invasive species. No data nor reports are available.

Hydrographic monitoring: Various monitoring program are run by the port authority. These include monitoring the bathymetry and hydrodynamics of the port region and dredging. Reports are available for 2019 and 2018 hydrographic monitoring. Although the Annex containing the raw data is referenced in the report, it is not present.

Other uses
Fishery, boating, and tourism.

TUBARAO (BRAZIL)

The port does not have a website and appears to be owned by the private mining company VALE.

Monitoring programs

Environmental monitoring: No clear existing monitoring programs were identified.

Hydrographic monitoring: No clear existing monitoring programs were identified. Brazil's Navy center of Navy Hydrography collect Hydrographic data, which are available upon request. It is not possible to verify which data exist for a given area before requesting data. Data could potentially not be for available for the port area per se.

Other uses
Tourism, fishery, recreational

SANTOS (BRAZIL)

The Port website does not provide information on environmental initiatives.

Monitoring programs

Environmental monitoring: No clear existing monitoring programs were identified.

Hydrographic monitoring: No clear existing monitoring programs were identified.

Other uses
Fishery, tourism (e.g., cruises), beach visiting, boating.

ITAGUAI (BRAZIL)

The Port website does not have information on environmental initiatives.

Monitoring programs

Environmental monitoring: No clear existing monitoring programs were identified.

Hydrographic monitoring: No clear existing monitoring programs were identified. The Brazil's Navy center of Navy Hydrography collect Hydrographic data which are available upon request. It is not possible to verify which data exist for a given area before requesting data. Data could potentially not be for available for the port area per se.

Other uses
Fishing, tourism.

SAO SEBASTIAO (BRAZIL)

The Port website has a detailed section on environmental initiatives.

Monitoring programs

Environmental monitoring: The port authority conducts several monitoring programs that include biological components and water and sediment quality. The website indicates the frequency of the sampling. Monitored Parameters are not reported clearly and completely. Data are not available.

Hydrographic Monitoring: No clear existing monitoring programs were identified. The Brazil's Navy center of Navy Hydrography collect Hydrographic data which are available upon request. It is not possible to verify which data exist for a given area before requesting data. Data could potentially not be for available for the port area per se.

Other uses
Tourism, beach visiting, recreational, boating, fishery.

OCEANIA

PORT HEDLAND (AUSTRALIA)

The port of Port Hedland is under the Pilbara Port Authority that runs several monitoring programs. The port authority website provides vague information on what is monitored; data are not available.

Monitoring programs

Environmental monitoring: Monitoring programs targeting benthic biota and invasive species seems to be in place. Marine and rainwater quality appear to be monitored (rainwater only occasionally due to dry climate). Monitoring activities for Marine mega-fauna (e.g., whales, turtles) seem to be linked mainly to dredging activity to avoid disturbance while activities are on-going.

Hydrographic monitoring: Hydrographic surveys are undertaken to inform dredging and to monitor the spoil grounds prior to, during, and following material relocation. No information on monitored parameters is available.

Other uses

Recreational fishing, boating.

PORT DAMPIER (AUSTRALIA)

The port of Dampier is under the Pilbara Port Authority that runs several monitoring programs. There is vague information on what is monitored on the port authority website; data are not available.

Monitoring programs

Environmental monitoring: Monitoring programs targeting benthic biota and invasive species seem to be in place. Marine and rainwater quality are monitored (rainwater only occasionally due to dry climate). Monitoring activities for marine mega-fauna (e.g. whales, turtles) seem to be linked mainly to dredging activity to avoid disturbance while activities are on-going.

Hydrographic monitoring: Hydrographic surveys are undertaken to control dredging and monitor spoil grounds prior to, during, and following material relocation. No information on monitored parameters is available.

Other uses

Boating, recreational fishing, tourism, fishery, beach visiting.

NEWCASTLE (AUSTRALIA)

The Port of New Castle website has a section on Sustainability and Environment where it is possible to find reports and policies on their environmental initiatives.

Monitoring programs

Environmental monitoring: The port monitors stormwater quality and partners with University of Newcastle to monitor 2 species of threatened frogs in the Port area. According to the EcoPort 2019 report, the port invests in sediment, water quality and biodiversity monitoring activities. The Port provides no further details nor data.
Similarly, the Port has a "Long Term Monitoring and Management Plan" related to dredging activities in which it refers to monitoring biodiversity and sediments quality at the dredged material disposal sites once every 10 years.

Hydrographic monitoring: The port is responsible for monitoring bathymetry (also at the dredged material dumping site) but no data are available.

Other uses

Recreational fishing, fishery, boating, beach visiting.

GLADSTONE (AUSTRALIA)

The port of Gladstone website has a detailed section on Environmental Monitoring activities.

Monitoring programs

Environmental monitoring: Water quality is monitored using manual and real-time samples. Data can be visualized but not directly downloaded (they can possibly be obtained upon request). Biological monitoring occurs.

The Port Curtis and Port Alma Ecosystem Research and Monitoring Program states that the Gladstone Port Corporation "must make the findings, including related data, of any or all of these studies publicly available upon request by any interested parties".

Hydrographic monitoring: No hydrographic monitoring program was identified.

Other uses
Recreation, transport (i.e. ferry), commercial and recreational fishery, boating, tourism (e.g. Cruises)

HAY POINT (AUSTRALIA)

The port of Hay Point has a detailed section on Environmental monitoring on their website.

Monitoring programs

Environmental monitoring: A long-term monitoring program (Ambient Monitoring) is in place that evaluates water and sediment quality, as well as biological components and habitats. Ambient Monitoring aims to provide baselines, with sampling occurring at various, parameter-specific, frequencies.
An additional Adaptive monitoring only occurs during dredging activities. Water quality parameters are a subset of those monitored in the Ambient monitoring and provided by real-time sensors. Megafauna is monitored only by visually verifying their presence on-site during dredging activities.

Hydrographic monitoring: Current speed and direction are monitored during both Ambient and Adaptive monitoring programs. The Port usually investigate bathymetry and sediment dynamics in concomitance with dredging intervention.

Other uses
Boating, beach visiting, tourism (e.g. local), recreational fishery, commercial fishery.

EXTRA PORTS

LOS ANGELES (CALIFORNIA, USA)

The port of Los Angeles website has section on Environment with a detailed description of management system and monitoring framework. The City of Los Angeles is directly involved in the management of the Port of Los Angeles.

The Port of Los Angeles is geographically adjacent to the port of Long Beach. Port of Los Angeles and Long beach collaborate in coordinating and supporting several environmental monitoring programs.

Monitoring programs

Environmental monitoring: Water quality (including sediment quality), biodiversity and biological components are monitored in the port area through both external (e.g. the Southern California Bight Regional Monitoring Program) and internal volunteer monitoring programs (e.g. biological baseline surveys). Both ports also monitor stormwater quality. Various programs have different frequency and temporal resolutions. In general, the ports have adopted a comprehensive set of monitoring programs. Several programs (not necessarily monitoring chemical or biological parameters) are in place to improve water and sediment quality (see the WATER RESOURCES ACTION PLAN). Ports coordinate and closely cooperate with EPA, state agency, and local municipalities).

Hydrographic monitoring: The Ports voluntarily conducted hydrodynamic and circulation studies over the years to describe water and sediment dynamics within the port basin and in relation to the wider San Pedro Bay. Data regarding variables such as water temperature, water levels and currents, along with other meteorological information, are available in real-time through the NOAA PORTS® program. Data may be accessed via API or other web services. Type and time range of retrievable data vary by stations. NOAA is responsible for the acquisition of bathymetric data. Several datasets may be searched and downloaded from https://maps.ngdc.noaa.gov/viewers/bathymetry/.

Other uses

Tourism (e.g., cruises, waterfront), boating, recreation, commercial fishery, recreational fishery.

SINGAPORE (SINGAPORE)

The port authority website does not have a section on environment and environmental policies. One page is dedicated to community outreach and environmental activity (e.g., cleanups).
The Maritime Singapore Green Initiative operates through the port to recognize and provide incentives to companies that adopt clean and green shipping practices.

Monitoring programs

Environmental monitoring: Monitoring programs for water quality and biological components are carried out by government agencies. Because of the size of Singapore, the national coastal water monitoring programs largely coincides with the area surrounding the port.
Water quality monitoring includes both manual and automatic sampling through a buoy system.
National Parks collects and manages data on biodiversity and a coral reef and seagrass monitoring program through the National Biodiversity Centre. Seagrass monitoring is conducted by a volunteer team affiliated with the international program Seagrass-Watch. Seagrass data are also submitted to Seagrass-Watch which grants access for a fee.

Hydrographic monitoring: The port has a Hydrographic department that produces and sells nautical charts. The port monitors water levels in real time (tides). Monthly datasheets of current measurements can be accessed for free.

Other uses
Tourism (e.g. cruises, boat tours), boating, recreational (e.g. watersports), beach visiting, recreational fishing, limited commercial fishery, aquaculture (e.g. coastal, innovative floating farms).

BUSAN (SOUTH KOREA)

The port authority website does not include a section on the Environment.

Monitoring programs

Environmental monitoring: The Korea Institute of Ocean Science and Technology (KIOST) recently conducted a pilot project to design and build a monitoring program to assess the health of marine ecosystems in Korea with a case study in Busan (http://dx.doi.org/10.1007/s12601-019-0003-0).

Hydrographic monitoring: The Korea Hydrographic and Oceanographic Agency (KHOA) is responsible for monitoring oceanographic variables (e.g. water levels, currents) and bathymetric surveys. Oceanographic data are available and open through the NEAR-GOOS portal. Bathymetric surveys are conducted in ports but data are not available.

Other uses
Tourism (e.g. cruises), recreational (e.g. waterfront, watersports), boating, beach visiting, commercial fishery, recreational fishing, aquaculture.

CALLAO (PERU)

The port authority website does not have a section on the Environment.

Monitoring programs

Environmental monitoring: No water quality or biological monitoring programs were identified.

Hydrographic monitoring: The Peruvian Navy conducted a bathymetric survey of the port of Callao and is responsible for water level (tide) measurements. Numerical wave models and forecasting are available for Callao Bay.

Other uses
Commercial fishery (e.g. anchovies), beach visiting, tourism (e.g. boat tours), boating.

CANADIAN PORTS

SAINT JOHN (New Brunswick)

The port website has a section on “environment” but there is no clear reference to monitoring activities.

Monitoring programs

Environmental monitoring: A 2017 Project from Canadian Water Network (Prof. Heather Hunt) developed methods for long term monitoring in the port (ichthyoplankton, fish communities, sand shrimp). No data are available. Another project focusing on Benthic invertebrates was carried out in 2012-2014 by H. Hunt (UNB). This projects are concluded and it is not clear if developed methods are currently implemented.
The port refers to the Canadian Environmental Assessment Agency to obtain information on Environmental Assessments, but no documents could be identified.
Port Saint John refers to partnership with Fisheries and Oceans Canada, ACAP Saint John, University of New Brunswick, Eastern Charlotte Waterways, and the Huntsman Marine Institute for monitoring activities, however these remain unspecified (2018 annual report).
Several projects are currently funded by DFO's Coastal Environmental Baseline Program that assess biodiversity, water quality and surface currents in and around the Port.

Hydrographic monitoring: Multibeam surveys have been conducted in the Port between 2000 and 2010 by the Department of Geodesy and Geomatics Engineering, University of New Brunswick.
DFO's Coastal Environmental Baseline Program is currently funding a project to study surface currents in and around the Port.
Water level observation are monitored by Fisheries and Oceans Canada.
Bathymetric data are available for certain areas from the Canadian Hydrographic Service.

Other uses
Tourism (e.g., cruises), boating, recreational (outdoor excursions), commercial fishery (herring, lobster and crab), recreational and traditional fishery, transportation (ferry).

QUEBEC (QUEBEC)

The port website has a section on sustainability and environmental policy. However, there is no detailed reference to ongoing monitoring activities. Some monitoring actions seem to be in a planning phase.

Monitoring programs

Environmental monitoring: The sustainable development strategy document for 2017-2022 mentions some monitoring activities and initiatives. The port undertook the Beauport 2020 environmental impact assessment during which some biological components (e.g., fish, birds and wetland habitat) were evaluated. No details or results are available.
The port also mentions planning for a water management system which should include a water quality assessment (possibly including drainage water and recreational water bodies).

Hydrographic monitoring: No hydrographic monitoring program was identified.
Water level observations are monitored by Fisheries and Oceans Canada.

Bathymetric data are available for certain areas from the Canadian Hydrographic Service.

Other uses
Tourism (e.g., cruises, events, waterfront), recreation and beach visiting, sailing, boating, recreational fishing.

MONTREAL (QUEBEC)

The port website has a section on "Environment" in which environmental monitoring is cited as an example of the Environmental Management System in place. However, no further information on monitoring programs or data are provided.

Monitoring programs

Environmental monitoring: The municipality of Montreal monitors water quality of the St. Lawrence River around the Island of Montreal, drainage water, and the internal rivers with 4 different monitoring programs. Data are accessible on the open data portal of the city.
No monitoring program focusing on biological communities was identified.

Hydrographic monitoring: No hydrographic monitoring program was identified.
Water levels are monitored by Fisheries and Oceans Canada.
Bathymetric data are available for certain areas from the Canadian Hydrographic Service.

Other uses
Boating, transportation (i.e., shuttle/ferry), tourism (e.g., cruises, waterfront events), beach visiting, recreational fishing.

VANCOUVER (BRITISH-COLUMBIA)

The port of Vancouver website has a section on Environment in which several environmental initiatives are described. In general, there are many initiatives, although they only broadly described.
Environmental initiatives related to aquatic systems address water quality (including stormwater), aquatic species, habitat enhancement.
Initiatives addressing water quality and impacts on species generally entail specific monitoring actions. For example, the Vancouver Fraser Port Authority issues recommendations and requirements to project proponents or to leaseholders through the Project and Environmental Review process. Data and results arising from these monitoring activities, when present, may be available as project report annexes. Website navigation to project reports is not straightforward. As an example, reports from an eight-year scientific monitoring program at Roberts Bank is available via the "news and media section" and not following the links from one section to the next (e.g. https://www.portvancouver.com/development-and-permits/project-and-environmental-reviews/applicant-per-test/status-of-applications/deltaport-third-berth-project/).

Similarly, environmental surveys (e.g., assessing existing biophysical conditions), may be available as project report annexes, as in the case of some Habitat enhancement projects.

Monitoring programs

Environmental monitoring: The Enhancing Cetacean Habitat and Observation (ECHO) Program is in place with the main aim of protecting cetaceans (e.g. killer whales) in the port region and includes:

- PollutionTracker monitoring program to assess contaminant in sediment and mussels.
- WhaleReport Alert System (WRAS) monitoring cetacean sightings.

Hydrographic monitoring: No hydrographic monitoring program for the port was identified.
Water level observations are monitored by Fisheries and Oceans Canada.
Bathymetric data are available for certain areas from the Canadian Hydrographic Service.

Other uses

Boating, Tourism (e.g., cruise, events, waterfront), beach visiting, commercial fishery, recreational fishery, transportation (e.g., ferry)

SEPT-ILES (QUEBEC)

The port website has a section on Environment through which information on the environmental observatory for the Bay of Sept-Îles and its monitoring activities are accessible. The environmental observatory for the Bay of Sept-Îles is coordinated by INREST (Institut Nordique de Recherche en Environnement et en Santé au Travail) and benefitted from the partnership with the research network CHONe2.
Results of monitoring activities conducted in this context and data are available in the book:

Observatoire environnemental de la baie de Sept-Îles (J. Carrière, ed.). (2018). Volume 1 and Volume 2 available at :
https://inrest.ca/wp-content/uploads/2020/01/rapport_global_volume_1.pdf
https://inrest.ca/wp-content/uploads/2020/01/rapport_global_volume_2.pdf

Monitoring programs

Environmental monitoring: The environmental observatory for the Bay of Sept-Îles was launched in 2013 and has coordinated monitoring activities for water and sediment quality, marine benthic communities (macroalgae and macrofauna) and cetacean surveys.

Hydrographic monitoring: Currents have been monitored in the context of the environmental observatory for the Bay of Sept-Îles.
Water level observations are monitored by Fisheries and Oceans Canada.
Bathymetric data are available for certain areas from the Canadian Hydrographic Service.

Other uses

Tourism (e.g. cruises), commercial and recreational fishery, boating, outdoor, whale watching.