Attachment A

Coastal Policy Assessment

- **New York State Coastal Consistency**
- **New York City Waterfront Revitalization Program Consistency Assessment**
- **Long Island Sound Coastal Consistency Assessment**
- **New York State Department of State Coastal Consistency Assessment**
- **Smithtown Local Waterfront Revitalization Assessment Form**
- **Southhold Local Waterfront Revitalization Assessment Form**

The NYSDEC's Artificial Reef Program (Program) maintains a series of reef sites in the waters of New York's Marine and Coastal District (MCD). Program goals are to administer and manage artificial reef habitat as part of a fisheries management program, provide fishing and diving opportunities, and enhance or restore fishery resources and associated habitat through the selective placement of artificial reef habitat (i.e. natural rock, concrete and steel) in the MCD under Programmatic guidelines. In 1993, NYSDEC completed a Generic Environmental Impact Statement (GEIS)/Reef Plan which allowed for the issuance of a permit for the development of artificial reefs at specific locations within the MCD, and adjacent Federal waters. As the Program developed, additional NYSDEC and United States Army Corps of Engineers (USACE) permits were obtained to place material to meet specific goals of the Program outlined in the GEIS/Reef Plan.

The proposed action includes the assessment of previously permitted sites, the expansion of seven existing sites (Fire Island, Hempstead, McAllister Grounds/Fishing Line, Moriches, Rockaway, Shinnecock, and Smithtown Reefs) and the addition and creation of four new sites (Sixteen Fathoms, Huntington/Oyster Bay, Port Jefferson/Mount Sinai and Mattituck). Artificial reefs are developed using the patch reef system. Patch reef development includes the placement of material in discrete locations or "targets" separated by undisturbed benthic habitat. This method results in a smaller disruption of the site's benthic footprint thereby reducing impacts to the benthic community. Materials are transported to the reef site either by barge (i.e. natural stone and concrete) or towed out by vessel (i.e. steel barges or vessels) under Program supervision. The materials are deployed on pre-designated site targets to produce a patch reef configuration. This configuration increases the enhancement of the local natural habitat by introducing profiled hard structure for colonization and reef development while maintaining areas of natural bottom habitat between patch reef structures. The different structures attract a variety of marine life including recreationally important finfish and crustacean (i.e. lobster) species sought by anglers and divers.

Included herein are the New York State Coastal Zone Program policies relevant to the proposed activities that have been assessed based on completion of the New York State Department of State Federal Consistency Assessment Form policy questions. The additional information provided demonstrates how the proposed Project would be consistent with the goals of the policies. An assessment of coastal zone consistency for each reef site related to local waterfront revitalization programs (LWRP) and coastal management programs is included herein. Table 1 provides the reef sites and which program they fall under for this consistency assessment. Figure 1 below provides the location of the New York artificial reef sites.

Table 1. New York Artificial Reef Sites – Coastal Zone Consistency Programs

Reef	Coastal Zone Consistency Program[1]	Acreage	Development Status (%)	Proposed Modification
Rockaway	New York City CMP	413	80%	Expand to 635 Acres
McAllister Grounds	NYS CMP	115	75%	Expand to 425 Acres
Fire Island	NYS CMP	744	70%	Expand to 850 Acres
Moriches	NYS CMP	14	90%	Expand to 850 Acres
Shinnecock	NYS CMP	35	85%	Expand to 850 Acres
Atlantic Beach	NYS CMP	413	87%	None
Hempstead	NYS CMP	744	60%	Expand to 850 Acres
Sixteen Fathom	NYS CMP	850	Undeveloped	New Site
Twelve Mile	NYS CMP	850	5%	None
Yellowbar	NYS CMP	7	60%	None
Kismet	NYS CMP	10	85%	None
Matinecock	LIS CMP	41	10%	None
Huntington / Oyster Bay	LIS CMP	50	Undeveloped	New Site
Smithtown	LIS CMP	3	80%	Expand to 31 Acres
Port Jefferson / Mount Sinai	LIS CMP	50	Undeveloped	New Site
Mattituck	LIS CMP	50	Undeveloped	New Site

[1]NYS CMP = New York State Coastal Management Program
LIS CMP = Long Island Sound Coastal Management Program

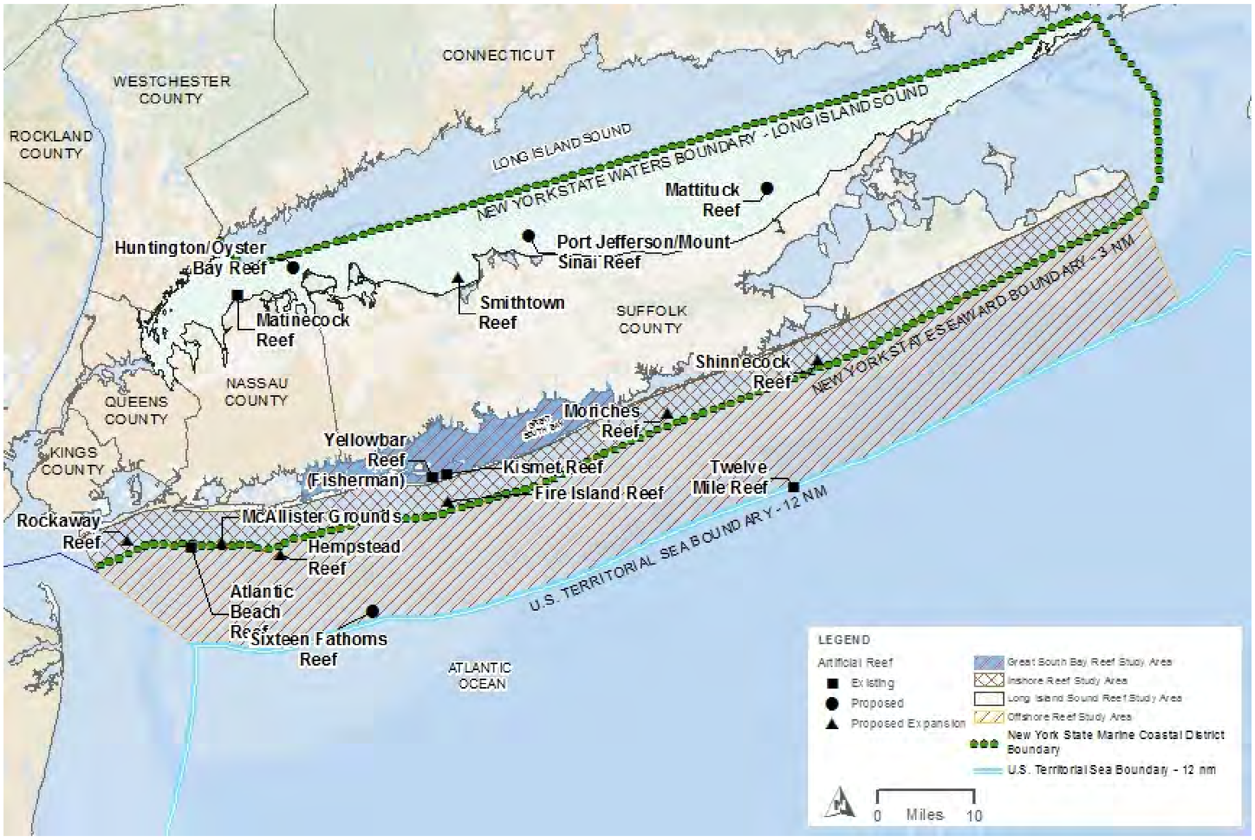

Figure 1. New York State Artificial Reef Sites

Local Waterfront Revitalization Program Assessments

One reef site is located within the New York City LWRP boundary. This reef site is identified as Rockaway Reef and is located within the Atlantic Ocean off the coast of the Rockaway Peninsula. Approximately 310 acres of this reef have already been developed and up to an additional 103 acres can be developed in the future. This reef is proposed to expand to 635 acres, providing an additional 222 acres that can be built upon. The 325 acres that can be developed at the Rockaway Reef site is the focus of this consistency assessment with the New York City LWRP. Included in this appendix is the completed NYC Consistency Assessment Form followed by an assessment of the Waterfront Revitalization Program (WRP) policies relevant to the proposed activities. The additional information provided demonstrates how the proposed Project would be consistent with the goals of the WRP polices. This assessment reflects the City Council approved revisions to the WRP dated October 2013, which were approved by the New York State Department of State and the U.S. Department of Commerce February 2016.

Long Island Sound Coastal Management Program Assessment

Five reef sites are located within Long Island Sound (LIS) including Matinecock, Smithtown, Huntington/Oyster Bay, Port Jefferson/Mount Sinai, and Mattituck reefs. Matinecock was previously permitted for 41 acres off the coast of Glen Cove and Smithtown was previously permitted for 3 acres. The Huntington/Oyster Bay, Port Jefferson/Mount Sinai, and Mattituck sites have been evaluated for potential development for new reef sites and are anticipated to be 50 acres in size. The Smithtown reef site has been proposed to expand to 31 acres. The potential future permitting and development of these sites is the focus of this assessment.

Below are the policies relevant to the proposed Project that have been assessed based on the Long Island Sound Coastal policy questions. The additional information provided demonstrates how the proposed Project would be consistent with the goals of the Long Island Sound coastal polices.

New York State Coastal Management Program

The remaining reef sites, as well as those requiring assessment under a LWRP and the Long Island Sound Coastal Management Program, have been evaluated for consistency with New York State Coastal Management Program. Included in this appendix are the New York State Coastal Zone Program policies relevant to the proposed activities that have been assessed based on completion of the New York State Department of State Federal Consistency Assessment Form policy questions. The additional information provided demonstrates how the proposed Project would be consistent with the goals of the policies. This assessment reflects the Coastal Zone Management Program approved in 1982 and all of its updates and changes up to 2017. The following information is provided in support of Section D.2 of the Federal Consistency Assessment Form (FCAF).

New York City Waterfront Revitalization Program Consistency Assessment

For Rockaway Reef

Located in New York City, Queens County, NY

FOR INTERNAL USE ONLY Date Received: _______________	WRP No. _______________ DOS No. _______________

NEW YORK CITY WATERFRONT REVITALIZATION PROGRAM
Consistency Assessment Form

Proposed actions that are subject to CEQR, ULURP or other local, state or federal discretionary review procedures, and that are within New York City's Coastal Zone, must be reviewed and assessed for their consistency with the *New York City Waterfront Revitalization Program* *(WRP)* which has been approved as part of the State's Coastal Management Program.

This form is intended to assist an applicant in certifying that the proposed activity is consistent with the WRP. It should be completed when the local, state, or federal application is prepared. The completed form and accompanying information will be used by the New York State Department of State, the New York City Department of City Planning, or other city or state agencies in their review of the applicant's certification of consistency.

A. APPLICANT INFORMATION

Name of Applicant: New York State Department of Environmental Conservation

Name of Applicant Representative: James J. Gilmore

Address: 205 North Belle Mead Road, East Setauket, NY 11733

Telephone: (631) 444-0430 Email: james.gilmore@dec.ny.gov

Project site owner (if different than above): NYS Office of General Services / Underwater Lands

B. PROPOSED ACTIVITY

If more space is needed, include as an attachment.

1. Brief description of activity

The proposed Project includes the assessment of previously permitted reef sites, the expansion of existing reef sites and the creation of four new reef sites. Previously permitted reef sites are located in the Atlantic Ocean, Great South Bay, and Long Island Sound. One reef site is located within the New York City Local Waterfront Revitalization Program boundary. This reef site is identified as the Rockaway Reef and is located off the coast of the Rockaway Peninsula. Approximately 310 acres of this reef have already been developed and up to 103 additional acres can be developed in the future. This reef is proposed to expand to 635 acres, providing an additional 222 acres that can be built upon.
Artificial reefs are developed using a patch reef system. Materials are transported to the reef site either by barge or towed out by vessel (i.e. steel barges or vessels) under Program supervision. The materials are deployed on pre-designated site targets to produce a patch reef configuration. This configuration increases the enhancement of the local natural habitat by introducing profiled hard structure for colonization and reef development while maintaining areas of natural bottom habitat between patch reef structures. The different structures attract a variety of marine life including recreationally important finfish and crustaceans (i.e. lobster) species sought by anglers and divers.

2. Purpose of activity

The NYSDEC's Artificial Reef Program (Program) maintains a series of reef sites in the waters of New York's Marine and Coastal District (MCD). Program goals are to administer and manage artificial reef habitat as part of a fisheries management program, provide fishing and diving opportunities, and enhance or restore fishery resources and associated habitat through the selective placement of artificial reef habitat (i.e. natural rock, concrete and steel) in the MCD under Programmatic guidelines.
All of these uses ultimately share the common purpose of enhancing or increasing the marine habitat available for associated fishes and other organisms. Planned manmade reefs can provide local economic benefits because fish and benthic organisms utilize the structure provided at known locations and are often popular attractions for commercial and recreational fishermen, and divers.

C. PROJECT LOCATION

Borough: Queens Tax Block/Lot(s): N/A

Street Address: N/A

Name of water body (if located on the waterfront): Atlantic Ocean

D. REQUIRED ACTIONS OR APPROVALS

Check all that apply.

City Actions/Approvals/Funding

City Planning Commission ☐ Yes ☐ No

☐ City Map Amendment
☐ Zoning Map Amendment
☐ Zoning Text Amendment
☐ Site Selection – Public Facility
☐ Housing Plan & Project
☐ Special Permit
(if appropriate, specify type: ☐ Modification ☐ Renewal ☐ other) Expiration Date: ______

☐ Zoning Certification
☐ Zoning Authorizations
☐ Acquisition – Real Property
☐ Disposition – Real Property
☐ Other, explain: ______

☐ Concession
☐ UDAAP
☐ Revocable Consent
☐ Franchise

Board of Standards and Appeals ☐ Yes ☐ No

☐ Variance (use)
☐ Variance (bulk)
☐ Special Permit
(if appropriate, specify type: ☐ Modification ☐ Renewal ☐ other) Expiration Date: ______

Other City Approvals

☐ Legislation
☐ Rulemaking
☐ Construction of Public Facilities
☐ 384 (b) (4) Approval
☐ Other, explain: ______

☐ Funding for Construction, specify: ______
☐ Policy or Plan, specify: ______
☐ Funding of Program, specify: ______
☐ Permits, specify: ______

State Actions/Approvals/Funding

☑ State permit or license, specify Agency: NYSDEC Permit type and number: ______
☐ Funding for Construction, specify: ______
☐ Funding of a Program, specify: ______
☐ Other, explain: ______

Federal Actions/Approvals/Funding

☑ Federal permit or license, specify Agency: USACE Permit type and number: ______
☐ Funding for Construction, specify: ______
☐ Funding of a Program, specify: ______
☐ Other, explain: ______

Is this being reviewed in conjunction with a Joint Application for Permits? ☑ Yes ☐ No

E. LOCATION QUESTIONS

		Yes	No
1.	Does the project require a waterfront site?	☐	☑
2.	Would the action result in a physical alteration to a waterfront site, including land along the shoreline, land under water or coastal waters?	☑	☐
3.	Is the project located on publicly owned land or receiving public assistance?	☑	☐
4.	Is the project located within a FEMA 1% annual chance floodplain? *(6.2)*	☐	☑
5.	Is the project located within a FEMA 0.2% annual chance floodplain? *(6.2)*	☐	☑
6.	Is the project located adjacent to or within a special area designation? *See Maps – Part III of the NYC WRP. If so, check appropriate boxes below and evaluate policies noted in parentheses as part of WRP Policy Assessment (Section F).*	☐	☑

- ☐ Significant Maritime and Industrial Area (SMIA) (*2.1*)
- ☐ Special Natural Waterfront Area (SNWA) (*4.1*)
- ☐ Priority Maritime Activity Zone (PMAZ) (*3.5*)
- ☐ Recognized Ecological Complex (REC) (*4.4*)
- ☐ West Shore Ecologically Sensitive Maritime and Industrial Area (ESMIA) (*2.2, 4.2*)

F. WRP POLICY ASSESSMENT

Review the project or action for consistency with the WRP policies. For each policy, check Promote, Hinder *or* Not Applicable (N/A). *For more information about consistency review process and determination, see **Part I** of the NYC Waterfront Revitalization Program. When assessing each policy, review the full policy language, including all sub-policies, contained within **Part II** of the WRP. The relevance of each applicable policy may vary depending upon the project type and where it is located (i.e. if it is located within one of the special area designations).*

For those policies checked Promote *or* Hinder, *provide a written statement on a separate page that assesses the effects of the proposed activity on the relevant policies or standards. If the project or action promotes a policy, explain how the action would be consistent with the goals of the policy. If it hinders a policy, consideration should be given toward any practical means of altering or modifying the project to eliminate the hindrance. Policies that would be advanced by the project should be balanced against those that would be hindered by the project. If reasonable modifications to eliminate the hindrance are not possible, consideration should be given as to whether the hindrance is of such a degree as to be substantial, and if so, those adverse effects should be mitigated to the extent practicable.*

		Promote	Hinder	N/A
1	**Support and facilitate commercial and residential redevelopment in areas well-suited to such development.**	☐	☐	☑
1.1	Encourage commercial and residential redevelopment in appropriate Coastal Zone areas.	☐	☐	☑
1.2	Encourage non-industrial development with uses and design features that enliven the waterfront and attract the public.	☐	☐	☑
1.3	Encourage redevelopment in the Coastal Zone where public facilities and infrastructure are adequate or will be developed.	☐	☐	☑
1.4	In areas adjacent to SMIAs, ensure new residential development maximizes compatibility with existing adjacent maritime and industrial uses.	☐	☐	☑
1.5	Integrate consideration of climate change and sea level rise into the planning and design of waterfront residential and commercial development, pursuant to WRP Policy 6.2.	☐	☐	☑

		Promote	Hinder	N/A
2	**Support water-dependent and industrial uses in New York City coastal areas that are well-suited to their continued operation.**	☐	☐	☑
2.1	Promote water-dependent and industrial uses in Significant Maritime and Industrial Areas.	☐	☐	☑
2.2	Encourage a compatible relationship between working waterfront uses, upland development and natural resources within the Ecologically Sensitive Maritime and Industrial Area.	☐	☐	☑
2.3	Encourage working waterfront uses at appropriate sites outside the Significant Maritime and Industrial Areas or Ecologically Sensitive Maritime Industrial Area.	☐	☐	☑
2.4	Provide infrastructure improvements necessary to support working waterfront uses.	☐	☐	☑
2.5	Incorporate consideration of climate change and sea level rise into the planning and design of waterfront industrial development and infrastructure, pursuant to WRP Policy 6.2.	☐	☐	☑
3	**Promote use of New York City's waterways for commercial and recreational boating and water-dependent transportation.**	☐	☐	☑
3.1.	Support and encourage in-water recreational activities in suitable locations.	☐	☐	☑
3.2	Support and encourage recreational, educational and commercial boating in New York City's maritime centers.	☐	☐	☑
3.3	Minimize conflicts between recreational boating and commercial ship operations.	☐	☐	☑
3.4	Minimize impact of commercial and recreational boating activities on the aquatic environment and surrounding land and water uses.	☐	☐	☑
3.5	In Priority Marine Activity Zones, support the ongoing maintenance of maritime infrastructure for water-dependent uses.	☐	☐	☑
4	**Protect and restore the quality and function of ecological systems within the New York City coastal area.**	☑	☐	☐
4.1	Protect and restore the ecological quality and component habitats and resources within the Special Natural Waterfront Areas.	☐	☐	☑
4.2	Protect and restore the ecological quality and component habitats and resources within the Ecologically Sensitive Maritime and Industrial Area.	☐	☐	☑
4.3	Protect designated Significant Coastal Fish and Wildlife Habitats.	☐	☐	☑
4.4	Identify, remediate and restore ecological functions within Recognized Ecological Complexes.	☐	☐	☑
4.5	Protect and restore tidal and freshwater wetlands.	☐	☐	☑
4.6	In addition to wetlands, seek opportunities to create a mosaic of habitats with high ecological value and function that provide environmental and societal benefits. Restoration should strive to incorporate multiple habitat characteristics to achieve the greatest ecological benefit at a single location.	☑	☐	☐
4.7	Protect vulnerable plant, fish and wildlife species, and rare ecological communities. Design and develop land and water uses to maximize their integration or compatibility with the identified ecological community.	☑	☐	☐
4.8	Maintain and protect living aquatic resources.	☑	☐	☐

		Promote	Hinder	N/A
5	**Protect and improve water quality in the New York City coastal area.**	☑	☐	☐
5.1	Manage direct or indirect discharges to waterbodies.	☐	☐	☑
5.2	Protect the quality of New York City's waters by managing activities that generate nonpoint source pollution.	☐	☐	☑
5.3	Protect water quality when excavating or placing fill in navigable waters and in or near marshes, estuaries, tidal marshes, and wetlands.	☑	☐	☐
5.4	Protect the quality and quantity of groundwater, streams, and the sources of water for wetlands.	☐	☐	☑
5.5	Protect and improve water quality through cost-effective grey-infrastructure and in-water ecological strategies.	☐	☐	☑
6	**Minimize loss of life, structures, infrastructure, and natural resources caused by flooding and erosion, and increase resilience to future conditions created by climate change.**	☐	☐	☑
6.1	Minimize losses from flooding and erosion by employing non-structural and structural management measures appropriate to the site, the use of the property to be protected, and the surrounding area.	☐	☐	☑
6.2	Integrate consideration of the latest New York City projections of climate change and sea level rise (as published in *New York City Panel on Climate Change 2015 Report, Chapter 2: Sea Level Rise and Coastal Storms*) into the planning and design of projects in the city's Coastal Zone.	☐	☐	☑
6.3	Direct public funding for flood prevention or erosion control measures to those locations where the investment will yield significant public benefit.	☐	☐	☑
6.4	Protect and preserve non-renewable sources of sand for beach nourishment.	☐	☐	☑
7	**Minimize environmental degradation and negative impacts on public health from solid waste, toxic pollutants, hazardous materials, and industrial materials that may pose risks to the environment and public health and safety.**	☐	☐	☑
7.1	Manage solid waste material, hazardous wastes, toxic pollutants, substances hazardous to the environment, and the unenclosed storage of industrial materials to protect public health, control pollution and prevent degradation of coastal ecosystems.	☐	☐	☑
7.2	Prevent and remediate discharge of petroleum products.	☐	☐	☑
7.3	Transport solid waste and hazardous materials and site solid and hazardous waste facilities in a manner that minimizes potential degradation of coastal resources.	☐	☐	☑
8	**Provide public access to, from, and along New York City's coastal waters.**	☑	☐	☐
8.1	Preserve, protect, maintain, and enhance physical, visual and recreational access to the waterfront.	☐	☐	☑
8.2	Incorporate public access into new public and private development where compatible with proposed land use and coastal location.	☐	☐	☑
8.3	Provide visual access to the waterfront where physically practical.	☐	☐	☑
8.4	Preserve and develop waterfront open space and recreation on publicly owned land at suitable locations.	☐	☐	☑

		Promote	Hinder	N/A
8.5	Preserve the public interest in and use of lands and waters held in public trust by the State and City.	☑	☐	☐
8.6	Design waterfront public spaces to encourage the waterfront's identity and encourage stewardship.	☐	☐	☑
9	**Protect scenic resources that contribute to the visual quality of the New York City coastal area.**	☐	☐	☑
9.1	Protect and improve visual quality associated with New York City's urban context and the historic and working waterfront.	☐	☐	☑
9.2	Protect and enhance scenic values associated with natural resources.	☐	☐	☑
10	**Protect, preserve, and enhance resources significant to the historical, archaeological, architectural, and cultural legacy of the New York City coastal area.**	☐	☐	☑
10.1	Retain and preserve historic resources, and enhance resources significant to the coastal culture of New York City.	☐	☐	☑
10.2	Protect and preserve archaeological resources and artifacts.	☐	☐	☑

G. CERTIFICATION

The applicant or agent must certify that the proposed activity is consistent with New York City's approved Local Waterfront Revitalization Program, pursuant to New York State's Coastal Management Program. If this certification cannot be made, the proposed activity shall not be undertaken. If this certification can be made, complete this Section.

"The proposed activity complies with New York State's approved Coastal Management Program as expressed in New York City's approved Local Waterfront Revitalization Program, pursuant to New York State's Coastal Management Program, and will be conducted in a manner consistent with such program."

Applicant/Agent's Name: James J. Gilmore

Address: 205 North Belle Mead Road, East Setauket, NY 11733

Telephone: (631) 444-0430 Email: james.gilmore@dec.ny.gov

Applicant/Agent's Signature: ______________________

Date: ______________

Submission Requirements

For all actions requiring City Planning Commission approval, materials should be submitted to the Department of City Planning.

For local actions not requiring City Planning Commission review, the applicant or agent shall submit materials to the Lead Agency responsible for environmental review. A copy should also be sent to the Department of City Planning.

For State actions or funding, the Lead Agency responsible for environmental review should transmit its WRP consistency assessment to the Department of City Planning.

For Federal direct actions, funding, or permits applications, including Joint Applicants for Permits, the applicant or agent shall also submit a copy of this completed form along with his/her application to the NYS Department of State Office of Planning and Development and other relevant state and federal agencies. A copy of the application should be provided to the NYC Department of City Planning.

The Department of City Planning is also available for consultation and advisement regarding WRP consistency procedural matters.

New York City Department of City Planning
Waterfront and Open Space Division
120 Broadway, 31st Floor
New York, New York 10271
212-720-3696
wrp@planning.nyc.gov
www.nyc.gov/wrp

New York State Department of State
Office of Planning and Development
Suite 1010
One Commerce Place, 99 Washington Avenue
Albany, New York 12231-0001
518-474-6000
www.dos.ny.gov/opd/programs/consistency

Applicant Checklist

- ☑ Copy of original signed NYC Consistency Assessment Form
- ☑ Attachment with consistency assessment statements for all relevant policies
- ☑ For Joint Applications for Permits, one (1) copy of the complete application package
- ☑ Environmental Review documents
- ☑ Drawings (plans, sections, elevations), surveys, photographs, maps, or other information or materials which would support the certification of consistency and are not included in other documents submitted. All drawings should be clearly labeled and at a scale that is legible.
- N/A Policy 6.2 Flood Elevation worksheet, if applicable. For guidance on applicability, refer to the WRP Policy 6.2 Guidance document available at www.nyc.gov/wrp

WRP Policy 4. Protect and restore the quality and function of ecological systems within the New York City coastal area.

WRP Policy 4.6: In addition to wetlands, seek opportunities to create a mosaic of habitats with high ecological value and function that provide environmental and societal benefits. Restoration should strive to incorporate multiple habitat characteristics to achieve the greatest ecological benefit at a single location.

The Rockaway Reef would enhance habitat for epibenthic, benthic and fish species. These habitat improvements would enhance fishery resources and provide recreational fishing and diving opportunities for anglers and divers. As such, the reef would provide both environmental and societal benefits, in compliance with this policy.

WRP Policy 4.7: Protect vulnerable plant, fish and wildlife species, and rare ecological communities. Design and develop land and water uses to maximize their integration or compatibility with the identified ecological community.

There are numerous Federal- and State-listed threatened, endangered, and special concern species that may occur in the vicinity of the Rockaway Reef site according to USFWS, NOAA, and the State of New York (USACE 2014 and 2016). These species are listed in Table 1.

Table 1. State and Federally Listed Protected Species Potentially Occurring in the Vicinity of the Rockaway Reef Site

Birds		
Common Name	**Scientific Name**	**Status**
common loon	*Gavia immer*	SSC
common tern	*Sterna hirundo*	ST
Cooper's hawk	*Accipiter cooperii*	SSC
least tern	*Sterna antillarum*	ST
osprey	*Pandion haliaetus*	SSC
peregrine falcon	*Falco peregrinus*	SE, FE
piping plover	*Charadrius melodus*	SE, FE
rufa red knot	*Calidris canutus*	FT
roseate tern	*Sterna dougallii*	SE, FT
Fish		
Atlantic sturgeon	*Acipenser oxyrinchus*	FE
Shortnose sturgeon	*Acipenser brevirostrum*	SE, FE
Reptiles		
loggerhead sea turtle	*Caretta caretta*	ST, FE
Hawksbill sea turtle	*Eretmochelys imbricate*	SE, FE
leatherback sea turtle	*Dermochelys coriacea*	SE, FE
Kemp's ridley sea turtle	*Lepidochelys kempii*	SE, FE
green sea turtle	Chelonia mydas	ST, FE
Marine Mammals		
finback whale	*Balaenoptera physalus*	SE, FE
sperm whale	*Physeter macrocephalus*	SE, FE
humpback whale	*Megaptera novaeangliae*	SE
North Atlantic right whale	*Eubalaena glacialis*	SE, FE
sei whale	*Balaenoptera borealis*	SE, FE
Status: ST – State Threatened, SE – State Endangered, SSC – State Special Concern, FT – Federally Threatened, FE – Federally Endangered. Sources: USACE 2014 and 2016, Kagueux, Wikgren, & Kenney 2010		

Temporary disruption of fish, marine mammal and reptile habitat is anticipated in the area of the reef site during reef construction. Because the species are mobile they will be able to avoid the construction area for the duration of construction and utilize adjacent reef areas that have already been constructed. Upon construction the new reef area would provide habitat for fish and crustaceans, providing new foraging areas and a greater abundance of prey for bird, fish, reptile, and mammal species. The Project would therefore benefit protected and vulnerable species and enhance the ecological community in compliance with this policy.

WRP Policy 4.8: Maintain and protect living aquatic resources.

The proposed Project would provide habitat for native aquatic species and thereby would enhance the aquatic resources and increase biodiversity in the area, in compliance with this policy. Enhancing aquatic resources would promote recreational fishing and diving. Species harvesting would be allowed in accordance with federal, local and state regulations that outline catch and size limitations, in order to ensure that the reef is utilized in sustainable ways. No species stocking or aquaculture is proposed as part of the Project.

WRP Policy 5. Protect and improve water quality in the New York City Coastal area.

WRP Policy 5.3: Protect water quality when excavating or placing fill in navigable waters and in or near marshes, estuaries, tidal marshes, and wetlands.

Construction of the reef would involve the placement of clean fill material consisting of natural stone, concrete, or steel in navigable waters. Fill material would be towed to the predetermined location by vessel, which would then be placed in discrete drop locations. Submerging the clean reef material would result in temporary resuspension of the sandy sediments found in the reef area. The sediments are expected to settle onto the bottom shortly after the reef material is placed. In an effort to protect the existing reef and surrounding resources, placement would occur during fair weather to avoid excessive turbidity increases. Following a temporary decrease in water quality associated with the placement of reef material, the water quality in the area of the reef would improve as a result of filter feeding organisms migrating into the area and attaching to the new available substrate. The development or expansion of the community of filter feeders which could include species such as barnacles and mussels would have long-term benefits to the water quality in the region; therefore, the proposed Project is consistent with this policy.

WFP Policy 8. Provide public access to, from, and along New York City's coastal waters.

WRP Policy 8.5: Preserve the public interest in and use of lands and waters held in public trust by the State and City.

The proposed Project would preserve the public interest in and use of waters held in public trust by the City by creating an enhanced habitat for aquatic species and providing additional public recreation opportunities through recreational fishing and diving; therefore, the proposed Project is consistent with this policy.

<u>Conclusion</u>.

Based on the review of the New York City Waterfront Revitalization Program Consistency Assessment Form, and further discussion of specific policies above, the proposed addition to the Rockaway Reef is consistent with the WRP policies.

Literature Cited

Kagueux, K., Wikgren, B., & Kenney, R. (2010). *Technical Report for the Spatial Characterization of Marine Turtles, Mammals, and Large Pelagc Fish to Support Coastal and Marine Spatial Planning in New York.* Albany, NY: State of New York's Ocean Planning and Coastal Management Program.

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Long Island Sound Coastal Consistency Assessment

For Matinecock, Smithtown, Huntington/Oyster Bay, Port Jefferson/Mount Sinai, and Mattituck Reefs

Located in Glen Cove, Nassau County, and Smithtown, Huntington, Port Jefferson, and Southold, Suffolk County, New York

Long Island Sound Coastal Policies

Developed Coast Policies

- *Policy #1 – "Foster a pattern of development in the Long Island Sound coastal area that enhances community character, preserves open space, makes efficient use of infrastructure, makes beneficial use of a coastal location, and minimizes adverse effects of development."*

  The proposed Project would provide additional hard-bottom habitat for marine flora and fauna, making beneficial use of a coastal location. Further, the Project would provide a beneficial water-dependent use of Long Island Sound's coastal resources. Therefore, the Project is consistent with this policy.

- *Policy #2 – "Preserve historic resources of the Long Island Sound coastal area."*

  The proposed Project does not involve disturbances to known historic resources and any resources would be protected to the greatest extent practicable. Geophysical surveys were conducted in the reef areas during siting to avoid potential cultural resources. Therefore, the Project is consistent with this policy.

- *Policy #3 – "Enhance visual quality and protect scenic resources throughout Long Island Sound."*

  The proposed Project involves the placement of hard structures underwater and would not affect scenic resources. Therefore, this policy is not applicable.

Natural Coast Policies

- Policy #4 – "*Minimize loss of life, structures, and natural resources from flooding and erosion.*"

  The proposed Project involves the construction of submerged reefs within open water areas along the coast of Long Island and does not include the construction of buildings or structures in upland areas subject to flooding and erosion. Therefore, this policy is not applicable.

- Policy #5 – "*Protect and improve water quality and supply in the Long Island Sound coastal area.*"

  Construction of the reefs would involve placement of fill material onto the bottom sediments within Long Island Sound. This activity would result in the short-term, temporary resuspension of sediment during construction. The sediments are anticipated to settle out of the water column quickly following construction activities. The placement of the materials would be completed in a manner that would place materials on the sediments in discrete locations, avoiding the existing reef. Placement would be completed in fair weather conditions to ensure minimal disruption of benthos and to minimize resuspension of sediments. Following a temporary decrease in water quality associated with the placement of reef material, the water quality in the area of the reef would improve as a result of filter feeding organisms migrating into the area and attaching to the new available substrate. The development or expansion of the community of filter feeders which could include species such as barnacles and mussels would have long-term benefits to the water quality in the region. Therefore, the Project is consistent with this policy.

- Policy #6 – "*Protect and restore the quality and function of the Long Island Sound ecosystem*."

  The proposed Project would add hard bottom habitat, increase habitat diversity and improve the quality and function of the Long Island Sound ecosystem for marine flora and fauna. Therefore, the Project is consistent with this policy.

- Policy #7 – "*Protect and improve air quality in the Long Island Sound coastal area*."

  The proposed Project involves transporting reef material by barge to the proposed reef location. The use of barges and heavy equipment during the construction phase of the Project would be limited to the greatest extent practicable to protect air quality; therefore, the proposed Project is consistent with this policy.

- Policy #8 – "*Minimize environmental degradation in the Long Island Sound coastal area from solid waste and hazardous substances and wastes*."

  The proposed Project does not involve the discharge of solid waste and hazardous substances and waste. Only clean materials would be used for artificial reef development. Therefore, the Project is consistent with this policy.

Public Coast Policies

- Policy #9 – "*Provide for public access to, and recreational use of, coastal waters, public lands, and public resources of the Long Island Sound coastal area*."

  The proposed Project would enhance habitat for epibenthic, benthic and fish species. The development of artificial reefs enhances recreational use by providing additional opportunities for recreational fishing and diving. As such, the Project is in compliance with this policy.

Working Coast Policies

- Policy #10 – "*Protect Long Island Sound's water-dependent uses and promote siting of new water-dependent uses in suitable locations*."

The proposed Project has a water-dependent use and would enhance habitat for epibenthic, benthic and fish species. The reef is located near harbors and promote water-dependent use of these coastal facilities by fishermen and divers. These habitat improvements would enhance fishery resources and provide recreational fishing and diving opportunities for anglers and divers. Therefore, the Project is consistent with this policy.

- Policy #11 – "*Promote sustainable use of living marine resources in Long Island Sound*."

  The proposed Project would enhance habitat for epibenthic, benthic, and fish species. Further, this would meet the NYSDEC's Artificial Reef Program goals of enhancing or restoring fishery resources, and promoting sustainable use of living marine resources. Therefore, the Project is consistent with this policy.

- Policy #12 – "*Protect agricultural lands in the eastern Suffolk County portion of Long Island Sound's coastal area*."

  The proposed Project does not involve agricultural lands in the eastern Suffolk County of Long Island Sound's coastal area; therefore, this policy is not applicable.

- Policy #13 – "*Promote appropriate use and development of energy and mineral resources*."

  The proposed Project does not involve the use and development of energy and mineral resources; therefore, this policy is not applicable.

New York State Department of State Coastal Consistency Assessment

NEW YORK STATE DEPARTMENT OF STATE
COASTAL MANAGEMENT PROGRAM

Federal Consistency Assessment Form

An applicant, seeking a permit, license, waiver, certification or similar type of approval from a federal agency which is subject to the New York State Coastal Management Program (CMP), shall complete this assessment form for any proposed activity that will occur within and/or directly affect the State's Coastal Area. This form is intended to assist an applicant in certifying that the proposed activity is consistent with New York State's CMP as required by U.S. Department of Commerce regulations (15 CFR 930.57). It should be completed at the time when the federal application is prepared. The Department of State will use the completed form and accompanying information in its review of the applicant's certification of consistency.

A. **APPLICANT** (please print)

1. Name: James J. Gilmore
2. Address: 205 North Belle Mead Road, East Setauket, New York 11733
3. Telephone: Area Code (631) 444-0430

B. **PROPOSED ACTIVITY:**

1. Brief description of activity:

The Project includes assessment of previously permitted sites, the expansion of 7 existing sites, and the addition and creation of four new artificial reef sites. Artificial reefs are developed using the patch reef system. Patch reef

2. Purpose of activity:

The purpose of the activity is to provide fishing and diving opportunities at the artificial reef sites, as well as enhance or restore fishery resources and

3. Location of activity:

Nassau, Suffolk, Qu	See attached map.	Waters of Long Island S
County	City, Town, or Village	Street or Site Description

4. Type of federal permit/license required: USACE and coordination with NOAA/NMFS, USC

5. Federal application number, if known: ______

6. If a state permit/license was issued or is required for the proposed activity, identify the state agency and provide the application or permit number, if known:

See Attachment I - Environmental Assessment of the Joint Permit Application for

C. **COASTAL ASSESSMENT** Check either "YES" or "NO" for each of these questions. The numbers following each question refer to the policies described in the CMP document (see footnote on page 2) which may be affected by the proposed activity.

1. Will the proposed activity result in any of the following:	YES	NO
a. Large physical change to a site within the coastal area which will require the preparation of an environmental impact statement? (11, 22, 25, 32, 37, 38, 41, 43)	✔	
b. Physical alteration of more than two acres of land along the shoreline, land under water or coastal waters? (2, 11, 12, 20, 28, 35, 44)	✔	
c. Revitalization/redevelopment of a deteriorated or underutilized waterfront site? (1)		✔
d. Reduction of existing or potential public access to or along coastal waters? (19, 20)		✔
e. Adverse effect upon the commercial or recreational use of coastal fish resources? (9,10)		✔
f. Siting of a facility essential to the exploration, development and production of energy resources in coastal waters or on the Outer Continental Shelf? (29)		✔
g. Siting of a facility essential to the generation or transmission of energy? (27)		✔
h. Mining, excavation, or dredging activities, or the placement of dredged or fill material in coastal waters? (15, 35)		✔
i. Discharge of toxics, hazardous substances or other pollutants into coastal waters? (8, 15, 35)		✔
j. Draining of stormwater runoff or sewer overflows into coastal waters? (33)		✔
k. Transport, storage, treatment, or disposal of solid wastes or hazardous materials? (36, 39)		✔
l. Adverse effect upon land or water uses within the State's small harbors? (4)		✔

2. Will the proposed activity affect or be located in, on, or adjacent to any of the following:	YES	NO
a. State designated freshwater or tidal wetland? (44)		✔
b. Federally designated flood and/or state designated erosion hazard area? (11, 12, 17)		✔
c. State designated significant fish and/or wildlife habitat? (7)	✔	
d. State designated significant scenic resource or area? (24)		✔
e. State designated important agricultural lands? (26)		✔
f. Beach, dune or Barrier Island? (12)		✔
g. Major ports of Albany, Buffalo, Ogdensburg, Oswego or New York? (3)	✔	
h. State, county, or local park? (19, 20)		✔
i. Historic resource listed on the National or State Register of Historic Places? (23)		✔

3. Will the proposed activity require any of the following:	YES	NO
a. Waterfront site? (2, 21, 22)		✔
b. Provision of new public services or infrastructure in undeveloped or sparsely populated sections of the coastal area? (5)		✔
c. Construction or reconstruction of a flood or erosion control structure? (13, 14, 16)		✔
d. State water quality permit or certification? (30, 38, 40)	✔	
e. State air quality permit or certification? (41, 43)		✔

	YES	NO
4. Will the proposed activity occur within and/or affect an area covered by a State-approved local waterfront revitalization program, or State-approved regional coastal management program? (see policies in program document*)	✔	

D. **ADDITIONAL STEPS**

1. If all of the questions in Section C are answered "NO", then the applicant or agency shall complete Section E and submit the documentation required by Section F.

2. If any of the questions in Section C are answered "YES", then the applicant or agent is advised to consult the CMP, or where appropriate, the local waterfront revitalization program document*. The proposed activity must be analyzed in more detail with respect to the applicable state or local coastal policies. On a separate page(s), the applicant or agent shall: (a) identify, by their policy numbers, which coastal policies are affected by the activity, (b) briefly assess the effects of the activity upon the policy; and, (c) state how the activity is consistent with each policy. Following the completion of this written assessment, the applicant or agency shall complete Section E and submit the documentation required by Section F.

E. **CERTIFICATION**

The applicant or agent must certify that the proposed activity is consistent with the State's CMP or the approved local waterfront revitalization program, as appropriate. If this certification cannot be made, the proposed activity shall not be undertaken. If this certification can be made, complete this Section.

"The proposed activity complies with New York State's approved Coastal Management Program, or with the applicable approved local waterfront revitalization program, and will be conducted in a manner consistent with such program."

Applicant/Agent's Name: James J. Gilmore

Address: 205 North Belle Meade Road, East Setauket, New York 11733

Telephone: Area Code (631) 444-0430

Applicant/Agent's Signature: ______________________________ Date: ______________

F. **SUBMISSION REQUIREMENTS**

1. The applicant or agent shall submit the following documents to the **New York State Department of State, Office of Planning and Development, Attn: Consistency Review Unit, One Commerce Plaza-Suite 1010, 99 Washington Avenue, Albany, New York 12231.**

   a. Copy of original signed form.
   b. Copy of the completed federal agency application.
   c. Other available information which would support the certification of consistency.

2. The applicant or agent shall also submit a copy of this completed form along with his/her application to the federal agency.

3. If there are any questions regarding the submission of this form, contact the Department of State at (518) 474-6000.

*These state and local documents are available for inspection at the offices of many federal agencies, Department of environmental Conservation and Department of State regional offices, and the appropriate regional and county planning agencies. Local program documents are also available for inspection at the offices of the appropriate local government.

Coastal Assessment

1. **The proposed activity will result in:**
   a. **Large physical change to a site within the coastal area which will require the preparation of an environmental impact statement**

- *Policy #11 – "Buildings and other structures will be sited in the coastal area so as to minimize damage to property and the endangering of human lives caused by flooding and erosion"*

  The proposed Project involves the construction of submerged reefs within open water areas along the coast of New York and does not include the construction of buildings or structures in upland areas; therefore, the proposed Project is consistent with this policy.

- *Policy #22 – "Development when located adjacent to the shore will provide for water-related recreation whenever such use is compatible with reasonably anticipated demand for such activities, and is compatible with the primary purpose of the development"*

  The proposed Project would enhance habitat for epibenthic and benthic marine life. The development of artificial reefs enhances recreational use by providing additional opportunities for recreational fishing and diving. As such, the reef would provide water-related recreation, in compliance with this policy.

- *Policy #25 – "Protect, restore or enhance natural and man-made resources which are not identified as being of statewide significance, but which contribute to the overall scenic quality of the coastal area."*

  The proposed Project involves the placement of hard structures underwater and would not affect scenic resources. Therefore, this policy is not applicable.

- *Policy #32 – "Encourage the use of alternative or innovative sanitary waste systems in small communities where the costs of conventional facilities are unreasonably high, given the size of the existing tax base of these communities"*

  The proposed Project does not involve the use of sanitary waste systems; therefore, this policy is not applicable.

- *Policy #37 – "Best management practices will be utilized to minimize the non-point discharge of excess nutrients, organics and eroded soils into coastal waters"*

  Construction of the reef would involve the placement of clean fill material consisting of natural stone, concrete, or steel in navigable waters. No stormwater or other run-off containing nutrients, organics or eroded soils from uplands is proposed into coastal waters; therefore, this policy is not applicable.

- *Policy #38 – "The quality and quantity of surface water and groundwater supplies, will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply"*

  The proposed Project does not involve the use of surface water or groundwater supplies; therefore, this policy is not applicable.

- *Policy #41 – "Land use or development in the coastal area will not cause national or State air quality standards to be violated"*

  The proposed Project involves transporting reef material by barge to the proposed reef location. The use of barges and heavy equipment during the construction phase of the Project would be completed in compliance with the Clean Air Act and the State air quality requirements; therefore, the proposed Project is consistent with this policy.

- *Policy #43 – "Land use or development in the coastal area must not cause the generation of significant amounts of acid rain precursors: nitrates and sulfates"*

  The proposed Project does not involve the generation or emission of significant amounts of nitrates and sulfates; therefore, this policy is not applicable.

b. Physical alteration of more than two acres of land along the shoreline, land under water or coastal waters

- *Policy #2 – "Facilitate the siting of water dependent uses and facilities on or adjacent to coastal waters"*

  The proposed Project has a water dependent use and is located within coastal waters; therefore, the proposed Project is consistent with this policy.

- *Policy #11 – "Buildings and other structures will be sited in the coastal area so as to minimize damage to property and the endangering of human lives caused by flooding and erosion"*

  See a. above.

- *Policy #12 – "Activities or development in the coastal area will be undertaken so as to minimize damage to natural resources and property from flooding and erosion by protecting natural protective features including beaches, dunes, barrier islands and bluffs"*

The proposed Project involves the construction of submerged reefs within open water areas. Therefore, this policy is not applicable.

- *Policy #20 – "Access to the publicly-owned foreshore and to lands immediately adjacent to the foreshore or the water's edge that are publicly-owned shall be provided and it shall be provided in a manner compatible with adjoining uses"*

  The proposed Project does not involve the use of publicly-owned foreshore or lands at the water's edge; therefore, this policy is not applicable.

- *Policy #28 – "Ice management practices shall not interfere with the production of hydroelectric power, damage significant fish and wildlife and their habitats, or increase shoreline erosion or flooding"*

  The proposed Project does not involve ice management; therefore, this policy is not applicable.

- *Policy #35 – "Dredging and filling in coastal waters and disposal of dredged material will be undertaken in a manner that meets existing State dredging permit requirements, and protects significant fish and wildlife habitats, scenic resources, natural protective features, important agricultural lands, and wetlands"*

  In compliance with this policy, the placement of fill material consisting of natural rock, steel, or concrete to construct the reefs would be completed in accordance with all applicable federal and state regulations and permit conditions.

- *Policy #44 – "Preserve and protect tidal and freshwater wetlands and preserve the benefits derived from these areas"*

  The proposed Project does not involve activities within tidal and freshwater wetlands; therefore, this policy is not applicable.

h. Mining, excavation, or dredging activities, or the placement of dredged or fill material in coastal waters

- *Policy #15 – "Mining, excavation or dredging in coastal waters shall not significantly interfere with the natural coastal processes which supply beach materials to land adjacent to such waters and shall be undertaken in a manner which will not cause an increase in erosion of such land"*

  The proposed Project does not involve mining, excavation and dredging; therefore, this policy is not applicable.

- *Policy #35 – "Dredging and filling in coastal waters and disposal of dredged material will be undertaken in a manner that meets existing State dredging permit requirements, and protects significant fish and wildlife habitats, scenic resources, natural protective features, important agricultural lands, and wetlands"*

  While the Project involves placement of fill in coastal waters, the Project is within marine habitats and will create new habitat. Therefore, the Project is consistent with this policy.

2. The proposed activity will affect or be located in, on, or adjacent to:

c. State designated significant fish and/or wildlife habitat

- *Policy #7 – "Significant coastal fish and wildlife habitats will be protected, preserved, and where practical, restored so as to maintain their viability as habitats"*

  The Kismet and Yellowbar reef sites located within the Great South Bay of Long Island are within significant coastal fish and wildlife habitat (SCFWH). The name of this SCFWH area is Great South Bay-West. The Great South Bay-West SCFWH includes a habitat impairment test that must be applied to any activity that is subject to consistency review under federal and State laws, or under applicable local laws contained in an approved local waterfront revitalization program. Any actions that would destroy the habitat or significantly impair the viability of the habitat shall not be undertaken.

  Portions of these reefs have already been developed in order to enhance the existing habitat for aquatic species. Placement would have localized temporary impacts to turbidity. Habitat will not be destroyed; there would be no significant impairments to vital resources; and the tolerance range of any organism would not be significantly altered. Therefore, the proposed Project is in compliance with this policy.

g. Major ports of Albany, Buffalo, Ogdensburg, Oswego, or New York

- *Policy #3 – "Further develop the State's major ports of Albany, Buffalo, New York, Ogdensburg, and Oswego as centers of commerce and industry, and encourage the siting, in these port areas, including those under the jurisdiction of State public authorities, of land use and development which is essential to, or in support of, the waterborne transportation of cargo and people"*

  Reef sites are located in Long Island Sound and Atlantic Ocean where there is active shipping from the Port of New York. Sites are located within the port district but outside of active shipping lanes and permitted "navigational depth clearances" to protect against deployed reef material interference with large vessels; therefore, the proposed Project is in compliance with this policy.

Attachment B

Site Specific Surveys

Final Report to NY DEC 17 May 2017

Project Title: Assess the most cost effective, repeatable, and appropriate biological assessment methods and sampling procedures to monitor Fishes, Crustaceans, and Epibenthic Organisms on Artificial Reefs on the Atlantic Beach and Hempstead Reefs.

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Summary

Monitoring biological life (fish, crustaceans, invertebrates) on artificial reefs requires several complementary methods in order to accurately assess all three types of organisms. A mix of remote and diver-based sampling techniques provides the most cost-effective approach for obtaining the required data. Species identification of pelagic and benthic organisms requires visual identification which for fish can be obtained via diver-conducted fish counts and baited video units. Benthic invertebrates and crustacean species identification requires diver-conducted surveys. These methods require several hours of boat time at each site which is sampled and are limited by water visibility and available light. Acoustic surveys using scientific echosounders and sidescan sonar can provide detailed information on the total abundance of pelagic and benthic fish (but not species identification) as well as the spatial (vertical and horizontal) extent of the reefs. Acoustic data are collected from a moving vessel which allows for sampling of multiple reefs over a larger spatial area. A combination of these methods can be done from a single vessel reducing ship-time costs. However, all of these sampling methods require additional data processing time on shore. The biological assessments of the artificial reefs are summarized below.

Key Findings

What factors determine success of artificial reefs ?

Material (rock, concrete, vessel), age (1 year to at least 26 years as several reef deployment dates are unknown), and size (volume of material deployed) of the reefs have an effect on the biological composition. However, these effects vary between fish and the benthic crustaceans and invertebrates. They are also VERY dependent on the in situ size and shape of the reef which in many cases can not be predicted by material type and total volume of material used because of variations in the deployment of the material by contractors. Measurements of the actual reefs that are produced on the bottom are critical in understanding their role in the ecosystem.

Do artificial reefs increase fish biomass and is there any halo effect ?

Fish aggregations were 8 times more likely to be observed acoustically when surveying on a reef than off reef. On-reef aggregations were 4 times as large (in terms of fish biomass) than off-reef aggregations. Any “halo” effect from the reefs was small (i.e. < 5 m horizontally), that is, fish aggregations were closely associated with the vertical relief of the reef from the bottom. Diver and BRUV surveys were conducted “on reef” with no “off reef” comparison.

How do artificial reefs vary with age ?

Younger reefs (those less than 5 years old) had higher total abundances of fish measured acoustically, although these differences were small (factor of 2 or less). Diver surveys found more blackfish and black sea bass on reefs less than 2 years old, but cunner abundance was higher on older reefs than on newer ones. The younger reefs tended to be smaller (in size), had surfaces dominated by barnacles with obvious foraging marks from fish, and were in early successional stages. The benthic community on reefs appears to develop over a period of 10-15 years with an initial community of barnacles, blue mussels, macroalgae, and bryozoans transitioning to a community (at the 10 year mark) composed of these species and coral, tunicates, and sponges. After this, the coral, tunicates, sponge, and barnacles become the largest component of the composition of benthic coverage on rock substrate.

How do artificial reefs vary by material type ?

Acoustically-measured fish aggregations were significantly higher at reef sites composed of concrete than rock or vessel sites. One caveat of this result is that the acoustic measurements will likely underestimate fish abundances at vessel sites due to the large internal spaces in these structures containing fish which are not sampled (due to reflections from the structure itself) by the echosounder. Diver sampling found higher abundances of black sea bass and blackfish on concrete and vessel sites, however cunner were significantly higher at rock sites. The location of cunner close to the bottom may reduce their detectability by acoustic surveys.

How do artificial reefs vary with size ?

Acoustically-measured fish aggregations were highest at medium-sized rock reefs (3000-5000 m^3), followed by large-sized rock reefs (> 5000 m^3). Diver sampling found highest abundances of cunner, black sea bass, and blackfish at medium-sized reefs (2000-4000 m^3). Based on the volume of the rocks that were deployed, the diver data suggests that reefs smaller than 2000 m^3 had less available habitat for fish than larger reefs. While reef volume is an important factor, the more critical factors (based on our observations) are vertical relief and rugosity (i.e. interstitial space). Crustaceans (lobsters and rock crabs) were present only at reefs with medium to high rugosity, and thus were not found at concrete reef sites due to the structures present.

Other findings

1. Reef site location (Atlantic Beach, Hempstead) did not alter any of the patterns listed above. On reef fish aggregations were larger and more frequent at Hempstead than at Atlantic Beach. Environmental conditions (CTD, Secchi disk depth) were similar at both sites.

2. Diver-based sampling found the highest diversity of fish and invertebrates in August, which was true for both August 2014 (21 species) and August 2015 (22 species) compared to June 2015 (16 species) and July 2015 (17 species). Summer-time sampling provided the best conditions in terms of sea state, weather, and light availability; although this period also had the most recreational fishing activity on the reefs (see Table 2).

3. Passive acoustic recordings made during June 2015 at a vessel site at Atlantic Beach found that odontocetes (i.e. bottlenose dolphins) were feeding at the reef nightly. These species were not observed via any other sampling method.

4. Diver and remote video sampling observed 8 of the same species (Table 4). Divers saw an additional 5 species (not observed on video). Remote video sampling observed 9 additional species (not seen by divers). It should be noted that there were significant differences in sampling time between diver surveys (6 hrs total) and remote video sampling (~ 80 hrs).

5. All sampling methods (except for passive acoustics) used in this project occurred during daylight hours. Remote video and acoustic echosounder sampling could also be used at night to examine diurnal variability in fish activity.

Recommendations

1. Rock reefs that are 10+ years in the water have the greatest diversity in benthic cover community. These reefs also had the highest diversity of invertebrate and crustacean infauna. Fish aggregated to new reefs very rapidly (within a year). Benthic cover and invertebrate infauna did not noticeably differ between reef ages 1-3 years. Monitoring of reefs should commence immediately upon their construction, and be repeated every 2-3 years to monitor community development.

2. Reefs that are greater than 2000-3000 m^3 were functionally similar to those greater in size as long as the vertical relief and rugosity were moderate to high. Our recommendation is to have material dominated by pieces equal to or larger than a basketball.

3. Reef type had significant effect on specific fish species abundances, due to vertical relief and interstitial space. For all types of material (rock, vessel, concrete), fish abundances increased with vertical profile and rugosity. Blackfish abundance was most affected by vertical profile. It is the shape and structure of the reef in situ that drives increases in fish abundance, not necessarily the type or volume of material deployed. For future reef deployments, materials and the size of material used should be chosen to maximize the rugosity and interstitial space available to organisms. Equally important is to measure what in situ reef structure exists post-deployment. For example, deployments of equal amounts of material can produce very different reef habitat depending on the movement of the barge during the deployment period (i.e. the material is spread out over a larger area vs being piled up on the bottom).

4. Sampling costs for this project were roughly 40% ship time, 40% personnel time, and 20% equipment and supplies. Based on our experience, a smaller vessel can be used to do the acoustic, remote video, and diver sampling which would reduce ship costs by more than 50%. We recommend that longer sampling intervals and a selection of a smaller number of representative reef sites to monitor will reduce monitoring costs .

Introduction

The State of New York has had a program of marine artificial reef construction since 1962 utilizing available suitable material to build reefs for fishery enhancement. The goals and objectives of the New York State Department of Environmental Conservation's (NYSDEC's) Marine Artificial Reef Program are to: provide fishing and diving opportunities for reef associated fishery resources by selective placement of artificial habitat; enhance or restore fishery resources and associated habitat, to the maximum extent practicable, utilizing artificial habitat and administer and manage artificial habitat to ensure its prudent use as part of an overall fishery management program.

In order to accomplish these goals, NYSDEC needs to conduct evaluations of the effectiveness of reefs in achieving goals, establish a fishery survey/monitoring program to monitor fish and crustacean populations associated with reefs, and ensure compliance with federal state permits, rules and regulations and management strategies for reef associated stocks. In order to assess the Program goal of enhancing or restoring fishery resources and associated habitat utilizing artificial reefs, the Department is looking to conduct this sampling effort to assess reef resources and make recommendations on the most effective, repeatable and meaningful methods to assess biological resources on the reef community.

Methods

In order to evaluate how reefs of different material-type, age, and size attract marine life a suite of complementary methods was employed to provide multiple types of data. Our sampling comprised several methods including Baited Remote Underwater Video (BRUV) cameras, environmental sampling, sidescan surveys to locate and characterize bottom structure, diver surveys, acoustic echosounder surveys to measure pelagic and near-bottom fish abundance, and passive acoustics for long-term monitoring of unique species such as marine mammals.

Survey Effort

The surveys conducted in August 2014 and monthly from April to September 2015 provided data useful for quantifying biological productivity of artificial reefs. A total of twenty-three stations (i.e., sites) were sampled during each monthly cruise (Table 1). Information on all the reef sites (including those not sampled) can be found in Appendix A (Table A1, A2; Figures A1,A2). Diver surveys were only conducted in summer months (Jun, Jul, Aug). Acoustic surveys using sidescan sonar and fisheries echosounders were conducted at both Hempstead and Atlantic Beach Reefs each month.

Table 1. Overview of sampling effort by month. Due to a malfunction with the CTD, vertical depth profile data was unavailable for the Aug 2015 sampling.

Survey Date	Sites Visited	Diver Survey	BRUVs Deployed	Env. Sampling	Acoustic Data
August 2014	H1, H2, H4, A2, A3, A4, A6	Y	Y	Y	Y
April 2015	H1, H2, A4, A6	N	Y	Y	Y
May 2015	H1, H2, H4, A2, A3, A14	N	Y	Y	Y
June 2015	H1, H2, H5, H6, A2, A7	Y	Y	Y	Y
July 2015	H8, H9, H10, A4, A8, A9	Y	Y	Y	Y
August 2015	H11, H12, H13, A6, A11, A12	Y	Y	N*	Y
September 2015	H14, A13, A14	N	Y	Y	Y

Environmental Sampling

At each site where net tows and BRUV deployments were conducted, additional sampling to characterize the marine environment was completed. Hydrographic profiles (temperature, salinity, density, and fluorescence) of the water column are obtained with a Seabird 19+ CTD.

Vertical net tows using a ½ m ring net with 150 μm mesh are used to characterize the zooplankton in the water column. Specimens were preserved in formalin, and later identified in the lab using microscopes. Secchi disk casts were also done to measure water clarity.

The number of commercial and recreational fishing boats seen within 0.5 miles during surveys of Atlantic Beach and Hempstead sites were counted by eye during the acoustic surveys for every monthly trip. We did not record the location of these boats, just a total count over the course of the survey.

Sidescan Surveys

Sidescan data were collected during all acoustic transects to assist us in locating the reef sites and describe bottom features. Data were processed to visually identify reef sites and estimate their spatial extent on the seafloor.

Acoustic Echosounder Surveys

A towfish equipped with scientific echosounders at 38, 120, 200, and 710 Hz was deployed during each survey to measure the abundance and distribution of pelagic and near-bottom fish schools (and in some cases, individual fish) associated with reef sites. The nautical area scattering coefficient (NASC, m^2 nmi^{-2}) represents vertically integrated acoustic backscatter per unit area that is proportional to fish biomass (Figures 1-3). Acoustic backscatter data were binned into 5 m horizontal by 2 m vertical sections. Furthermore, only data within 6 m of the bottom were included for the reef analyses. Since a large proportion of analysis bins consisted of empty water a minimum threshold of 0.75 NASC was set, which is approximately equivalent to the acoustic backscatter of one fish. Between on- and off-reef samples, 92.4% and 99.2% were respectively below this NASC threshold.

Statistical Analysis of Acoustic Data

Statistical significances in mean NASC among reefs of different materials, volumes, ages, and location (i.e., Hempstead and Atlantic Beach Reefs) were tested using a Kruskal-Wallis one-way analysis of variance (KW-test, $\alpha = 0.05$). The KW-test is used to test whether or not mean NASC among groups are derived from the same underlying distribution and are therefore equal to one another (i.e., null hypothesis testing). This test was chosen instead of a traditional ANOVA since NASC data were not normally distributed. A two-sample Kolmogorov-Smirnov test (KS-test, $\alpha = 0.05$) was used to compare the distribution of NASC values from reefs with different characteristics. In addition to the KW-test, a Mann-Whitney-Wilcoxon test (MWW-test) was used to verify which pairwise differences were statistically significant. The MWW-test is a rank test that is commonly used for non-normally distributed data and is analogous to how a two-sample *t*-test operates with normally distributed data. The KS-test compares different cumulative density functions (CDFs) by calculating the largest difference between the two distributions. All mean NASC values were reported with their respective coefficient of variation (CV) which is a measure of how dispersed the data are relative to the sample mean; this is calculated via dividing the standard deviation by the sample mean.

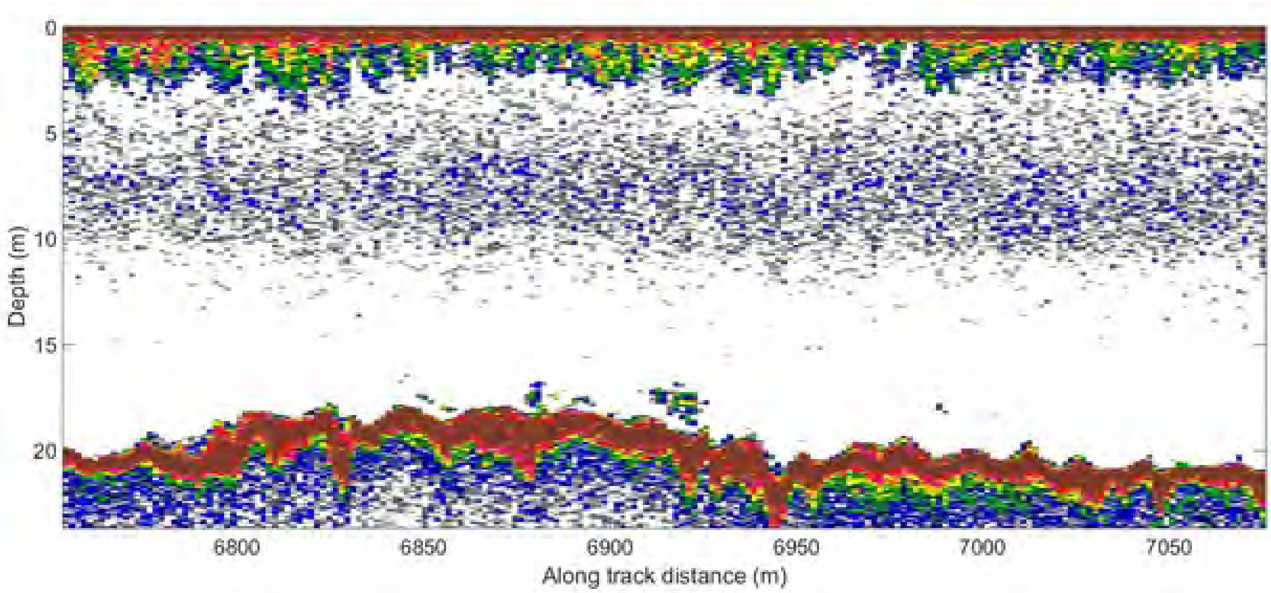


Figure 1. Sample echogram at 120 kHz illustrating a small fish aggregation on a reef which represents a NASC value on the order of 100 m^2nmi^{-2}.

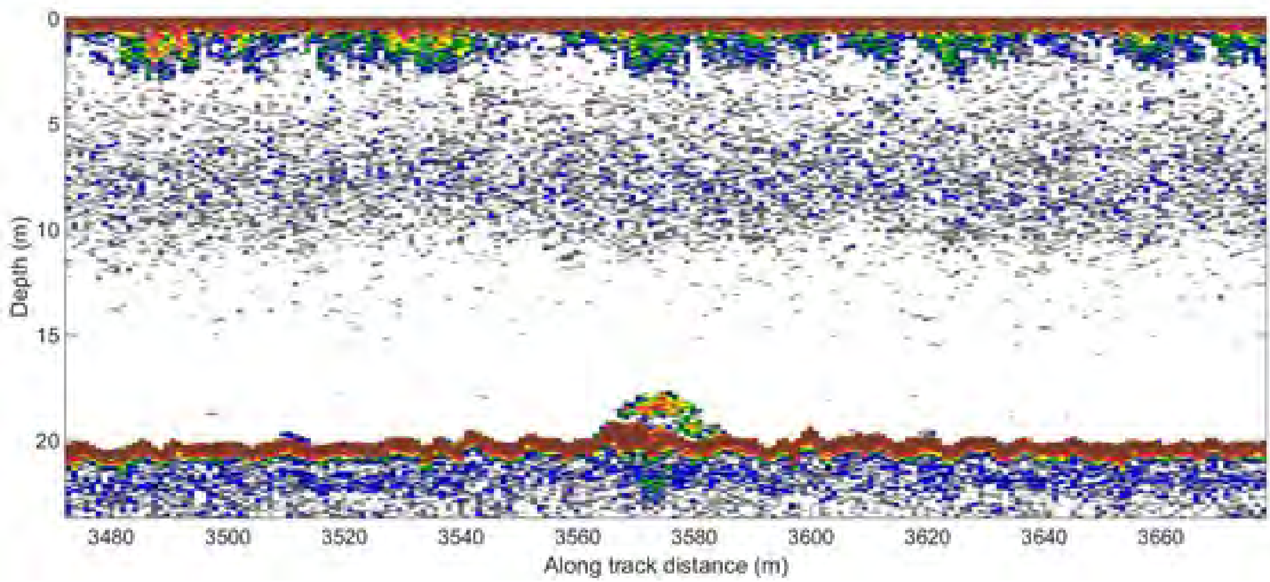


Figure 2. Sample echogram at 120 kHz showing a small near-bottom aggregation of fish that represent a NASC of approximately 1000 m^2nmi^{-2}.

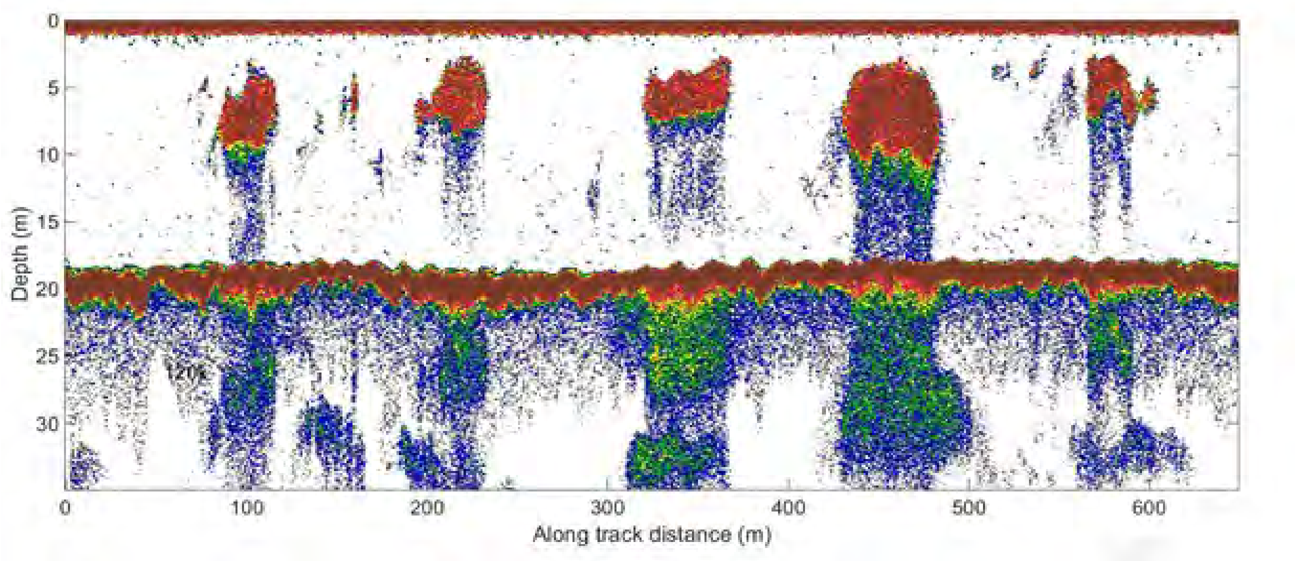


Figure 3. Sample echogram 120 kHz showing menhaden schools in July 2015 at the Atlantic Beach reef. Each large aggregation has a NASC on the order of >100,000 $m^2 nmi^{-2}$.

Passive Acoustic Monitoring

A passive acoustic monitor (PAM) was placed at A2, a large barge reef located at the Atlantic Beach reef site. The PAM recorded 2 minutes for every 20 minutes of the soundscape (10% duty cycle). While programmed to record for several months, technical difficulties resulted in just over a week's worth of data.

Diver Fish Surveys and Video Transects

Two common visual census techniques were used to quantify treatment effects (reef size, age of reef, or material type) on fish and crustacean density and composition: point counts and video belt transects. A point count consists of standing in a specific location and counting fish. One counts the number of individual fish (of each species) within a circle of a certain radius. Observation radius was a function of water clarity which was always less than 5 m and rarely less than 2 m. Video belt transect consisted of a diver swimming along a transect tape, recording down-looking video with a field of view approximately 1 m in width. This allowed us to quantify benthic coveragage of macroalgae and benthic invertebrates. Additional video was taken on the return swim, the camera was set at an 45-degree downward angle to monitor the bottom and the near-bottom zone for diversity and relative abundance of fish.

SCUBA-equipped observers conducted visual counts of piscivore- and reef-associated fish composition and density at each artificial reef using a slightly modified version of the stationary point method of Bohnsack & Bannerot (1986). One diver at each end of a 25 m transect counted all of the fish that entered a visual cylinder of the water column 5 m in diameter for 5 minutes. On rare occasions the density of cunner reduced the fish count times to 2 minutes. When densities increase such that the counts are above 100 fish per minute it becomes difficult to track whether fish are being recounted so in these cases the time was reduced to ensure data integrity.

All data presented are calculated as fish density per (minute m^2). In addition to the diver fish surveys, Video Belt Transect surveys were conducted in conjunction with the fish point counts to provide a comparative estimate of the densities and compositions of fishes and to quantify invertebrates and fouling communities on the artificial reefs. In addition, at the end of each transect 1 m^2 of the rock matrix was excavated by hand to record invertebrate species present. We compare community structure (i.e., species identity and abundance) of the fish, crustaceans and fouling communities between all the sampling locations.

Benthic Cover Analysis

The benthic coverage data included in the diver surveys was analyzed using two software programs, Coral Point Count (CPC) and Image J. Images were extracted from the diver videos. Each image was imported into CPC and the scaling calibration was performed using the transect tape as a point of reference for distance. Total image area was obtained from this process. Before processing every image, images were assigned species codes for all organisms present in the image (Table 2)

Table 2. List of species code and what organism each represents in benthic cover analysis.

SPECIES CODE	Species identification
BARN	Barnacle
BLUE	Blue mussel (*Mytilus edulis*)
BRYO	Bryozoan
CCR	Crustose coralline remnant
CERA	Ceramic
CORAL	Coral
CREP	*Crepidula fornicata*
DARK	Too dark to see image or transect tape in the way
GAP	Interstitial space
MACR1	Macroalge
MACROBARN	Macroalgae and barnacle area, too difficult to tease them apart
SED	Sediment surface
SILT	Layer of silt above substrate
SKATE	Skate eggs
SPNG	Sponge
TUNI	Tunicate
WREC	Artificial wreck
UNK5	too difficult to ID from images

Once this list was created, each area in the image was outlined and given a specific species code. Coral point count automatically creates a table which lists each area outlined followed by the species code given. Areas which were too was dark to determine what was present and areas where the transect covered the bottom were labeled DARK. After exporting all data from the CPC analysis, this DARK area was removed from the total image area to obtain an accurate total image area based on the area of the image that was visible. This value would then be used for percent cover estimation. ImageJ was used in specific cases in which the only organism present was for example coral and there were too many areas which had coral present to outline in CPC (the limit for outlined areas is 250). In order to standardize the image area, pixel/cm was obtained from CPC and the same pixel/cm number was imported into ImageJ to ensure that the total image area was identical. Using ImageJ, a black/white analysis was performed and the area of the coral from the image was extracted, without having to outline all coral colonies. Once all images were analyzed, data was exported to an excel file where it was manipulated to a form easy to use with R. All figures and analysis was done using R code.

Rugosity and Interstitial Space Analysis

After reviewing the video of transects at each site, it appeared that the size of the rock drop was not necessarily related to what we were observing underwater in terms of structure. In order to assess whether the qualities of the reef had an effect on fish and invertebrate diversity and abundance, we set out to quantify the relative amount of rugosity of each site. Rugosity is a unitless measure of the variation in the change of height of a surface over a horizontal distance. The interstitial space available was quantified using the video transects where images were taken and the void spaces were measured. This was done for rock and sunken vessel reefs. Videos of the different sites were compared several times to one another to obtain a relative rugosity between sites as well as a relative amount of interstial space amount. Sites were assigned categories for relative rugosity and interstitial space amount as "low", "moderate", and "high" (Figure 4). The relative rugosity of a site typically corresponded with the amount of interstitial space amount, however this was not always the case, especially if the size of the rock differed substantially between sites. These relative values were used in further analyses looking to see if they were related to the abundance and diversity of different species.

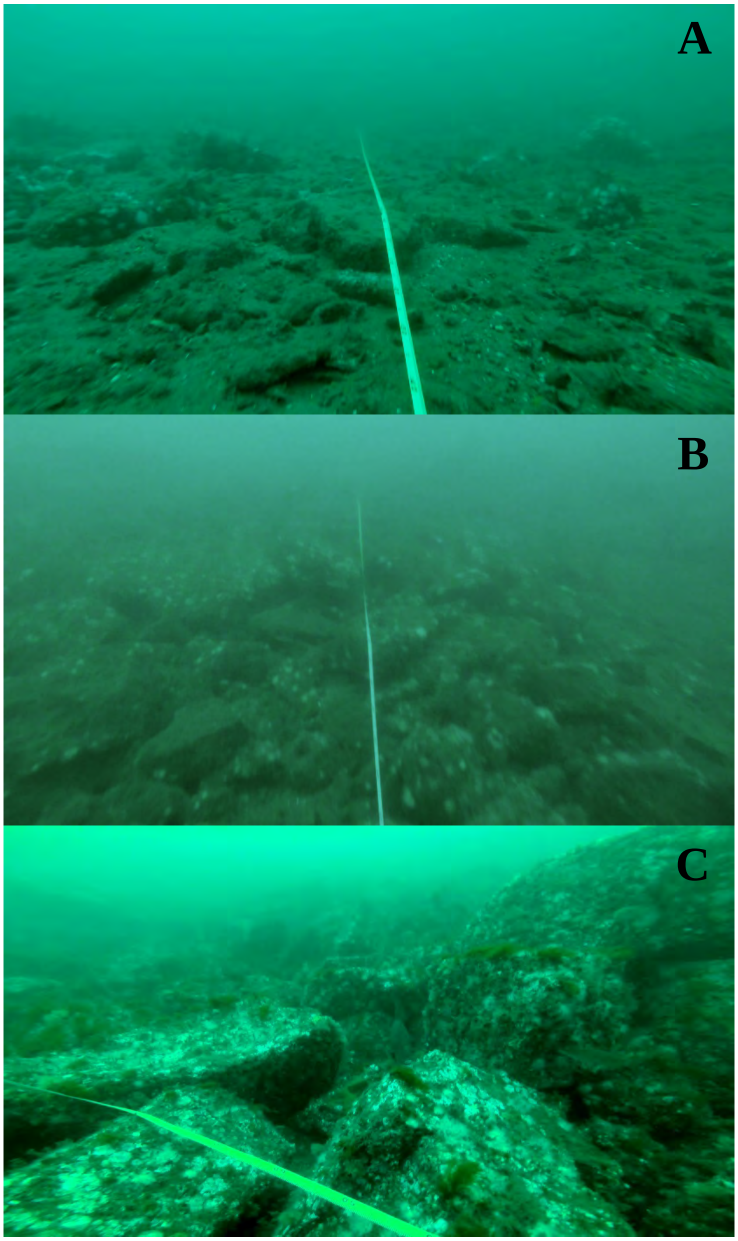


Figure 4. Rugosity categories: (A) Low, (B) Moderate, (C) High.

Baited Remote Underwater Video

Carnivorous fish were surveyed using baited remote underwater video (BRUV). Data from studies using BRUVs have previously been found to compare well with those obtained from underwater visual census techniques and from baited hook and lines methods for sampling relatively common species in both tropical and temperate reef ecosystems. At each reef site sampled by divers, 5 BRUVs were deployed on or adjacent to the reef. BRUVs were baited with 1 kg of frozen bunker and deployed for at least 90 minutes of recording time. BRUV footage was viewed and fish species time-logged. The BRUV data produced a list of species occurrence. We also examined the effect of reef material, size, and age on the number of BRUV observations of different categories of fish. Taxonomic categories used in the BRUV analysis were: skates (winter, little, clearnose); sharks (smooth dogfish, spiny dogfish, dusky shark); teleosts (Atlantic cod, red hake, black sea bass, cunner, scup, tautog, northern sea robin, striped sea robin, striped bass, bluefish, conger eel, summer flounder, winter flounder); cunner; black sea bass; and tautog.

Results

Survey Effort

Typical cruise tracks are shown for both the sidescan and acoustic echosounder surveys at both the Atlantic Beach and Hempstead sites (Figures 5,6). Cruise tracks were generally identical from survey to survey with the exception of when deviations needed to occur to avoid other vessels or sample specific locations.

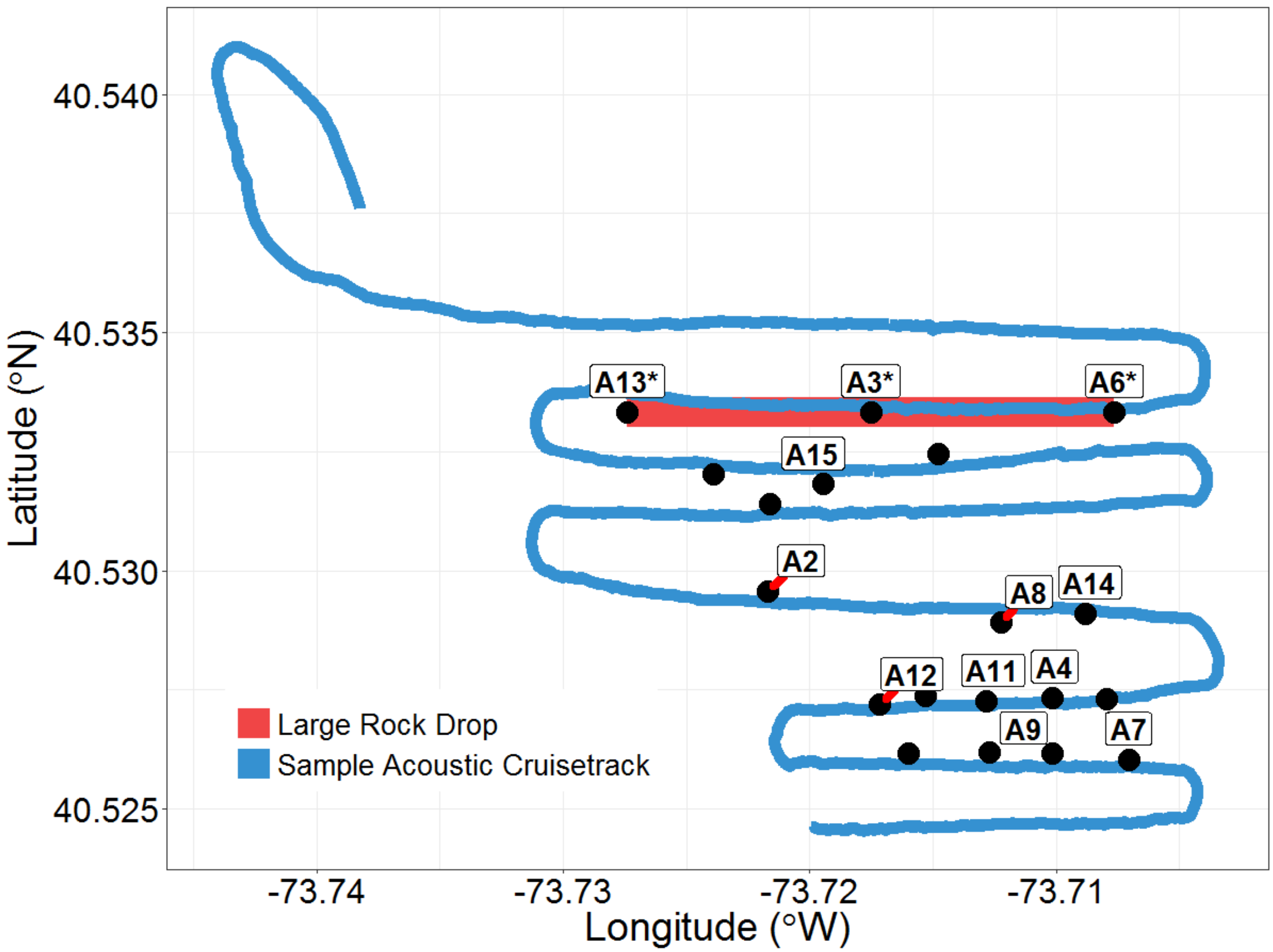


Figure 5. Overview plot of sampling effort at the Atlantic Beach Reef. Black point represent reef stations. Labeled points indicate stations where environmental, diver, and/or BRUV surveys were conducted. The solid red horizontal line indicates the large Atlantic Beach rock pile. The blue line represents a sample acoustic survey track. The ‘*’ denotes reef stations that were part of the large Atlantic Beach rock pile as opposed to standalone sites.

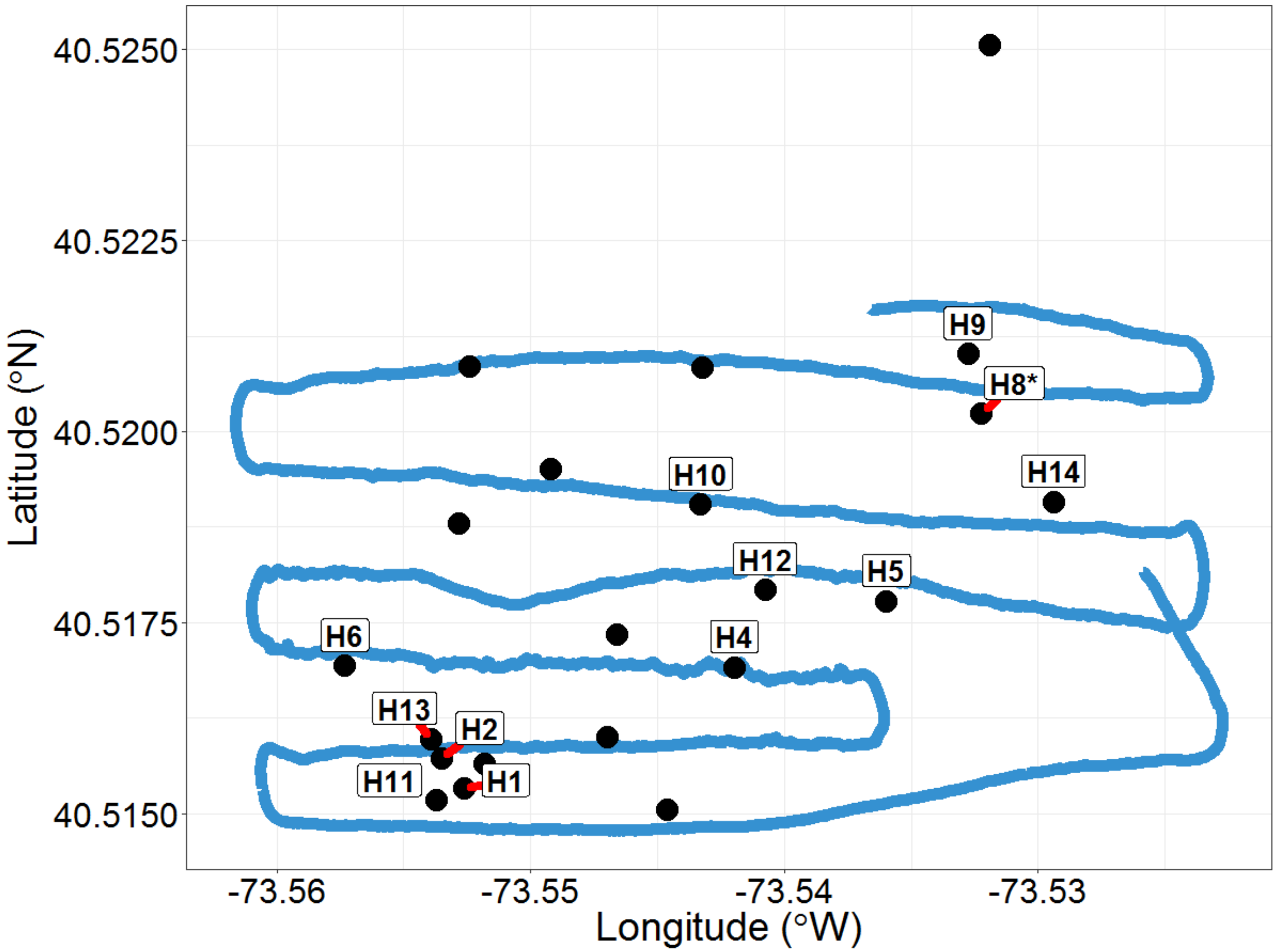


Figure 6. Overview plot of sampling effort at the Hempstead Reef. Black point represent reef stations. Labeled points indicate stations where environmental, diver, and/or BRUV surveys were conducted. The blue line represents a sample acoustic survey track. Station H8 (marked with an asterisk) was at the location of the Armored Personnel Carrier group in the station information from the DEC. However, when we dove on the site, we found no vehicles/vessels and instead think the site location that we observed acoustically is part of the rubble or debris field from the H9 drop which is located just north of H8.

Environmental Sampling

Hydrographic profiles (temperature, salinity, density, and fluorescence) of the water column are obtained with a Seabird 19+ CTD (Figure 7). When examining the CTD data, there were notable trends in the vertical temperature, density, and salinity profiles with time. Temperature gradually increased from April to September while both salinity and density decrease over the same time period. The fluorescence vertical profile did not yield any linear trend with time; however, there were significant peaks in both April and September which may line up with both spring and fall blooms of phytoplankton.

Analysis of net tows collected during each respective cruise were dominated (in terms of biovolume) by copepods, notably adult *Paracalanus parvus*, *Calanus finmarchicus*, and general cladocerans. Gelatinous zooplankton (i.e., salps, ctenophores, and cnidarians) were noticeably absent from tows between May and July 2015. Secchi disk casts showed turbid water nearly every trip with the exception of May 2015 (Figure 8).

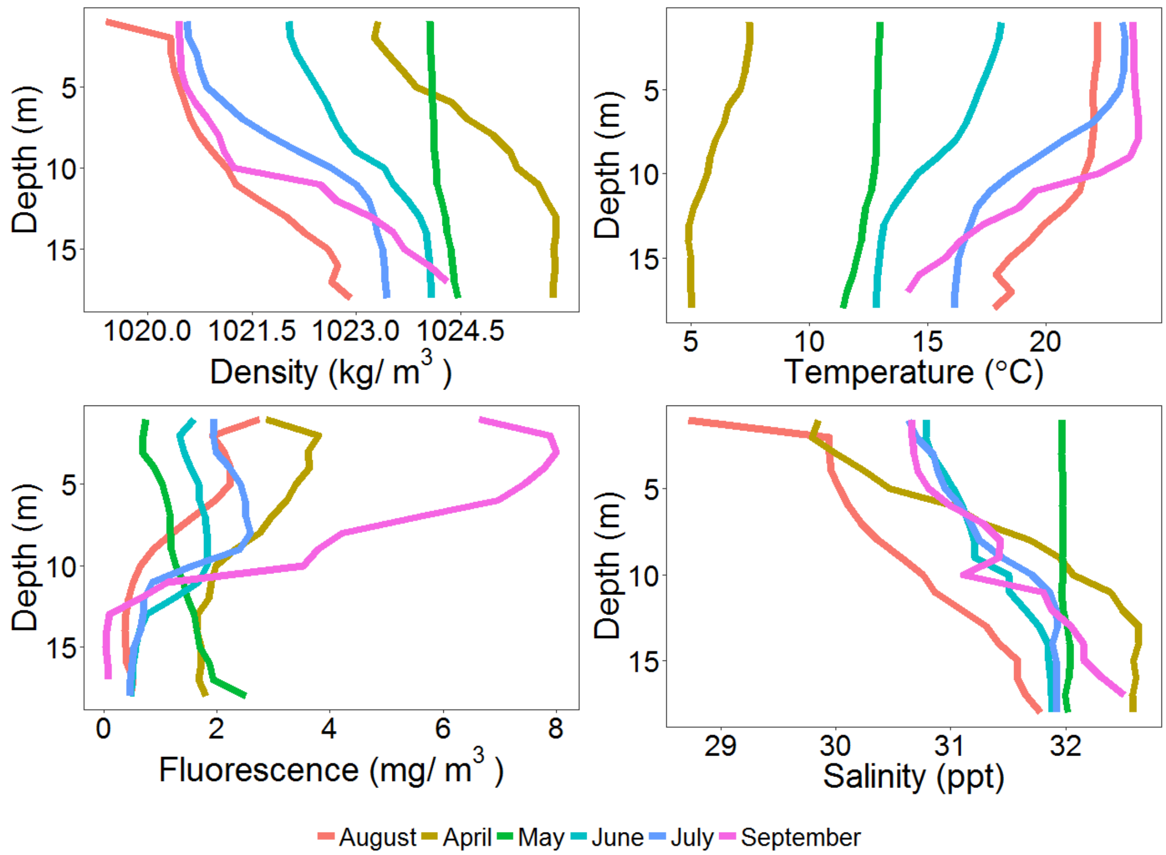


Figure 7. CTD vertical depth profiles showing density (top-left), temperature (top-right), fluorescence (bottom-left), and salinity (bottom-right). The August depth profile represents the August 2014 CTD; August 2015 CTD depth profiles were not available due to a malfunction.

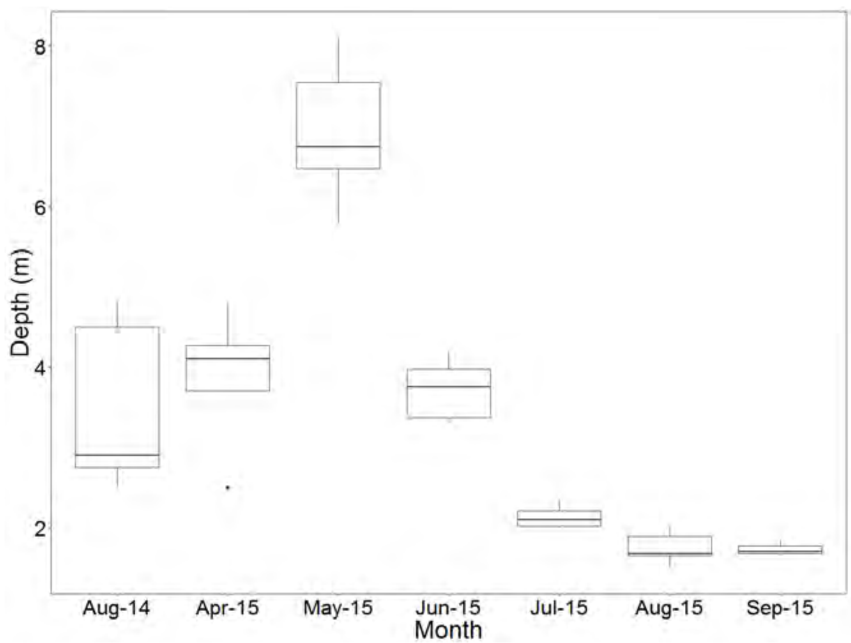


Figure 8. Secchi disk cast depths (m) for each survey month.

Recreational Reef Usage

The number of commercial and recreational fishing boats seen within 0.5 miles during surveys of Atlantic Beach and Hempstead sites were counted by eye during the acoustic surveys for every monthly trip (Table 3). There was an expected seasonal trend with fishing usage of reefs peaking during the summer months and waning during the early spring and into fall. There were also significantly more recreational fishing boats observed at the Atlantic Beach Reef; there was no substantial difference in the number of party boats observed at both reefs.

Table 3. Description of fishing usage at the Atlantic Beach and Hempstead Reefs. Letter codes next to each sampling date indicate the day of week (i.e., Monday – M, Tuesday – Tu, Wednesday – W, Thursday – Th, Friday – F, and Saturday – S).

	Atlantic Beach			Hempstead		
Date	**Time (EST)**	**Party**	**Recreational**	**Time (EST)**	**Party**	**Recreational**
08/15/2014 (F)	No Survey	-	-	07:04-16:11	0	0
08/16/2014 (S)	08:21-12:58	2	47	13:57-15:05	0	0
08/18/2014 (M)	09:59-12:27	0	7	No Survey	-	-
04/16/2015 (Th)	12:45-17:14	0	0	07:12-11:59	0	0
04/17/2015 (F)	07:16-09:47	0	0	No Survey	-	-
05/19/2015 (Tu)	07:21-11:17	0	0	12:25-15:46	0	5
05/20/2015 (W)	12:20-14:10	0	0	07:10-11:14	0	3
06/12/2015 (F)	07:22-13:20	0	7	14:37-17:43	0	0
06/16/2015 (Tu)	15:14-17:23	0	0	07:02-14:36	1	2
07/13/2015 (M)	07:04-12:03	0	19	12:56-17:50	0	2
07/14/2015 (Tu)	07:12-11:03	0	4	11:49-17:18	0	0
08/12/2015 (W)	07:12-11:47	0	25	12:25-16:43	2	3
08/13/2015 (Th)	07:24-11:00	0	13	11:44-16:45	0	0
09/10/2015 (Th)	07:15-12:02	0	1	13:14-16:46	0	0

Sidescan Surveys

Sidescan data were collected to assist us in locating the reef sites and describe bottom features. Although some reefs were not observed at their reported longitude/latitude coordinates, sidescan imagery provided more accurate estimates of location (Figure 9). Likewise, large debris fields not necessarily associated with reported reef deployments were observed (Figure 10). Other important information such as reef classification, height, and vertical relief can be approximated from sidescan images (Figures 11-13). All available sidescan images can be found in Appendix B.

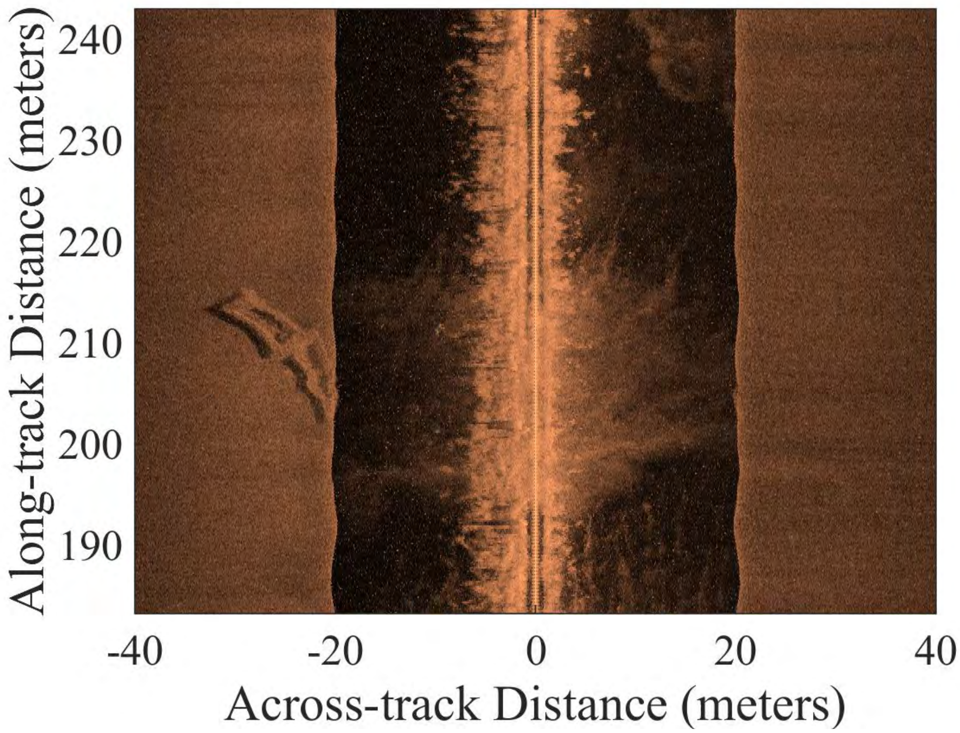


Figure 9. Sidescan image from Hempstead (H4, two linked steel barges) on 16 August 2014. The blackened region between -20 and 20 meters represents the nadir zone which is the unsampled water column directly underneath the sidescan transducer. The edges of this zone at -20 and 20 m of this zone represent the seabed. Black shading around the edge of the reef represents its respective vertical profile.

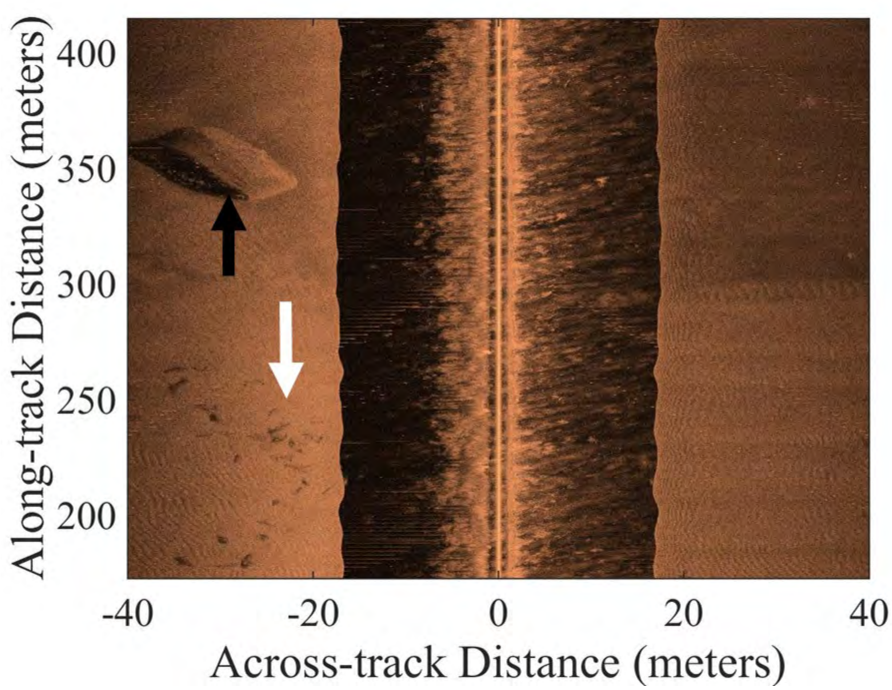


Figure 10. Sidescan image from Atlantic Beach (H5, 80 ft. barge) in August 2015. The black arrow indicates the barge and the white arrow indicates commonly observed debris fields which surrounded many of these reefs.

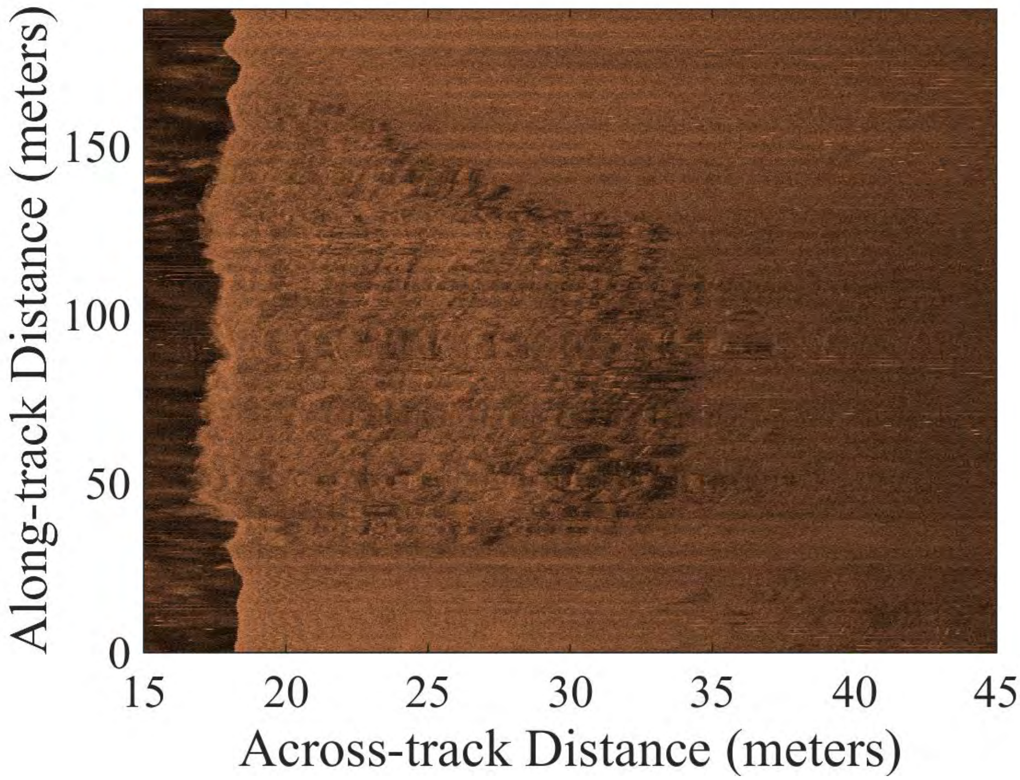


Figure 11. A zoomed-in sidescan image showing a 2014 rock deployment from 2014 at Hempstead (H2) from August 2015.

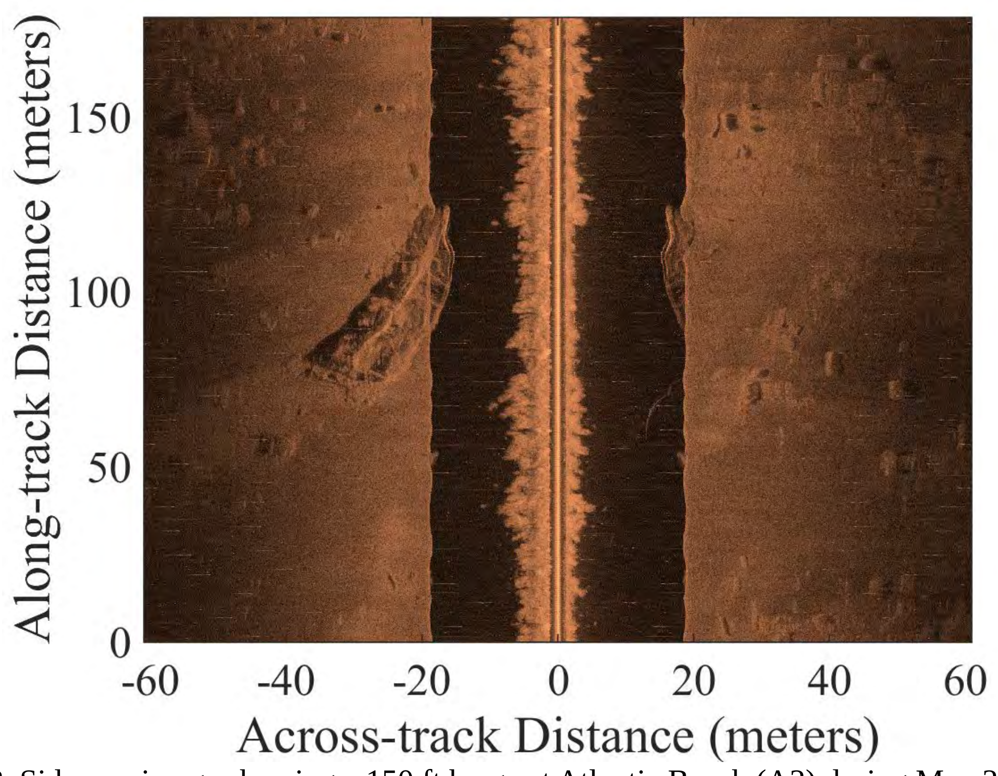


Figure 12. Sidescan image showing a 150 ft barge at Atlantic Beach (A2) during May 2015.

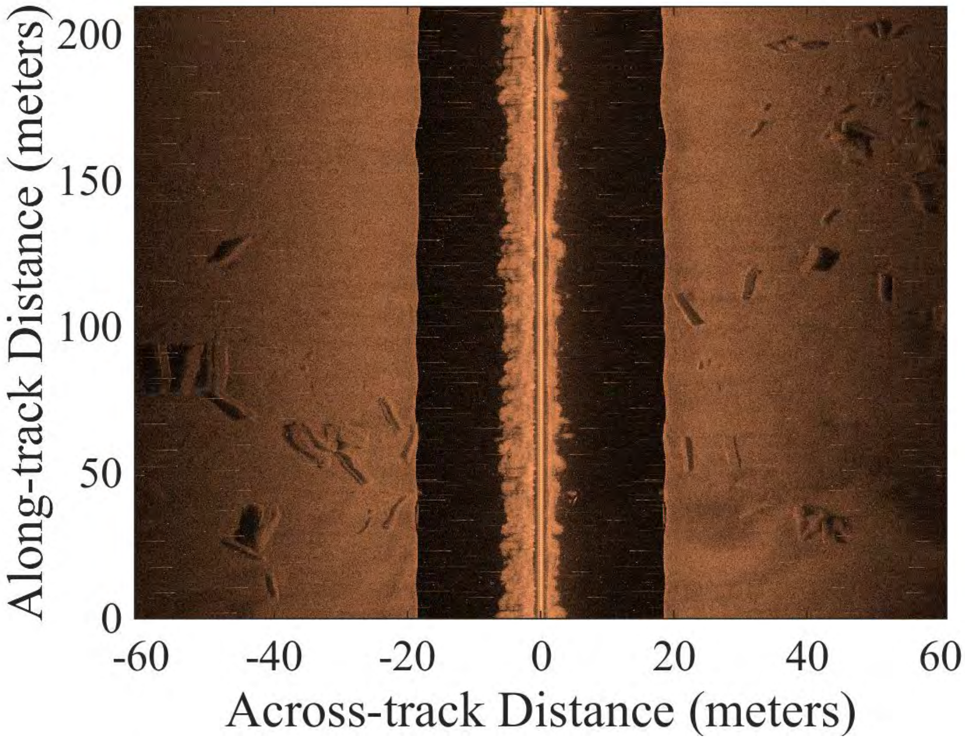


Figure 13. Sidescan image show concrete bridge slabs from Hempstead (H9) during May 2015. Visual observations during diver surveys indicated that other debris such as rock and metal were also present at H9. Both long-and-narrow and broad-and-flat rectangles are likely concrete slabs in different orientations relative to the seabed.

Species observed from Diver and BRUV sampling

There were differences in the species observed by divers and BRUVs, likely due to biases in the sampling methods (such as diver avoidance, observation duration). Divers and BRUVs both observed eight species of fish in common, divers observed an additional five species of fish not seen on BRUVs, and BRUVs saw nine species of fish not observed by the divers (Table 4). BRUV total survey time (80 hrs) was more than an order of magnitude more than the diver surveys (6 hrs).

BRUVs were not used to sample benthic infauna or invertebrates so diver surveys are the only source of observations of those organisms.

Table 4. A comparison of the species observed by the BRUVs versus divers.

Species	**Diver Surveys**	**BRUVs**
Cunner (*Tautogolabrus adspersus*)	X	X
Blackfish (*Tautoga onitis)*	X	X
Black Sea Bass (*Centropristis striata*)	X	X
Cod (*Gadus spp.*)	X	X
Northern Sea Robin (*Prionotus carolinus*)	X	
Goby (*Gobiosoma spp.*)	X	

Clearnose Skate (*Raja eglanteria*)	X	X
Gray Triggerfish (*Balistes capriscus*)	X	
Summer Flounder (*Paraclichthys dentatus*)	X	X
Butterfly Fish (*Chaetedon spp.*)	X	
Conger Eel (*Conger oceanicus*)	X	X
Striped Bass (*Morone saxatilis*)	X	X
Rock Gunnel (*Pholis gunnellus*)	X	
Winter (*Leucoraja ocellata*) or Little Skate (*Leucoraja erinacea*)		X
Scup (*Stenotomus chrysops)*		X
Smooth Dogfish (*Mustelus canis*)		X
Spiny Dogfish (*Squalus acanthias*)		X
Striped Sea Robin (*Prionotus evolans*)		X
Red Hake (*Urophycis chuss*)		X
Winter Flounder (*Pleuronectes americanus*)		X
Bluefish (*Pomatomus saltatrix*)		X
Dusky Shark (*Carcharhinus obscurus*)		X
American Lobster (*Homarus americanus*)	X	
Rock Crab (*Cancer irroratus)*	X	
Spider Crab (*Libinia* spp.)	X	
Common Sea Star (*Asterias rubens*)	X	
Blue Mussels (*Mytlius edulis*)	X	
Barnacles (Balanidae *spp.*)	X	
Northern Star Coral (*Astrangia poculata*)	X	
Sea Anemones (Actiniardia spp.)	X	
Purple-spined Sea Urchins (*Arbacia punctulata*)	X	
Orange tunicate spp.	X	
Yellow sponge spp.	X	
Branching Brown Macroalgae spp.	X	
Branching Red Macroalgae spp.	X	
Hydroid/Bryozoan spp.	X	
Skate/Dogfish Egg Case	X	
Brittle Star (*Ophiopholis spp.*)	X	
Waved Whelk (*Buccinum undatum*)	X	
Scale Worm (Polynoide spp.)	X	

For diver surveys, fish densities for each of the artificial reef sites visited in 2014 and 2015 varied greatly between sites (Figure 14). The most numerous fish species in the vast major of sites was cunner (Figure 15). Graphs of the total fish density reflected that of cunner density so the three most numerous species (cunner, black sea bass and blackfish) are presented individually. The presence of different diver observed species are reported for each summer month (i.e., June, July, and August) (Table 5). BRUV observations (reported as fraction of cameras that recorded the presence of the species) showed site to site variability as well for all taxonomic groups (Figures 16, 17).

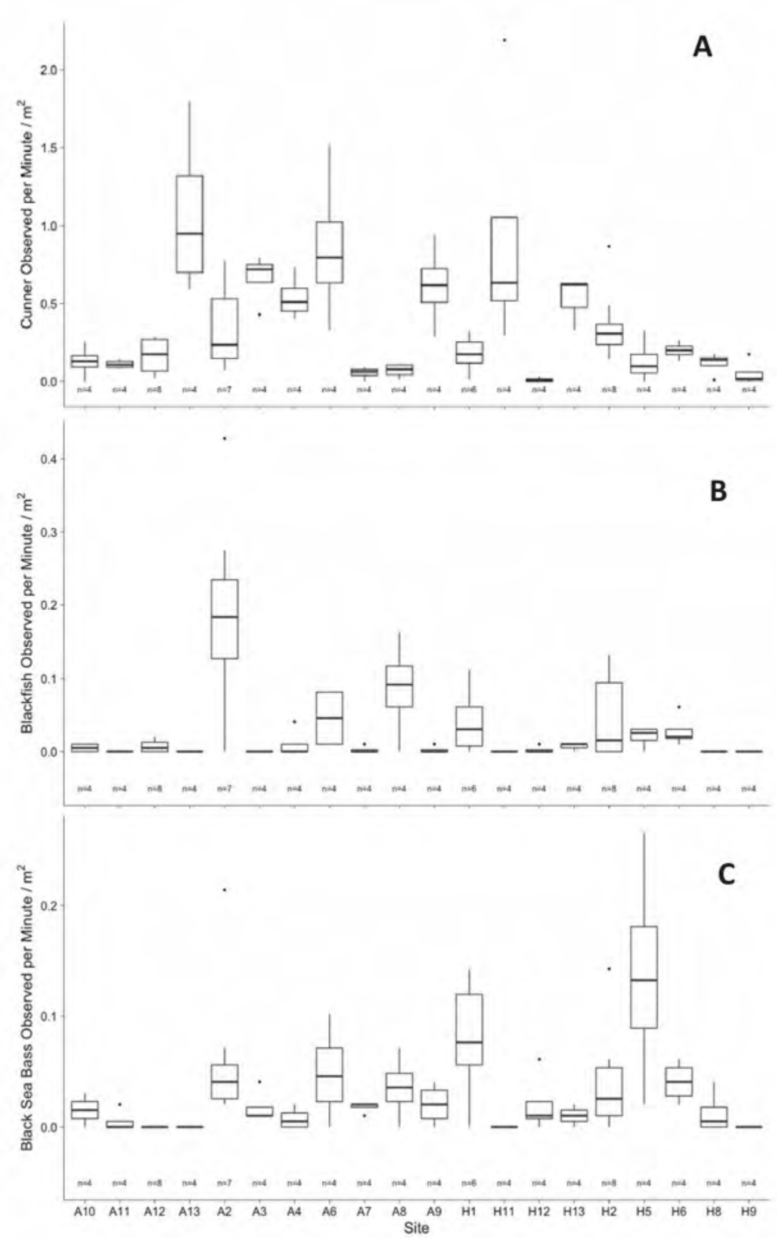


Figure 14. Fish density at each of the artificial reefs combining 2014 and 2015 count data.

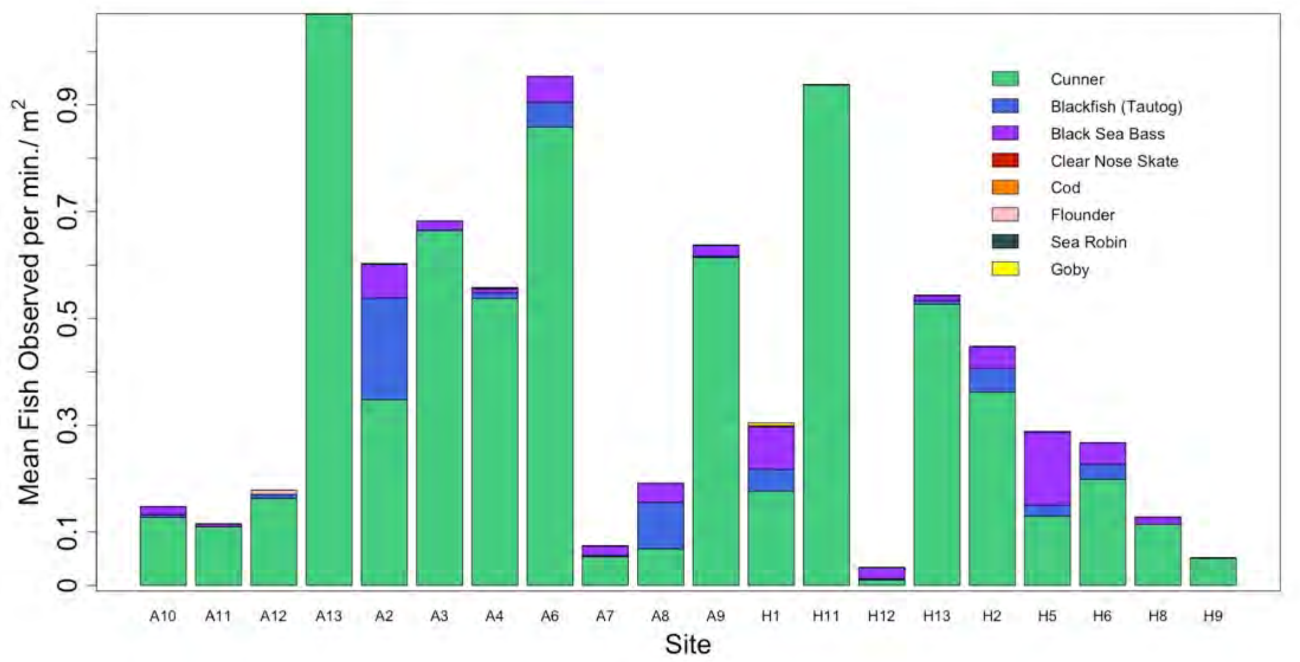


Figure 15. Fish density at each of the artificial reef sites broken down by species.

Table 5. Diver observed species list by summer sampling month.

Species	2015 June	2015 July	2014 & 2015 August	2014 August	2015 August
Cunner (*Tautogolabrus adspersus*)	X	X	X	X	X
Blackfish (*Tautoga onitis)*	X	X	X	X	X
Black Sea Bass (*Centropristis striata*)	X	X	X	X	X
Cod (*Gadus spp.*)	X				
Northern Sea Robin (*Prionotus carolinus*)			X	X	
Goby (*Gobiosoma spp.*)	X		X	X	
Clearnose Skate (*Raja eglanteria*)	X	X			
Gray Triggerfish (*Balistes capriscus*)			X	X	
Summer Flounder (*Paraclichthys dentatus*)			X	X	X
Butterfly Fish (*Chaetedon spp.*)			X	X	
Conger Eel (*Conger oceanicus*)			X	X	X
Striped Bass (*Morone saxatilis*)			X	X	
Rock Gunnel (*Pholis gunnellus*)		X			
American Lobster (*Homarus americanus*)		X	X	X	X
Rock Crab (*Cancer irroratus*)	X	X	X	X	X
Spider Crab (*Libinia* spp.)	X				
Common Sea Star (*Asterias rubens*)		X	X	X	X
Blue Mussels (*Mytlius edulis*)	X	X	X	X	X
Barnacles (Balanidae *spp.*)	X	X	X	X	X

Northern Star Coral (*Astrangia poculata*)	X	X	X	X	X
Sea Anemones (Actiniardia spp.)		X	X	X	
Purple-spined Sea Urchins (*Arbacia punctulata*)			X	X	X
Orange tunicate spp.	X	X	X	X	X
Yellow sponge spp.	X	X	X	X	X
Branching Brown Macroalgae spp.	X	X	X	X	X
Branching Red Macroalgae spp.			X	X	X
Hydroid/Bryozoan spp.	X		X		X
Skate/Dogfish Egg Case	X		X		X
Brittle Star (*Ophiopholis spp.*)		X	X		X
Waved Whelk (*Buccinum undatum*)			X		X
Scale Worm (Polynoide spp.)		X	X		X

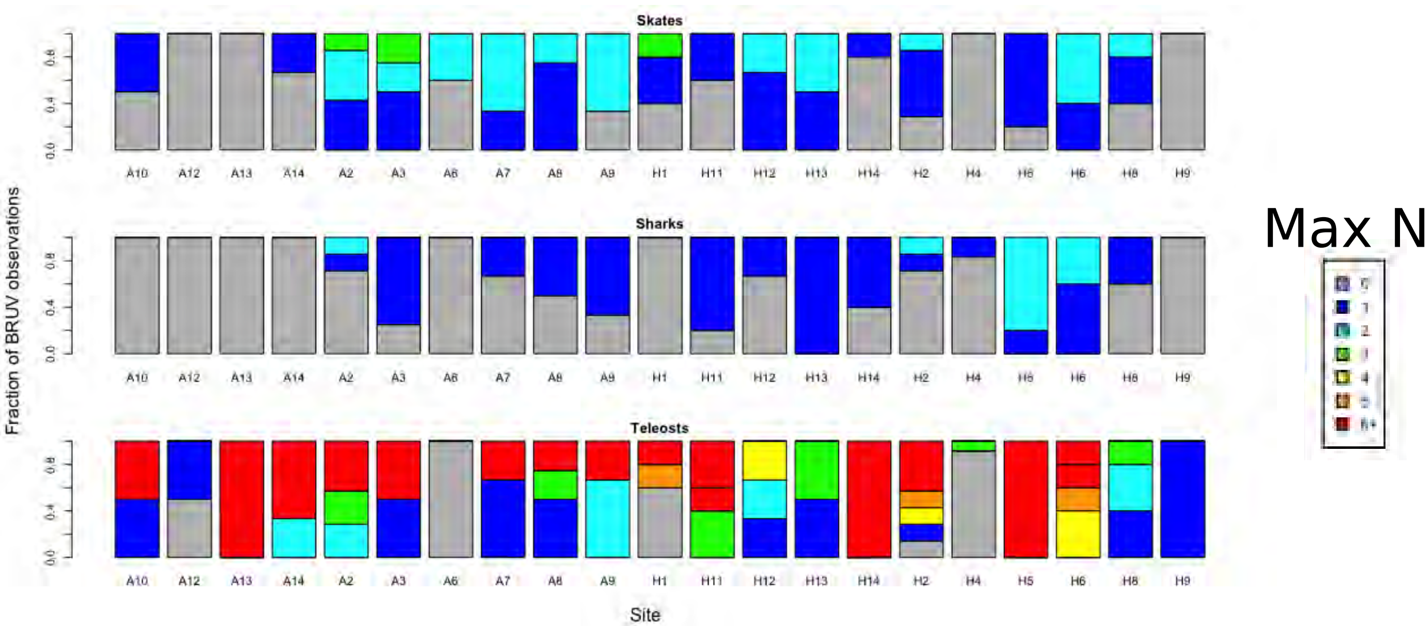


Figure 16. BRUV fish species fraction of observations for all sites for skates, sharks, and teleosts.

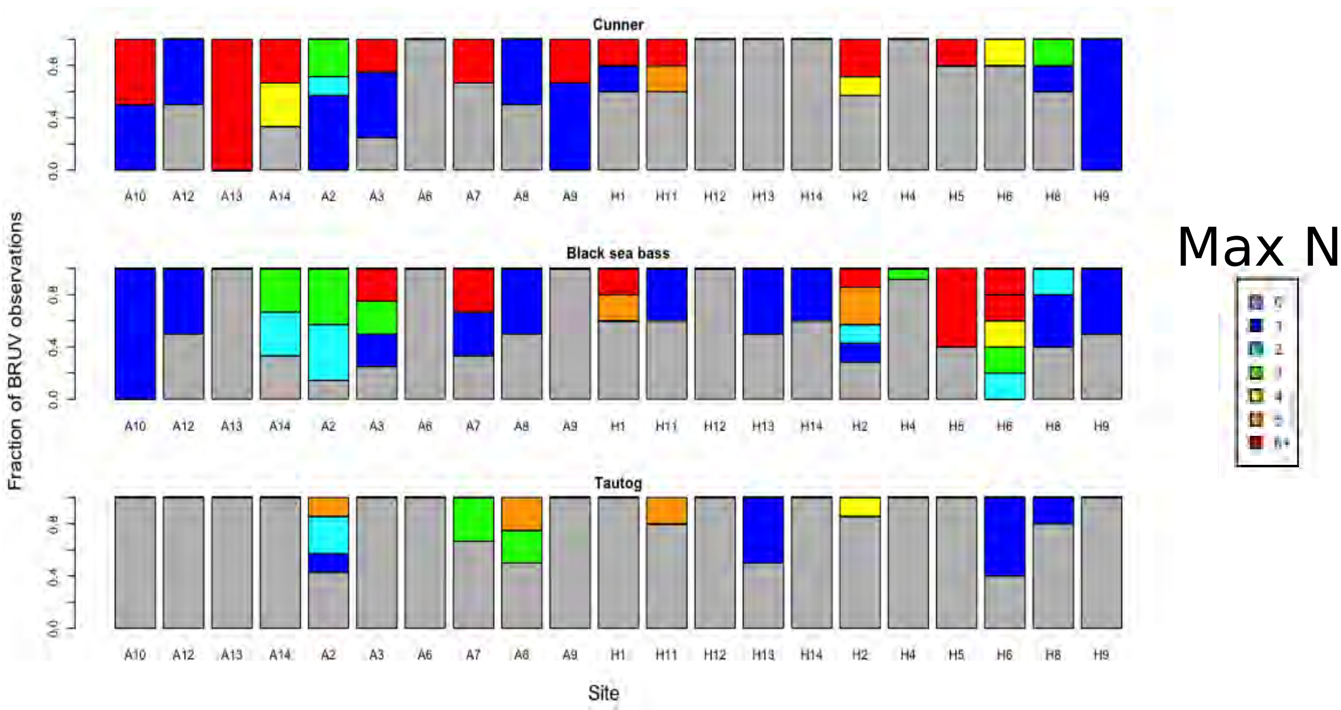


Figure 17. BRUV fish species fractional observations for all sites for cunner, black sea bass, and blackfish.

Passive Acoustic Monitoring

Passive acoustic monitoring on the A2 barge site identified the presence of odontocetes (likely dolphins), oyster toadfish, and weakfish. For oyster toadfish, 5 and 10% of the audio files recorded boat whistles and low frequency grunts respectively. For weakfish, a two hour chorusing event along with overlapping calls were recorded. Odontocetes were heard every night between 7pm and 4am; they were also heard during the daytime 6 out of 7 days (Figure 18). Vessel noise was more prevalent during daytime hours than at night. Approximately 33% of all audio files recorded odontocete clicks/whistles. The co-occurrence of odontocetes and boats at this reef site (Figure 19) suggests that there may be direct or indirect competition between odontocetes and human fishers at the artificial reef sites.

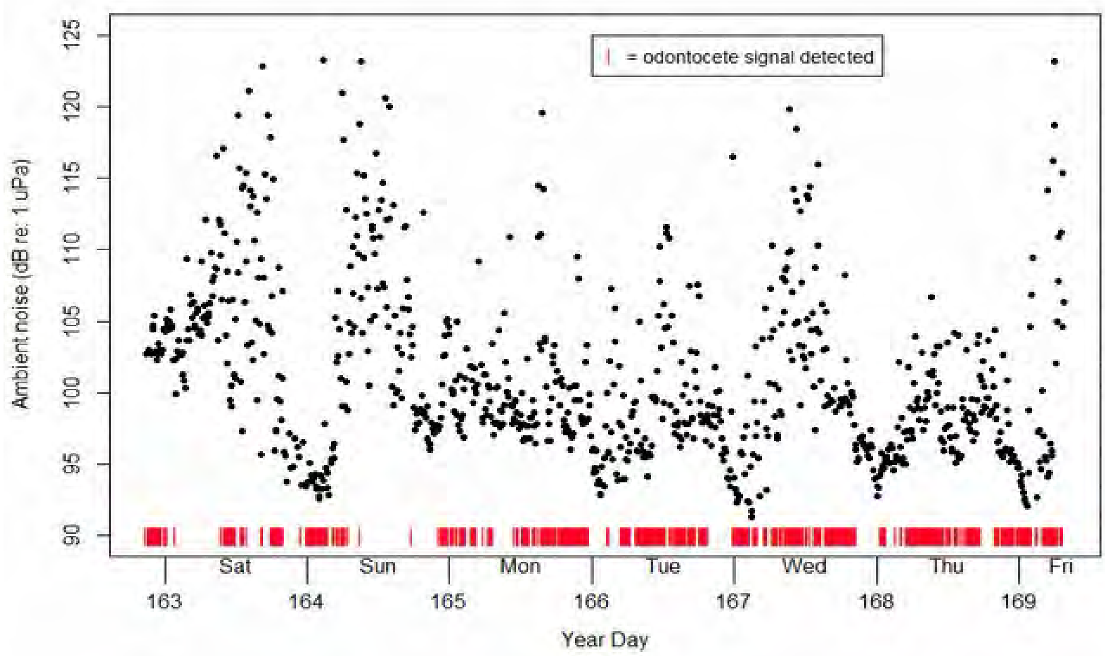


Figure 18. Broadband (100 - 12.5 kHz) sound pressure levels peaked at midday, and were highest on Saturday, Sunday, and Friday. Dolphin vocalizations (presence indicated by red vertical lines along the x-axis) were present during all days (and nights) sampled.

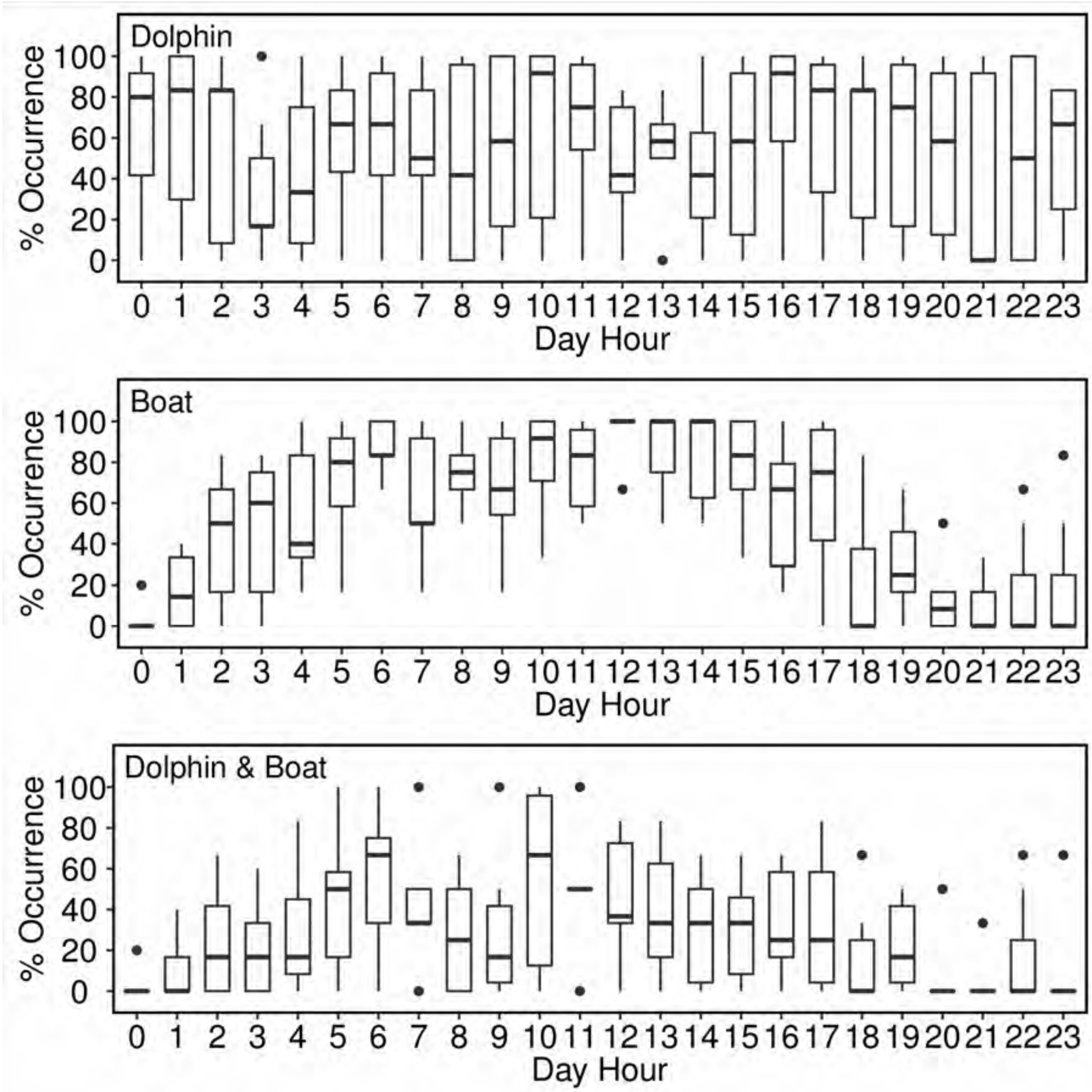


Figure 19. Dolphin detection (top) was evenly distributed throughout the 24 hours of the day while boat detection peaked during the middle of the day (middle). Overlap of boats and dolphins (bottom) was most frequent between sunrise and sunset, especially in the 6th and 10th hours.

Fish abundance at reefs vs off-reef sites and comparison between Atlantic Beach and Hempstead sites

For near-bottom NASC values (i.e., within 6m of the seabed) (Figure 20), mean on-reef NASC (460 m^2nmi^{-2}, $CV = 3.6$) was significantly higher and more consistent than off-reef (140 m^2nmi^{-2}, $CV = 8.8$; MWW-test, $p < 0.01$). This significant difference is further validated by a significant difference between the two distributions (KS-test, $D_{(2)} = 0.28$, $p < 0.01$; Figure 21). When broken up by each sampling site (i.e., Atlantic Beach and Hempstead Reefs; Figure 22), the mean on-reef NASC at Hempstead (670 m^2nmi^{-2}, $CV = 3.4$) was significantly higher than at Atlantic Beach (370 m^2nmi^{-2}, $CV = 3.5$; MWW-test, $p < 0.01$). Both sites also had a relatively similar amount of variation in NASC as well (*CV*s of 3.4 and 3.5 for Hempstead and Atlantic Beach respectively). Likewise, mean off-reef NASC at Hempstead (160 m^2nmi^{-2}, $CV = 7.5$) was significantly higher than at Atlantic Beach (120 m^2nmi^{-2}, $CV = 10.0$; MWW-test, $p < 0.01$; Figure 24). Mean on-reef NASCs at both Hempstead and Atlantic Beach were significantly higher than off-reef at either site ($p < 0.01$) and had relatively less variability (Figure 23). These statistically significant pairwise differences were also reflected in the differences among the distributions which were also statistically significant (KS-test, $p < 0.01$; Figure 24).

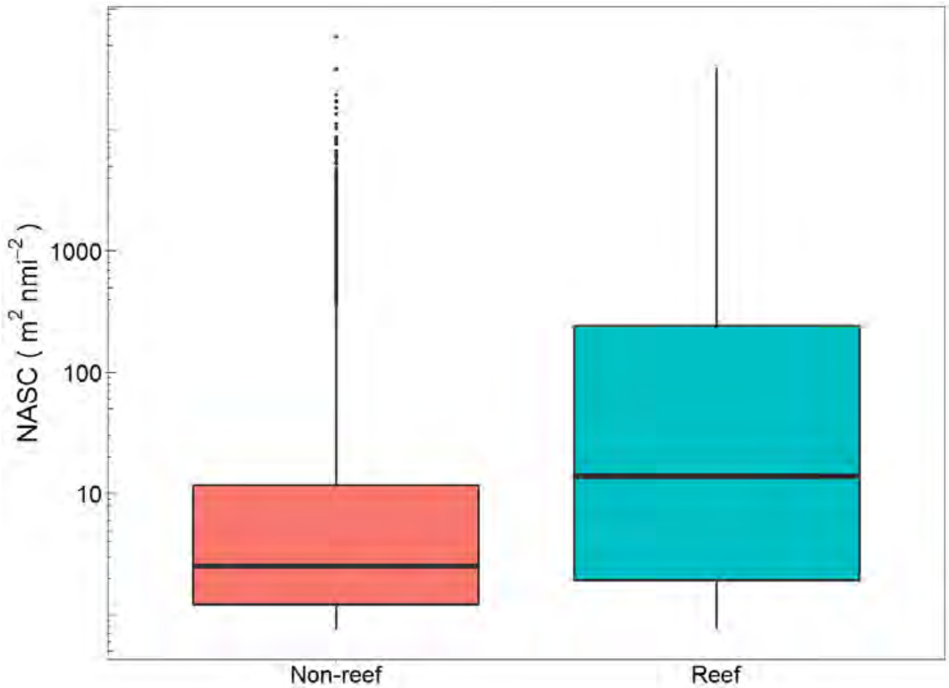


Figure 20. Observed NASC (m^2nmi^{-2}) on- ($N = 5947$) and off- ($N = 2027$) reefs. The solid line within each box represents the median. The extent of each vertical line represents the interquartile range.

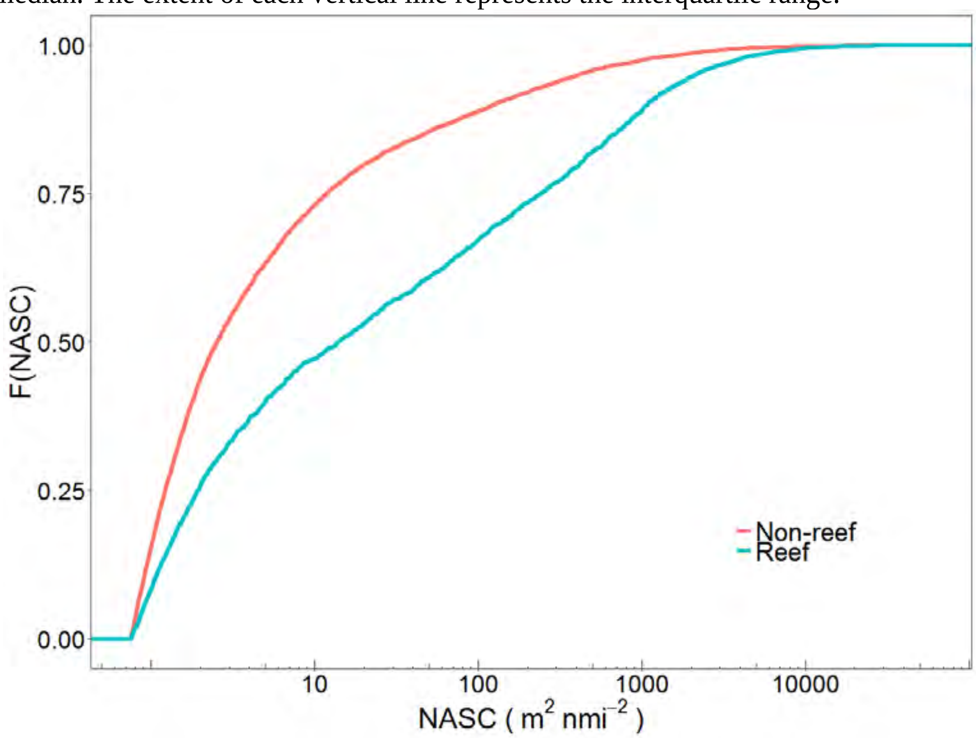


Figure 21. The empirical cumulative density functions of on- and off-reef NASC values (blue and red respectively).

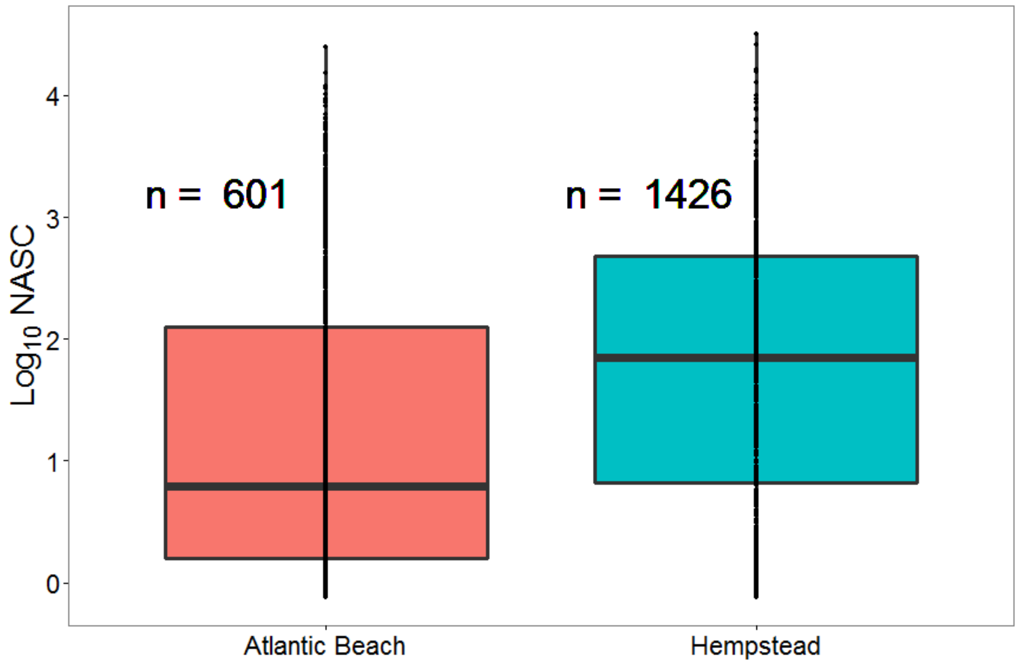


Figure 22. Observed $\log_{10}$-transformed NASC ($m^2 nmi^{-2}$) on on-reef sites at Atlantic Beach and Hempstead. The solid line within each box represents the median. The extent of each vertical line represents the interquartile range.

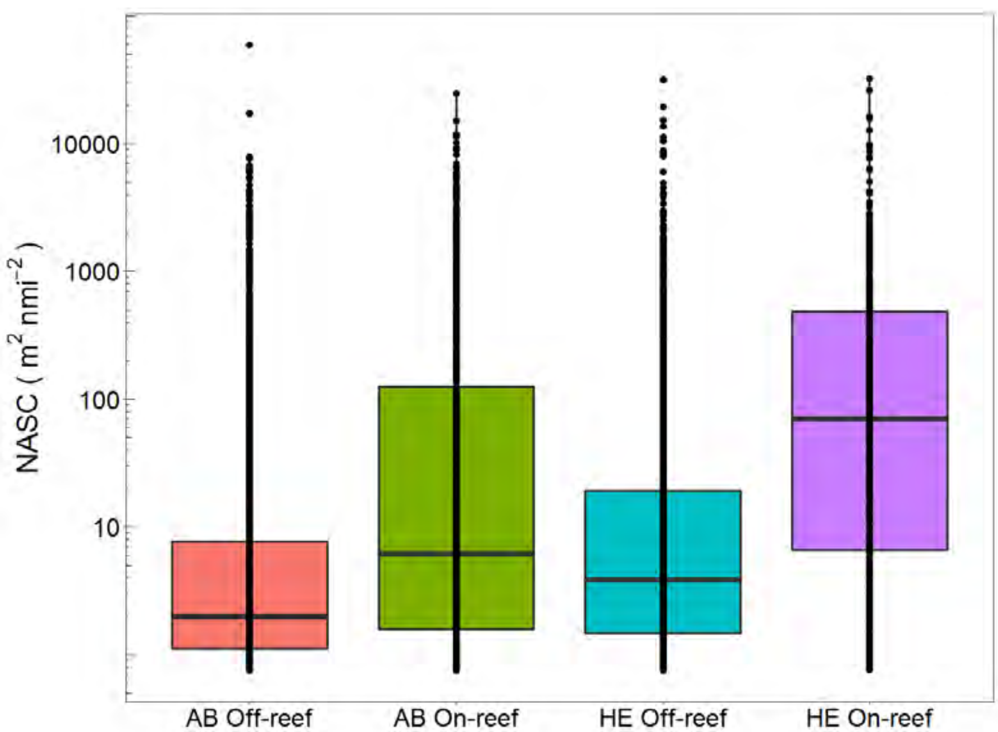


Figure 23. Observed NASC ($m^2 nmi^{-2}$) off-reef at Atlantic Beach (N = 3485), on-reef at Atlantic Beach (N = 1426), off-reef at Hempstead (N = 2489), and on-reef at Hempstead (N = 601). The Atlantic Beach and Hempstead Reefs are denoted by "AB" and "HE" respectively. The solid line within each box represents the

median. The extent of each vertical line represents the interquartile range. Each point represents a single NASC value.

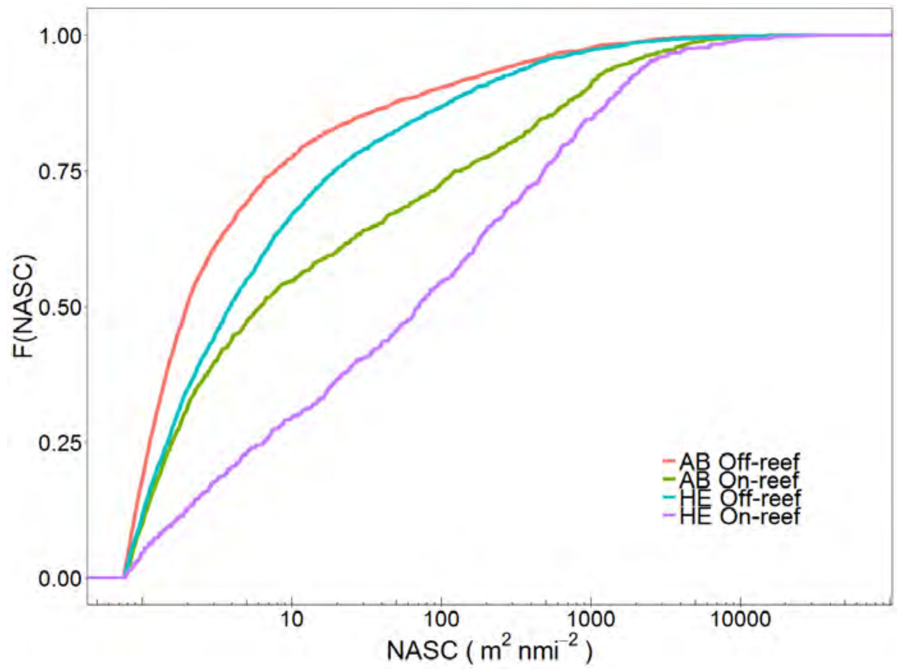


Figure 24. The empirical cumulative density functions of observed NASC for AB off-reef, AB on-reef, HE off-reef, and HE on-reef (red, green, blue, and magenta respectively).

However, BRUV data found that fish were more frequently observed (for all taxonomic groups except sharks) at the Atlantic Beach sites (Figure 25). It should be noted that the BRUVs (benthic) and acoustic echosounders (at least 0.5 m above bottom) are sampling different vertical locations of fish.

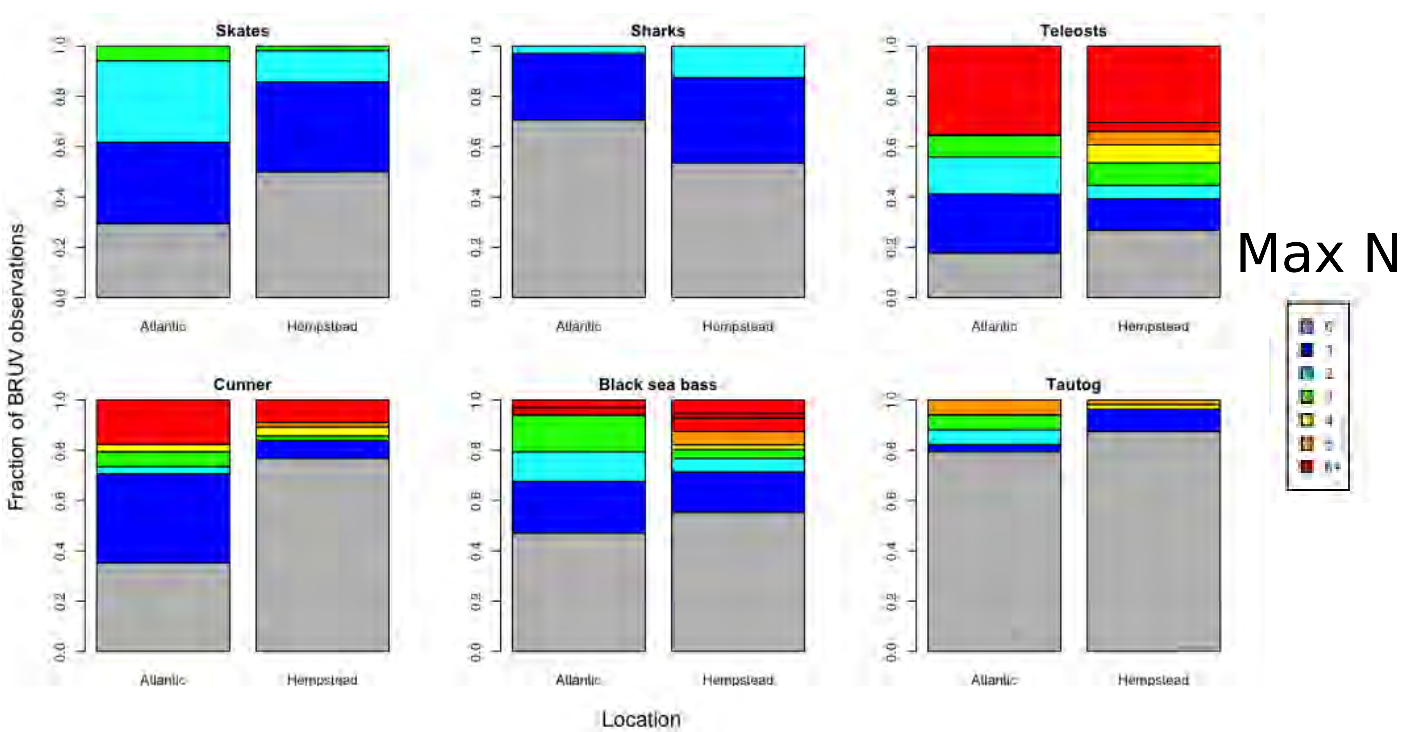


Figure 25. BRUV data found that fish were more frequently observed at the Atlantic Beach site than at Hempstead for all taxonomic groups except sharks (which were rare at both sites).

Halo effect of reefs

The area of influence (i.e. "Halo effect") around each reef was also evaluated. There was little evidence for a strong reef effect in the surrounding waters around each reef. Although there were intermittent near-bottom fish aggregations that were off-reef, they appeared to be randomly distributed and were observed both near (< 10m) and far (> 100m) from the closest reef. Cross-sections of cruise track data (Figures 26-28) showed that the majority of fish aggregations (i.e., high NASC values) were found on-reef with sharp drop-offs as soon as one moves off-reef.

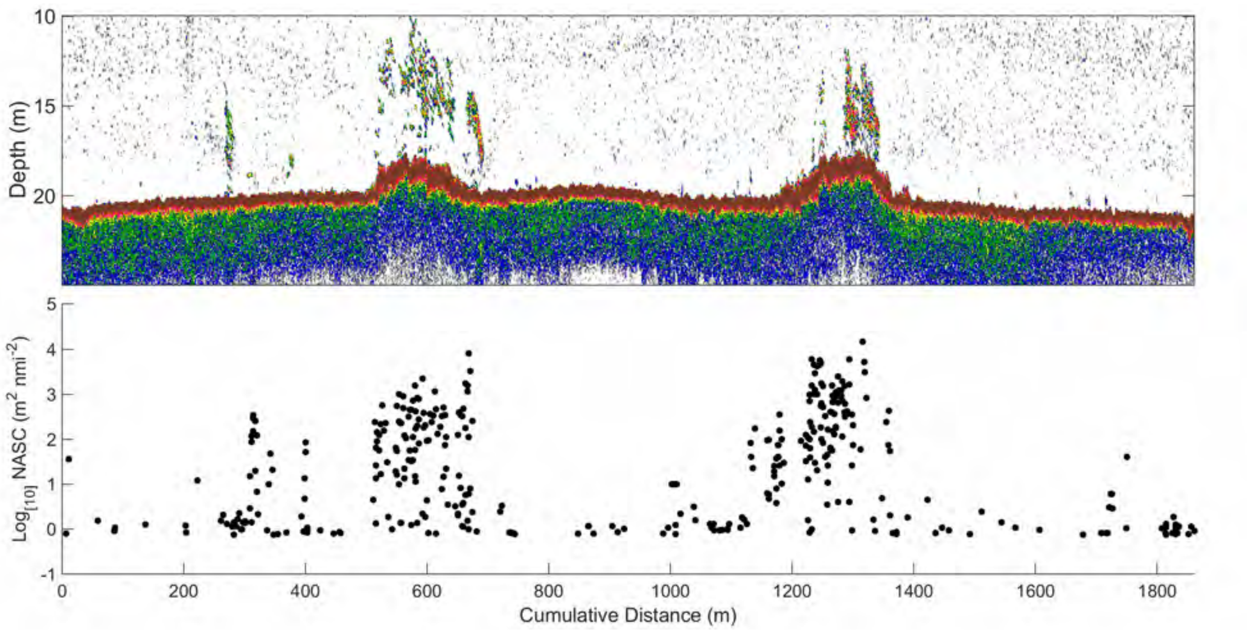


Figure 26. Along-track echogram (top) and NASC values (bottom) with cumulative distance on two rock reefs (deployed on Hempstead Reef during 2013/2014) on 18 August 2014. Both plots are lined up.

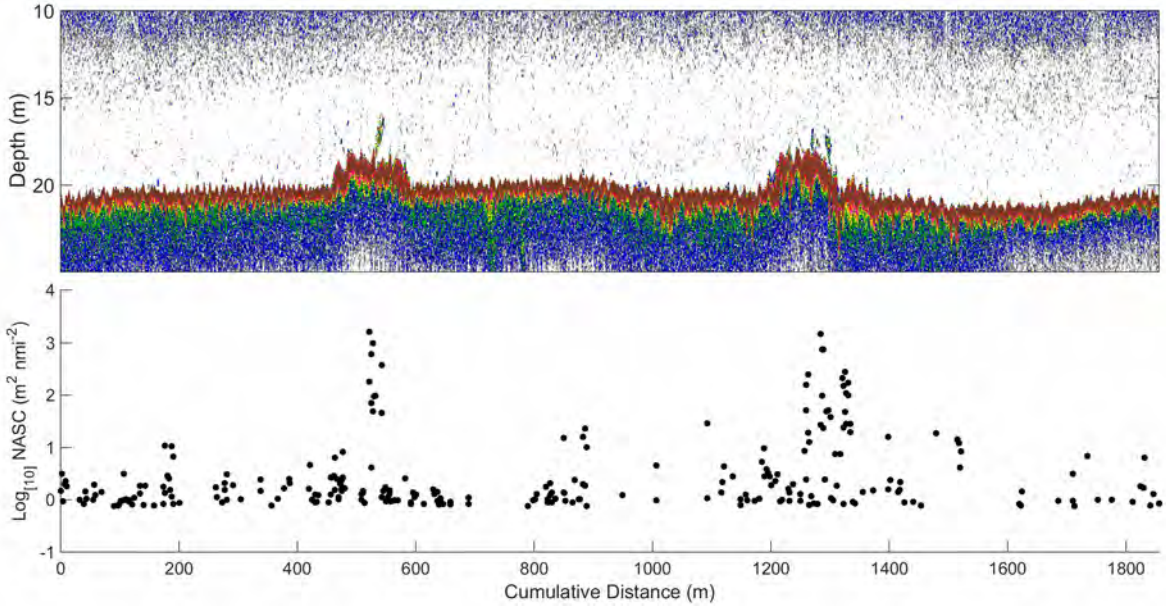


Figure 27. Along-track echogram (top) and NASC values (bottom) with cumulative distance on two rock reefs (deployed on Hempstead Reef during 2013/2014) on 15August 2014. Both plots are lined up.

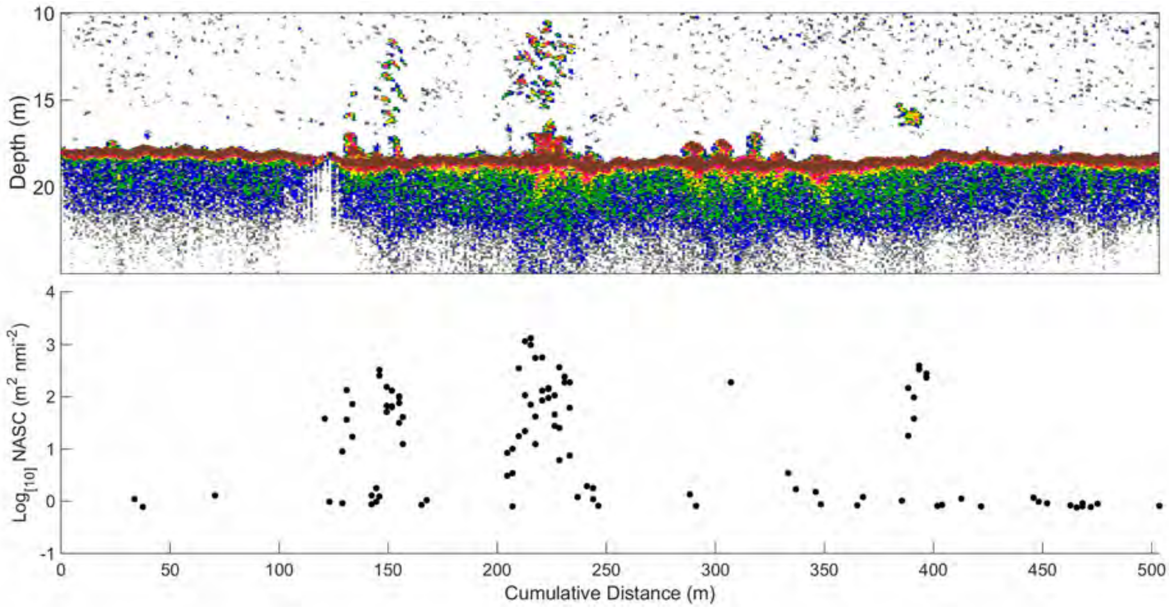


Figure 28. Along-track echogram (top) and NASC values (bottom) with cumulative distance on a concrete reef (deployed on Hempstead Reef during 1998) on 18 August 2014. Both plots are lined up.

Reef Material Comparisons

Each material type had a diverse community of benthic organisms (Table 6). Total coverage ranged from 5-78%. The entire benthic coverage was statistically greater on the sunken vessels due to higher coral coverage (Figure 29C). Another striking difference was the 8X greater tunicate coverage on the sunken vessels (Figure 29D). Overall, the rock had the greatest amount of bare space ($p<0.001$; Figure 30). We also wanted to assess how material type affected benthic coverage while controlling for time. When assessing materials of a similar age (1996-2003), the sunken vessels had greater coverage of corals ($p=0.001$; Figure 31C) and tunicates ($p=0.016$; Figure 31F). This suggests that the benthic community on the sunken vessels may reach a climax community more quickly than the other material types.

Table 6. Species list observed by divers as a function of reef structure material.

Species	Rock	Sunken Vessel	Concrete
Cunner (*Tautogolabrus adspersus*)	X	X	X
Blackfish (*Tautoga onitis)*	X	X	X
Black Sea Bass (*Centropristis striata*)	X	X	X
Cod (*Gadus spp.*)		X	
Northern Sea Robin (*Prionotus carolinus*)	X		
Goby (*Gobiosoma spp.*)	X		
Clearnose Skate (*Raja eglanteria*)	X		
Gray Triggerfish (*Balistes capriscus*)	X		
Summer Flounder (*Paraclichthys dentatus*)	X	X	
Butterfly Fish (*Chaetedon spp.*)	X		
Conger Eel (*Conger oceanicus*)		X	
Striped Bass (*Morone saxatilis*)		X	
Rock Gunnel (*Pholis gunnellus*)	X		
American Lobster (*Homarus americanus*)	X	X	
Spider Crab (*Libinia* spp.)	X		
Rock Crab (*Cancer irroratus)*	X		
Common Sea Star (*Asterias rubens*)	X	X	
Blue Mussels (*Mytlius edulis*)	X	X	X
Barnacles (Balanidae *spp.*)	X	X	X
Northern Star Coral (*Astrangia poculata*)	X	X	X
Sea Anemones (Actiniardia spp.)		X	
Purple-spined Sea Urchins (*Arbacia punctulata*)	X		
Orange tunicate spp.	X	X	
Yellow sponge spp.	X		
Branching Brown Macroalgae spp.	X	X	X
Branching Red Macroalgae spp.	X		
Hydroid/Bryozoan spp.	X	X	X
Skate/Dogfish Egg Case	X	X	
Brittle Star (*Ophiopholis spp.*)	X		
Waved Whelk (*Buccinum undatum*)	X		
Scale Worm (Polynoide spp.)	X		

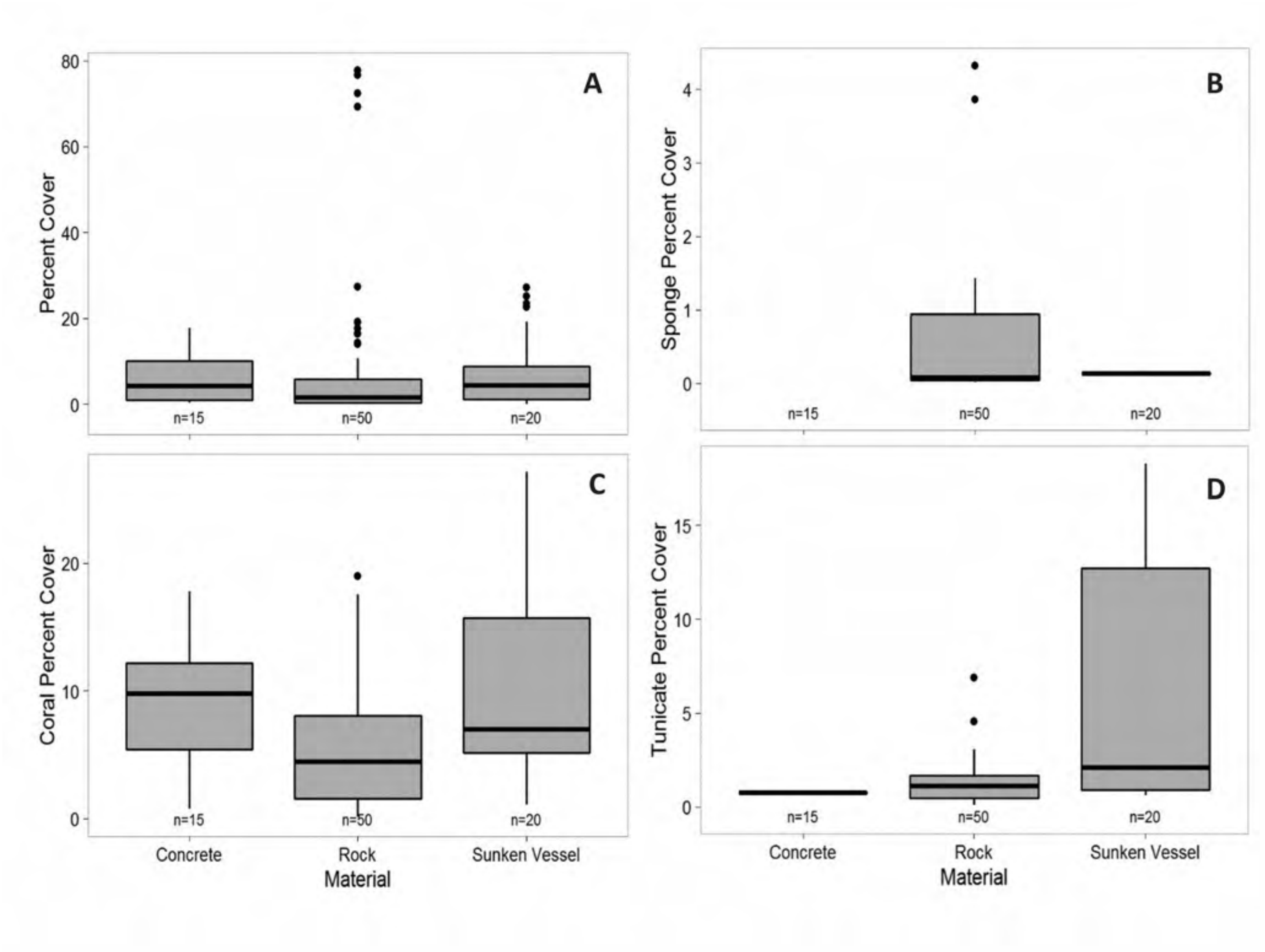


Figure 29. Benthic coverage as a function of material type for (A) All Organisms (including Barnacle, Blue Mussel, Bryozoan, Crustose Coralline Algae, Coral, *Crepidula* spp., Macroalgae, Sponge, and Tunicate percent coverage), (B) Sponges, (C) Corals, and (D) Tunicates. This included all years of deployed reefs.

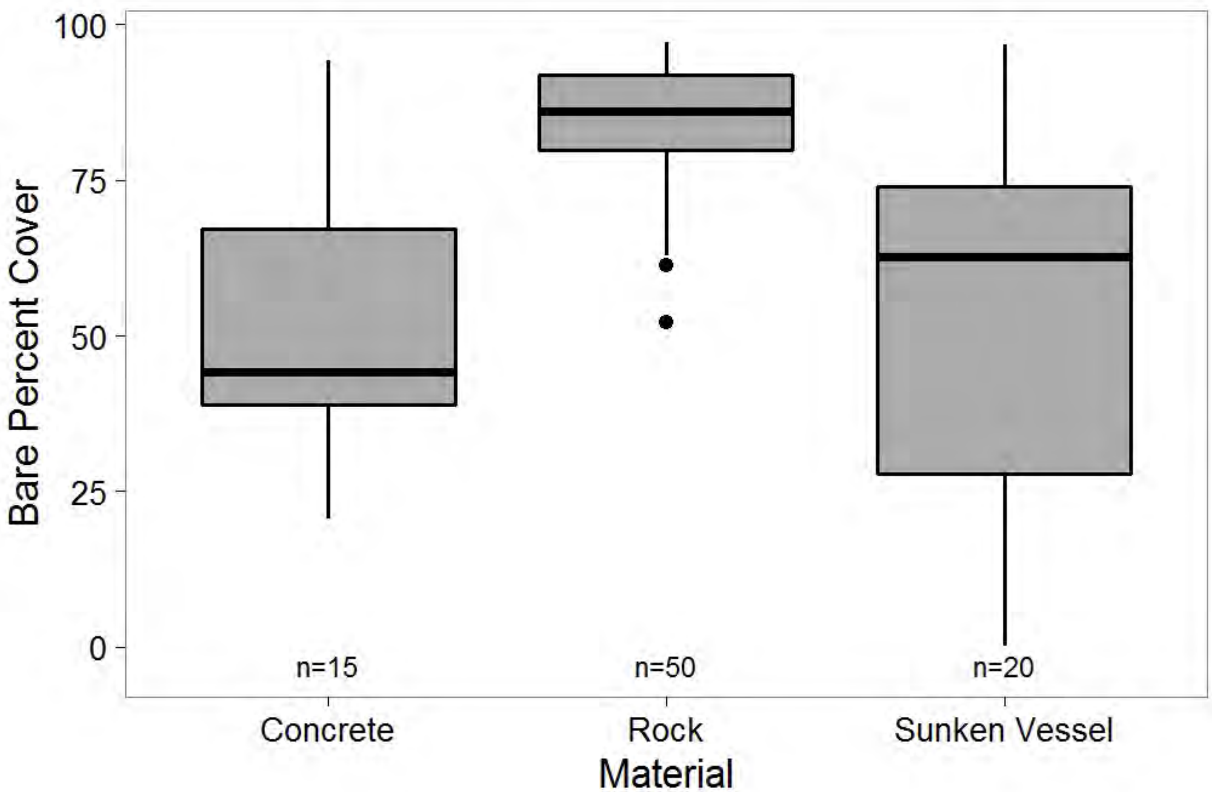


Figure 30. Bare space available by material type including all years of deployed reefs.

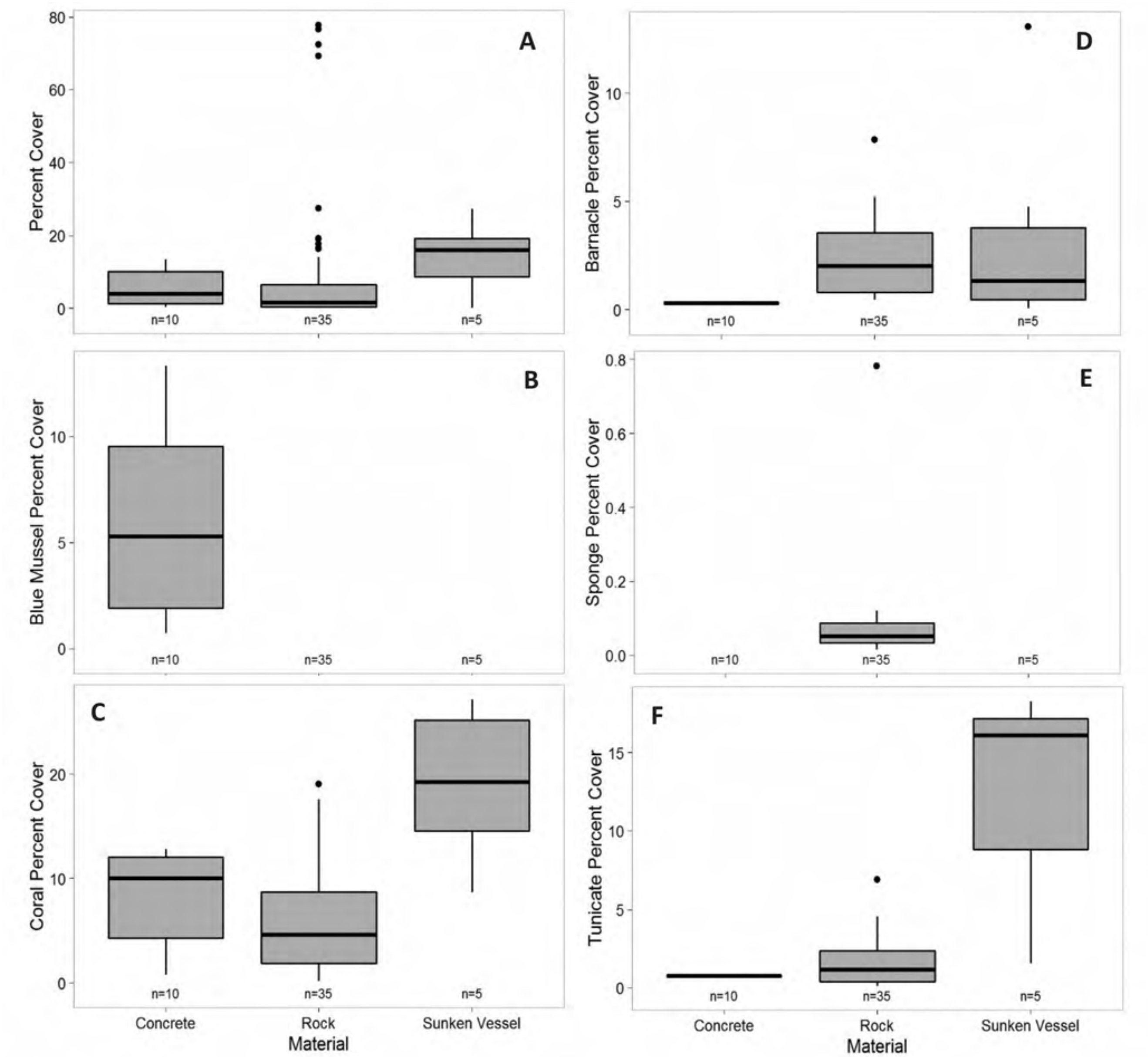


Figure 31. Benthic coverage on different material types controlling for age of material (1998 concrete, 2003 rock, and 1996 vessels) for (A) Total Coverage (including Barnacle, Blue Mussel, Bryozoan, Crustose Coralline Algae, Coral, *Crepidula* spp., Macroalgae, Sponge, and Tunicate percent coverage), (B) Blue Mussels, (C) Coral, (D) Barnacles, (E) Sponges, and (F) Tunicates.

Fish species presence information from the BRUVs showed that rock and vessel reefs had more species than concrete reefs (Table 7). Fractional presence data from the BRUVs however showed that teleosts (at least one fish) were always present at concrete sites which was not the case for the other material type (Figure 32).

Table 7. Presence of different species detected by BRUVs on reefs of different types of materials.

	Reef Material Type		
Species	Concrete	Rock	Sunken Vessel
Winter or little skate	X	X	X
Scup	X	X	X
Black sea bass	X	X	X
Cunner	X	X	X
Tautog		X	X
Striped sea robin		X	X
Northern sea robin		X	
Unidentified sea robin			X
Atlantic cod			
Red hake			
Unidentified gadiform			
Summer flounder		X	X
Winter flounder			
Unidentified flatfish		X	
Striped bass		X	
Bluefish			
Conger Eel		X	
Clearnose Skate		X	
Smooth dogfish	X	X	X
Spiny dogfish	X	X	X
Unidentified dogfish			
Dusky Shark			
Unidentified fish		X	

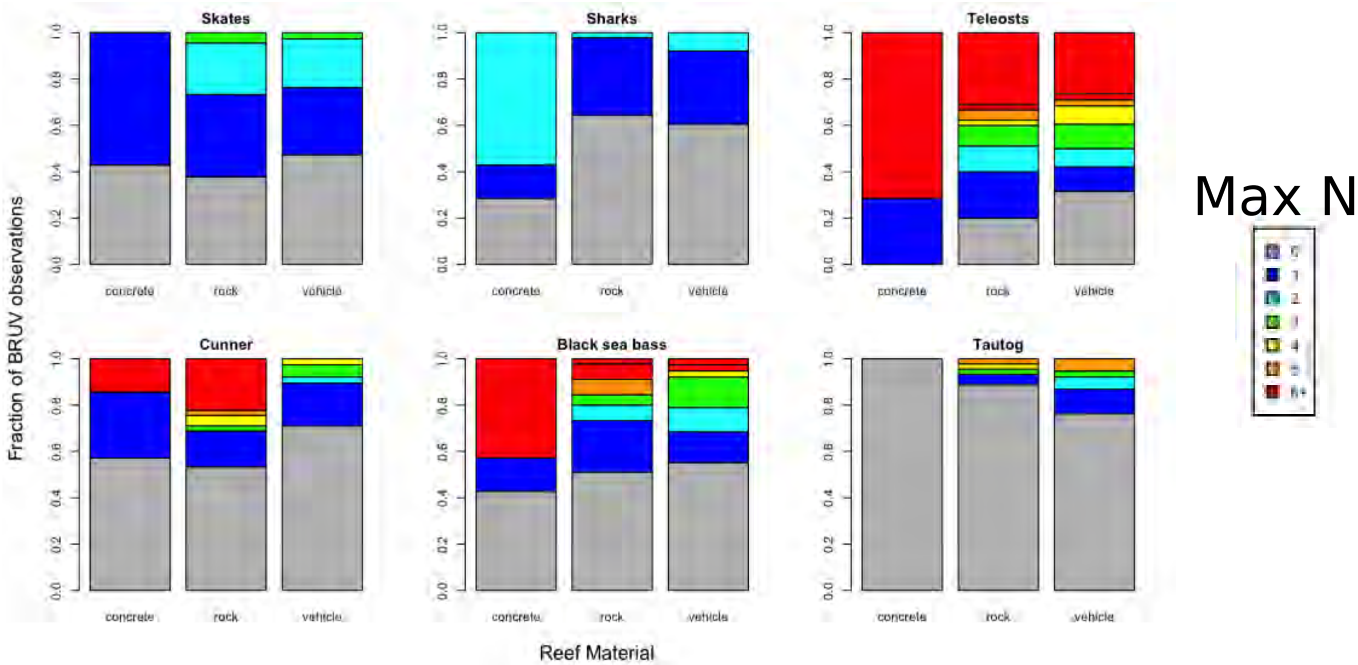


Figure 32. Fraction of BRUV deployments were various fish taxa were observed grouped by material type (all ages).

For diver surveys. fish density was significantly different on the reefs of different materials (Figure 33). Cunner were more abundant on the rock reefs than either the concrete or sunken vessels (p=0.02). This may be a preference for the interstitial spaces provided by the rock material or a result of a predation depression on these reefs due to the higher densities of black sea bass and blackfish on the concrete and sunken vessels. It was apparent that the blackfish densities were correlated with the height profile of the reef (Figure 34). When we compared the rugosity (vertical height) of the sunken vessels, the blackfish increased until they were as numerous as the cunner on these sunken vessels. Therefore, we believe that it is the vertical height more than the material type that is increasing the blackfish densities.

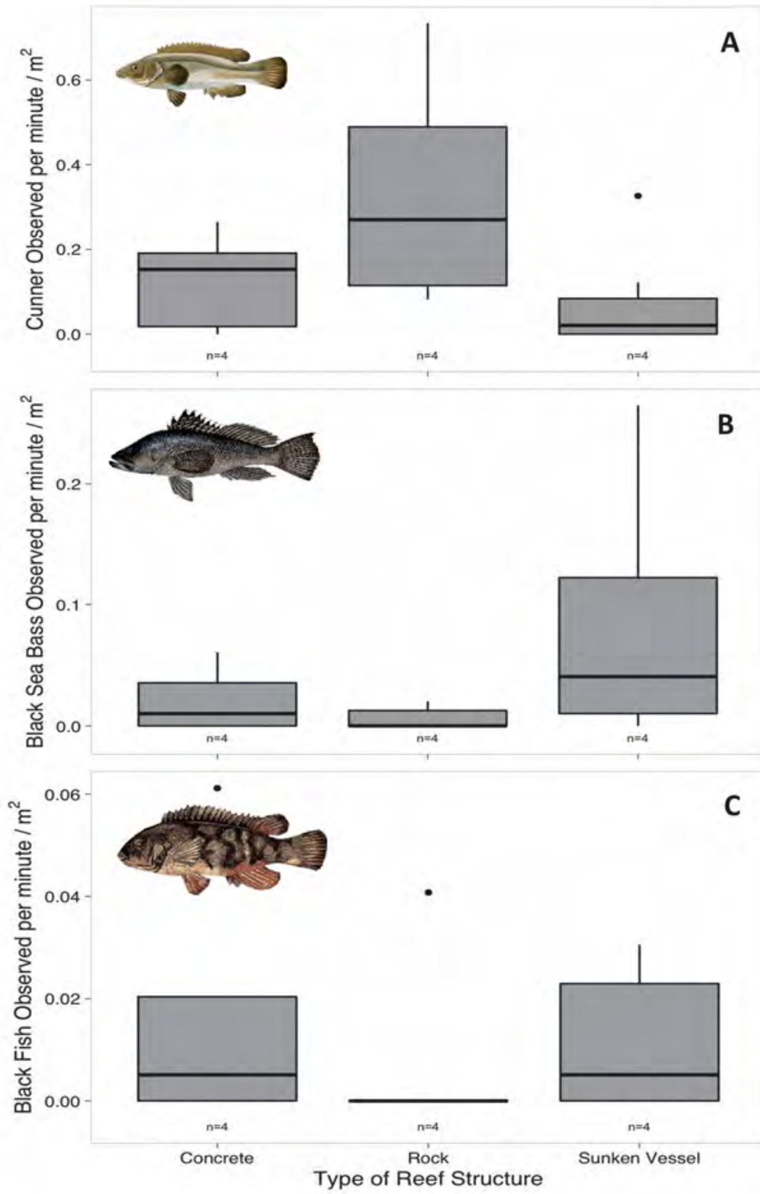


Figure 33. Fish density by structure type controlling for age of material (1998 concrete, 2003 rock, and 1996 vessels) for (A) cunner, (B) black sea bass, and (C) blackfish.

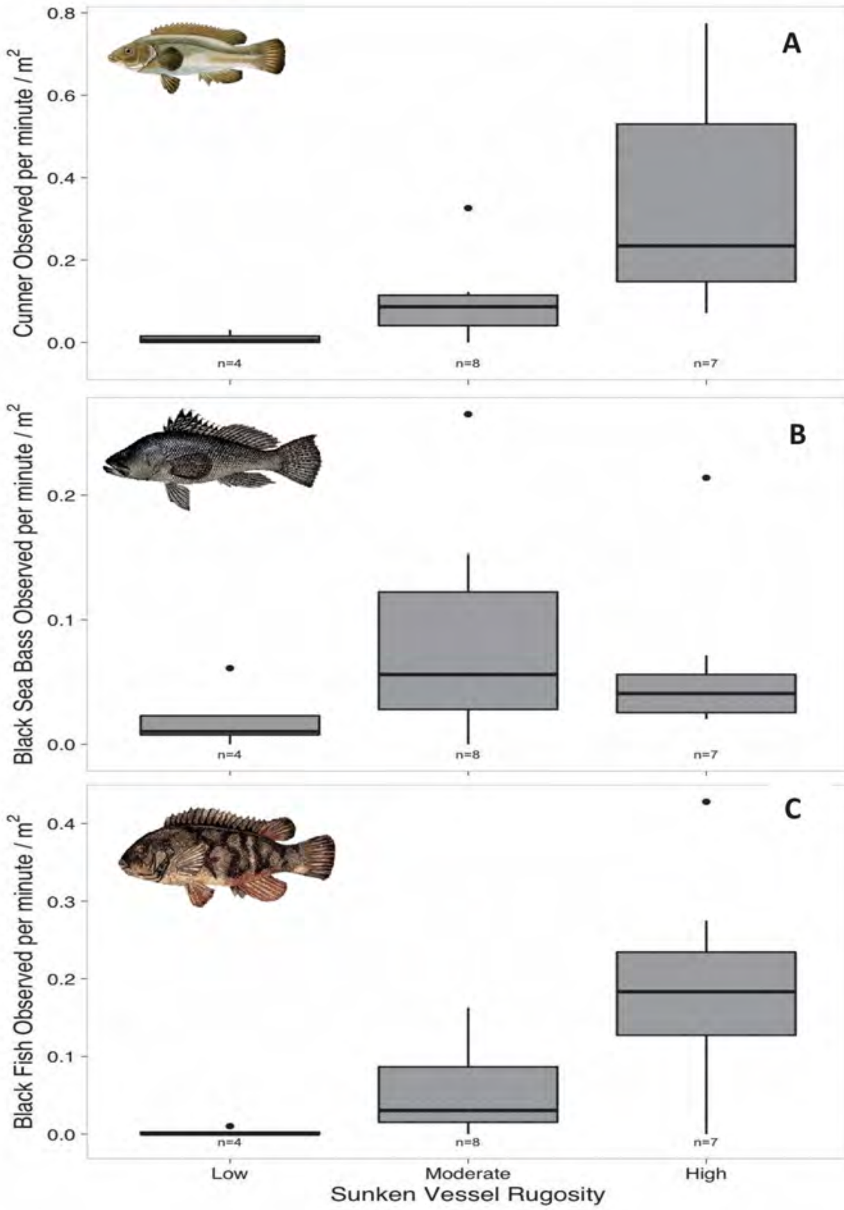


Figure 34. Fish density as a function of vessel profile for (A) cunner, (B) black sea bass, and (C) blackfish.

Acoustic observations of fish biomass (as measured by NASC) on concrete, rock, and vessel reefs were 380 (CV = 1.4), 150 (CV = 1.9), and 30 (CV = 1.5) m^2nmi^{-2} respectively (Figure 35). Statistically significant differences in mean NASC among the different material-types were detected (KW-test; $\chi^2_{(2)} = 18.2$, $p < 0.01$). The mean concrete NASC was significantly larger than those observed on rock ($p < 0.01$) and vessels ($p < 0.01$); however, no significant differences were detected in mean NASC between rock and vessel reefs ($p = 0.46$). In terms of the distributions for each reef-type (Figure 36), concrete reefs were also significantly different from rock (KS-test; $D_{(2)} = 0.32$, $p < 0.01$) and vessels ($D_{(2)} = 0.50$, $p < 0.01$). Since the active acoustic data could not see into the interior space of these reefs where many fish hide, the amount of void space may have a significant impact on measured NASC. This potential undersampling may explain why mean NASC on solid concrete blocks (i.e., relatively low interstitial space) were significantly higher than rocks and vessels which have increased internal space.

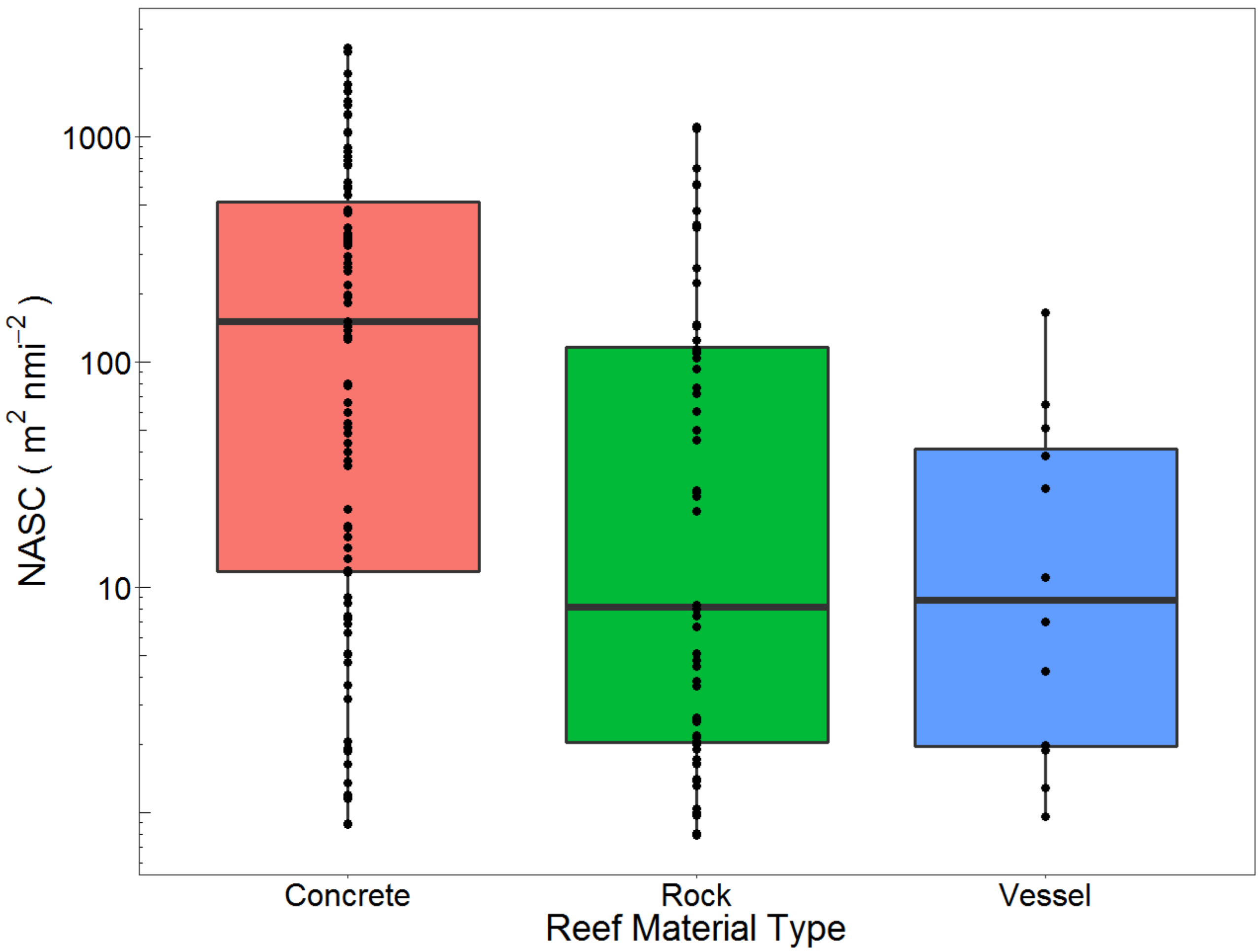


Figure 35. Observed NASC on concrete (*N* = 91), rock (*N* = 60), and vessel (*N* = 12) reefs. The solid line within each box represents the median. The extent of each vertical line represents the interquartile range. Each individual point represents a single NASC measurement.

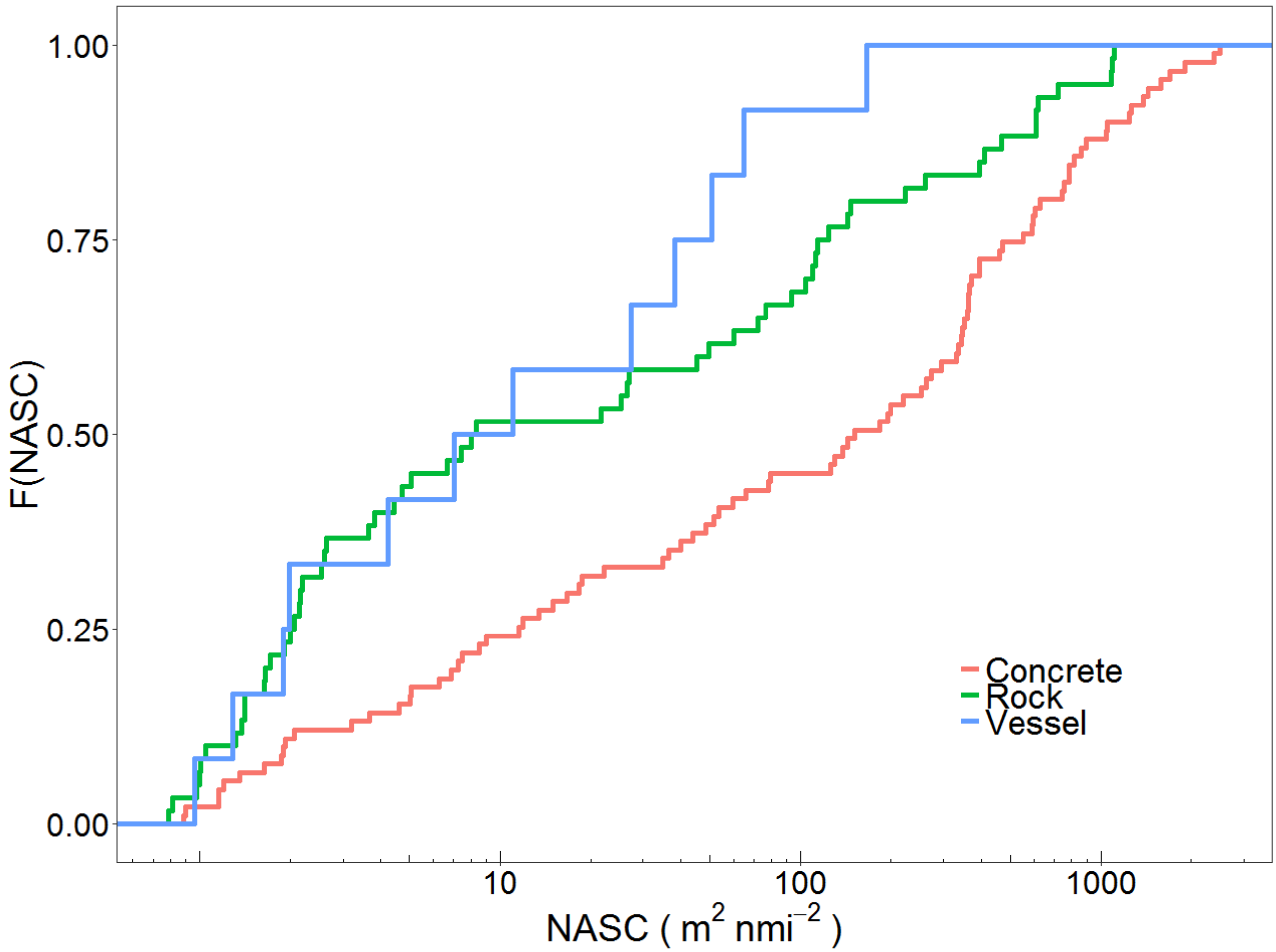


Figure 36. The empirical cumulative density functions of NASC values for concrete, rock, and vessel reefs (red, green, and blue respectively).

Reef Size Comparisons

To assess the size of the reef on fish density using diver survey data, we compared differing sizes of rock drops. Prior to analysis, we used the transect video to verify that the reefs were comparable. Two low rugosity sites were removed (A7 and A10) prior to analysis since these drops were spread over a large area and did not function as the other reefs of similar drop sizes but like those of the smallest volume size. The smallest rock drops only possessed cunner in any numbers. For both the cunner and the black sea bass there appeared to be a trend of decreasing density with increasing rock drop size (Figure 37). Although only the cunner densities were statistically different between reef sizes. We believe that this is reflected more by the congregating nature of the smaller reefs. Rock drops of 2000-3000 m^2 were sufficiently large to be utilized by both cunner and black sea bass. As the rock drops increased in size, the fish had a greater amount of space to utilize.

BRUV data showed a more uniform distribution of fractional presence of most taxonomic groups of fish across the range of reef sizes (Figure 38). The BRUV data in Figure 38 include all ages and material types which may account for this difference. When the BRUV data were controlled for age of reef (similar to the aforementioned diver analysis), the smaller reef sites had more species observed than the largest reef sites (Table 8).

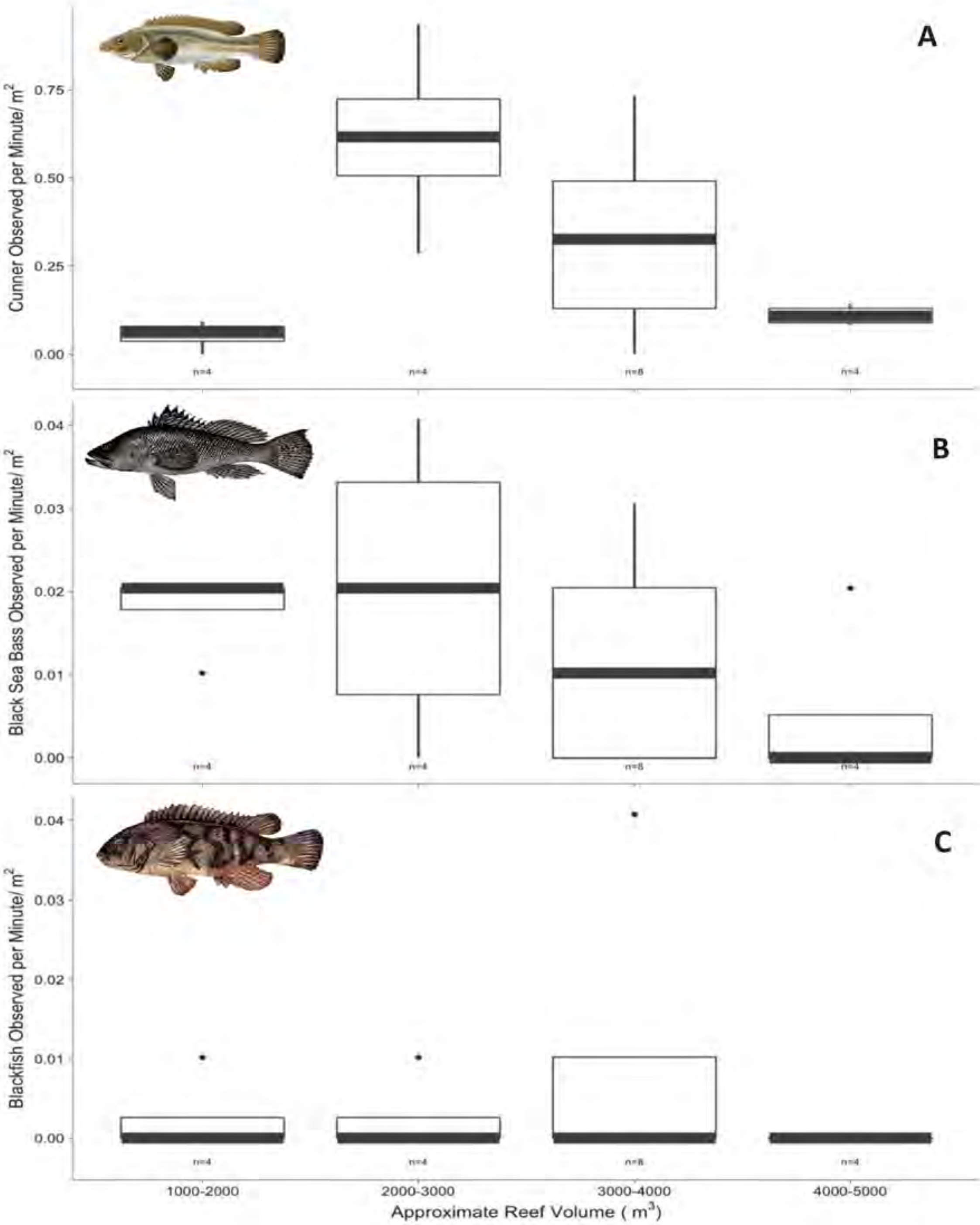


Figure 37. Fish density as a function of reef volume for (A) cunner density, (B) black sea bass density, and (C) blackfish density.

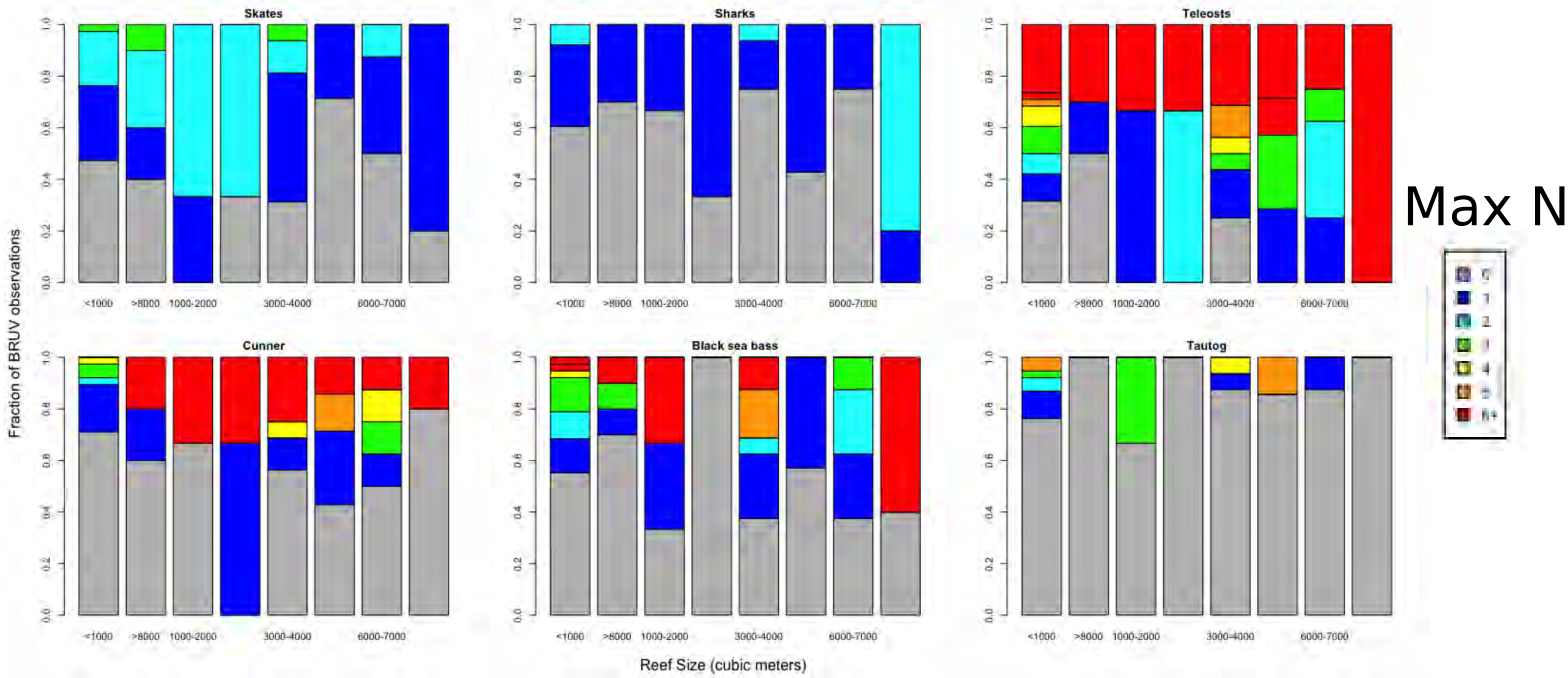


Figure 38. BRUV fractional presence of fish taxa as a function of reef size (all ages and materials included).

Table 8. A comparison of the species seen in BRUVs for rock piles in the volume range of 1000-3000 m^3, & 5000+ m^3. Unfortunately when we standardized for age, we were not left with any data for 3000-5000 m^3. NA = Not Available.

	Volume Range (m^3)		
Species	1000-3000	3000-5000	5000+
Winter or little skate	X	NA	X
Scup	X	NA	X
Black sea bass	X	NA	X
Cunner	X	NA	X
Tautog	X	NA	
Striped sea robin	X	NA	
Northern sea robin	X	NA	X
Unidentified sea robin		NA	
Atlantic cod		NA	X
Red hake		NA	
Unidentified gadiform		NA	
Summer flounder	X	NA	
Winter flounder		NA	
Unidentified flatfish		NA	X
Striped bass	X	NA	
Bluefish		NA	
Conger Eel	X	NA	
Clearnose Skate	X	NA	

Smooth dogfish	X	NA	X
Spiny dogfish	X	NA	X
Unidentified dogfish		NA	
Dusky Shark		NA	
Unidentified fish	X	NA	X

Mean NASC observed on reefs with volume ranges of 1000-3000, 3000-5000, and 5000+ m^3 were 60 ($CV = 2.9$), 200 ($CV = 1.6$), and 90 ($CV = 1.7$) m^2nmi^{-2} respectively (Figure 39). No significant differences in mean NASC were detected among the different size ranges (KW-test; $\chi^2_{(2)} = 5.53$, $p = 0.06$). However, there was a statistically significant difference between the distributions of NASC on 1000-3000 and 3000-5000 m^3 range reefs (KS-test; $D_{(2)} = 0.47$, $p = 0.02$, Figure 40). Although the neither distribution of NASC on 1000-3000 or 3000-5000 m^3 were not significantly different than 5000+ m^3 reefs, this is likely a consequence of the low sample size ($N = 3$) observed on the largest reefs.

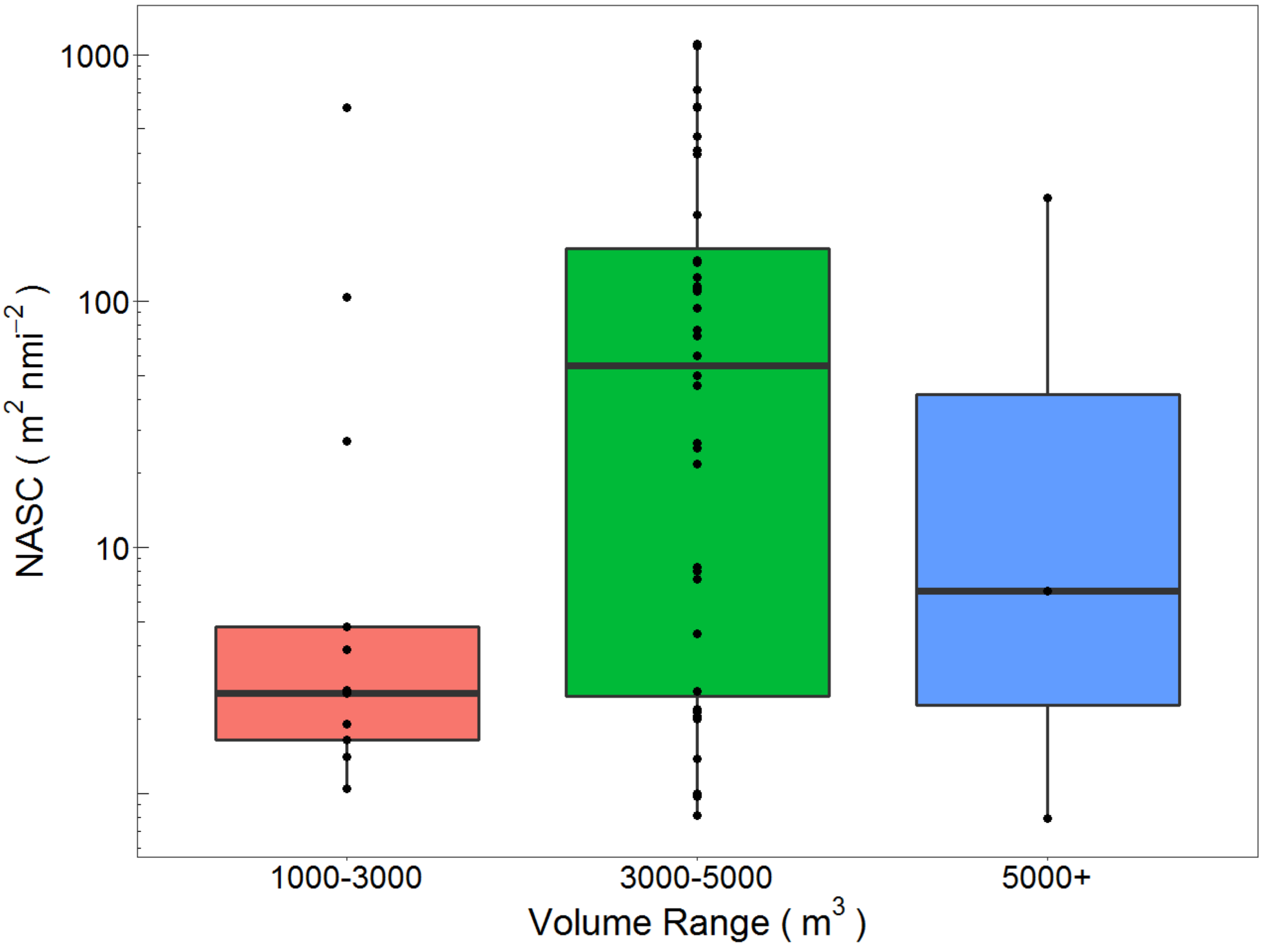


Figure 39. Observed NASC on reefs with size ranges of 1000-3000 m^3 ($N = 13$), 3000-5000 m^3 ($N = 40$), and 5000+ m^3 ($N = 3$). The solid line within each box represents the median. The extent of each vertical line represents the interquartile range. Each individual point represents a single NASC measurement.

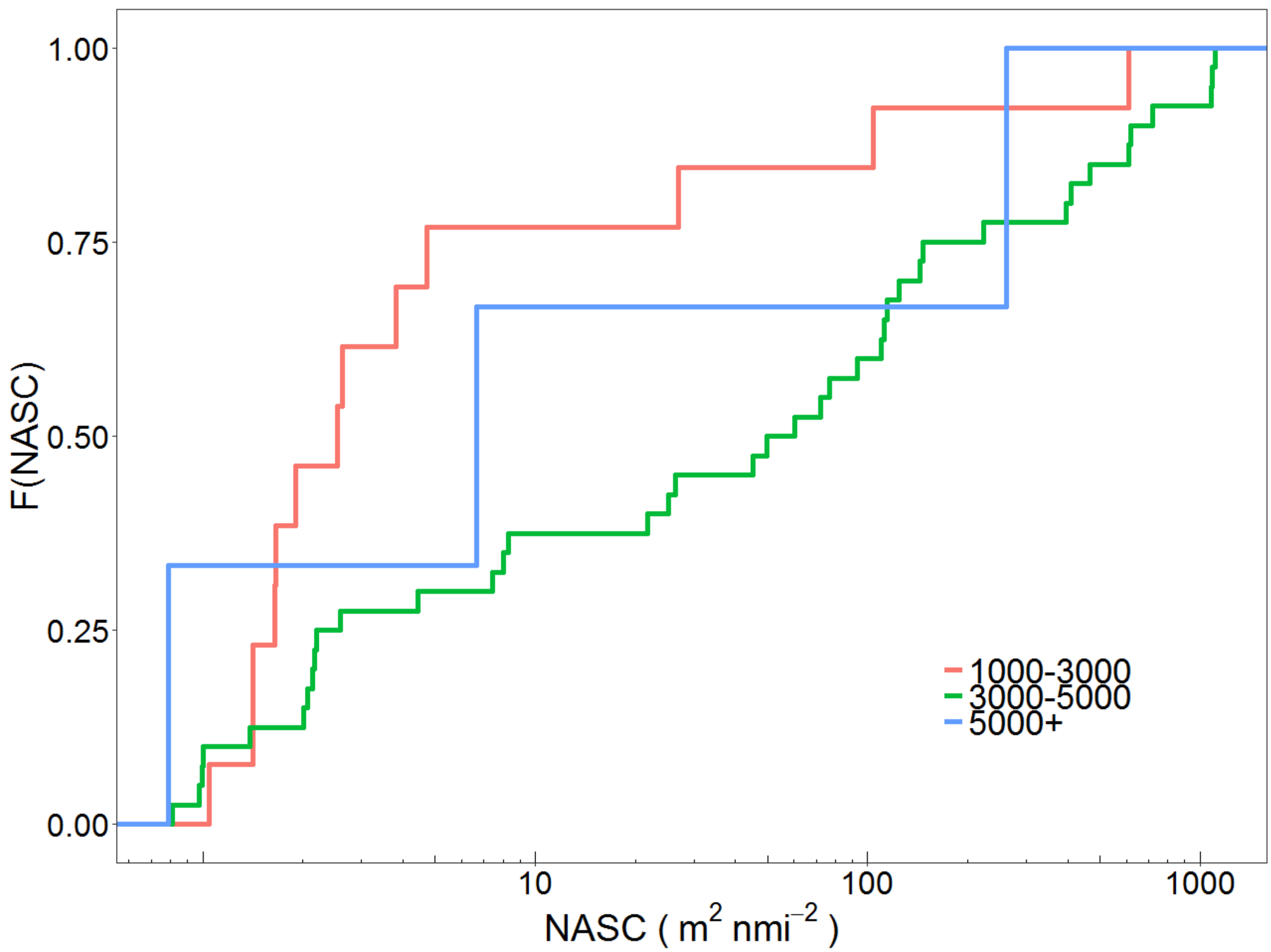


Figure 40. The empirical cumulative density functions of NASC values for 1000-3000, 3000-5000, and 5000+ m^3 reefs (red, green, and blue respectively).

Reef Age Comparisons

In order to assess the effect of reef age independently of the other variables, the diver analysis was performed on rock reefs of similar rugosity (moderate to high). Invertebrate species were different on the rock reefs of different ages (Table 9, Figure 41). The youngest reefs had 5-6 species. Those reefs that were a decade older had twice as many invertebrates present on the reef. The 1998-2001 rock reefs had the greatest invertebrate diversity (13 species). Overall percent bottom cover increased with age of reef. The oldest rock material had sponges and barnacles which were not present in younger reefs (Figure 42). For reefs younger than a decade, no tunicates and only a single coral were observed.

Table 9. Species list observed by divers by age of rock material compiled from diver surveys, limited to moderate and high rugosity.

	Rock Deployment Year (exclude low Rugosity)					
Species	**1989**	**1996**	**1998-2001**	**2003**	**2013**	**2014**
Cunner (*Tautogolabrus adspersus*)	X	X	X	X	X	X
Blackfish (*Tautoga onitis*)		X	X	X	X	X

Black Sea Bass (*Centropristis striata*)		X	X	X	X	X
Northern Sea Robin (*Prionotus carolinus*)				X		
Goby (*Gobiosoma spp.*)					X	X
Clearnose Skate (*Raja eglanteria*)					X	
Gray Triggerfish (*Balistes capriscus*)			X			
Summer Flounder (*Paraclichthys dentatus*)		X	X	X		
Butterfly Fish (*Chaetedon spp.*)				X		
Rock Gunnel (*Pholis gunnellus*)				X		
American Lobster (*Homarus americanus*)		X	X	X		
Rock Crab (*Cancer irroratus)*	X	X	X	X		X
Spider Crab (*Libinia* spp.)						X
Common Sea Star (*Asterias rubens*)	X	X		X	X	X
Blue Mussels (*Mytlius edulis*)	X	X	X	X	X	X
Barnacles (Balanidae *spp.*)	X	X	X	X	X	X
Northern Star Coral (*Astrangia poculata*)	X		X	X		
Purple-spined Sea Urchin (*Arbacia punctulata*)			X			
Orange tunicate spp.	X		X	X	X	
Yellow sponge spp.	X		X	X		
Branching Brown Macroalgae spp.	X	X	X		X	X
Branching Red Macroalgae spp.			X	X		
Hydroid/Bryozoan spp.	X				X	
Skate/Dogfish Egg Case	X	X				
Brittle Star (*Ophiopholis spp.*)			X	X		
Waved Whelk (*Buccinum undatum*)			X			
Scale Worm (Polynoide spp.)			X	X		

When comparing the total coverage of the benthic community on the rock, there was a trend of increasing coverage from initial deployment until approximately 15 yrs (Figure 42A). Then overall coverage began to decline. While the mechanism of this change in trajectory of total coverage can not be equivocally stated, this could be the result of community succession until competitive dominants begin to reduce species diversity. Interestingly, at the same time point (1998-2001) coral and tunicates where at their greatest density and following that older material had the greatest coverage of sponges (Figure 42B-D). All three of these species are competitive dominants for holding space and were essentially absent in the reefs that had been deployed within the last three years. When we examine what is happening with the bare space present on the rock material over time, it is apparent that at the point of the reversal in increasing benthic coverage there is the least amount of bare space and that bare space continues to increase from that point (Figure 43).

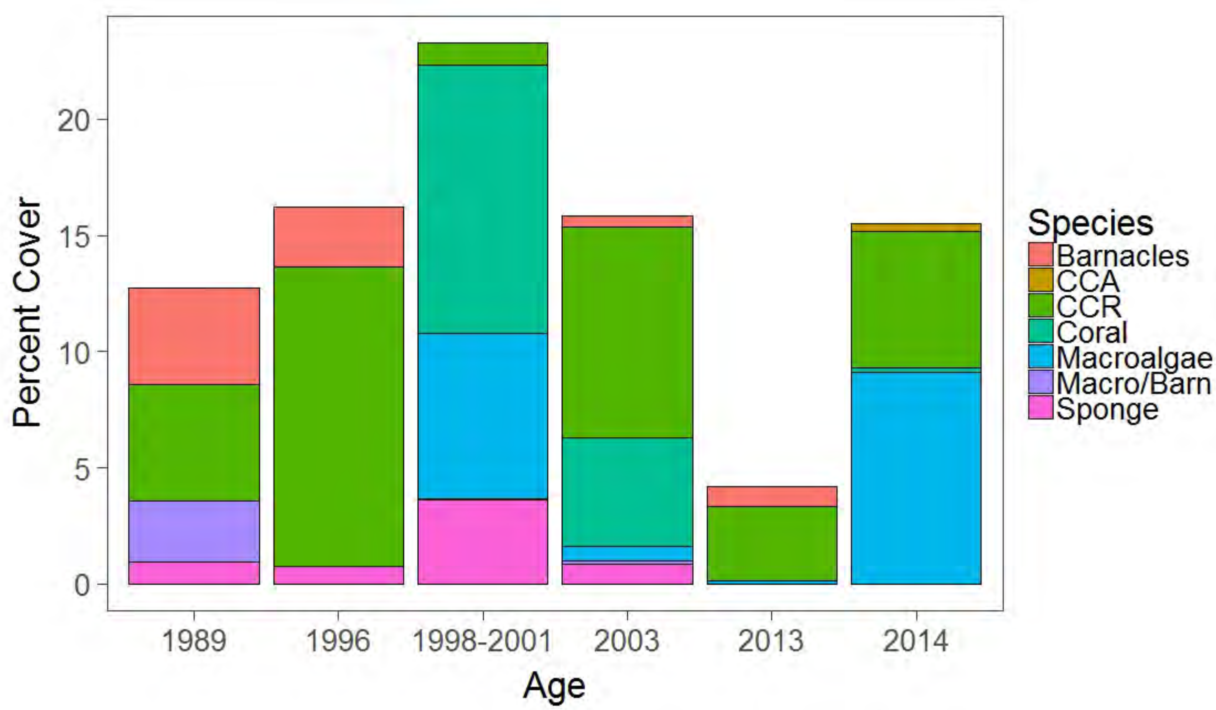


Figure 41. Benthic coverage varied with age of rock reefs (all volumes included) although the newest reefs were dominated by macroalgae and CCR. Benthic coverage categories were: Barnacles; CCA = Crustose Coralline Algae; CCR = Crustose Coralline Remnant; Coral; Macroalgae (all species); Macro/Barn = Macroalgae and barnacle area, where it was too difficult to discern; Sponge (all species); Tunicates (all species).

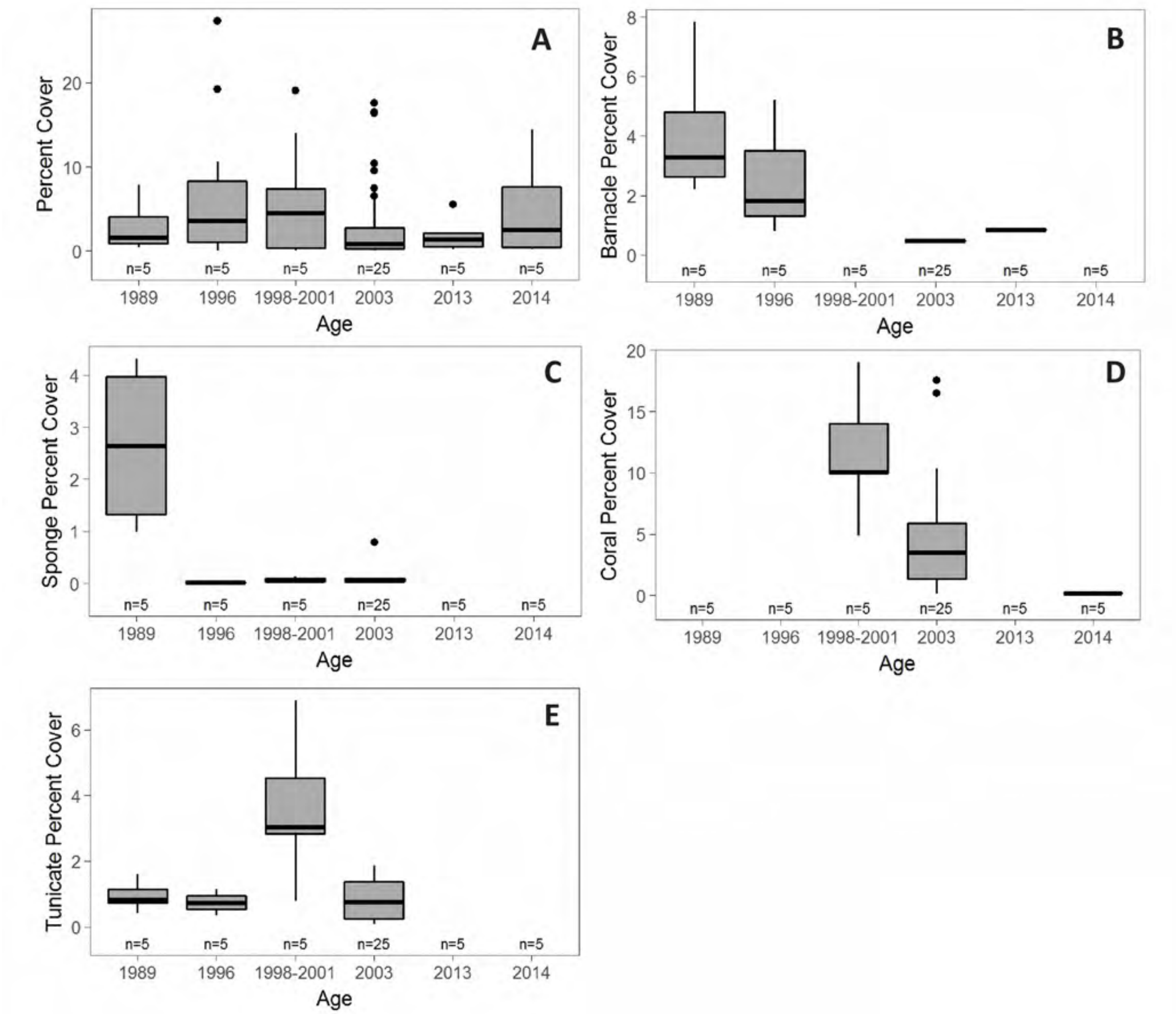


Figure 42. Benthic cover of rock (all volumes) over time of (A) Total Coverage (including Barnacle, Blue Mussel, Bryozoan, Crustose Coralline Algae, Coral, *Crepidula* spp., Macroalgae, Sponge, and Tunicate percent coverage), (B) Barnacle, (C) Sponge, and (D) Coral, and (E) Tunicate Coverage. This plot includes all reef volumes. Blue mussels were not plotted here since no blue mussels were picked up on rock during the video belt transects.

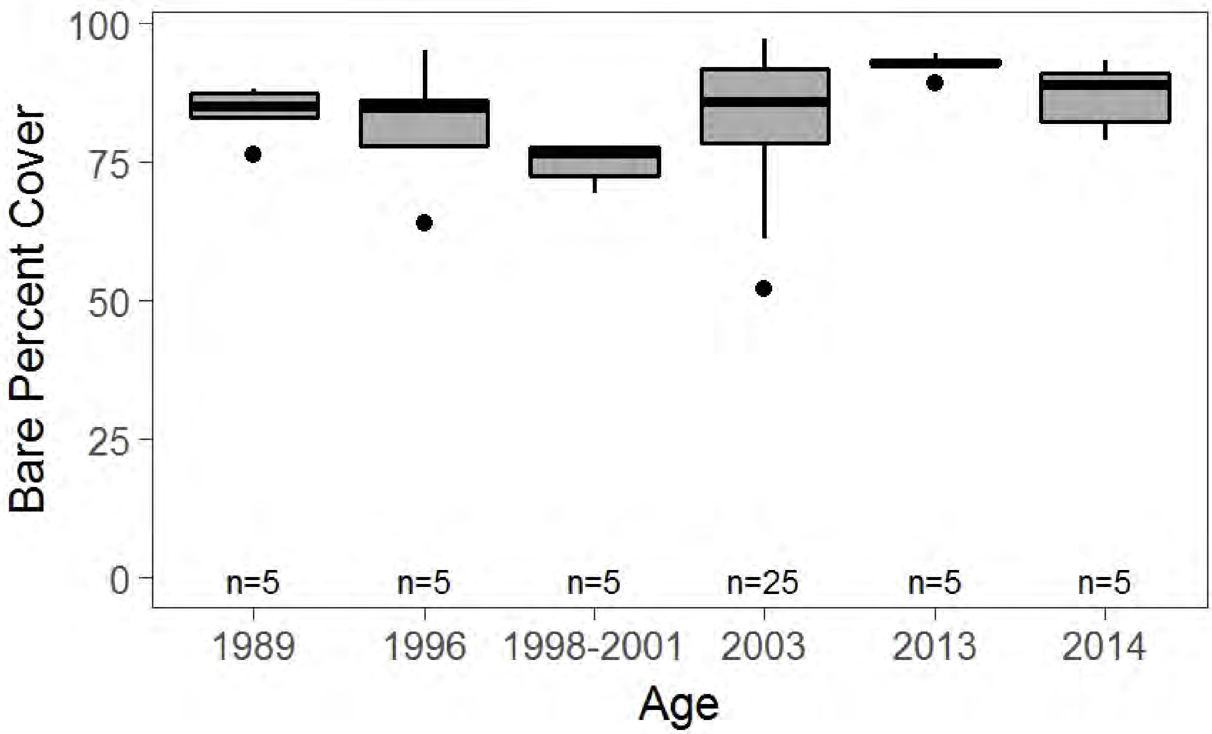


Figure 43. Percentage of bare space over time. This plot includes all rock reefs of all volumes of drops.

We deployed BRUVs to study the presence/absence of certain species based on age. However, visibility was poor on the 2003 rock drops when sampled and therefore we only had BRUV data for the 2013 and 2014 rock drops so no reef age analysis could not be completed.

We examined fish density on the different rock deployments over time regardless of the size of the deployment (Figure 44). This demonstrated that there appeared to be increasing densities of cunner over time, but significant decreases in black sea bass (p=0.007) and blackfish (p=0.019) after the first few years of deployment. This may be due to the initial and rapid coverage of the rock material by barnacles (H1 and H2) that were quickly reduced in density by the next time point (2003).

Next we wanted to control for the size of the rock drop over time to see if that changed the trends observed when grouping them all together. This however, did significantly reduce the number of time points that could be compared (Figure 45). While there was no trend for the cunner, a similar decrease in both black sea bass which was significant (p=0.04) and blackfish which was not significant over time was observed. One observation that is not apparent in these figures is that the black sea bass present on the youngest reefs were smaller than those present on the older reefs. This high density of smaller black sea bass on these younger reefs may explain the higher blackfish densities as well.

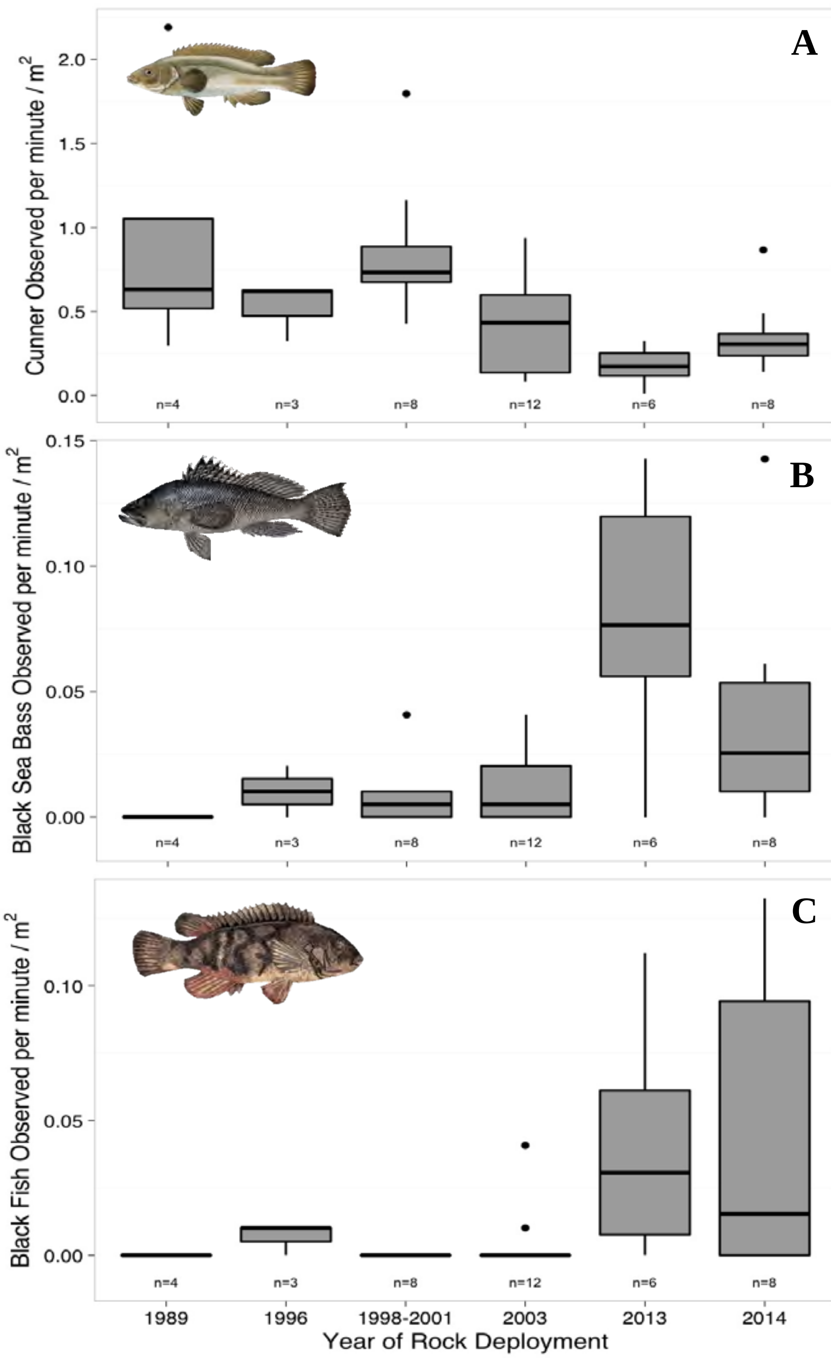


Figure 44. Fish density as a function of rock age of (A) cunner, (B) black sea bass, and (C) blackfish. (All reef volumes)

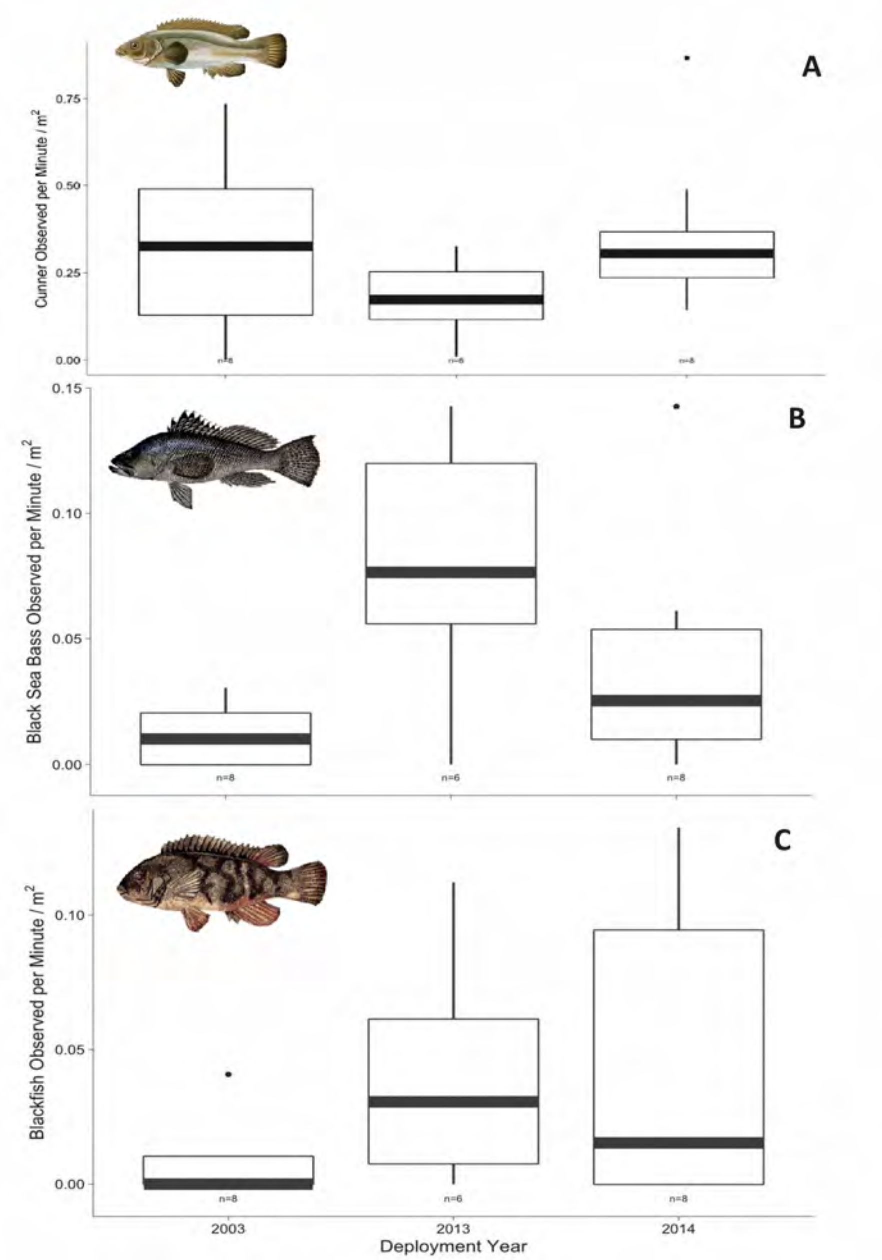


Figure 45. Fish density as a function of age of material controlling for rock dump size (3000-5000 m^2) for (A) cunner density, (B) black sea bass density, and (C) blackfish density.

Mean NASC observed on reefs deployed in 2003, 2013, and 2014 were 200 ($CV = 3.4$), 320 ($CV = 2.0$), and 470 ($CV = 1.6$) m^{2}nmi^{-2} respectively (Figure 46). However, no significant differences in mean NASC were detected among deployment years (KW-test; $p = 0.16$, $\chi^2_{(2)} = 3.6$). Likewise, there were no statistically significant pairwise differences among the distributions for each year ($D_{(2)} < 0.15$, $p > 0.05$; Figure 47). However, due to the relative proximity of two reefs deployed in 2013 and 2014 respectively and the difficulty in discriminating the two via echograms, it is likely that some NASC values are inappropriately labeled. To account for this potential error, the 2013 and 2014 reefs were pooled together (Figure 48). The grouped mean NASC on the 2013/2014 reefs was 420 ($CV = 3.2$) and was not statistically higher than the mean NASC on 2003 reefs (MWW test; $p = 0.93$).

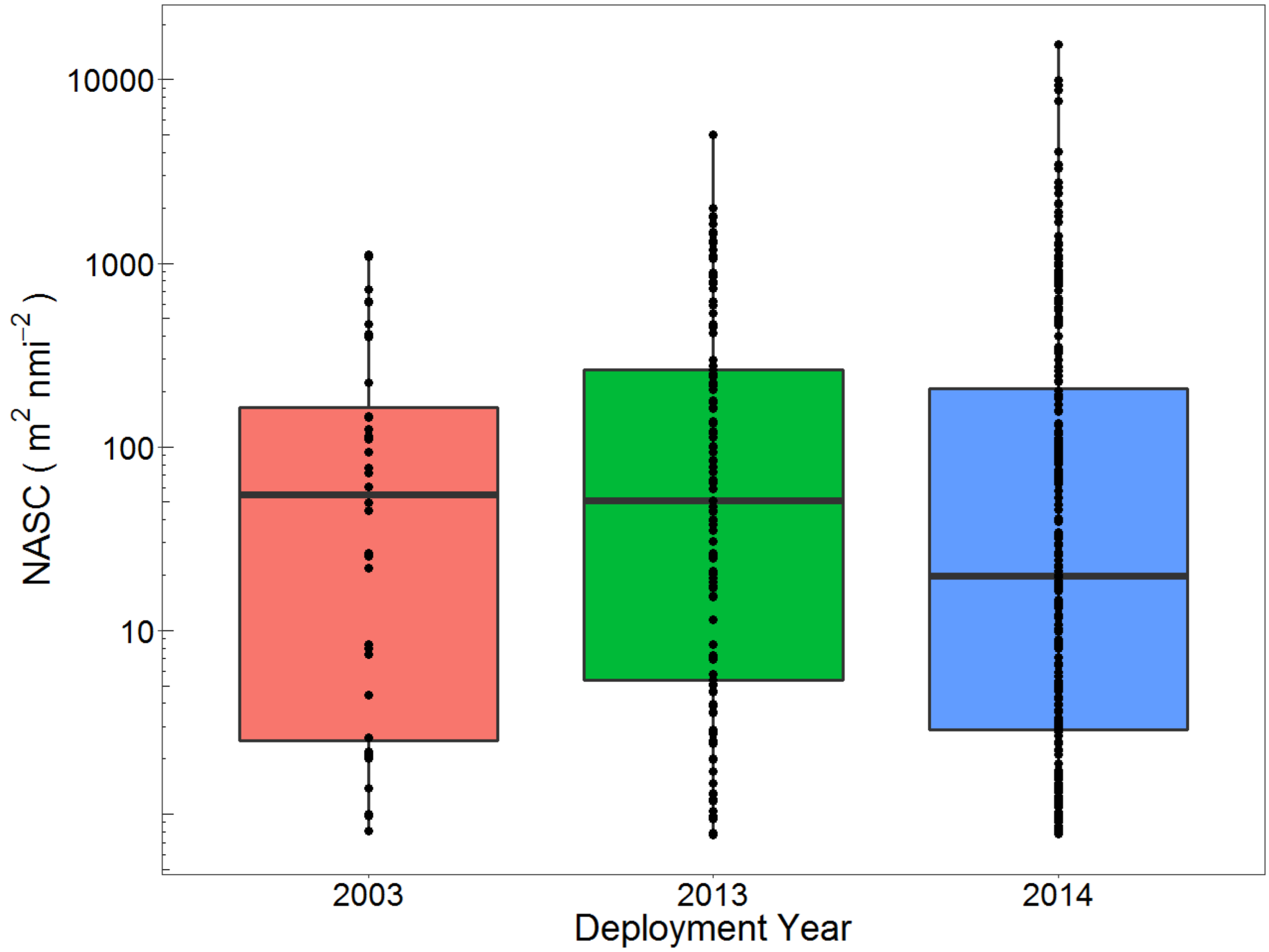


Figure 46. Observed NASC (m^2nmi^{-2}) on reefs deployed in 2003 (*N* = 40), 2013 (*N* = 113), and 2014 (*N* = 248). The solid line within each box represents the median. The extent of each vertical line represents the interquartile range. Each individual point represents a single NASC measurement.

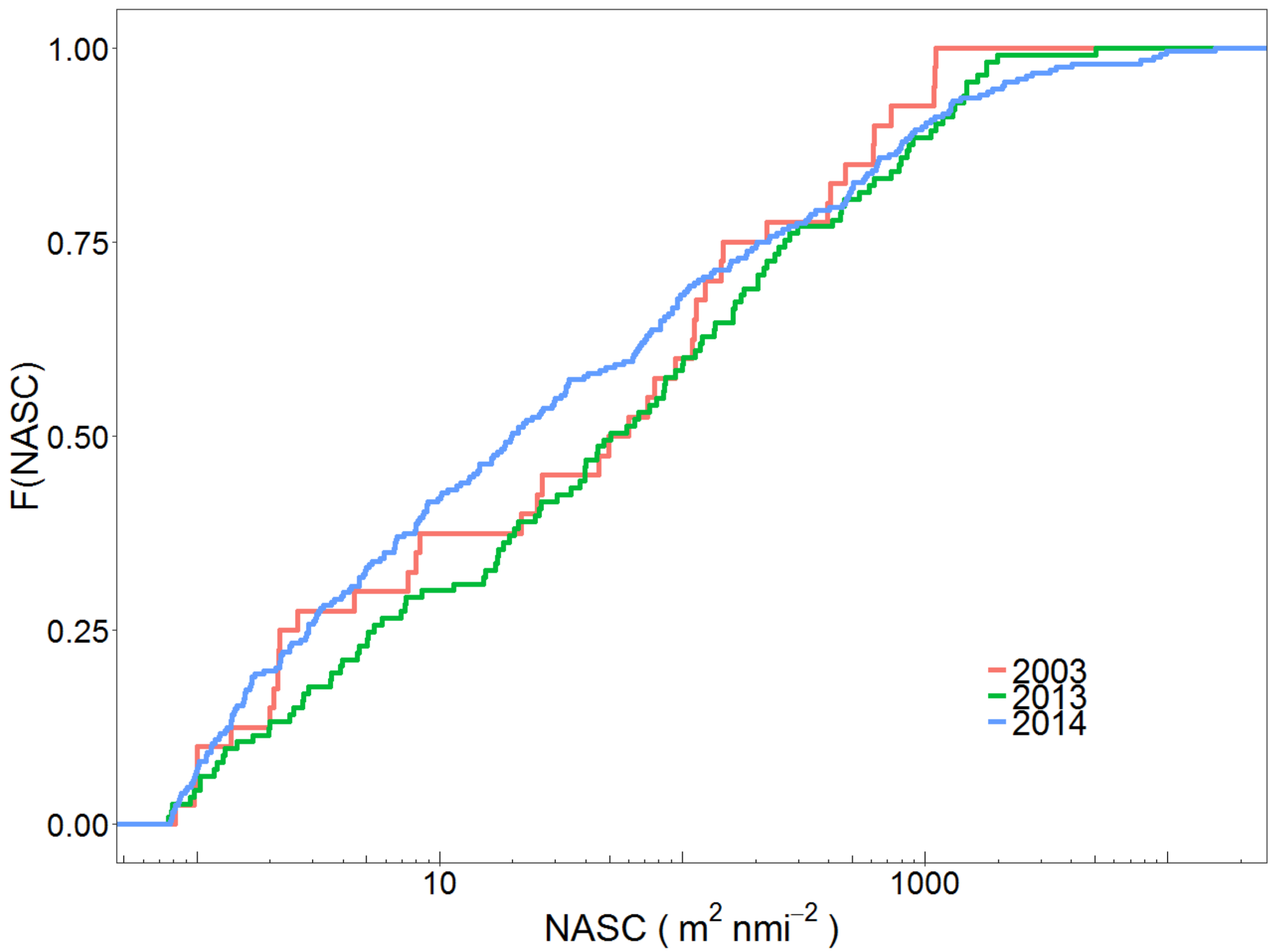


Figure 47. Empirical cumulative density function of NASC ($m^2 nmi^{-2}$) among reefs deployed in 20013, 2013, and 2014 (red, green, and blue respectively).

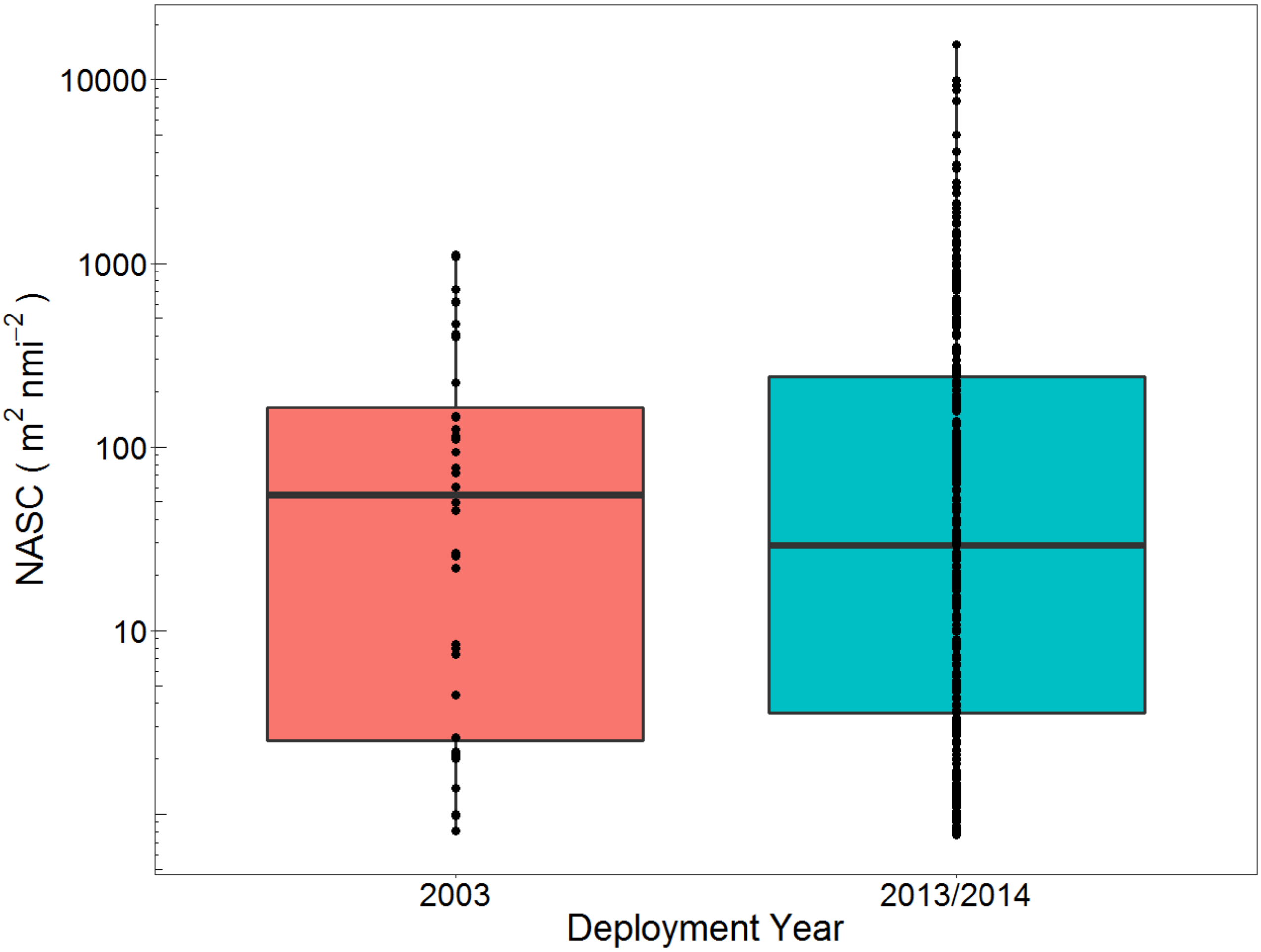


Figure 48. Observed NASC ($m^2 nmi^{-2}$) on reefs deployed in 2003 (N = 40) and 2013/2014 (N = 361). The solid line within each box represents the median. The extent of each vertical line represents the interquartile range. Each individual point represents a single NASC measurement.

Rugosity and interstitial space

The effect of rugosity (change in height of the reef relative to the horizontal dimension– which is a function of size of rock material) on fish density was examined for rock reefs. Using the Video Belt Transects, each rock reef was designated qualitatively as either low, medium or high rugosity (Figure 49). There was a trend in increasing cunner and blackfish density with increasing rugosity (Figure 49). However, only the cunner density were statistically higher with higher rugosity. The largest density of blackfish observed on the rock reefs was where the rugoisty was high. Similarly we were interested in what impact interstitial space would have on fish density. There were statistically greater densities of cunner as the interstitial space increased on the reefs and the greatest blackfish densities were on the reefs with high interstitial space however, this was not significant (Figure 50). Species diversity was highest with moderate and high interstitial space as well (Table 10).

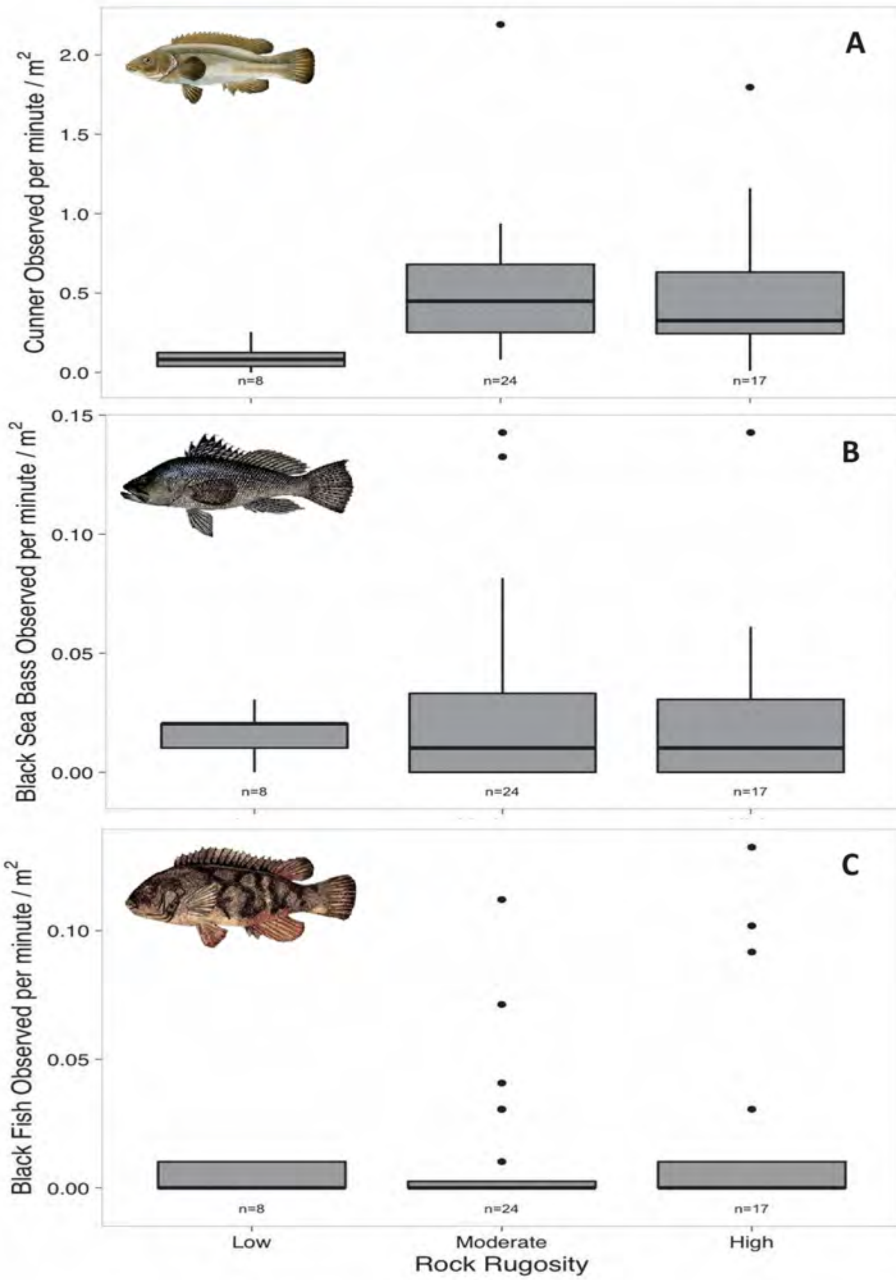


Figure 49. Fish density as a function of rock rugosity for (A) cunner, (B) black sea bass, and (C) blackfish.

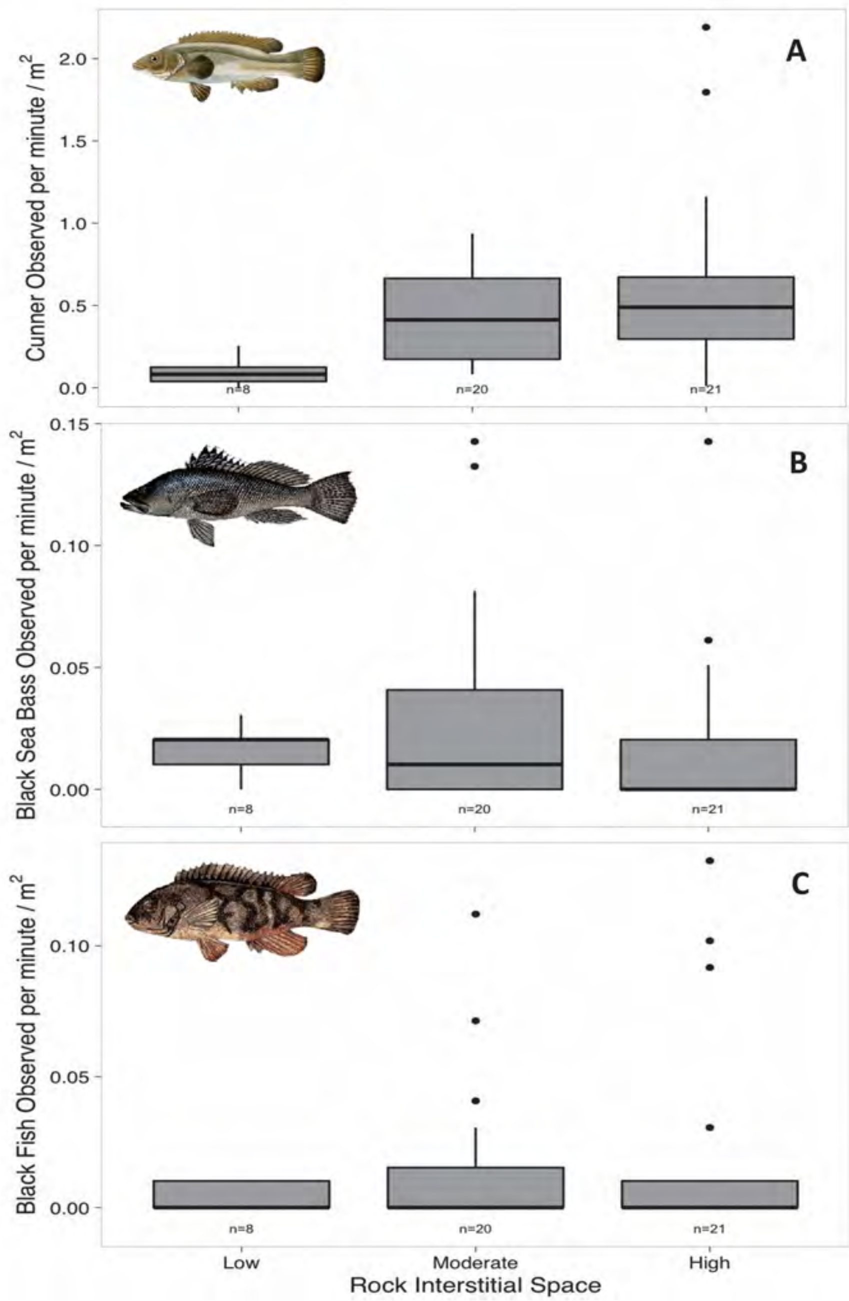


Figure 50. Fish density as a function of interstitial space for (A) cunner, (B) black sea bass, and (C) blackfish.

Table 10. Species list observed by divers as a function of interstitial space compiled from diver surveys.

	Rock Interstitial Space Amount		
Species	**Low**	**Moderate**	**High**
Cunner (*Tautogolabrus adspersus*)	X	X	X
Blackfish (*Tautoga onitis)*	X	X	X
Black Sea Bass (*Centropristis striata*)	X	X	X
Northern Sea Robin (*Prionotus carolinus*)		X	

Goby (*Gobiosoma spp.*)			X
Clearnose Skate (*Raja eglanteria*)	X		X
Gray Triggerfish (*Balistes capriscus*)		X	
Summer Flounder (*Paraclichthys dentatus*)		X	X
Butterfly Fish (*Chaetedon spp.*)		X	
Rock Gunnel (*Pholis gunnellus*)	X	X	
American Lobster (*Homarus americanus*)		X	X
Spider Crab (*Libinia* spp.)			X
Rock Crab (*Cancer irroratus)*		X	X
Common Sea Star (*Asterias rubens*)	X	X	X
Blue Mussels (*Mytlius edulis*)	X	X	X
Barnacles (Balanidae *spp.*)	X	X	X
Northern Star Coral (*Astrangia poculata*)	X	X	X
Purple-spined Sea Urchins (*Arbacia punctulata*)			X
Orange tunicate spp.	X	X	X
Yellow sponge spp.	X		X
Branching Brown Macroalgae spp.	X	X	X
Branching Red Macroalgae spp.		X	
Hydroid/Bryozoan spp.			X
Skate/Dogfish Egg Case			X
Brittle Star (*Ophiopholis spp.*)		X	X
Waved Whelk (*Buccinum undatum*)			X
Scale Worm (Polynoide spp.)		X	X

Conclusions

Multiple methods are needed for assessing the benthic community and fish associated with artificial reefs in New York coastal waters. Diver and camera surveys are needed to collect species-specific information, but active acoustic monitoring allows for quantitative comparisons to be more easily made due to the increased sampling capability. Passive acoustic monitoring provides a low-cost, high-temporal resolution sampling capability and also provided the only measurements of odontocete and human usage of the reef over day and night periods. Long-term monitoring of various reef sites would be useful as well as focused short-term studies investigating mesoscale or seasonal processes such as effect of fishing season on recreational or commercial species abundance at the reefs. Our recommendations and key findings are located at the beginning of the report.

Appendix A. Reef Sampling Overview

Table A1. Overview of sampled reef sites. Survey names started with "H" and "A" indicate Hempstead and Atlantic Beach Reefs respectively. "UID" stands for "unidentified" and represents any information that was not available and could not be derived from the study's observations. Single asterisks indicate a sample site that was not a listed reef. Double asterisks indicate a sampling site that was part of the large Atlantic Beach rock pile.

Survey Name	Date(s)	Material	Deployment Year	Volume(m^3)
H1	August-2014,April-2015,May-2015,June-2015	Rock	2013	3400
H2	August-2014, April-2015, May-2015,June-2015	Rock	2014	3500
H4	August-2014, May-2015	Vessel	2000	144
H5	June-2015	Concrete	1998	7536
H6	Jun-2015	Vessel	2000	315
H8*	July-2015	Rubble/Debris	UID	6600
H9	July-2015	Concrete	1998	4239
H10	July-2015	APC(?)	1996	1.5
H11	August-2015	Rock	2013	4400
H12	August-2015	Vessel	UID	96
H13	August-2015	Rock	2014	3500
H14	September-2015	Vessel	UID	315
A2	August-2014,May-2015,June-2015	Vessel	UID	483
A3**	August-2014,May-2015	Rock	1998-2001	742500(west)
A4	August-2014,April-2015,July-2015	Rock	2003	3200
A6**	August-2014,April-2015,August-2015	Rock	1998-2001	742500(center)
A7	June-2015	Rock	2003	1100
A8	July-2015	Vessel	UID	322.5
A9	July-2015	Rock	2003	2100
A11	August-2015	Rock	2003	4300
A12	August-2015	Vessel	Vessel	300
A13**	September-2015	Rock	1998-2001	742500(east)
A14	May-2015,Sep-2015	Rock	2003	6400

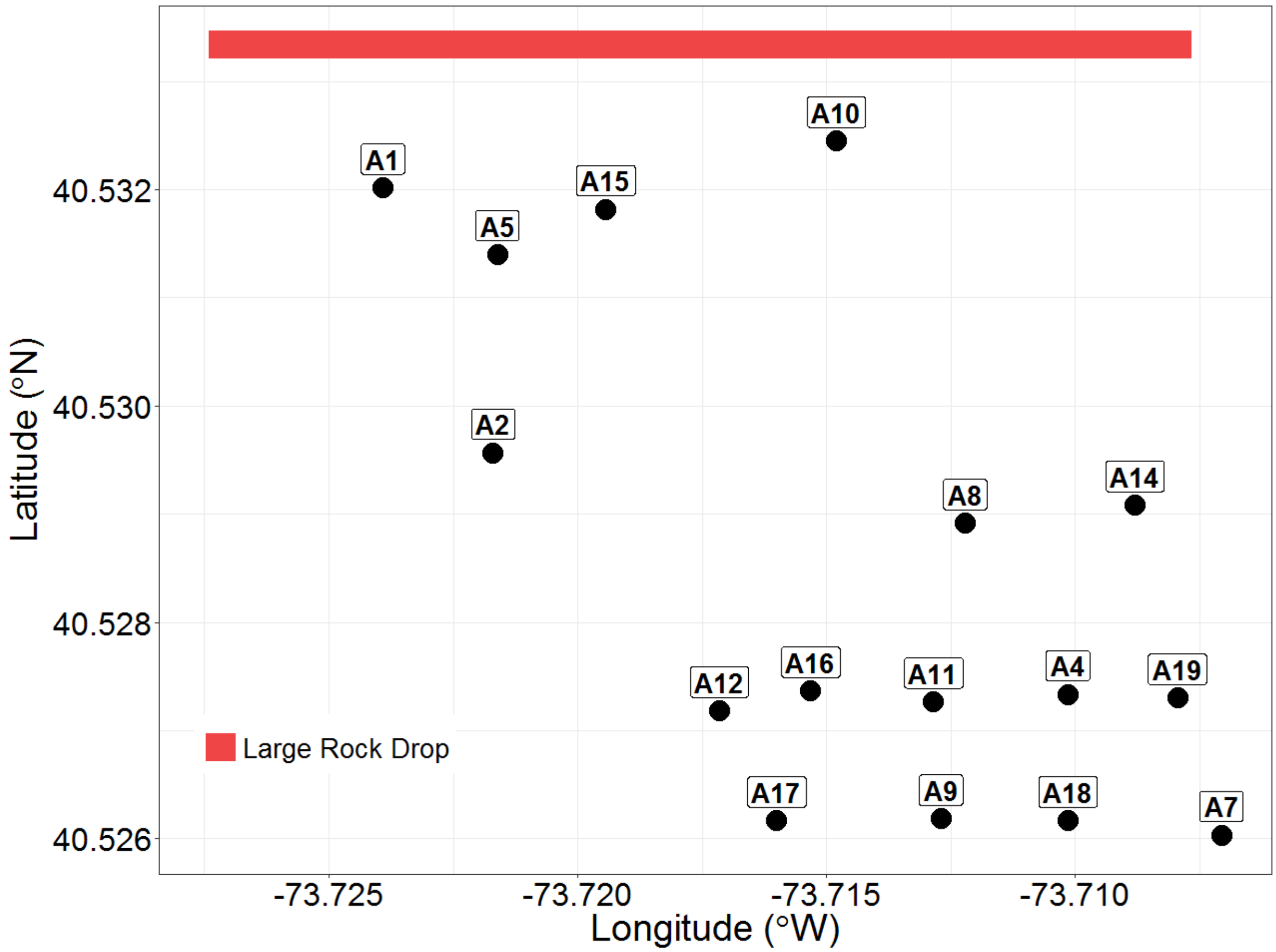


Figure A1. Overview map of all reef stations at the Atlantic Beach Reef.

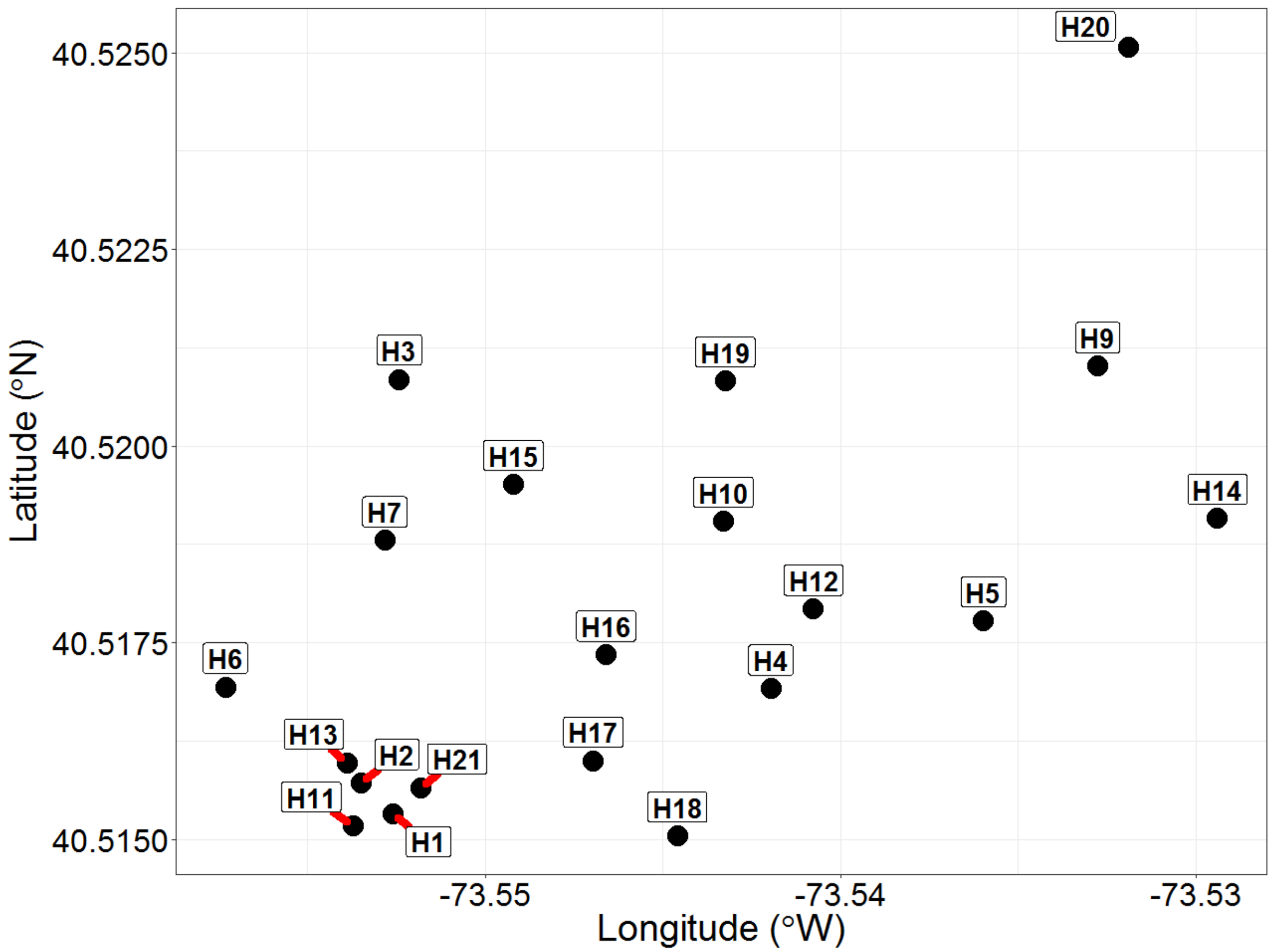


Figure A2. Overview map of all reef stations at the Hempstead Reef.

Table A4. Master list of all Atlantic Beach and Hempstead reef sites as provided to the project by the DEC.

DEC Reference Name	Survey Name	Lat (Deg.)	Lon (Deg.)	Year Drop	Material	Volume (m^3)
H1	H6	40.51693333	-73.55731667	1998	Trawler (metal?)	180
H2	H3	40.52085	-73.55241667	UID	"Rubble"	2.25
H3	H7	40.5188	-73.55283333	UID	"Rubble"	2.25
H4	H15	40.51951667	-73.54921667	UID	"Rubble"	2.25
H5	H16	40.51735	-73.5466	UID	"Rubble"	2.25
H6	H17	40.516	-73.54696667	UID	"Rubble"	2.25
H7	H18	40.51505	-73.5446	UID	"Rubble"	2.25
H8	H19	40.52083333	-73.54325	1996	APC Group (2?)	UID
H9	H10	40.51905	-73.5433	1996	APC Group (2?)	1.5
H10	H12	40.51793333	-73.54076667	UID	"Vessel"	96
H11	H4	40.51691667	-73.54196667	2000	2x Steel Barges (end-to-end)	144
H12	H5	40.51778333	-73.53598333	1998	Concrete (Bridge Slab)	7536
H13	H9	40.52101667	-73.53276667	1998	Concrete (Bridge Slab)	4239
H14	H20	40.52506667	-73.5319	1989	Wood (Drydock)	UID
H15	H14	40.51908333	-73.5294	UID	Steel Barge	315
H16	H11	40.515175	-73.553725	2013	Redrock	4400
H17	H1	40.515325	-73.5526	2013	Greyrock	3400
H18	H21	40.51565833	-73.55181667	2013	Greyrock	3700
H19	H13	40.515975	-73.5539	2014	80% Red Rock, 20% Red Gravel Sand	3500
H20	H2	40.51571667	-73.55349167	2014	Redrock	3500
A1	A1	40.53201667	-73.72391667	UID	Rock	UID
A2	A5	40.5314	-73.72161667	UID	Barge	144
A3	A2	40.52956667	-73.7217	UID	Barge	483
A4	A15	40.53181667	-73.71943333	UID	Barge	345
A5	A10	40.53245	-73.7148	UID	Barge	273
A6	A12	40.52718333	-73.71715	UID	Barge	30
A7	A16	40.52736667	-73.71531667	2003	Rock	1100
A8	A17	40.52616667	-73.716	2003	Rock	4300
A9	A8	40.52891667	-73.71221667	UID	Barge	322.5
A10	A11	40.52726667	-73.71285	2003	Rock	4300
A11	A9	40.52618333	-73.7127	2003	Rock	2100
A12	A4	40.52733333	-73.71015	2003	Rock	3200
A13	A18	40.52616667	-73.71015	2003	Rock	3200
A14	A14	40.52908333	-73.7088	2003	Rock	6400
A15	A19	40.5273	-73.70795	2003	Rock	2100
A16	A7	40.52603333	-73.70706667	2003	Rock	1100
ABROCK	A6*	40.53333333	-73.70765	1998-2001	Rock	1800 yd long
ABROCK	A3*	40.53333333	-73.717525	1998-2001	Rock	1800 yd long
ABROCK	A13*	40.53333333	-73.7274	1998-2001	Rock	1800 yd long

Appendix B. Sidescan images of reef sites at the Atlantic Beach and Hempstead Reefs. Note that the drydock (**H20**) is not present since it was not sampled during acoustic surveys. Likewise, a rubble reef (**H7**) is also missing due to no valid identification in any of the sidescan surveys.

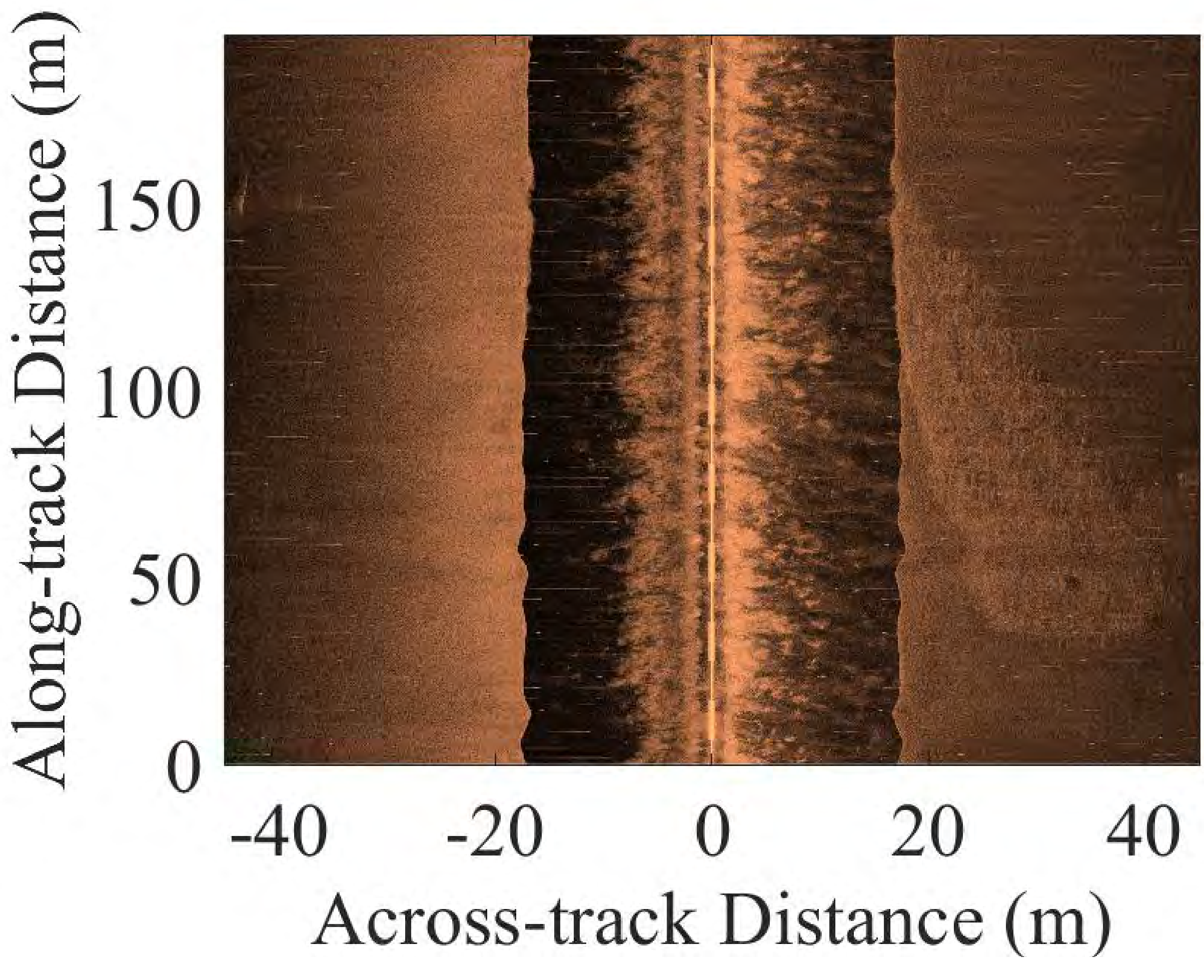


Figure B1. Rock reef (**A1**) at the Atlantic Beach Reef deployed at an unknown date.

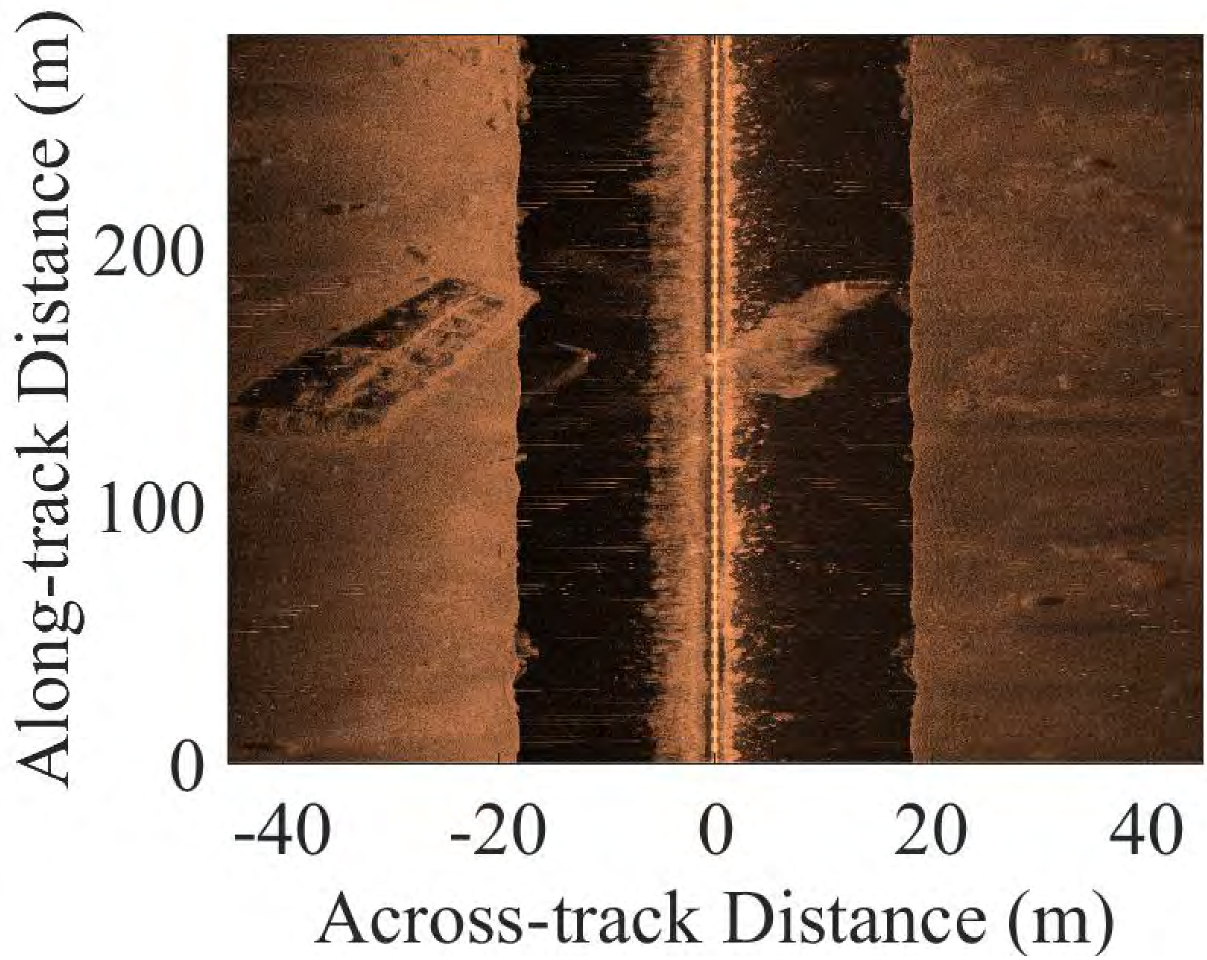


Figure B2. A 150 ft. barge (**A2**) at the Atlantic Beach Reef which was deployed at an unknown date.

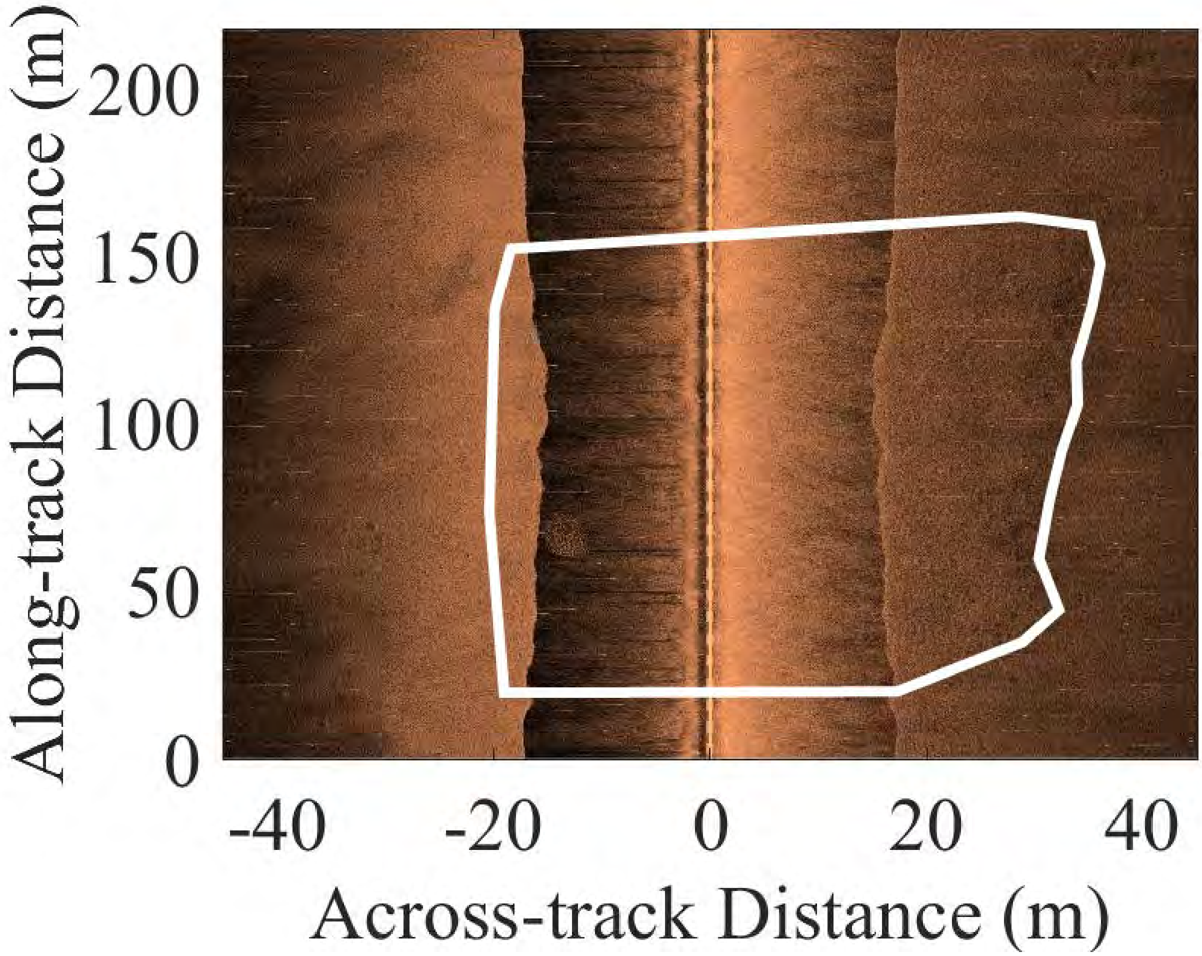


Figure B3. A rock reef (**A4**) deployed at the Atlantic Beach Reef which was deployed in 2003. The white box indicates the approximate area of the reef which was passed over directly by the boat in most surveys.

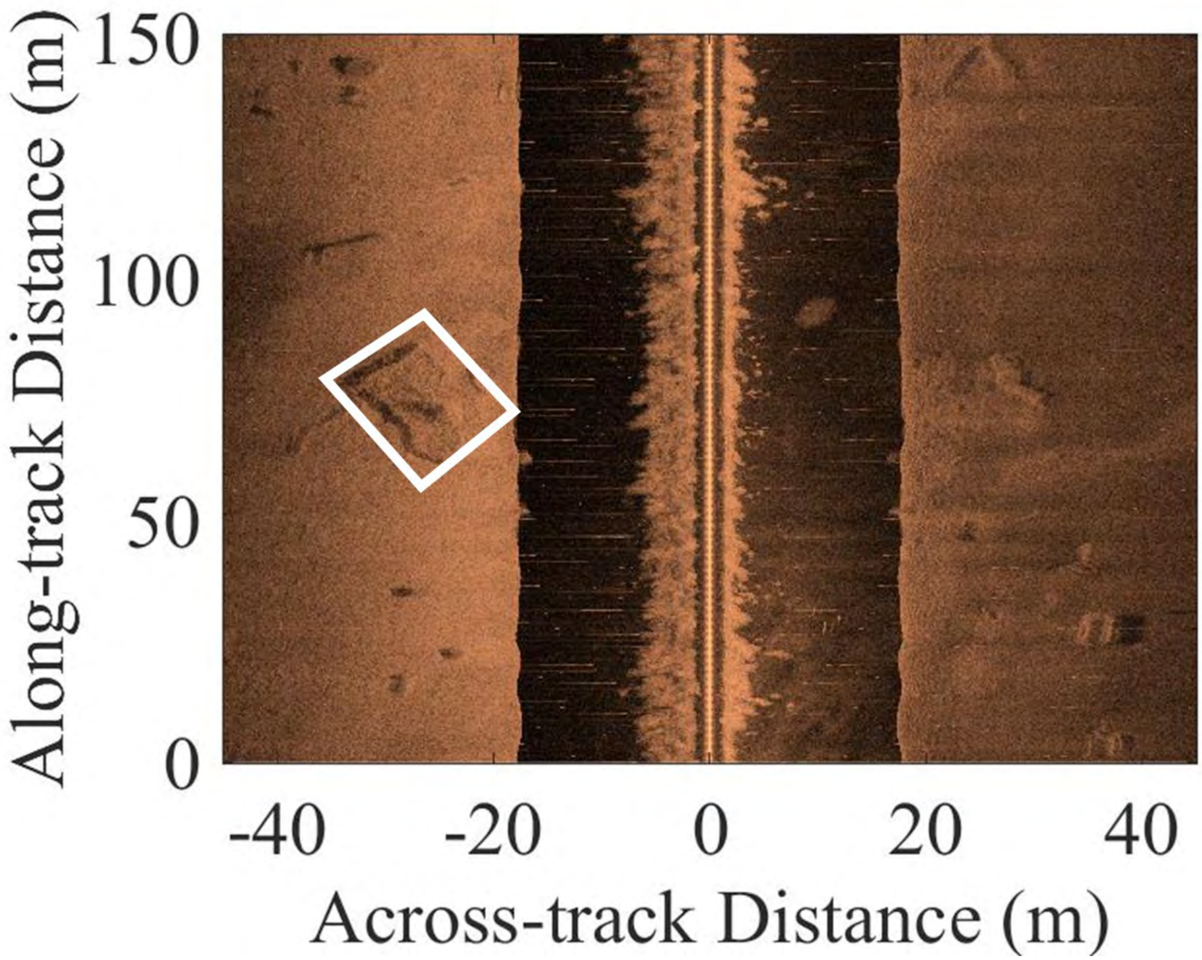


Figure B4. An 80 ft. barge (**A5**) at the Atlantic Beach Reef which was deployed at an unknown date. The white box indicates the outline of the barge.

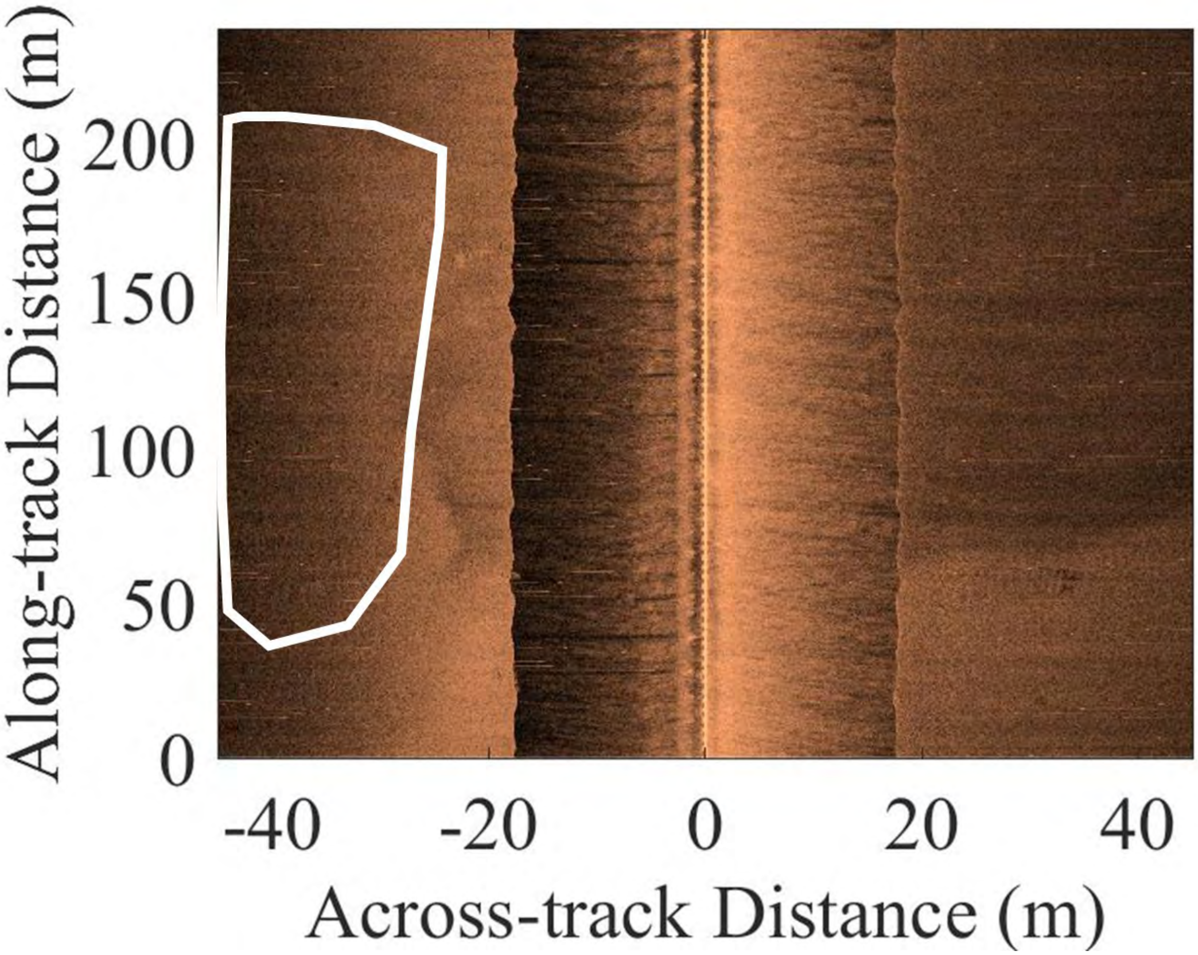


Figure B5. A rock reef (**A7**) located at the Atlantic Beach Reef which was deployed in 2003.

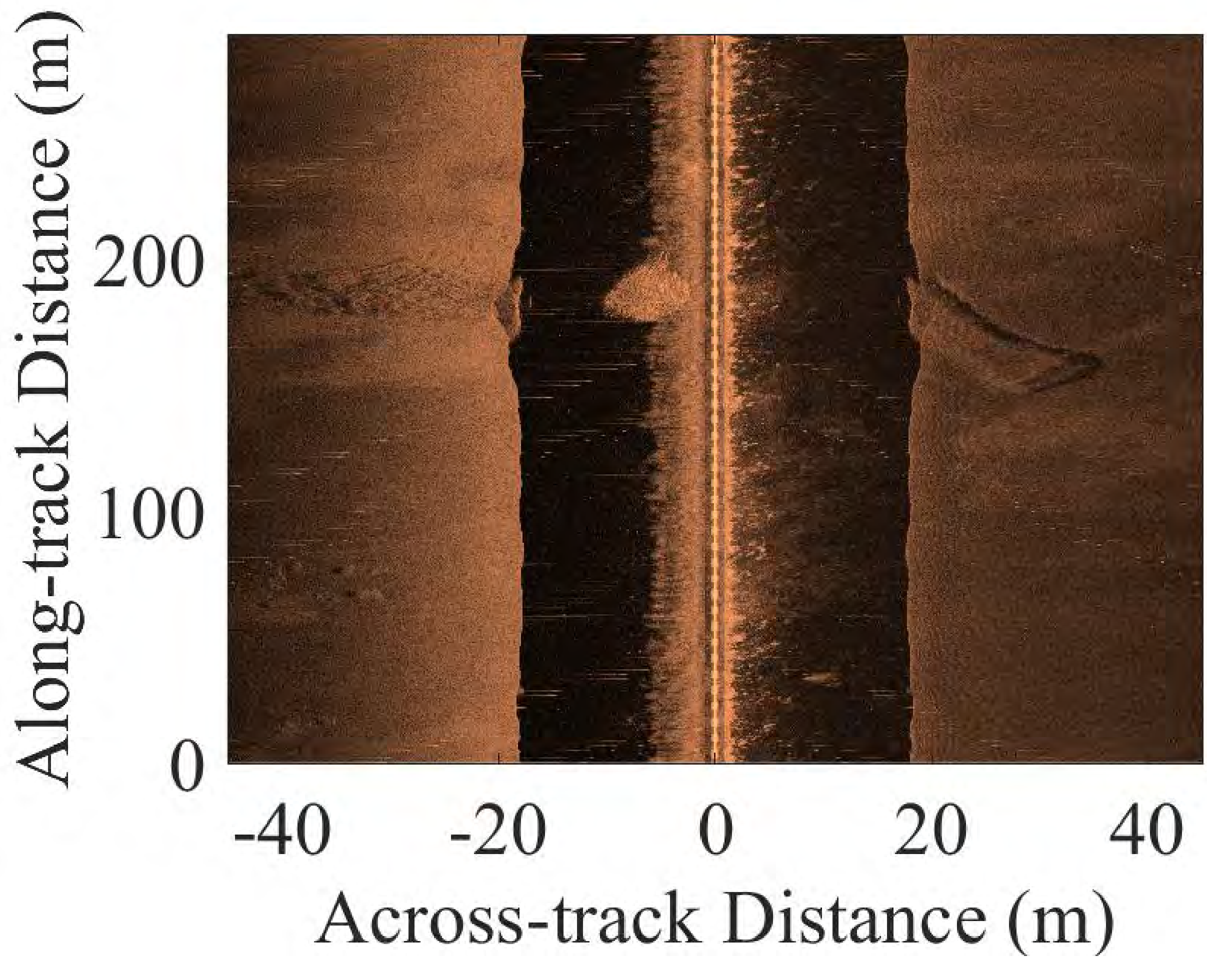


Figure B6. A 140 ft. barge (**A8**) at the Atlantic Beach Reef which was deployed at an unknown date.

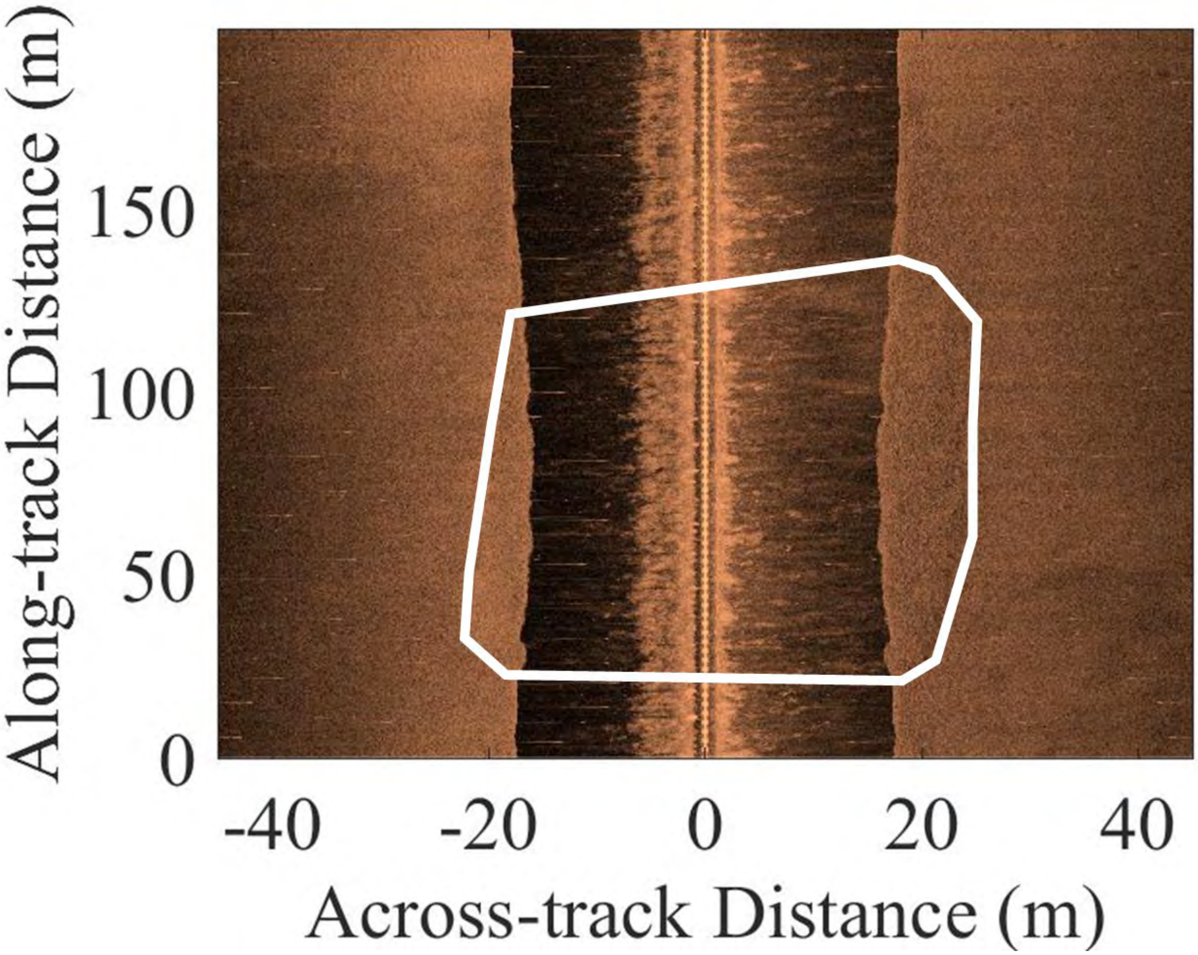


Figure B7. A rock reef (**A9**) at the Atlantic Beach Reef which was deployed in 2003.

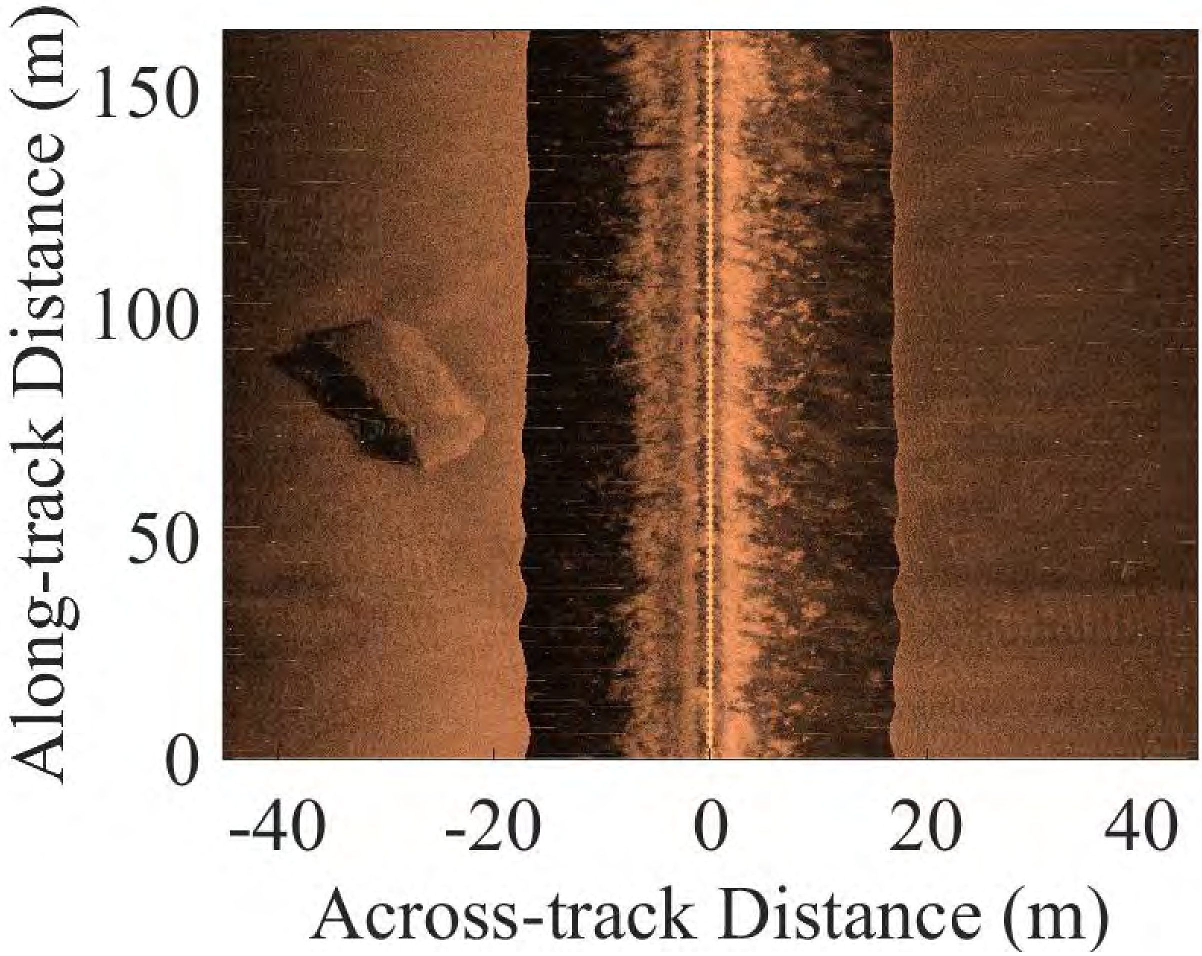


Figure B8. An 85 ft. barge (**A10**) at the Atlantic Beach Reef which was deployed at an unknown date.

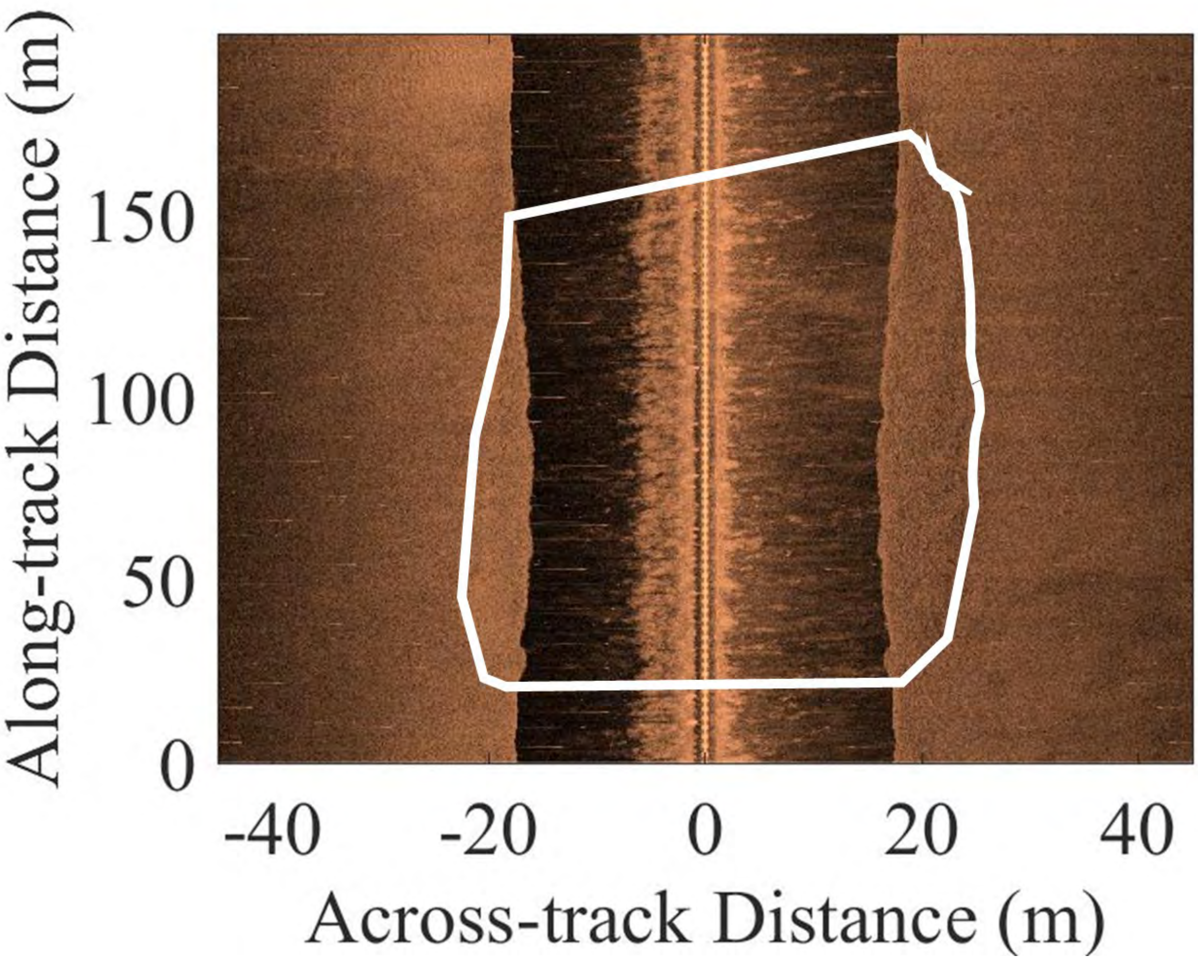


Figure B9. A rock reef (**A11**) at the Atlantic Beach Reef which was deployed in 2003.

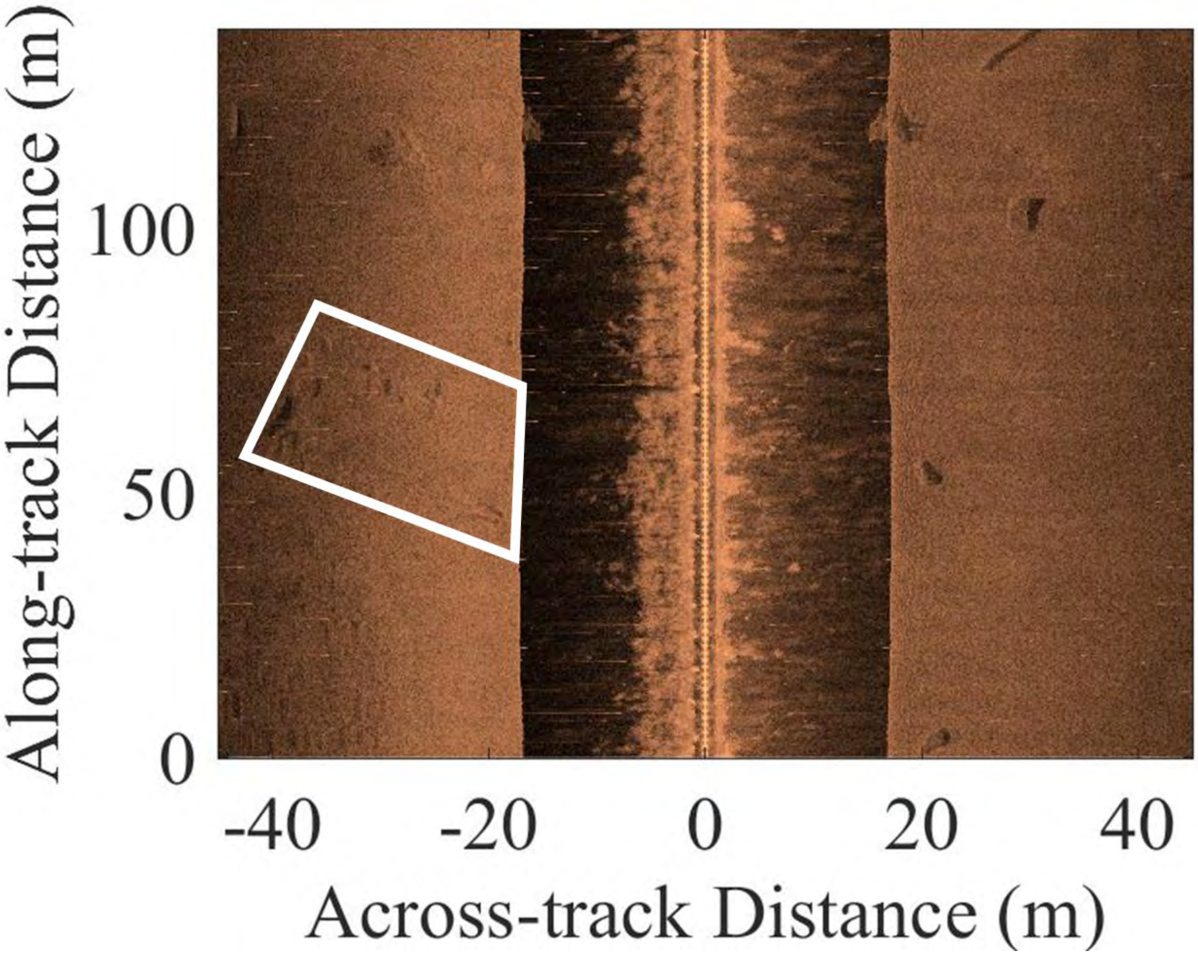


Figure B10. A 100 ft. barge (**A12**) at the Atlantic Beach Reef which was deployed at an unknown date. There is some uncertainty as to the identification of this reef; however, it is at the reported deployment coordinates and was mostly buried during the diver survey.

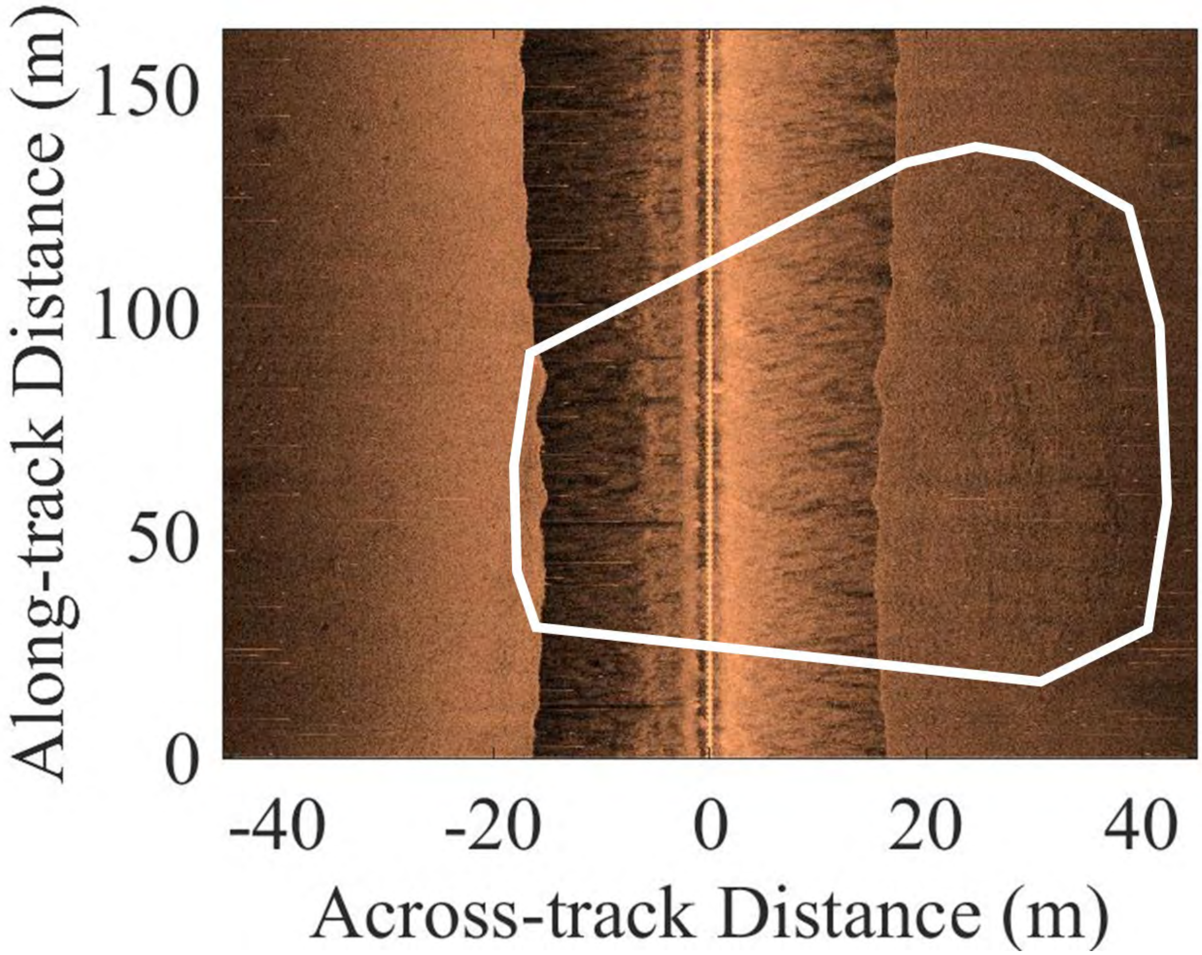


Figure B11. A rock reef (**A14**) at the Atlantic Beach Reef which was deployed in 2003.

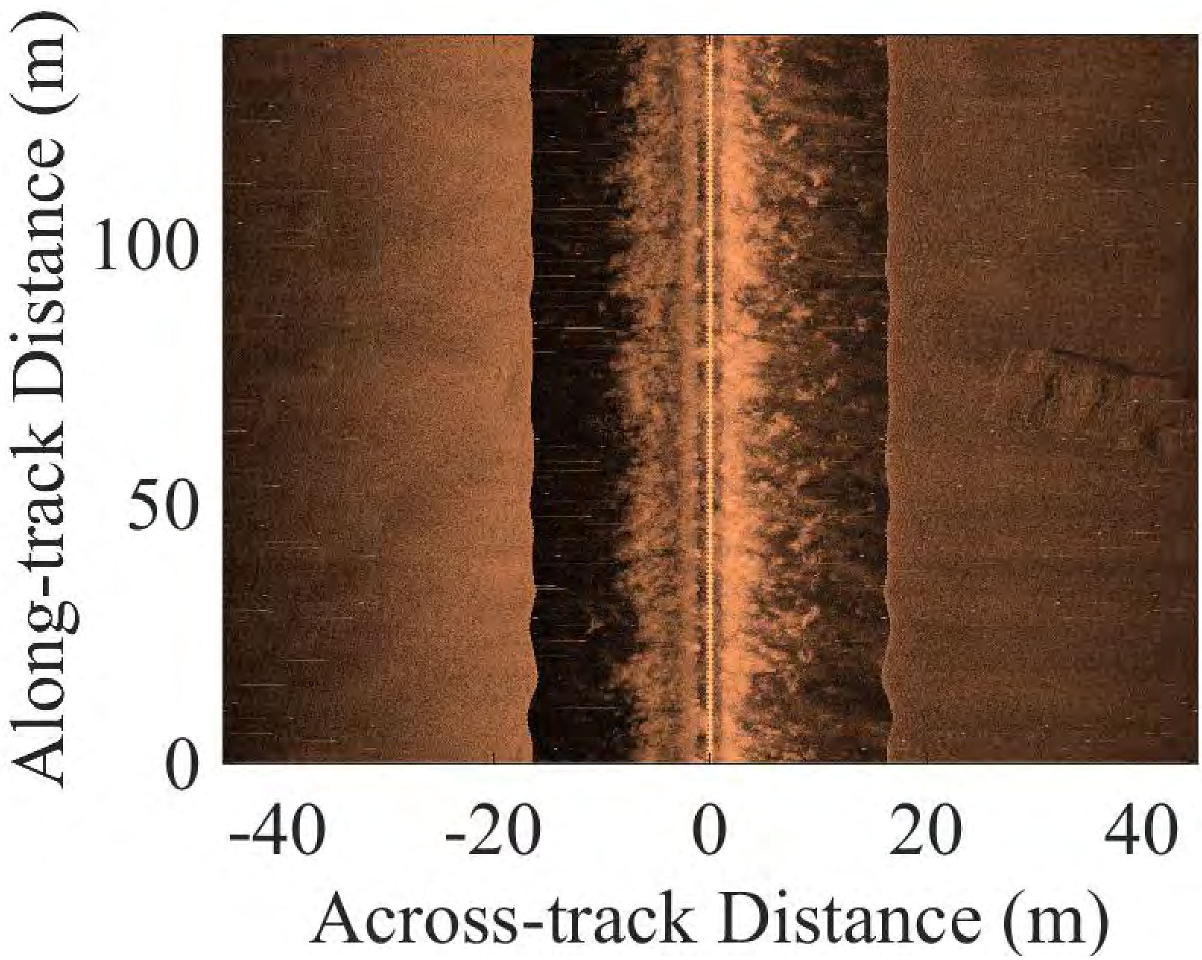


Figure B12. The edge of a 150 ft. barge (**A15**) at the Atlantic Beach Reef which was deployed at an unknown date.

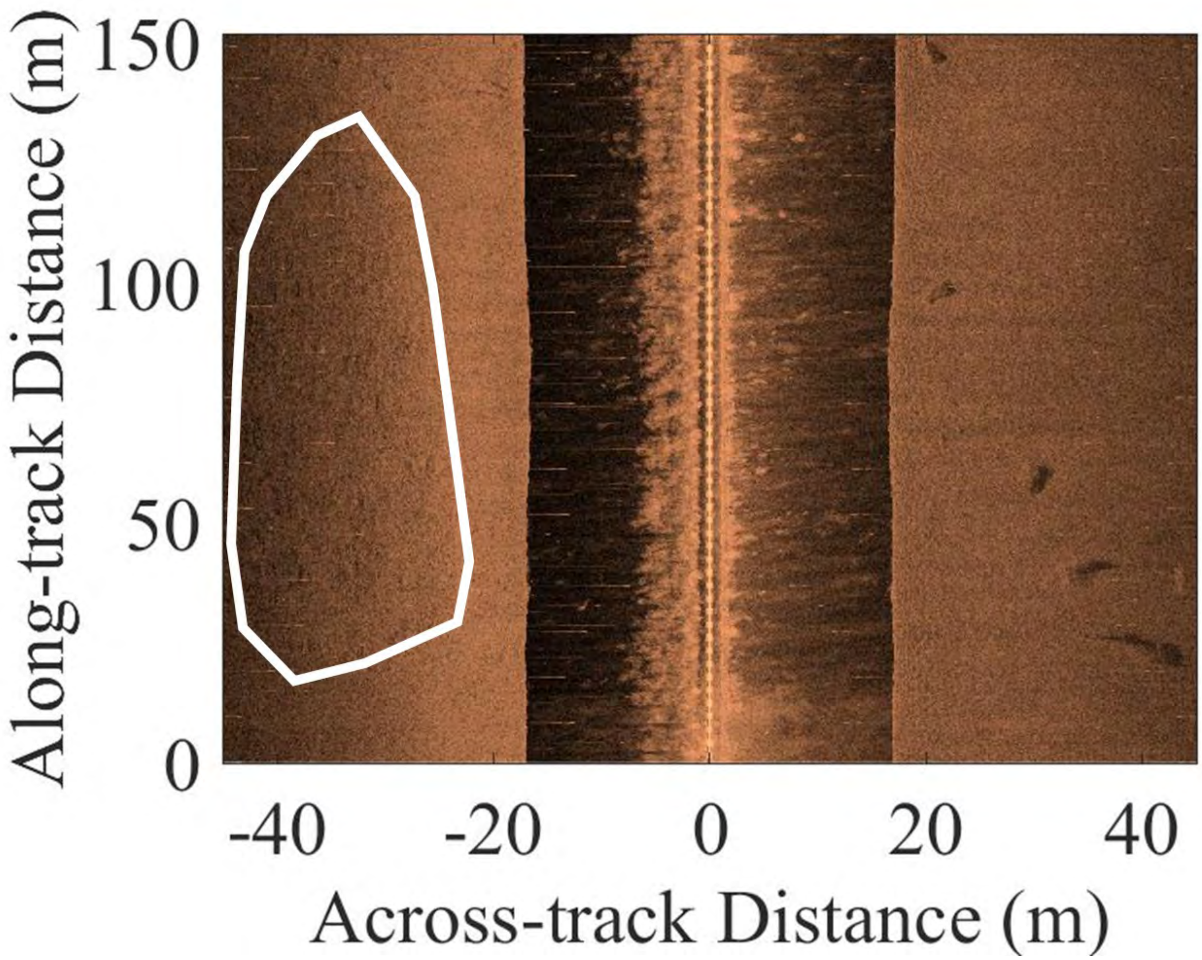


Figure B13. A rock reef (**A16**) at the Atlantic Beach Reef which was deployed in 2003.

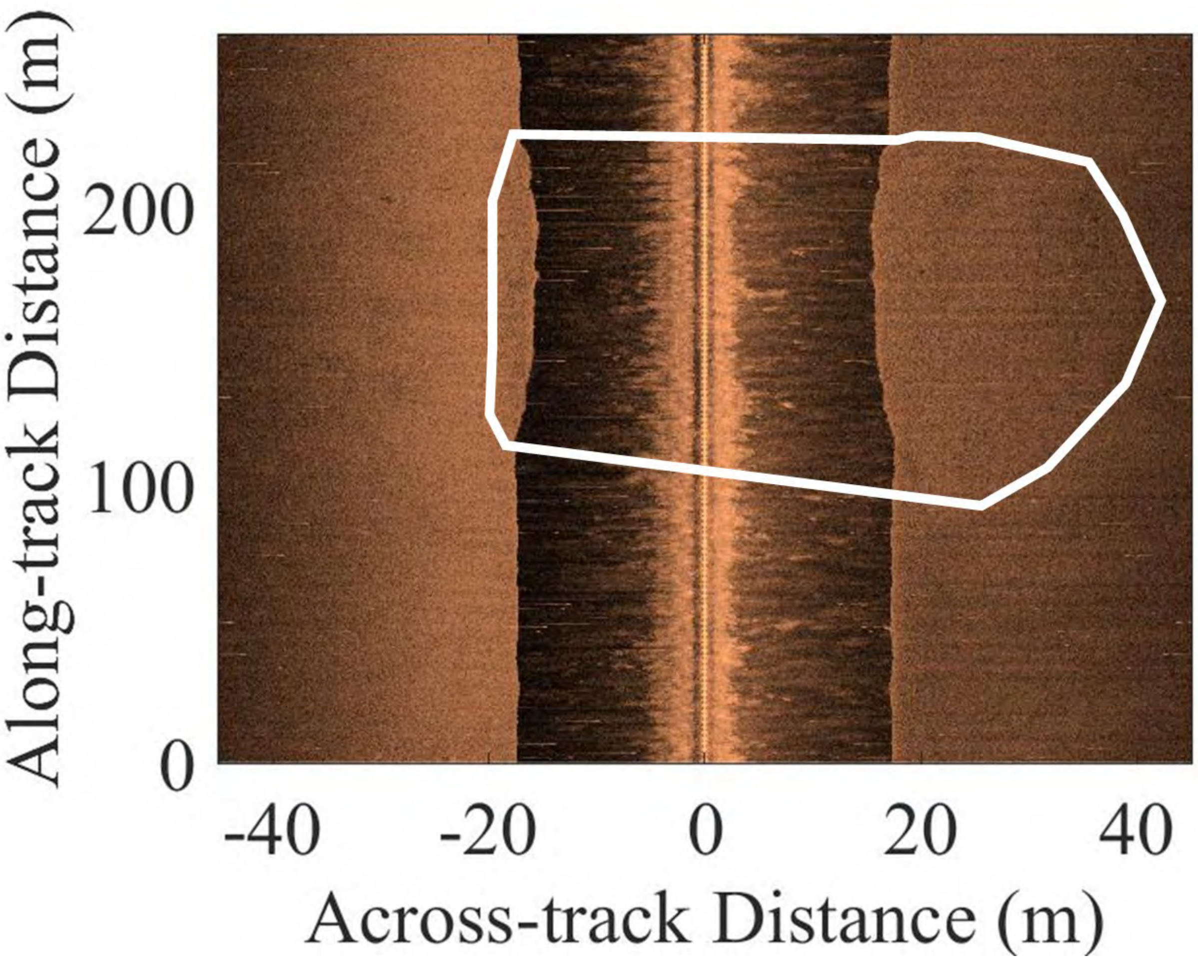


Figure B14. A rock reef (**A17**) at the Atlantic Beach Reef which was deployed in 2003.

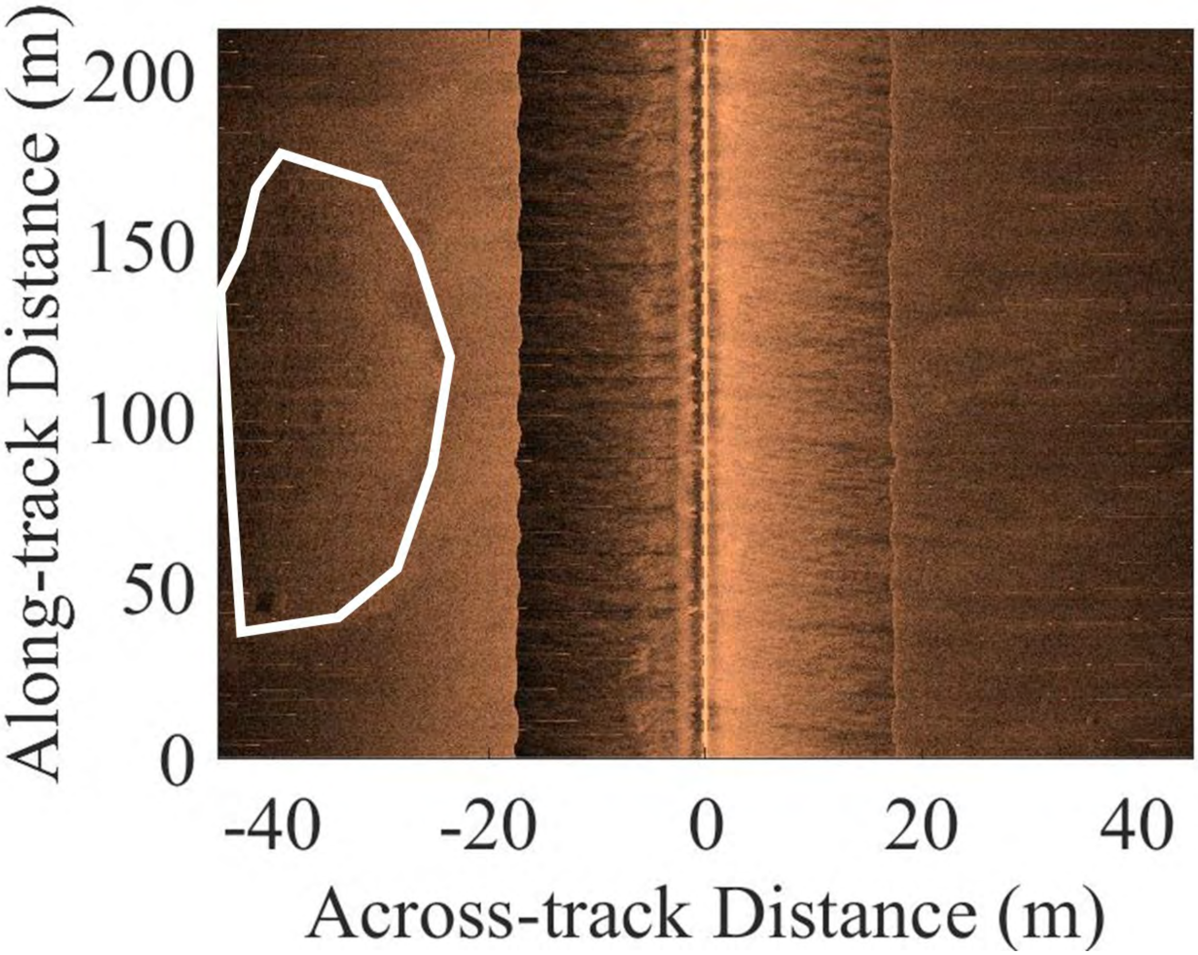


Figure B15. A rock reef (**A18**) at the Atlantic Beach Reef which was deployed in 2003.

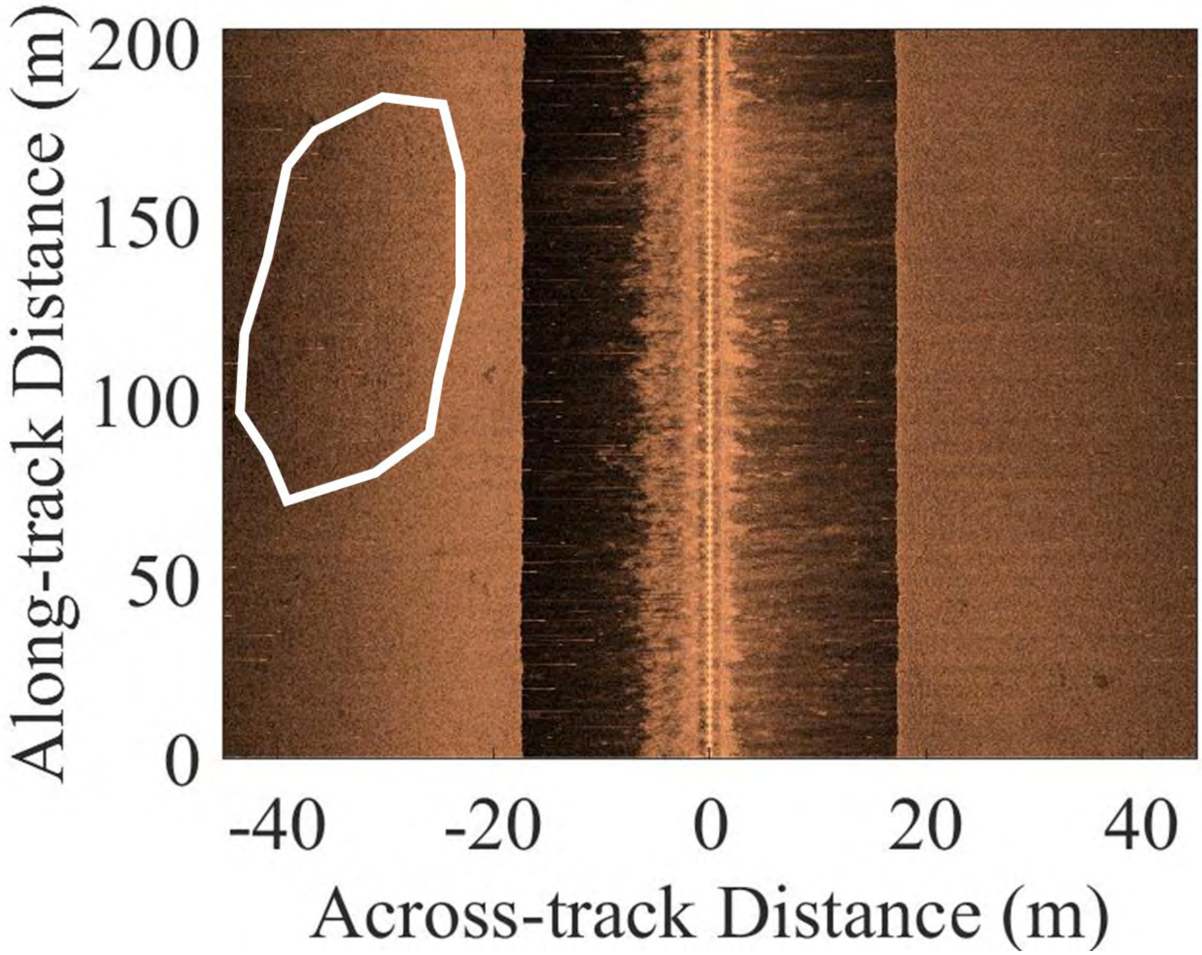


Figure B16. A rock reef (**A19**) at the Atlantic Beach Reef which was deployed in 2003.

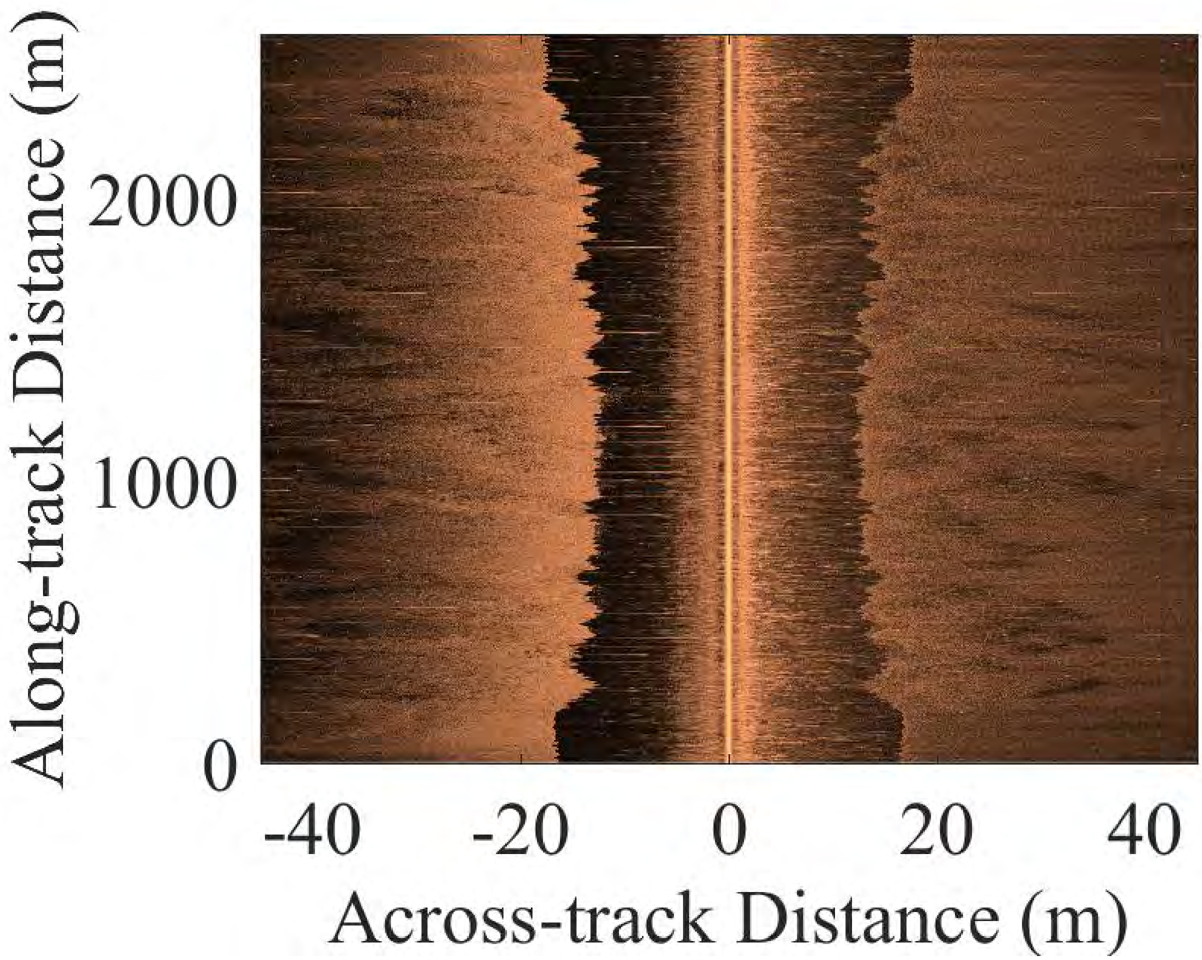


Figure B17. The large rock drop (**A3*, A6*, A13***) at the Atlantic Beach Reef which was deployed between 1998 and 2001.

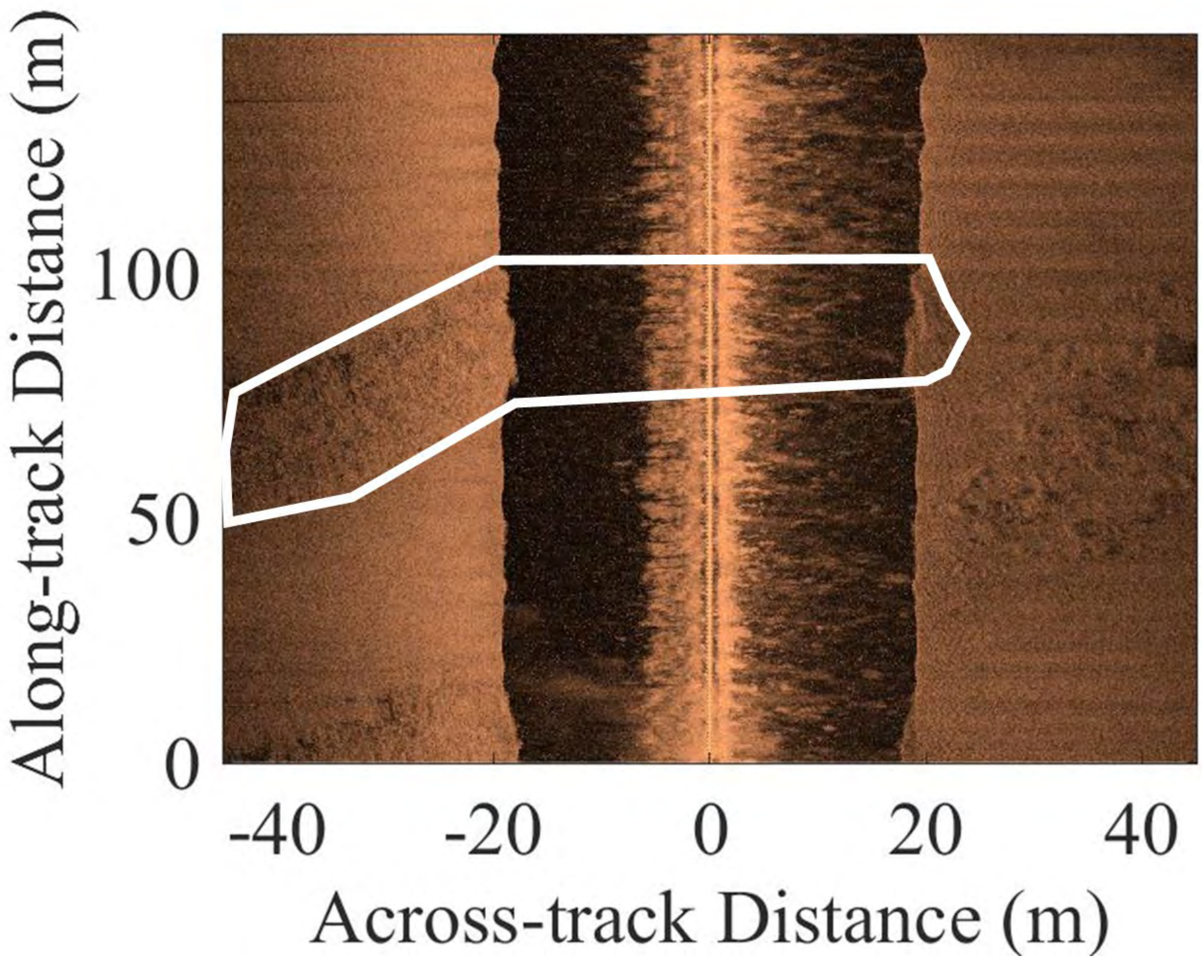


Figure B18. A greyrock reef (**H1**) at the Hempstead Reef which was deployed in 2013.

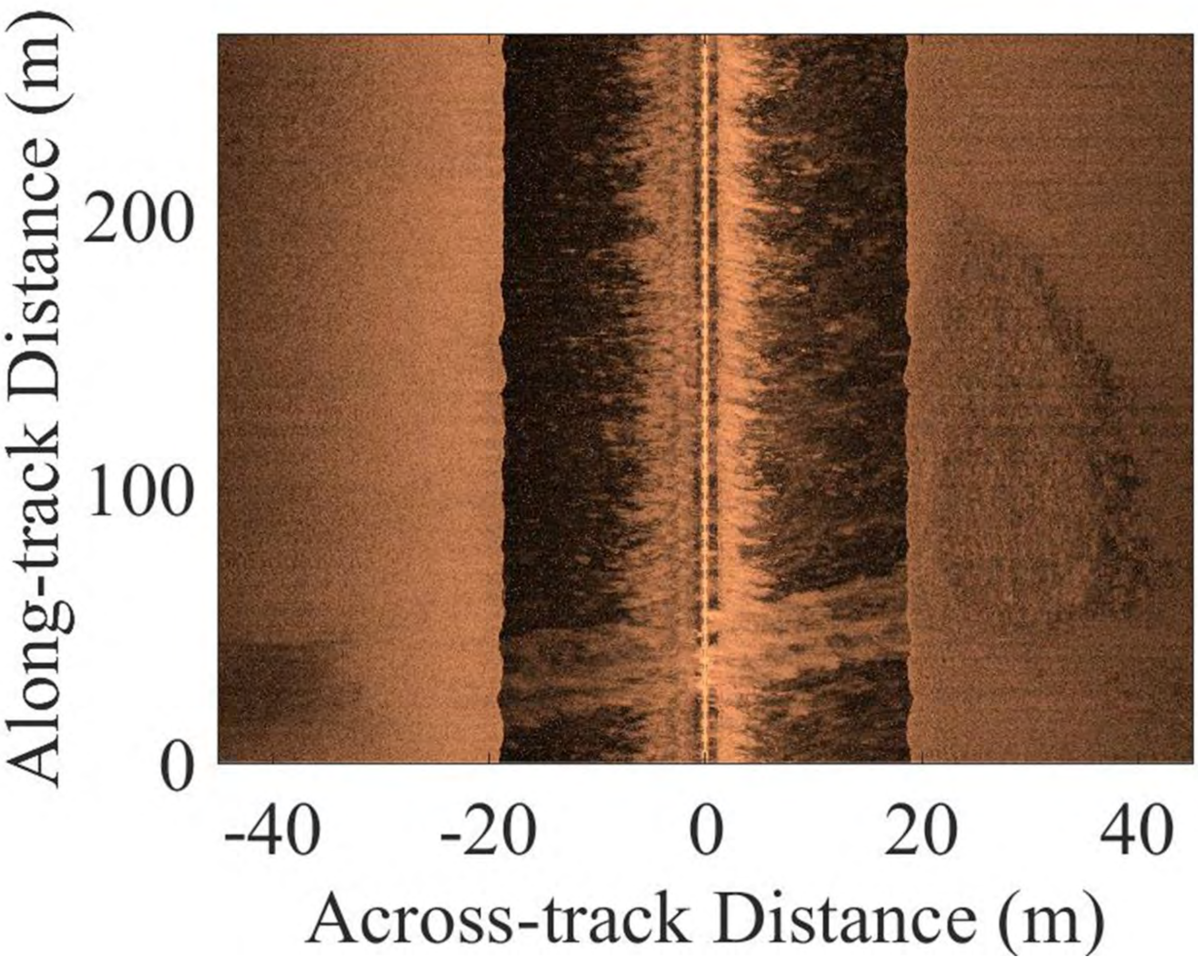


Figure B19. A redrock reef (**H2**) at the Hempstead Reef which was deployed in 2014.

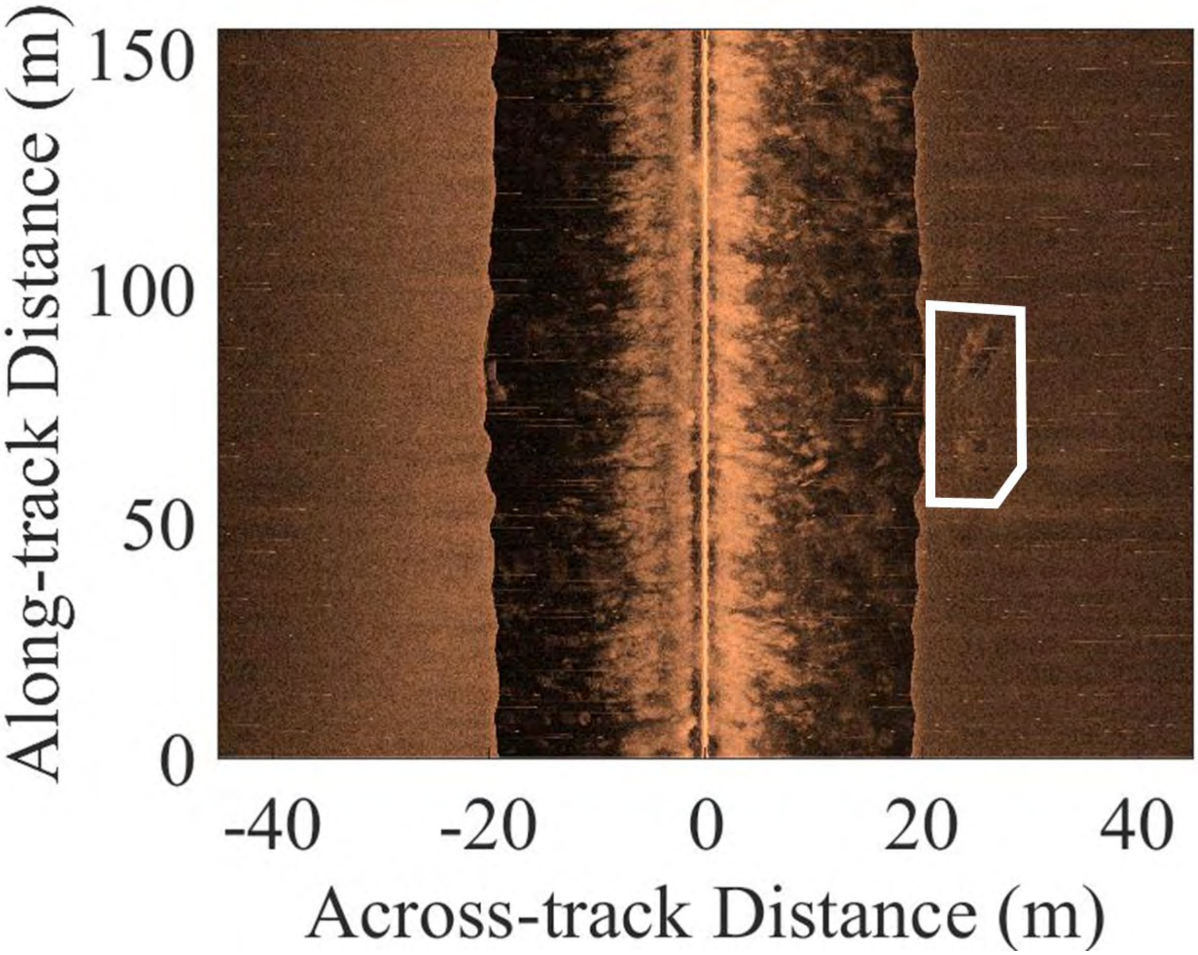


Figure B20. A rubble reef (**H3**) at the Hempstead Reef which was deployed at an unknown date.

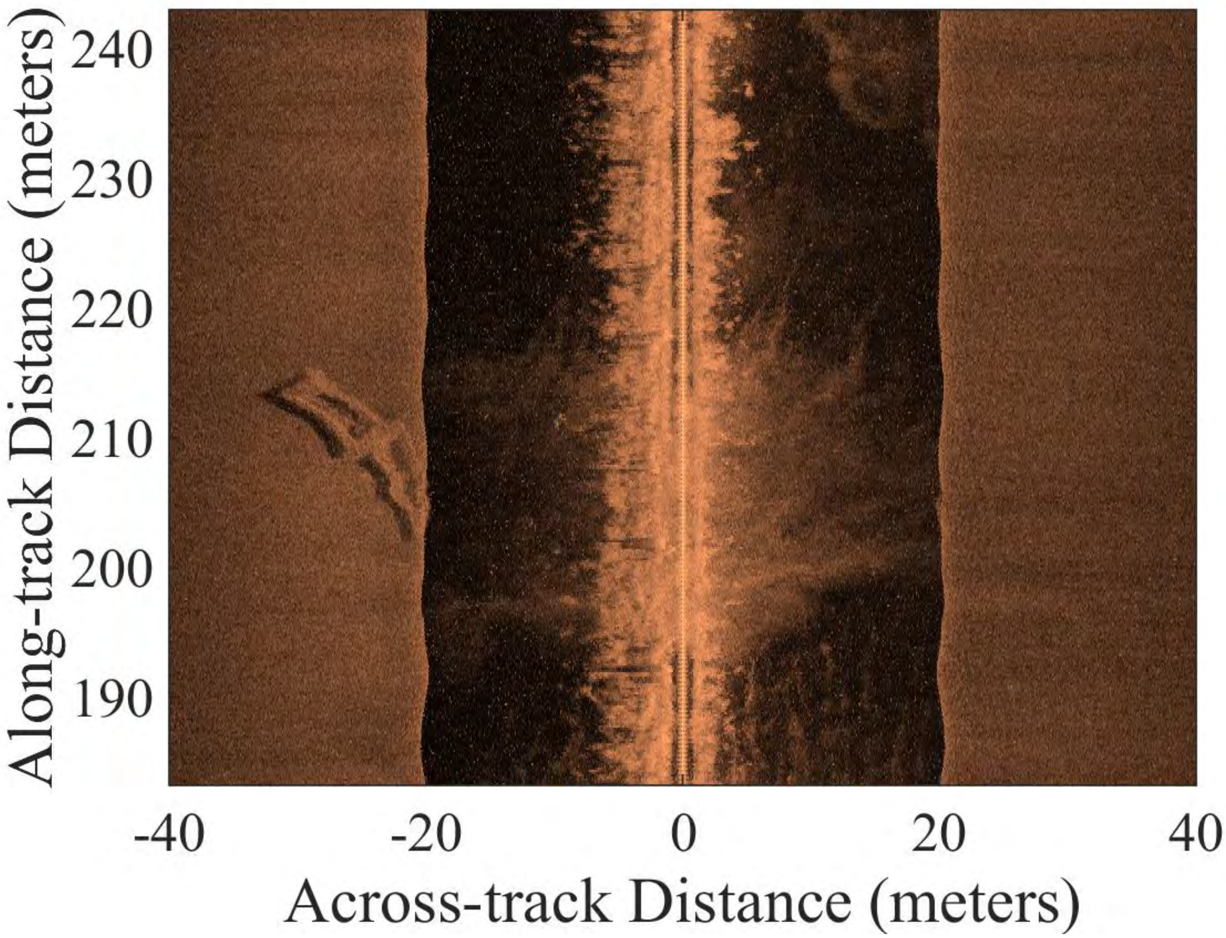


Figure B21. Two linked steel barges totaling 80 ft. in length (**H4**) at the Hempstead Reef which were deployed in 2000.

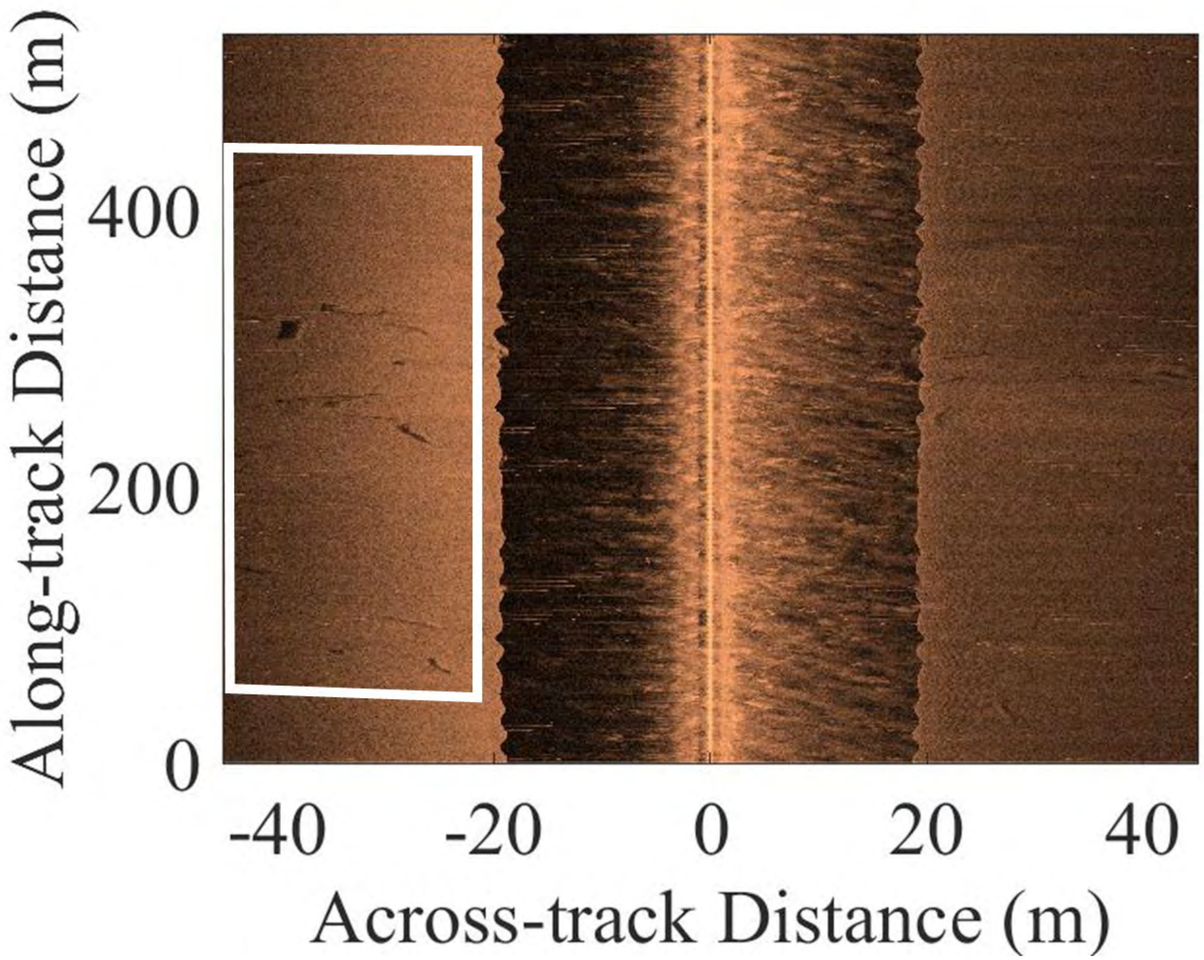


Figure B22. A concrete reef (**H5**) at the Hempstead Reef which was deployed in 1998. This reef was highly dispersed with non-concrete debris mixed with the deployed concrete bridge slabs.

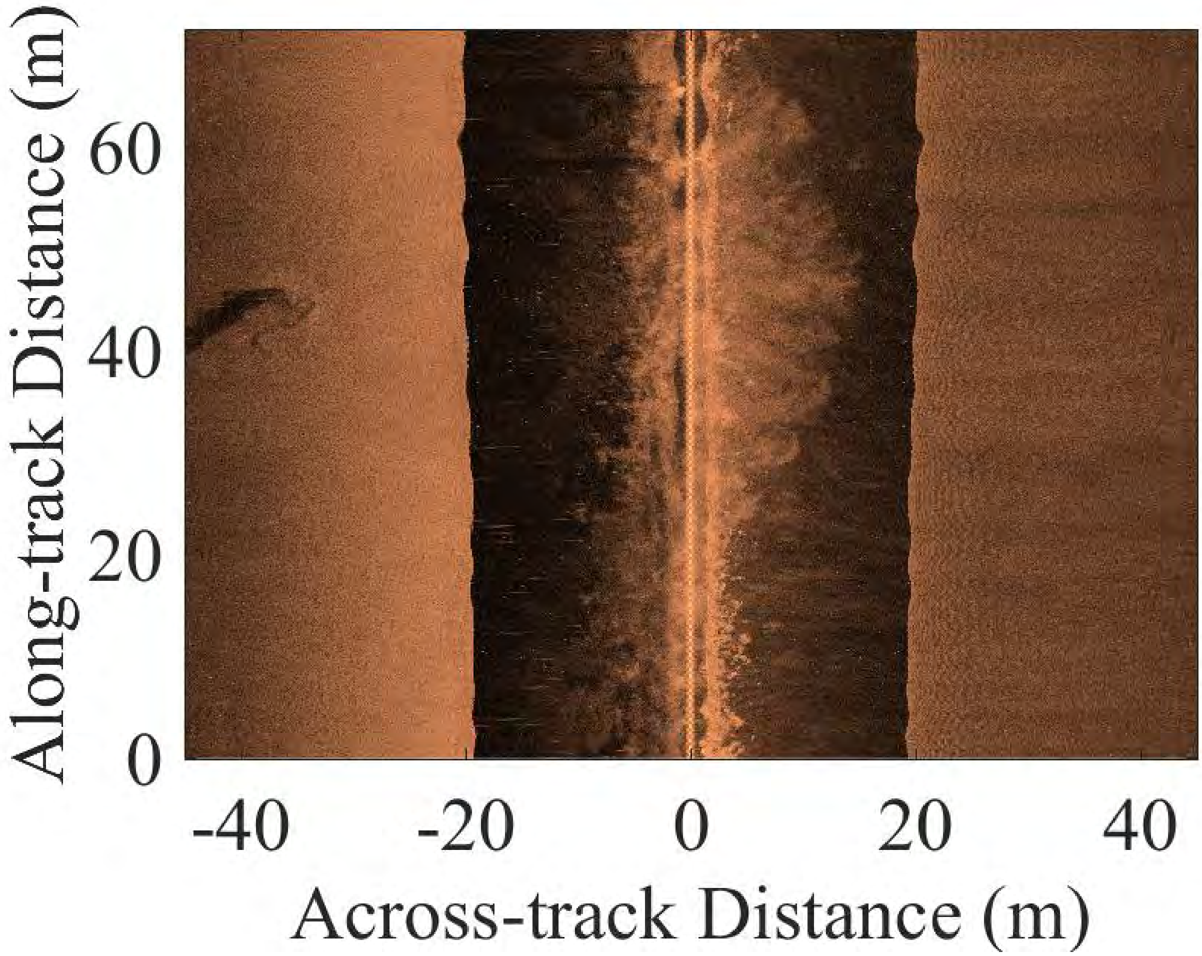


Figure B23. A 78 ft. trawler (the Lucisaura, **H6**) at the Hempstead Reef which was deployed in 1998.

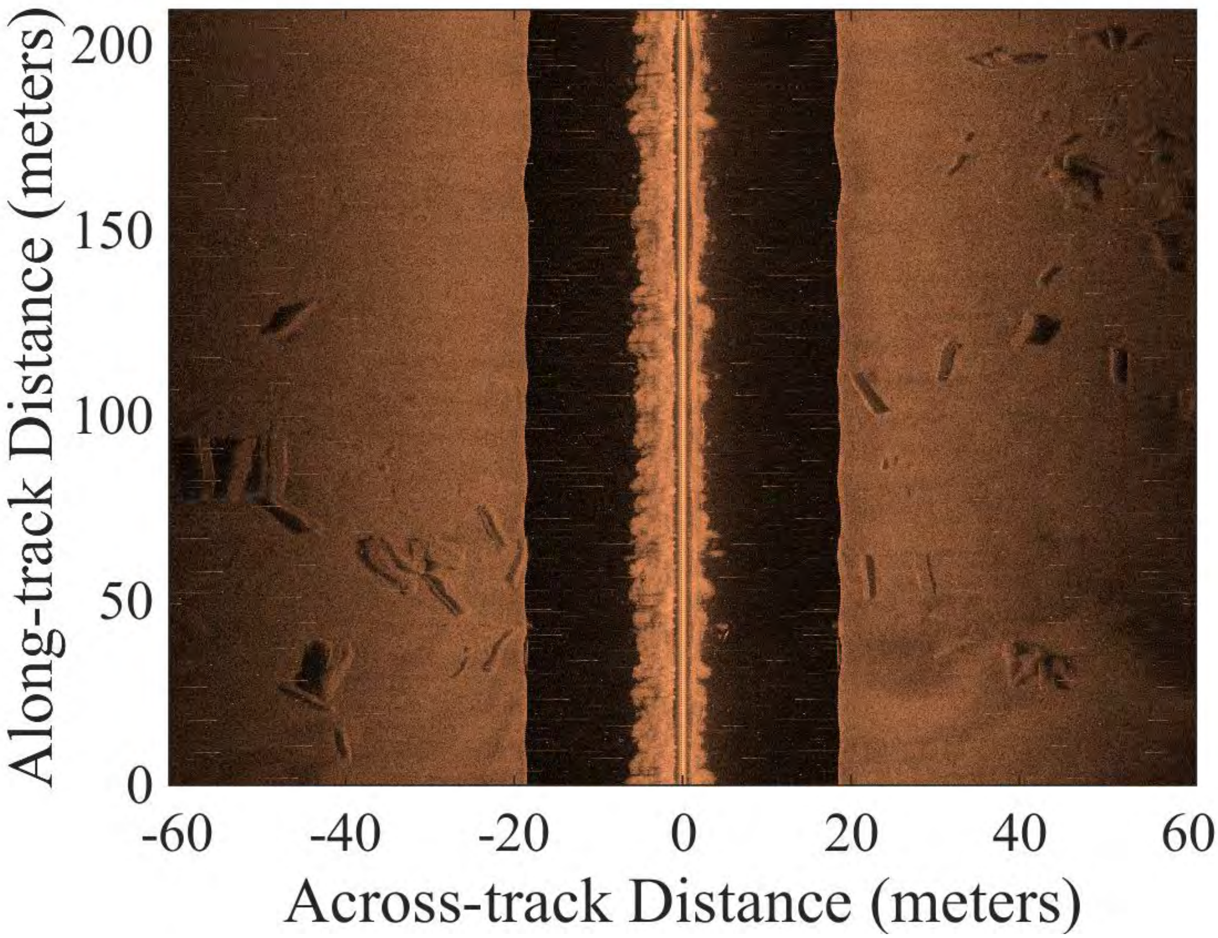


Figure B24. A concrete reef (**H9**) at the Hempstead Reef which was deployed in 1998. This reef was highly dispersed with non-concrete debris mixed with the deployed concrete bridge slabs.

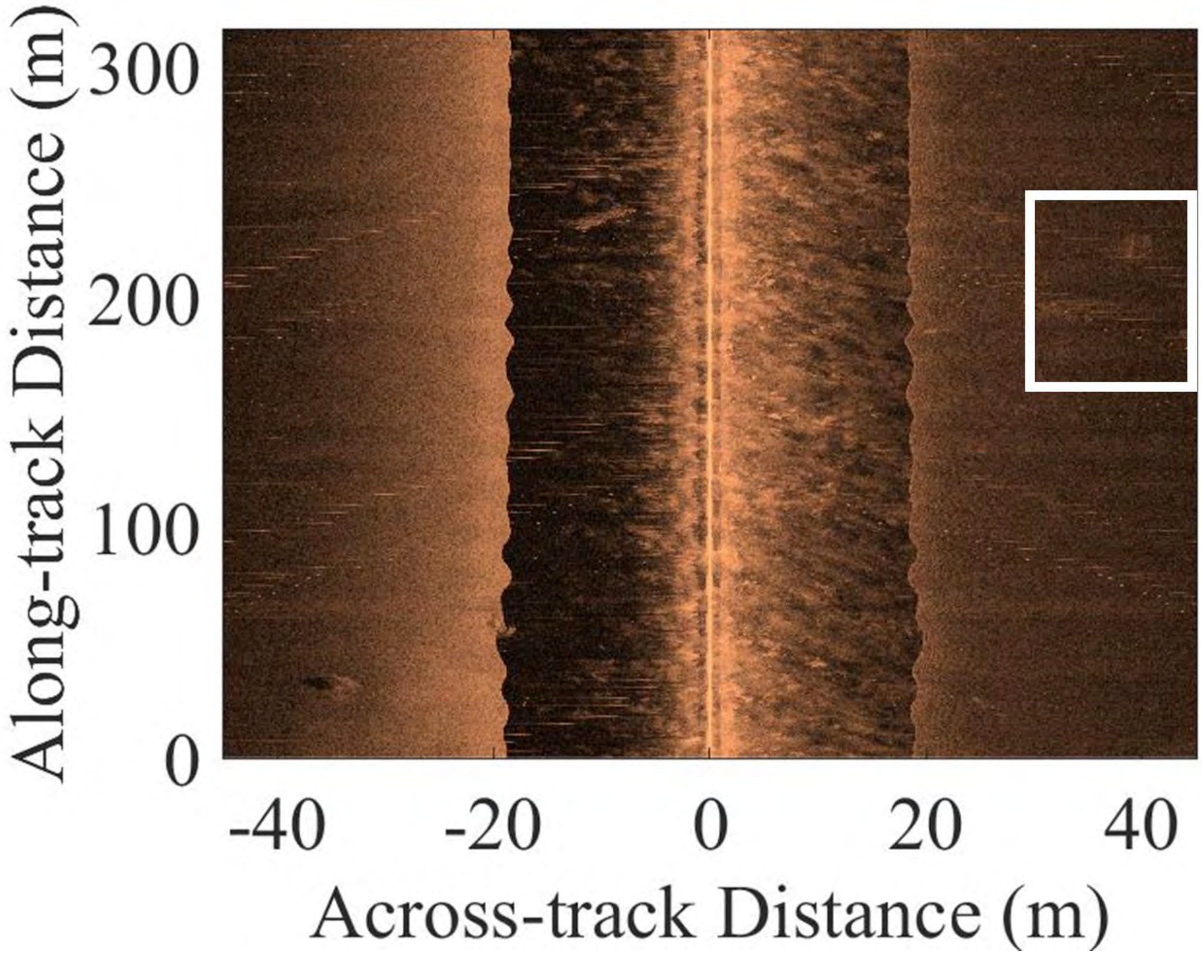


Figure B25. An APC group (**H10**) at the Hempstead Reef which was deployed in 1996. There were some identification issues due to other debris fields that are also present and not being at the reported coordinates.

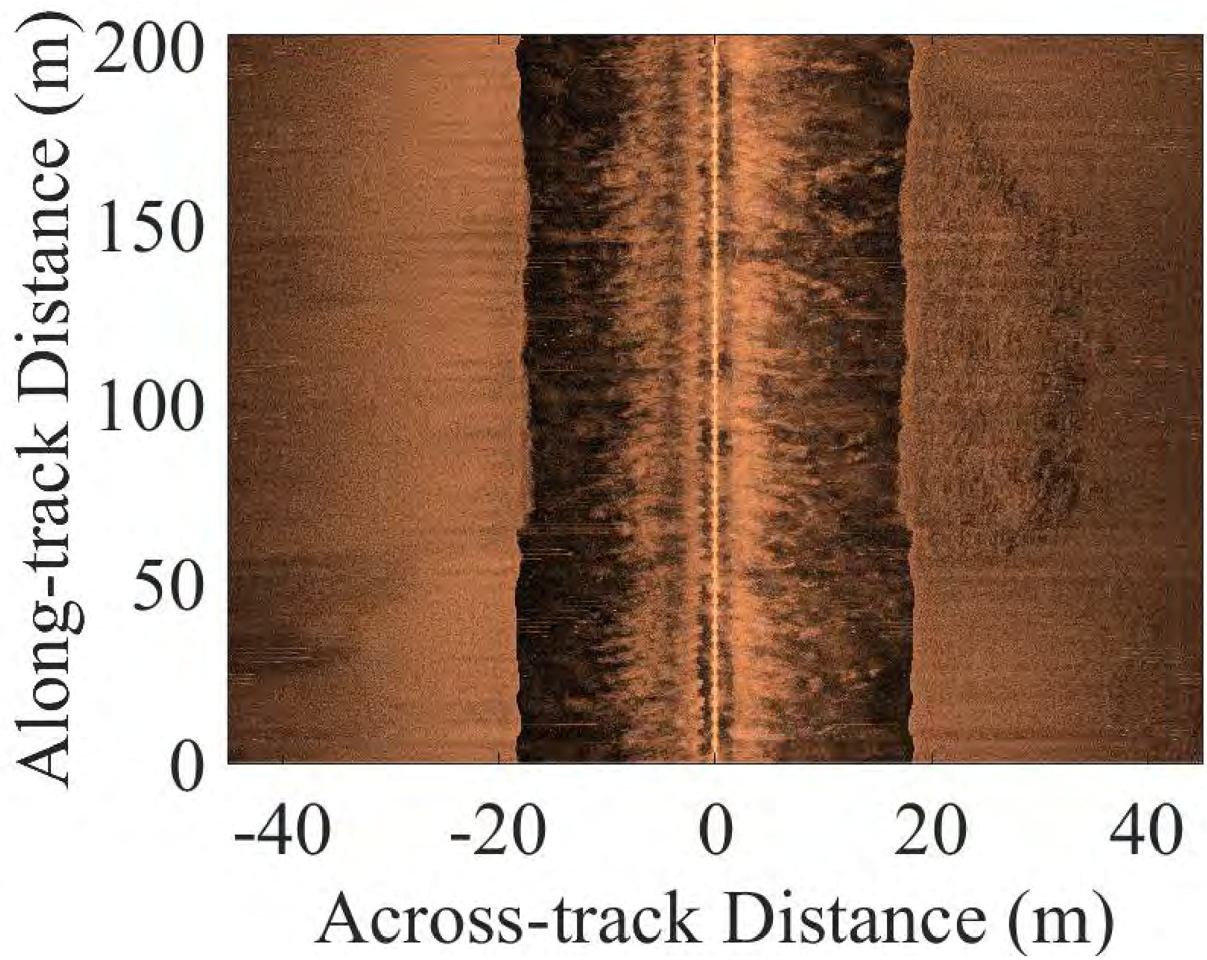


Figure B26. A redrock reef (**H11**) at the Hempstead Reef which was deployed in 2013.

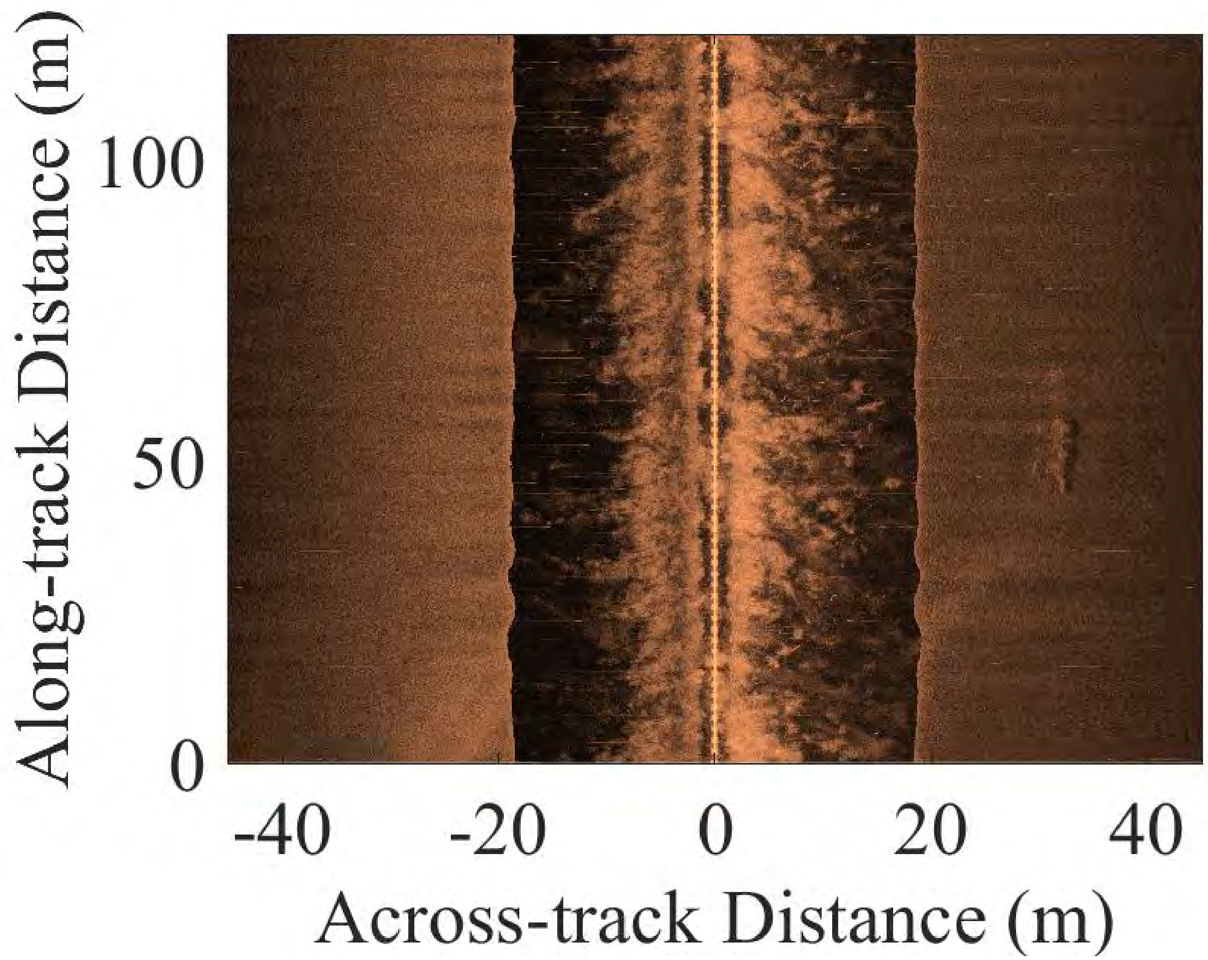


Figure B27. An unidentified, 40 ft. vessel (**H12**) at the Hempstead Reef which was deployed at an unknown date.

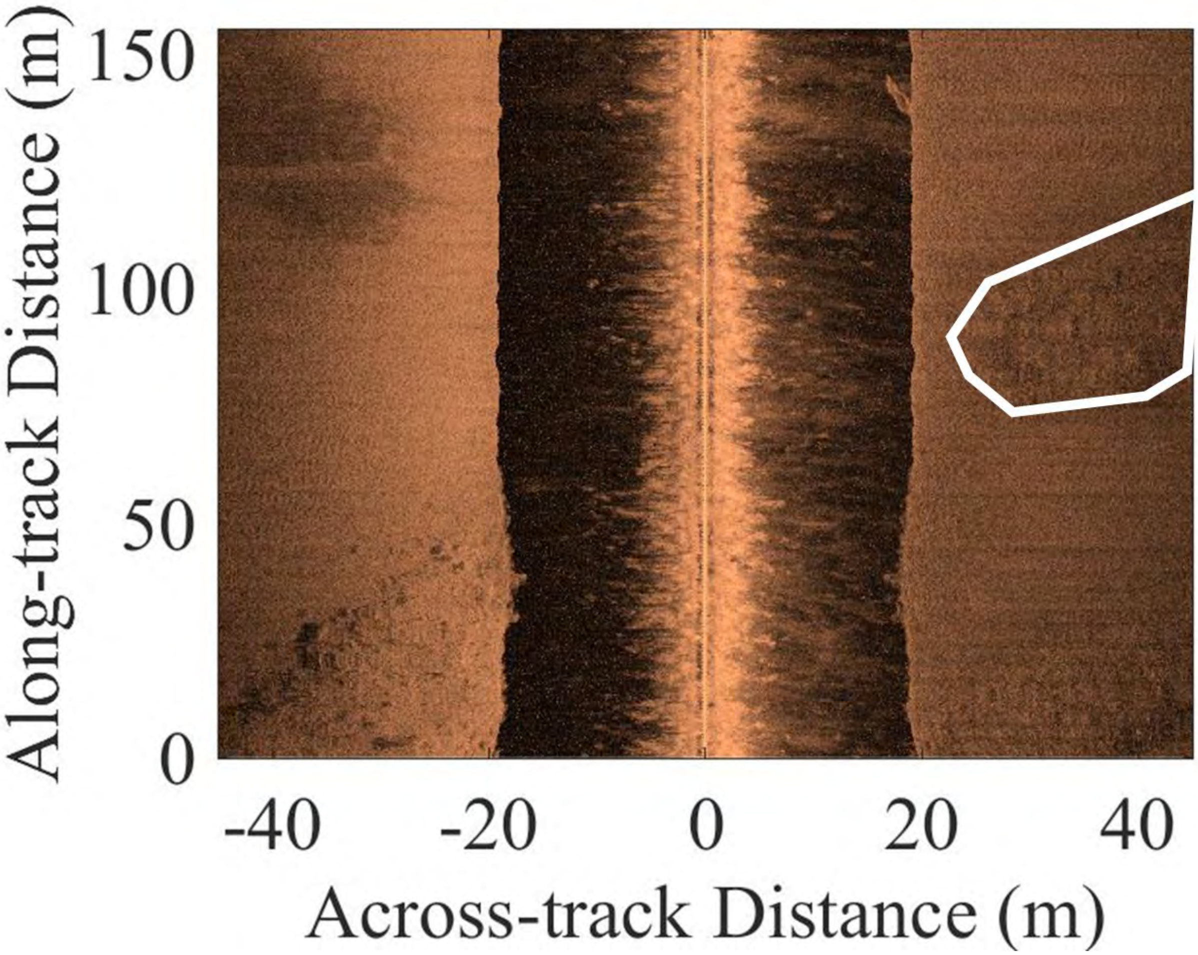


Figure B28. An 80% redrock, 20% red gravel sand reef (**H13**) at the Hempstead Reef which was deployed in 2014.

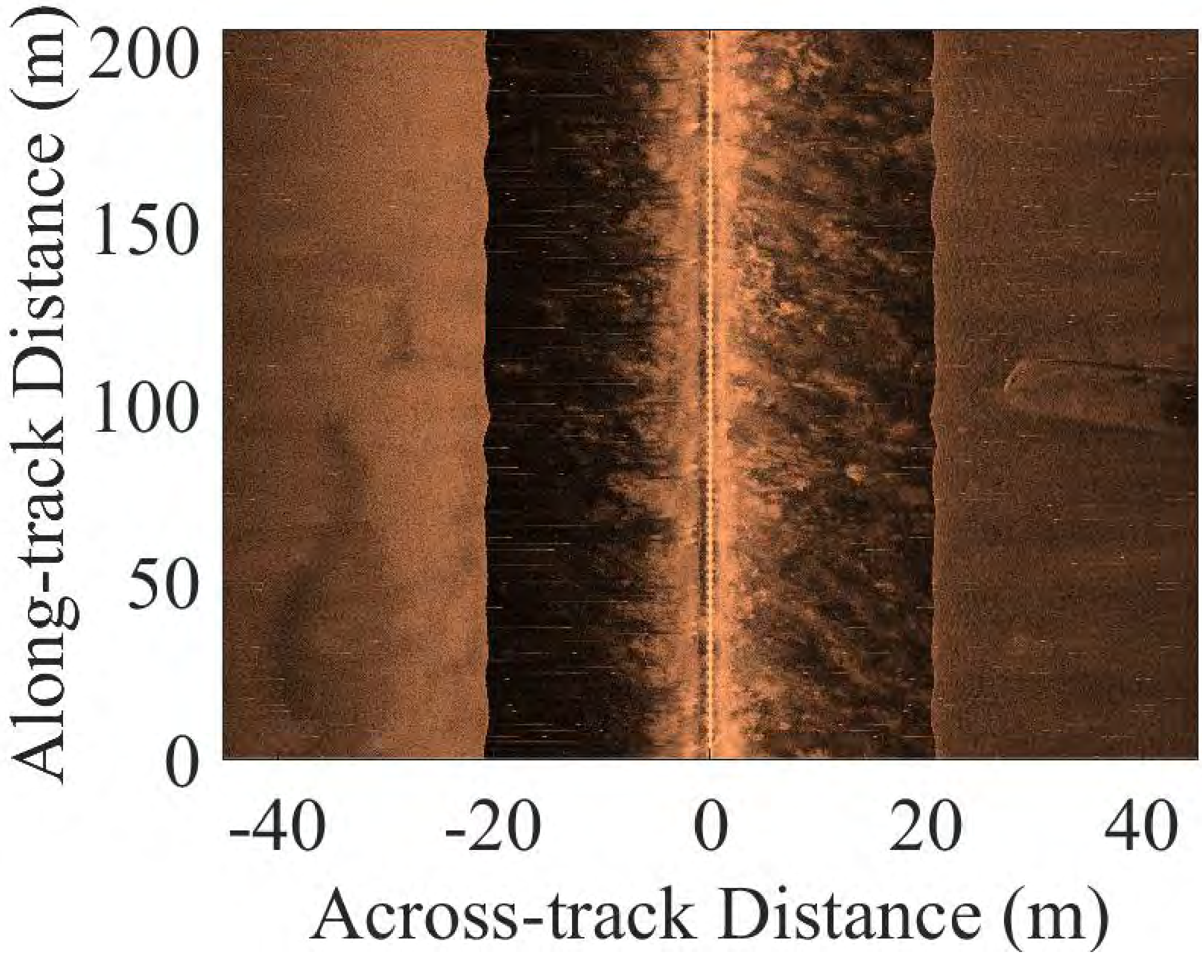


Figure B29. A 115 ft. steel barge (**H14**) at the Hempstead Reef which was deployed at an unknown date.

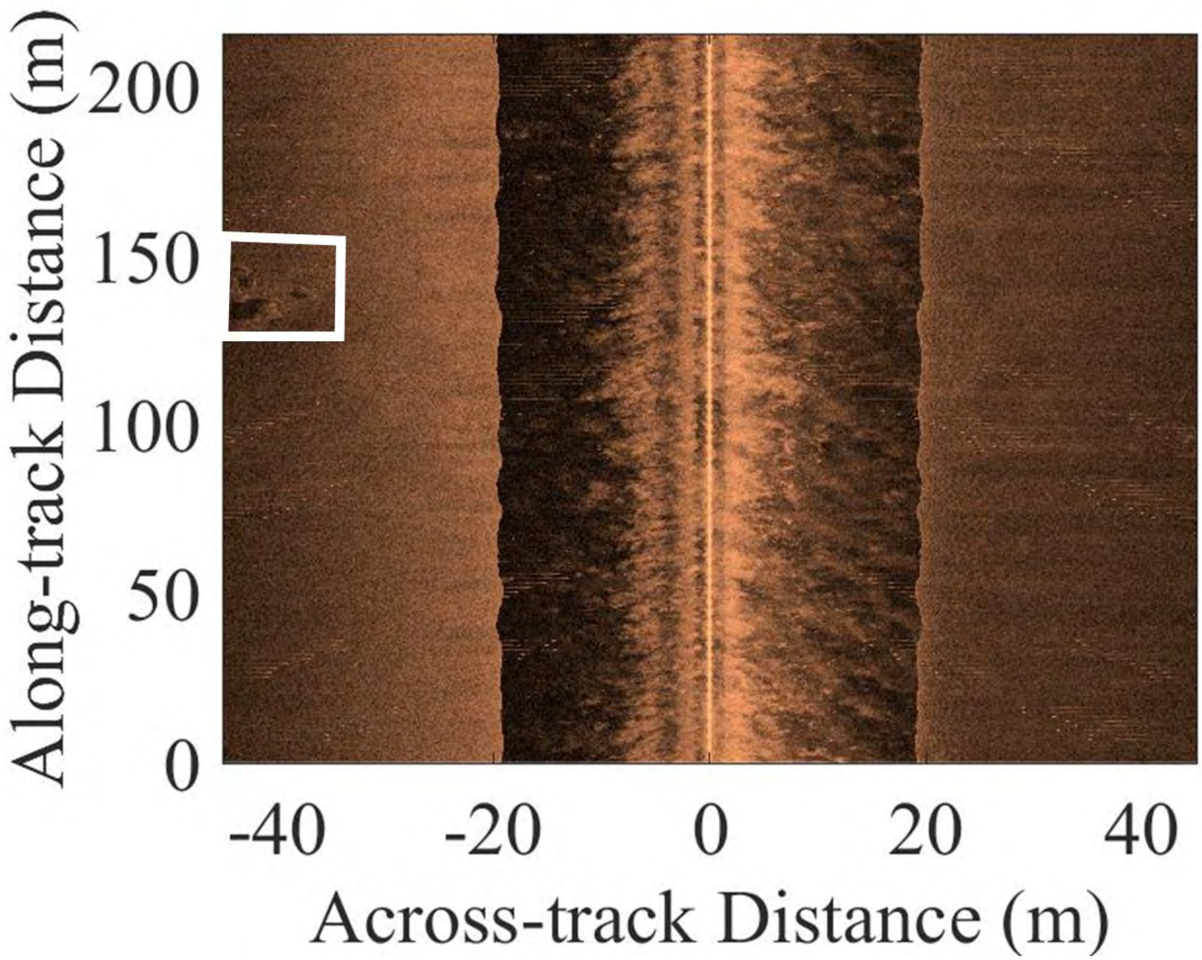


Figure B30. A rubble reef (**H15**) at the Hempstead Reef which was deployed at an unknown date.

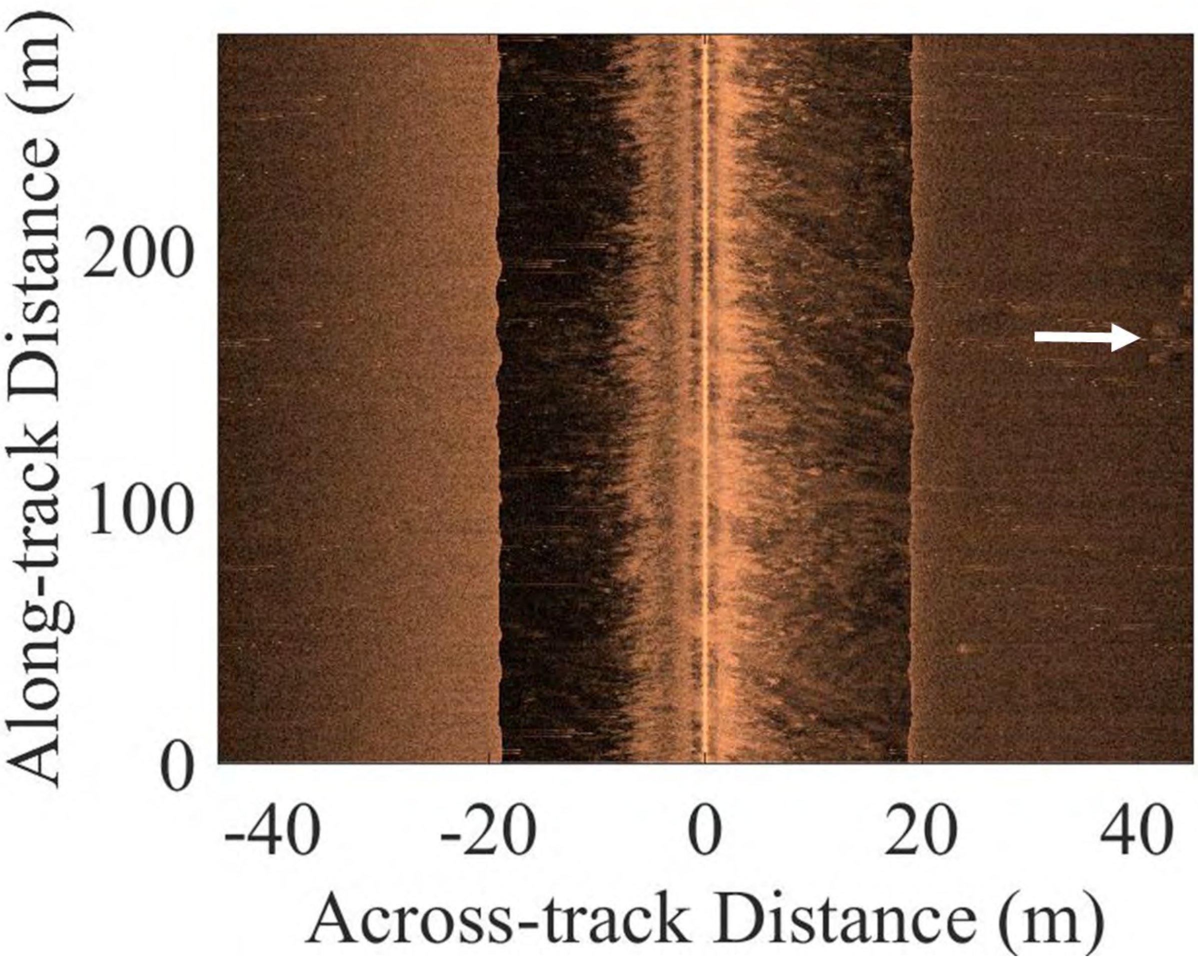


Figure B31. A rubble reef (**H16**) at the Hempstead Reef which was deployed at an unknown date. The white arrow points to the reef which sits at the edge of the sidescan image.

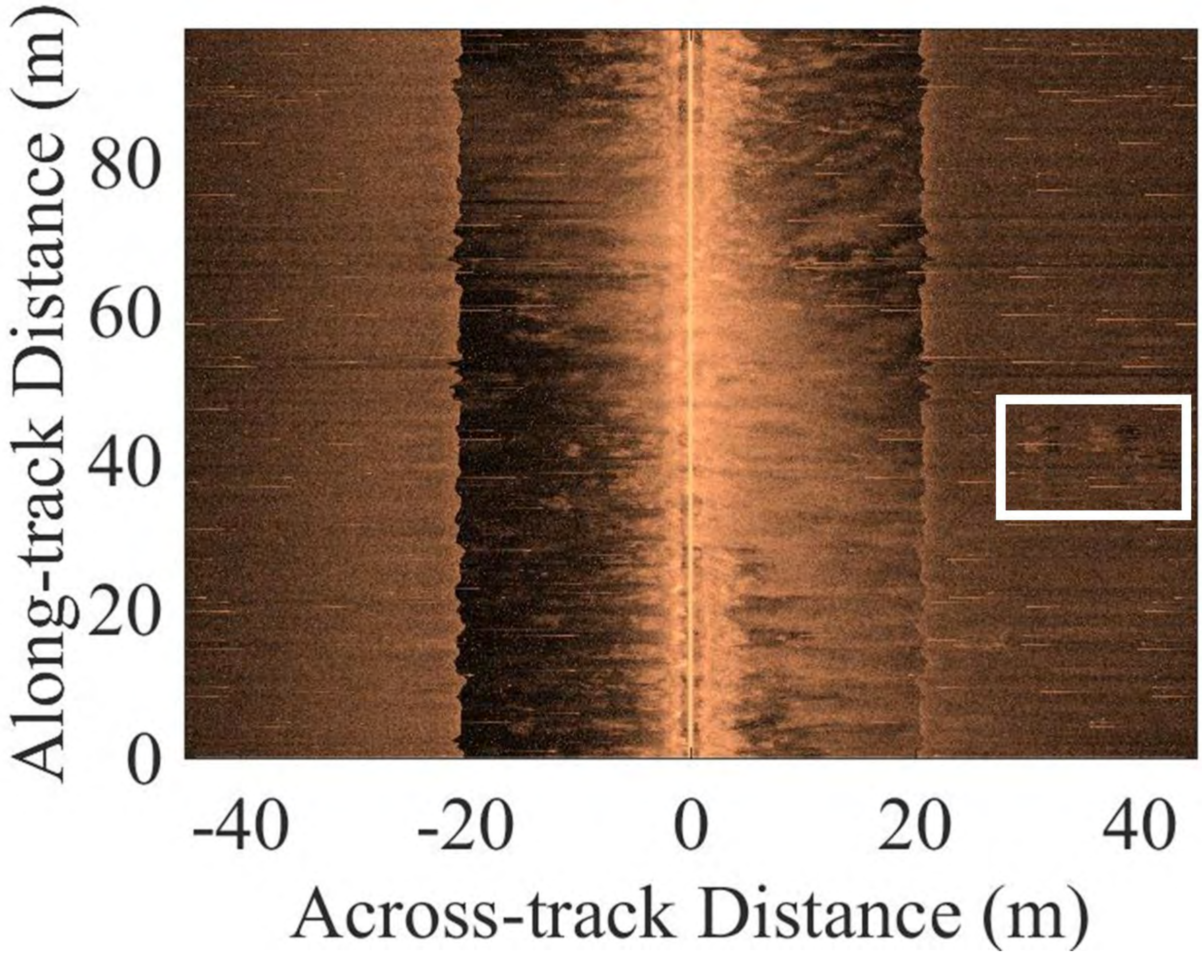


Figure B32. A rubble reef (**H17**) at the Hempstead Reef which was deployed at an unknown date.

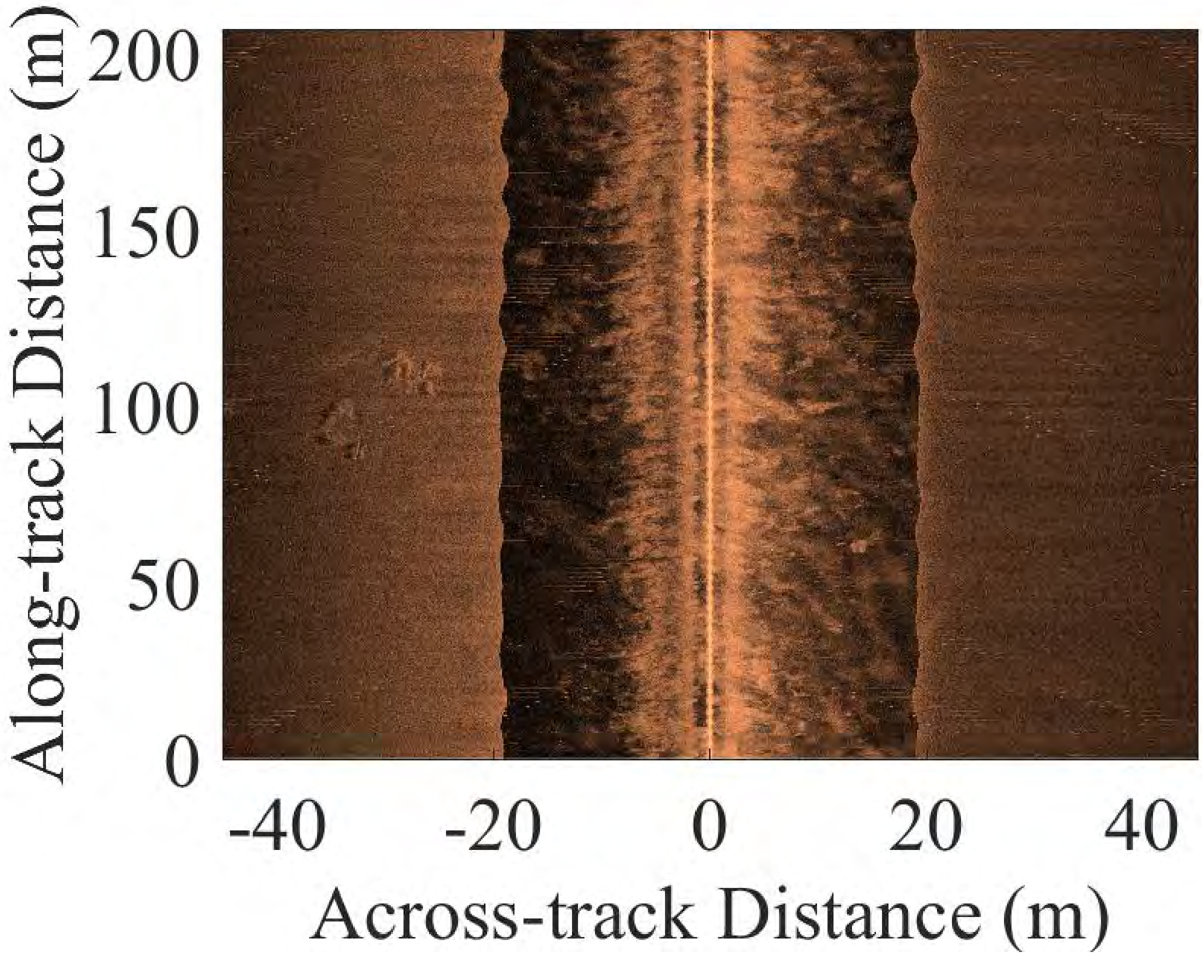


Figure B33. A rubble reef (**H17**) at the Hempstead Reef which was deployed at an unknown date.

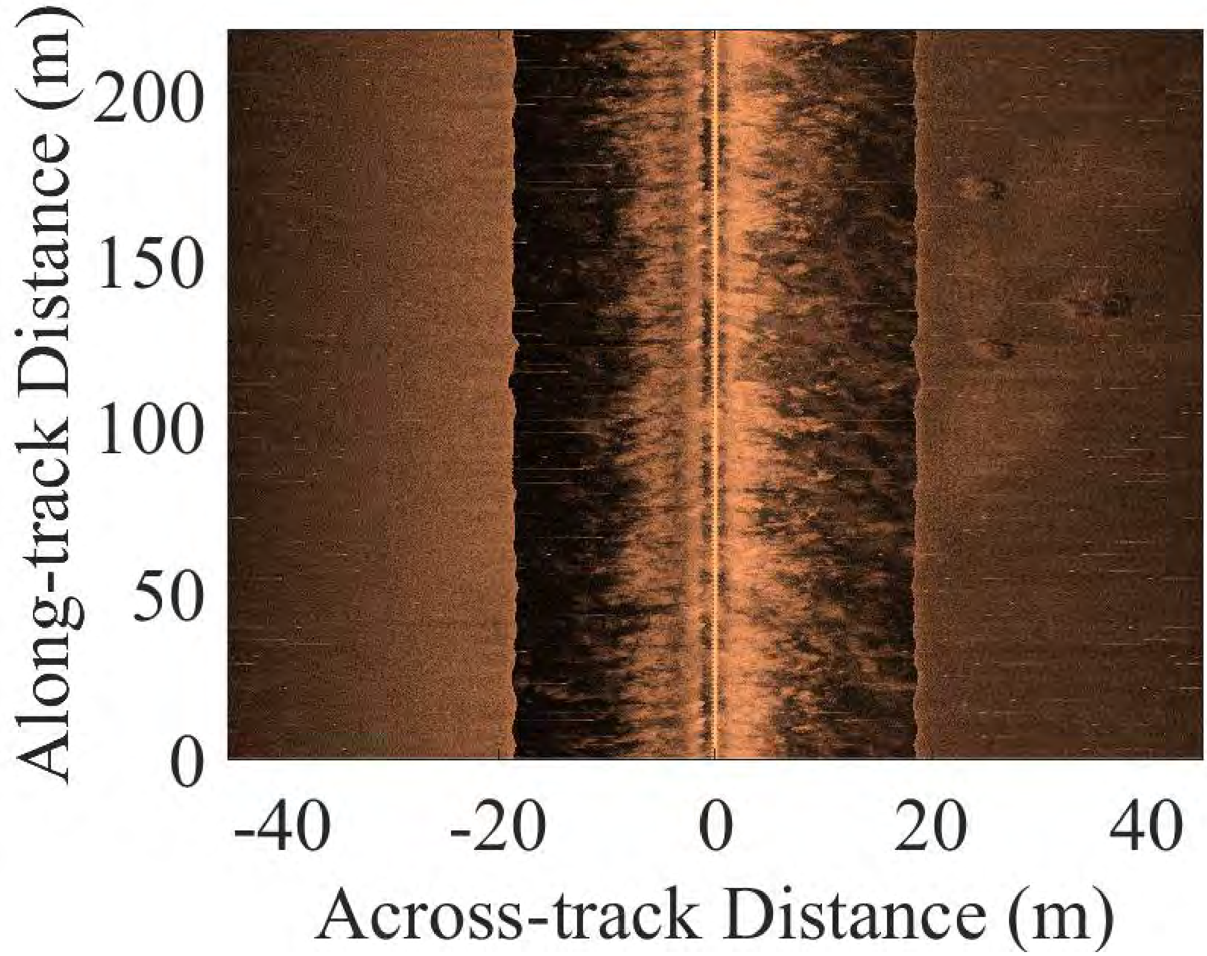


Figure B34. An APC group (**H19**) at the Hempstead Reef which was deployed in 1996. There were some identification issues due to other debris fields that are also present and not being at the reported coordinates.

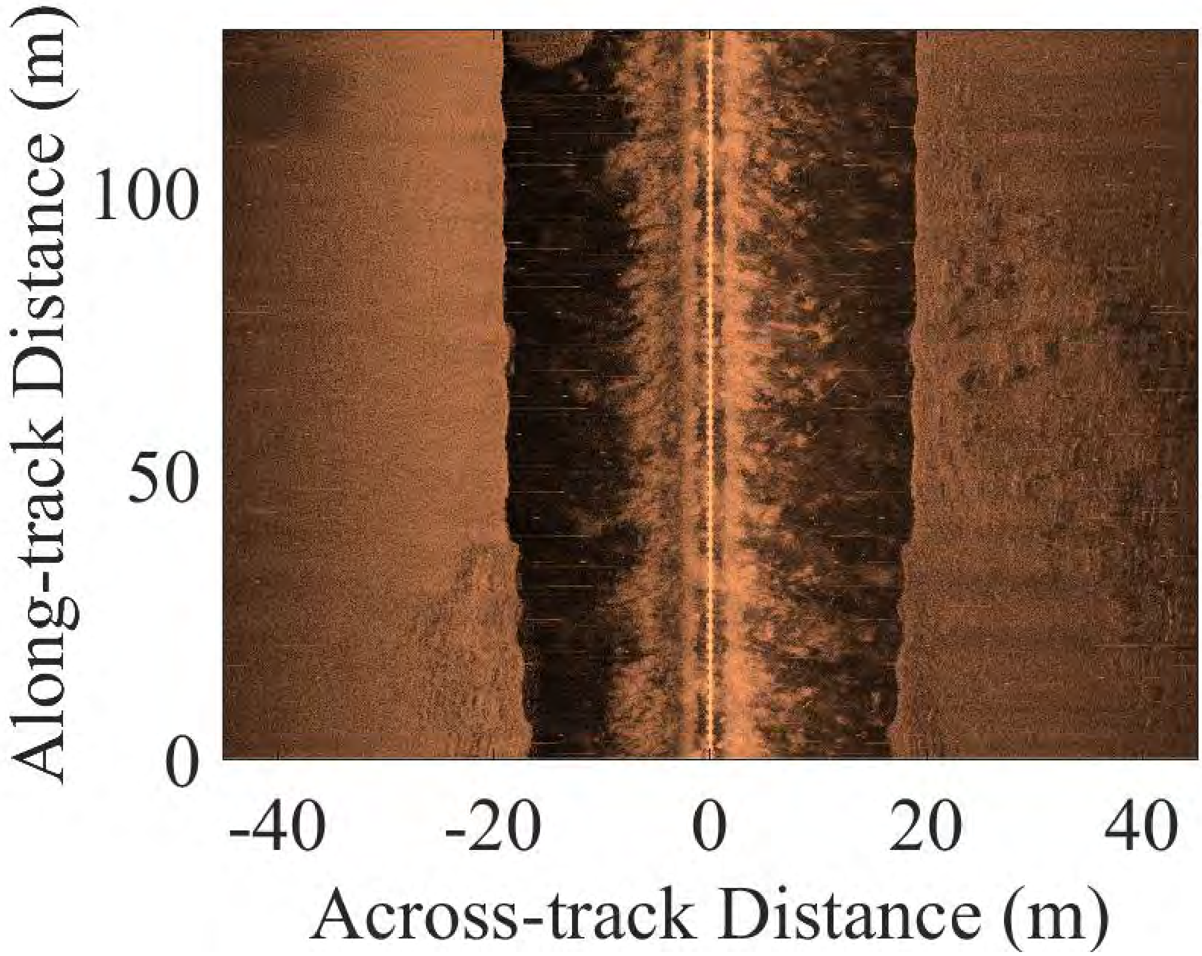
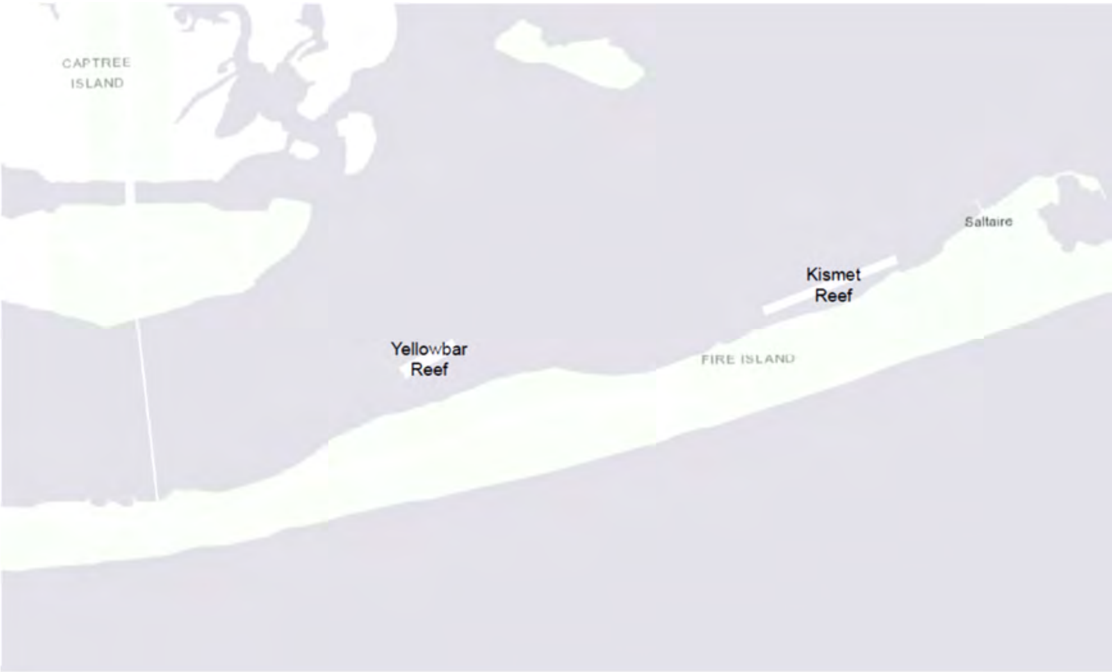


Figure B35. A greyrock reef (**H21**) at the Hempstead Reef which was deployed in 2013.

A preliminary investigation of the bathymetry and benthic characteristics of Kismet and Yellowbar artificial reefs



Introduction/Methods:

In order to characterize the water depth/bathymetry, benthic substrate and infauna at Kismet and Yellowbar artificial reefs, surveys were conducted on 3/20/19 and 4/11/19.

Bathymetry:

Transects were overlaid on the reefs 100 feet apart with sample points every 250 feet along each transect (Figure 1 and 2). At each sample point the depth was recorded and adjusted for the tidal height. Some stations were unable to be collected on Kismet reef. Depth readings were interpolated in ArcGIS using the IDW spatial analyst tool to create bathymetry maps of the reefs.

Depth readings were also collected above previously deployed materials, except at two patch reefs on Yellowbar reef.

Benthic Sampling:

Two benthic samples were collected on each reef site using a ponar grab with a 6" x 6" sampling area (Figure 3 and 4). Locations for grabs were selected in a deep and shallower location based on the bathymetry maps. Sediment samples were photographed to characterize the sediment types and sieved through a 1mm sieve to collect benthic infauna. Animals collected were placed in jars with alcohol to preserve the samples. Samples were processed in the lab and animals were grossly characterized and enumerated.

Benthic Sediment Characteristics:

To further characterize the sediment types and current condition of the bottom habitat on each site, underwater photographs were taken at stations spaced 250 feet apart in a zig-zag pattern from west to east along each reef (Figure 3 and 4). Photos were collected by attaching a GoPro with a green water filter to the stem of a 25 lb mushroom anchor with the camera facing downward. The anchor was lowered to the bottom on each station and retrieved after 5 minutes.

Results/Discussion:

The depths at both sites (Figures 5 and 6) were similar to the depths reported on NOAA nautical charts for the area. Due to control depth restrictions (16 ft at Kismet, 20 ft at Yellowbar), materials at both sites would be limited to low lying structure with limited vertical profile. In addition, most of the eastern half of Kismet reef would be off limits from material deployments.

Previously deployed materials were all within the control depth limits except for a few materials on Kismet reef (Table 1 and 2). This may indicate that these materials have been buried over time. Due to the strong current at both locations, sediments are readily moved around and materials are known to become covered and uncovered from time to time.

Benthic grab samples on Kismet reef were mainly comprised of sand, gravel, stone, and shell hash. Gravel and stone made up approximately 25-50% of each sample. The bottom at Kismet reef was firmer than Yellowbar which made it harder to effectively sample with the ponar grab. Both grabs at Kismet reef were about 75% full.

Samples collected at Yellowbar reef were mainly sand, gravel, and shell hash. Each sample was about 95% or more sand.

The same sediment types at both reefs was also reported by the USGS USseabed project. The USGS study characterized the sediment in these areas as sand/gravelly sand.

Photos of the bottom at both reefs confirmed the results of the sediment collected in the grab samples. Sand, gravel/stone, and shell hash was the predominant material seen in the photos. The most notable finding was the presence of a sponges at two sites on Kismet reef. Photos of the benthic grabs and underwater shots can be viewed in the appendix.

Benthic infauna was comprised of copepods, shrimp, barnacles, molluscs (blue mussel, crepidula, other unknown molluscs), marine worms, a hermit crab and a hydroid (Table 3). Of note, was the greater total individual counts at Kismet reef (>200 individuals per sample) when compared to Yellowbar (<50 individuals per sample). This may be a result of the substrate or location of Kismet reef.

The types of animals observed were comparable to those documented in similar studies. For instance, a benthic invertebrate study conducted in sandy habitats found marine worms, molluscs, arthropods, and echinoderms to make up the majority of samples (ACOE, 2004). Although our samples lacked echinoderms, this may be due to differences in sample equipment, locations (i.e. ocean vs. bay), or the time of year sampling occurred.

References:

https://nauticalcharts.noaa.gov/rnconline/rnconline.html

https://pubs.usgs.gov/ds/2005/118/

US Army Corps of Engineers, 2004. Benthic Invertebrate Survey: East of Shinnecock Inlet to East of Fire Island Inlet. 94 pp.

Figures/Tables:

Figure 1: Kismet transects and depth stations.

Figure 2: Yellowbar transects and depth stations.

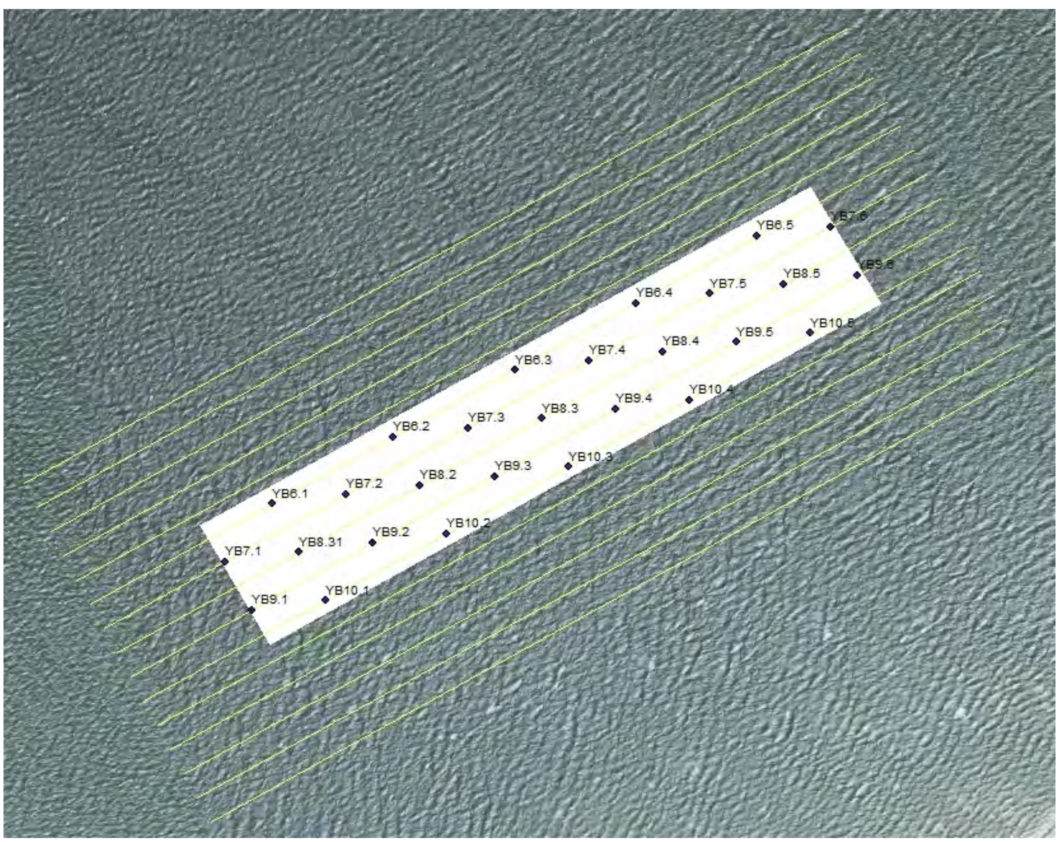


Figure 3: Benthic grab (yellow) and photo stations (red) on Kismet reef.

Figure 4: Benthic grab (yellow) and photo stations (red) on Yellowbar reef.

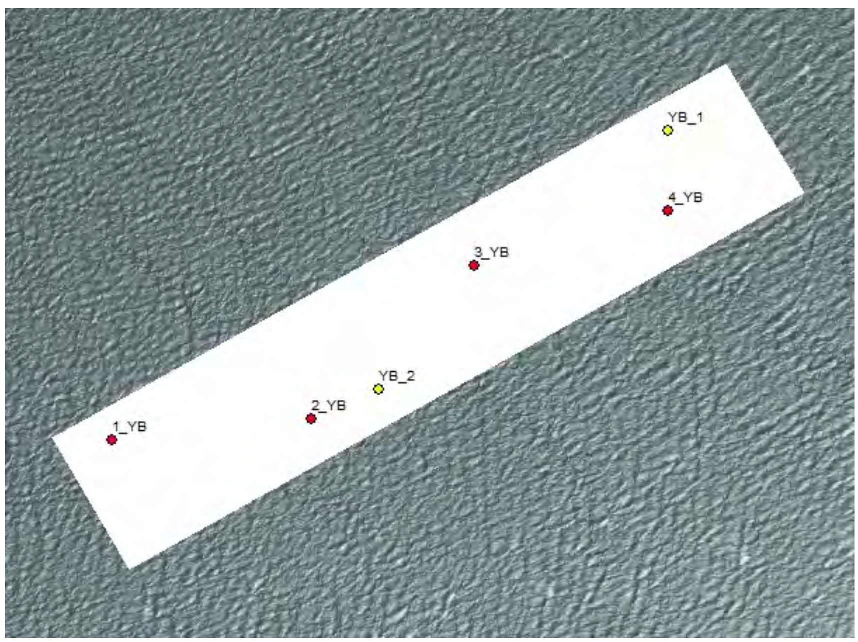


Figure 5: Kismet bathymetry

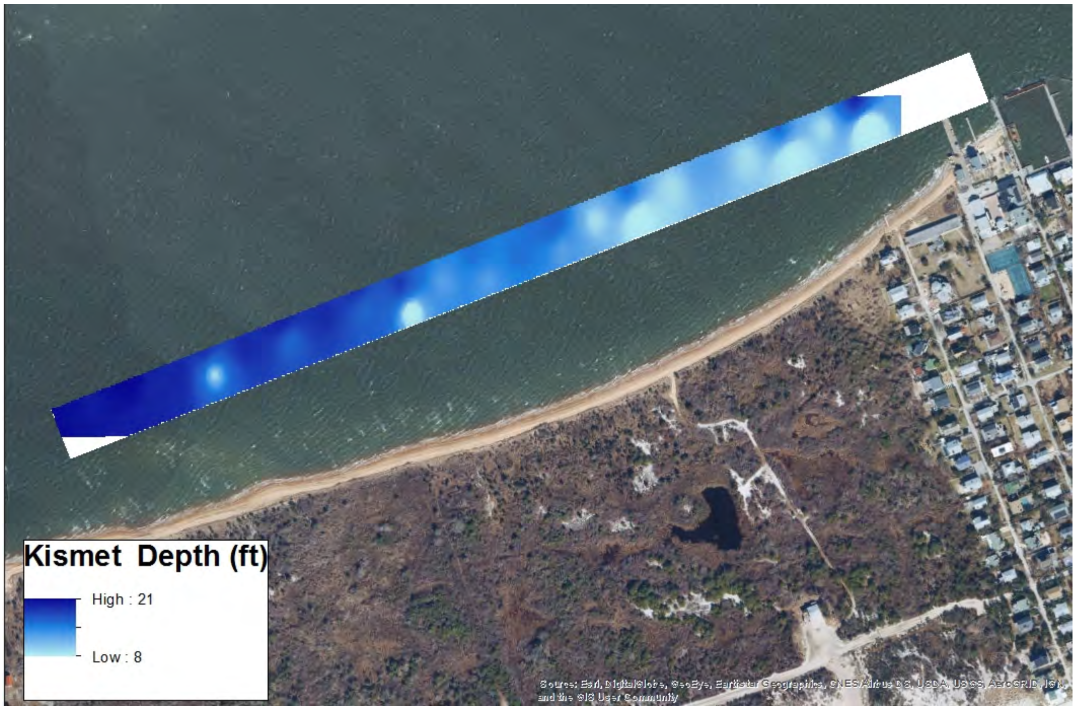


Figure 6: Yellowbar bathymetry

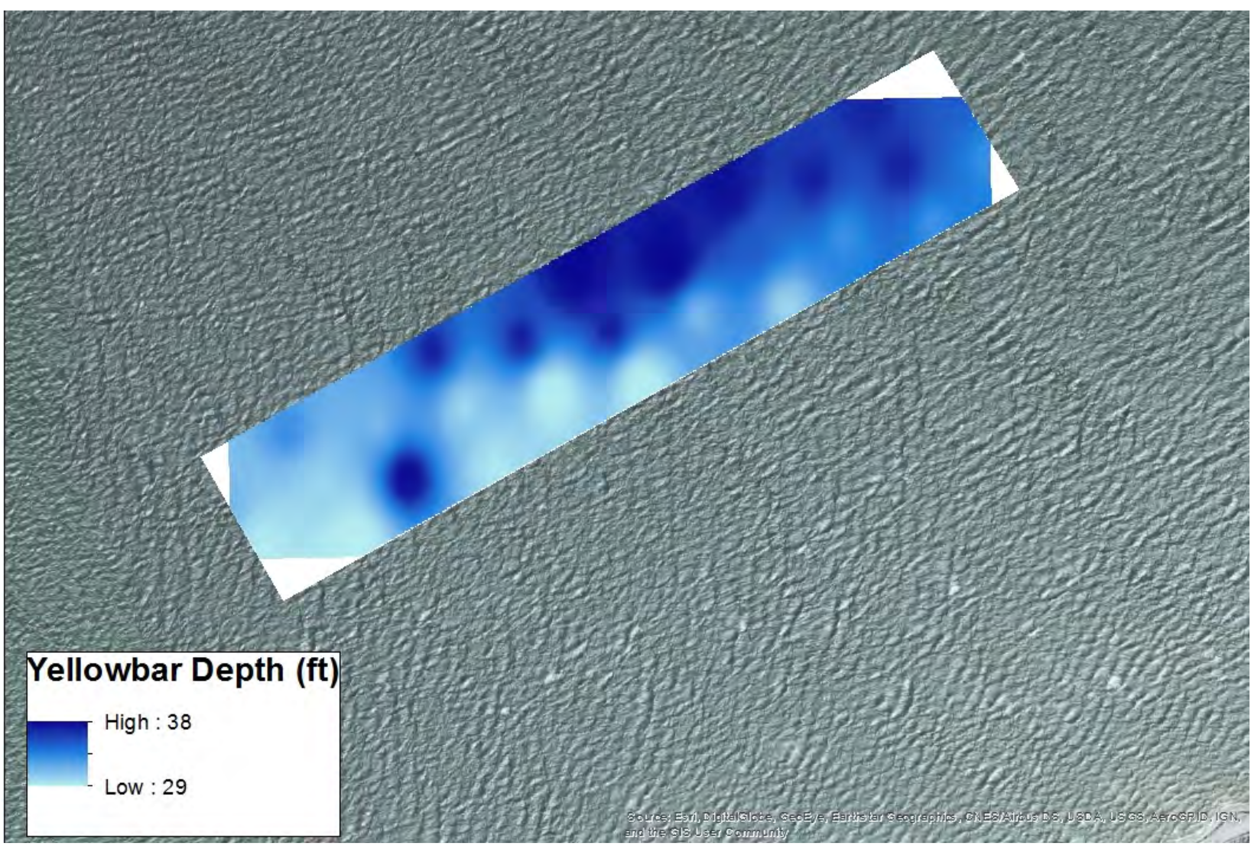


Table 1: Kismet previously deployed material depths

Material	Depth	Latitude	Longitude
Concrete Blocks	15.2	40°38.162	73°12.833
Concrete Blocks	16.9	40°38.179	73°12.810
Concrete Blocks	20.5	40°38.191	73°12.785
100' Barge	16.6	40°38.280	73°12.496
85' Barge	17.8	40°38.311	73°12.435
Concrete Ballasted Tires	18.4	40°38.213	73°12.671
Concrete Ballasted Tires	15.6	40°38.251	73°12.579
Concrete Culvert	18.4	40°38.208	73°12.725
Rubble Pile	15.9	40°38.152	73°12.880

Table 2: Yellowbar previously deployed material depths

Material	Depth	Latitude	Longitude
Unknown	26.9	40°38.058	73°14.204
Unknown	24	40°38.052	73°14.276
Unknown	23.5	40°38.079	73°14.316
Reef Balls		40°37.947	73°14.549
36' Steel Cruiser *Charade*	34.9	40°38.014	73°14.431
Concrete Culvert		40°38.008	73°14.431
62' Wooden Trawler *Connie F*	33.7	40°38.001	73°14.479
48' Wooden Vessel *Peregrine*	20.7	40°38.030	73°14.571
60' Steel Barge CorEW33	32.8	40°37.994	73°14.466

Table 3: Benthic invertebrate counts

	Station			
	K1	K2	YB1	YB2
Arthropods	13	9	1	24
Molluscs	107	186	2	
Worms	135	31	36	2
Hermit Crab		1		
Hydroid			1	

Appendix:

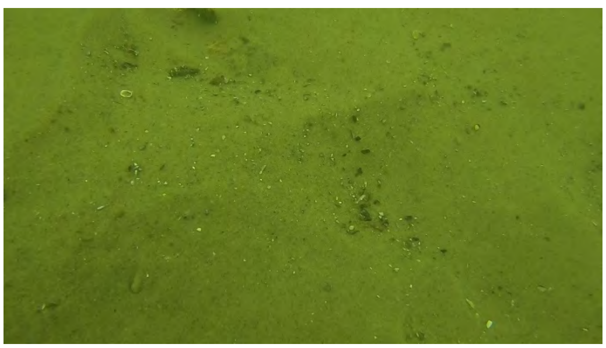
Kismet reef benthic grab samples

K1

K2

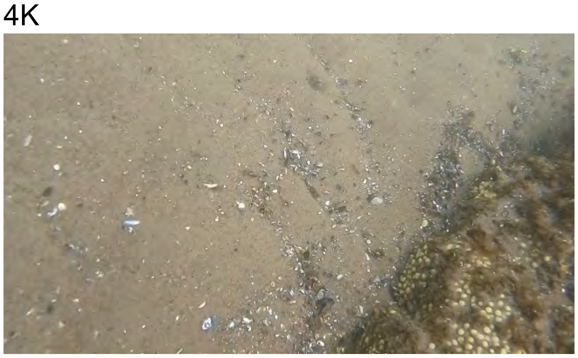
Kismet reef underwater photos

1K



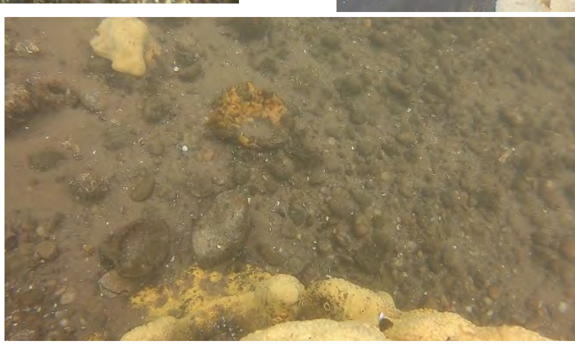
3K

4K



5K

6K



Yellowbar reef benthic grab samples

YB1

YB2

Yellowbar reef underwater photos

1YB

2YB

3YB

4YB