Massachusetts Department of Fish and Game

In-Lieu Fee Program

Marine Habitat Enhancement, Yarmouth MA Artificial Reef (IL05) 2020 Annual Report

Implemented by the Division of Marine Fisheries

DFG ILF Project Number: ILF4-CSTL-IL05
Army Corp Permit #: NAE - 2012 - 00311
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The Massachusetts In Lieu Fee Program

Administered by the Department of Fish and Game

Dan McKiernan, Director

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Project Overview

In 2019, the Massachusetts Department of Fish and Game (DFG) In-Lieu Fee Program (ILFP) funded DFG's Division of Marine Fisheries (DMF) to implement a marine subtidal habitat enhancement project in Nantucket Sound. The project is located within a 125-acre permitted site located 2.2 miles off the coast of Yarmouth (Figure 1). The site was permitted in 2014 under the Corps General Permit number NAE-2012-00311. Project construction consisted of deploying two-thousand cubic yards of granite and secondary use concrete to create dispersed patches of structured habitats extending two to six feet off the bottom. Construction was completed on January 14, 2020 and a side scan survey of the site was completed on January 23, 2020. Deployment and side scan survey results were reported to the ILFP in *Marine Habitat Enhancement, Yarmouth MA Artificial Reef* [*Annual Report - Revised August 6, 2020*]. The report also included a request by DMF for an adjustment of available credits to reflect the actual (vs. the proposed) amount of habitat enhanced by the project.

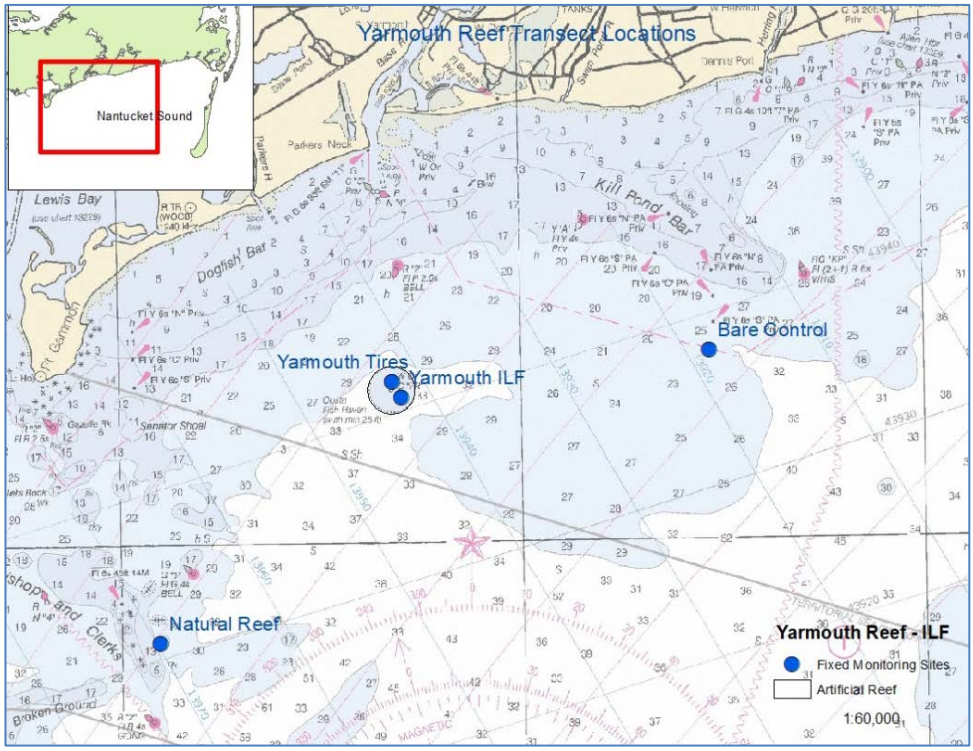

Figure 1. Location of Artificial Reef and Monitoring Stations.

On November 24, a larger credit release was approved by the Corps to account for the actual project enhancement area. Potential project credits were adjusted to 0.70 acres of structured habitat enhancement within a 2.1-acre footprint, replacing the initially proposed credits of 0.33 acres within a 1.1-acre footprint (Table 5). The Corps also confirmed the release of 0.2796 credits for successfully meeting the project's design and construction performance standards. The release of the remaining 0.0699 construction and design credits is contingent upon the completion of a follow-up side scan survey in 2025.

Ecological performance monitoring accounts for fifty percent (0.3495 credits) of available project credits. Monitoring methods herein describe the data collection methods employed to assess diversity and size class similarity of species inhabiting the new artificial reef as well as a nearby natural rocky reef and bare sand control site over time. This report includes a summary of data collected during the first year of monitoring. A full evaluation of ecological performance monitoring will require several additional years of data collection.

Monitoring

Monitoring data is collected by DMF staff in accordance with the schedule included in the Project Prospectus (Table 1). Diver-based underwater visual census (UVC) transect surveys and video surveys using Baited Remote Underwater Video (BRUV) are conducted annually between May and October when migratory species are present in Nantucket Sound. An additional set of UVC surveys are collected once per year during the off-season between November and April. Monitoring was delayed from March through June due to restrictions enacted during the COVID-19 pandemic. There were five monitoring field days between June and October. On June 3, HOBO remote temperature loggers and VEMCO acoustic receivers were positioned on station and UVC transect sampling locations were established. Two transects were established on the natural rocky reef and the bare sand control, and four transects were established on the ILF reef. Monitoring occurred on July 1 at the ILF reef site and on September 24 the natural rocky reef and bare sand control sites. UVC transect and the. One BRUV sampling event took place on September 1 and two additional events occurred on October 2.

Figure 2. DMF staff monitoring the ILF reef site during COVID-19 restrictions.

Table1. Monitoring Schedule

		Pre-Deploy (2019)	Year 0 (2020)		Year 1 and 2 (2021-2022)		Year 3 and 4 (2023-2024)	2025
			May-Oct	Nov-Apr	May-Oct	Nov-Apr	Annual	Annual
UVC transect survey Quadrats (sessile species) and Swath (mobile species) along 50m fixed transects								
	natural reef	x	x	x	x	x	x	x
	artificial reef	x	x	x	x	x	x	x
Camera/ Video survey	natural reef	x	3		3		3	3
	artificial reef	x	3		3		3	3
Side scan survey		x	x					x
Temp / acoustics			x	x	x	x	x	x
completed								

Methods

Ecological performance monitoring parameters are designed for this project to assess species diversity and species size class distributions (production) at the newly deployed reef structures when compared with a nearby natural rock reef site.

Species diversity is assessed using diver-based underwater visual census (UVC) surveys along 50m transects. Finfish and mobile macroinvertebrates are counted within two-meter width swaths along both sides of a transect. Sessile invertebrate and macroalgae percent cover estimates are collected from 20 $1m^2$ quadrats along each transect. Quadrat locations are determined by randomly selecting two quadrats every ten meters from each side of the transect (20 quadrats/50m).

Mobile species detectability using UVC surveys can be significantly underestimated due to poor visibility and diver effect (reaction of fish to divers). To help address this, remote acoustic sensors are deployed year-round to a fixed location within the new reef habitat to record presence of any fish that has been implanted with an acoustic tag. Fish presence is recorded when a fish travels within +/- four hundred feet of the receiver. The receiver records date/time, and tag ID, which can then be traced back to species, tagged location, etc., from a database. Divers recover the acoustic receiver data from the field once per year for processing. Unique mobile species (species not recorded in UVC's) counts from acoustic receivers also inform mobile species diversity metrics. In addition to remote acoustic sensors, BRUV footage is also analyzed for mobile species presence.

Size class distribution (production) is assessed using BRUV data collected from fixed stations at the rock reef, tire reef, ILF reef, and bare sand sites. Visibility is estimated directly from BRUV videos using a bait box (0.8 m from camera) as a guide. Still frames for analysis are captured from each 30-minute recording in 30-second increments for a total of 60 analyzed frames per recording (sampling event). The identity of each species of fish, an index of its relative abundance (MaxN), and quantitative length estimates of two species of economic significance, *Centropristis striata (*black sea bass(BSB)), and *Stenotomus chrysops* (scup) are documented within each frame. Unique mobile species (species not recorded in UVC's) counts from BRUV's also inform mobile species diversity metrics.

Specific field sampling methods are further described in Appendix A - *Yarmouth Artificial Reef Monitoring SOP's for the ILF-funded deployment in 2020*.

Results

Field collection of 2020 monitoring data was successfully completed in accordance with the monitoring schedule (Table 1). Mobile species data is summarized in Table 6 and sessile species data is summarized in Table 7. Monitoring provided the first evaluation of the site since deployments in January. Not enough data has been collected to address project ecological diversity or performance standards at this time; however, there were some notable preliminary observations.

Species diversity - UVC surveys observed 16 unique species on the ILF reef site compared to 19 species at the natural rocky reef site and 6 species at the bare sand site.

For mobile species, more finfish species were identified at the natural rocky reef site (10) than at the ILF reef site (6) or the bare sand site (3). Mobile macroinvertebrates were notably absent from the rocky reef during UVC surveys. Two structure preferring macroinvertebrate species, hermit crab and American Lobster were observed on the ILF reef but not on the natural rocky reef. Species detection differences across both sites may have been influenced by the temporal differences in sampling events (July 1 at ILF reef vs. Sept. 24 at rocky reef site) and will be assessed in future monitoring. BRUV footage analyses identified at least four unique finfish species (butterfish, dogfish sp. (smooth or spiney), sand tiger shark, and northern puffer) not found in UVC surveys.

For sessile species, more than twice as many species of macroalgae were identified at the natural rocky reef site (7) than at the ILF reef site (3). The sessile invertebrate yellow sponge (*Cliona celata*) was observed at both the natural rocky reef and the ILF reef site. Barnacles (*Balanus balanoides)* were only observed on the

ILF reef. Tufted or bushy bryozoan (*Bugula / Crisularia turrita*) was only observed at the natural rocky reef site. Species data is summarized in Table 2.

Size class distribution – DMF is still processing BRUV survey data collected in 2020. Video images have been reviewed to identify unique species. Still frame extraction and analysis for abundance and fish lengths is ongoing and expected to be completed in early 2021. Status of all data collection and processing is summarized in Table 3. Preliminary BRUV species presence results are summarized in Table 8.

Table 2. 2020 Species Summary Table

2020 Species Summary		2020 Transects			2020 BRUV (preliminary)		
		Rocky Reef Site	Yarmouth ILF Reef Site	Bare Sand Site	Rocky Reef Site	Yarmouth ILF Reef Site	Bare Sand Site
Total # of Species		19	16	6	6	5	5
Mobile Species		10	10	6	6	5	5
	Finfish	10	6	3	6	5	4
	Macro Invertebrates	0	4	3	0	0	1
Sessile Species		9	6				
	Macroalgae	7	3				
	Macro Invertebrates	2	2				

Figure 3. Still images taken from 2020 BRUV footage. Top left: black sea bass, scup and tautog at Natural Reef. Top Right: sand tiger shark and black sea bass at Yarmouth ILF Reef. Middle: close-up of black sea bass at Yarmouth ILF Reef. Bottom Left: adult and juvenile black sea bass at Yarmouth Tire Reef. Bottom Right:

Table 3. Status of Data Collection

	Ecological Performance: Diversity (species presence / richness)			Ecological Performance: Production (Size / age class / % cover similarity)		Status of Data 12/2020
	Mobile	Sessile		Mobile	Sessile	
UVC Transect Survey	X[1]	X[1]		X	X[1]	Collected, processed
BRUV	X			X[1]		Collected, in processing
Remote Acoustic	X					Collection ongoing –, 1 data dump per year (no data until late spring 2021)
[1] primary data source for analysis						

CY2020 Budget Update

In Calendar year 2020 the ILF Yarmouth reef project (IL05) expended $82 on boat and fuel maintenance, $604 in dive pay (including indirect and payroll) for monitoring, and $55,277 for contracted material deployments, totaling $55,963 in expenses. No expenses were charged for field supplies, gear maintenance, or monitoring supplies. Equipment and supplies used for 2020 monitoring were purchased in 2019, including SCUBA fills, which were purchased in bulk. A breakdown of the expenses from CY2019 and CY2020 compared to the approved 5-year budget is summarized in Table 4. The remaining balance for the project is $22,220. A line item adjustment category has been added to include estimated adjustments needed over the duration of the project to keep the project within the proposed budget.

Table 4. Budget summary table.

Line Item	Approved 5-Year Budget	Additional Approved funding	CY2019 Expenses	CY 2020 Expenses	Cumulative Charges	Remaining Balance	Line Item Budget Adjustments
SCUBA air tank fills	$2,160	$0	$800	$0	$800	$1,360	
Field Supplies for monitoring	$3,500	$0	$0	$0	$0	$3,500	($1,000)
Boat fuel and maintenance	$10,500	$0	$961	$82	$1,043	$9,457	(5,277)
Gear maintenance	$5,000	$0	$0	$0	$0	$5,000	($1,500)
Monitoring supplies	$11,000	$0	$4,173	$0	$4,173	$6,827	($4,000)
Vehicle travel and lodging	$2,750	$0	$0	$0	$0	$2,750	($1,500)
Material Deployment Contract	$180,000	$50,000	$191,000	$55,277	$246,277	($16,277)	
Dive pay	$10,187	$0	$0	$604	$604	$9,583	($3,000)
Total	**$225,097**	**$50,000**	**$196,934**	**$55,963**	**$252,898**	**$22,200**	**($16,277)**

Credit Release/Performance Standards

On November 24, DFG received notification from the Corps confirming that a larger credit release was appropriate to account for the project's actual (versus the proposed) enhancement area. Project credits have been adjusted to 0.70 acres of structured habitat enhancement within a 2.1-acre footprint, replacing the initially proposed credits of 0.33 acres within a 1.1-acre footprint (Table 5). The Corps also approved the release of 0.2796 credits for successfully meeting the project's design and construction performance standards. The release of an additional 0.0699 construction and design credits is contingent upon the completion of a follow-up side scan survey in 2025. A copy of the ACOE credit release letter is included in Appendix B.

The remaining fifty percent (0.3495 credits) of credits are linked to the project's ecological performance standards. Newly deployed structures are expected to undergo early successional changes and require several years of monitoring data before any similarity assessments can occur. Accordingly, no additional credits are being requested for release at this time.

Summary and Conclusions

MA DMF has completed the second year of the ILF Yarmouth Artificial Reef Habitat Enhancement Project, and the first season of ecological performance monitoring. Despite the completion of only one monitoring season, a few interesting observations are noteworthy, notwithstanding data limitations. Scup and BSB were observed at all sampling sites, indicating a wide/uniform species distribution throughout Nantucket Sound. Tautog and cunner were only observed on sites with structure while dogfish sp. (smooth or spiny) and butterfish were only observed on the bare sand control site. Northern sea robin and summer flounder were only observed at the natural rock reef site. Sand tiger sharks were only observed on artificial reef structures (old and new). A northern puffer was only recorded at the ILF reef site.

More than twice as many species of macroalgae were identified at the natural rocky reef compared to the newly deployed structures. This is expected for macroalgae and for several sessile invertebrate species as new structures undergo several stages of colonization and die off during early successional stages. The new deployment experienced a barnacle set sometime in the spring that had died off substantially by June when monitoring began. Barnacle colonization and subsequent die offs were also observed after materials were deployed to the Harwich reef in March 2016 and to the Boston Harbor HubLine reef deployed in February 2006.

Divers observed adult finfish species while monitoring the ILF reef site, and angling was observed at the ILF reef during all monitoring visits, indicating that large fish were consistently present on the ILF reef this year. A more robust analysis of 2020 species size class distribution will be conducted after BRUV video data have been fully processed.

A total of $686 (excluding one contractor payment for material deployment which were budgeted for 2019) was expended in 2020, well below the proposed 2020 budget of $6,744.

Forty percent of the available project credits (0.2796 credits) were released upon completion of the design and construction phase. An additional 10% release (0.0699 credits) for design and construction is contingent upon a follow-up side scan survey to be performed in 2025 in order to demonstrate that materials have remained in place. The release of the remaining 0.35 potential project credits will require meeting specific monitoring performance benchmarks outlined in Table 5 and is expected to take several years.

A short video was created using GoPro footage collected during the July 1, 2020 site monitoring and posted to the MA Marine Fisheries YouTube Channel. When conditions allow, DMF will produce additional short videos using monitoring footage to further inform the public of progress being made on the project. Links to new videos will be included in future project annual reports.

Acknowledgements

We appreciate all those who assisted in the field and reviewed this draft, especially Steven Voss, Kathryn Ford, Tay Evans, Vin Malkoski, Forest Schenck, of DMF. Thanks to Aisling O'Shea, Elisabeth Cianciola and Ron Amidon of DFG for edits to drafts, help with the budget and assistance in the field during deployments. Thanks also to the Town of Yarmouth Department of Natural Resources and the Cape Cod Salties for their continued project support.

Appendices

A. Yarmouth Artificial Reef Monitoring SOP's for the ILF-funded deployment in 2020
B. File No. NAE-2012-00311, State of Massachusetts In-Lieu Fee Program Instrument, Credit Release, 2019-CS-Artificial Reef Habitat Enhancement, Yarmouth, Massachusetts

Table 5. Goals, Performance Standards, Metrics and Mitigation Credit Release Schedule (updated 12/2020)

Type of mitigation	**Project Area[1]**		**Proposed Habitat Area[1]**		**Proposed Credits[1]**
Artificial Reef Habitat	2.1 acres		Reef structure – 0.70 acres Undisturbed sandy bottom – 1.4 acres Total enhanced area = 2.1 acres		.70 wetland credits (*multiplier 1:3 for 2.1 acres of enhanced marine subtidal habitat*)
Performance Standards & metrics	**% total Credit**	**Credit amount**		**Timeline -credit release**	**Comments**
Design & Construction Parameters:	**50%**	**0.35** (0.1830)			Designed to maximize its potential to function effectively as sub-tidal structured habitat
Materials deployed to site as specified in design	40%	0.2796 (0.1464)	2019 / 2020	Post-construction	Completed. 40% credit based on adjusted credit release (reference ACOE 11/24/20 letter)
Material remains within proposed site and remains stable in accordance with permit conditions	10%	0.0699 (0.0366)	2024	Post 5-year monitoring report	Upon completion of 5-year (2025) side scan sonar survey
Monitoring: Conducted as per monitoring plan					**Submitted annually** **Year 1, season 1 monitoring data is included with this report.** **Ecological performance is assessed across two or more years of monitoring data.**
Ecological Performance: Diversity	**25%**	0.175 (0.0915)			Monitoring results show evidence of similarity of species diversity
Species diversity – mobile species	12.5%	0.08735 (0.04575)	2020-2024	Percent similarity exceeds 60% in two monitoring periods	The resident mobile species assemblage on the reef shall have species richness similar to natural reefs within the region.
Species diversity – sessile species	12.5%	0.08735 (0.04575)	2020-2024	Percent similarity exceeds 60% in two monitoring periods	The resident sessile species assemblage on the reef shall have species richness similar to natural reefs within the region
Ecological Performance: Production	**25%**	0.175 (0.0915)			Monitoring results show evidence of multiple size classes of predator and prey species
Size/age class similarity of mobile species – upper-level consumers	12.5%	0.0875 (0.04575)	2020-2024	Percent similarity exceeds 60% in two monitoring periods	Mobile species size class distribution on the artificial reef shall be similar to natural reefs within the region
Size/age class similarity of sessile species – benthic community/ lower level producers	12.5%	0.0875 (0.04575)	2020-2024	Percent similarity exceeds 60% in two monitoring periods	The relative abundance of the top 10 sessile species on the artificial reef shall be similar to the top 10 sessile species on natural reefs within the region
Total Credit Potential	**100%**	**0.70** **(0.366)**		**2020-2024**	**Wetlands Mitigation Credits**

Table 6. 2020 Mobile Species Monitoring Results

	Season / Year	Summer/Fall 2020										
	Location	Natural Rock Reef (RR)		ILF Reef (IR)				Bare Control (BC)		RR	IR	BC
	Transect (bearing)	1 (0)	2 (260)	1 (80)	2 (135)	3 (230)	4 (300)	1 (90)	2 (180)	Avg Ct / transect		
Arthropods	American lobster (*Homarus americanus*)	0	0	0	0	0	1	0	0	0	0.25	0
	Rock crab (*Cancer irroratus*)	0	0	0	0	0	0	0	0	0	0	0
	Jonah crab (*Cancer borealis*)	0	0	0	0	0	0	0	0	0	0	0
	Spider/decorator crab Family Majidae (*Libina/Hyas*)	0	0	0	0	0	0	1	1	0	0	1
	Large hermit crabs (*Pagarus sp.*)	0	0	0	0	0	1	5	0	0	0.25	2.5
	Lady Crab (*Ovalipes ocellatus*)	0	0	0	0	1	0	0	0	0	0.25	0
Cnidarian/Tunicates	Frilled anemone (*Metridium senile*)	0	0	1	0	0	0	0	0	0	0.25	0
	Northern cerianthid (*Cerianthus borealis*)	0	0	0	0	0	0	0	0	0	0	0
	European sea squirt (*Ascidiella aspersa*)	0	0	0	0	0	0	0	0	0	0	0
	Sea Vase sea squirt (*Ciona intestinalis*)	0	0	0	0	0	0	0	0	0	0	0
	Club tunicate (*Styela clava*)	0	0	0	0	0	0	0	0	0	0	0
Echinoderms	Green urchin (*Stronglyocentrotus droebachiensis*)	0	0	0	0	0	0	0	0	0	0	0
	Blood star (*Henricia sp.*)	0	0	0	0	0	0	0	0	0	0	0
	Sea star w/ orange madreporite (*Asterias forbesi*)	0	0	0	0	0	0	0	0	0	0	0
	Sea star w/ white madreporite (*Asterias vulgaris*)	0	0	0	0	0	0	0	0	0	0	0
	Sand dollar (*Echinarachnius parma*)	0	0	0	0	0	0	0	0	0	0	0
Gastropods	Northern moon snail (Euspira *heros*)	0	0	0	0	0	0	1	0	0	0	0.5
	Common/waved whelk (*Buccinum undatum*)	0	0	0	0	0	0	0	0	0	0	0
	Channeled whelk (*Busycotypus canaliculatus*)	0	0	0	0	0	0	0	0	0	0	0
Sponges	Yellow Sponge (*Cliona celata*)	0	0	4	0	2	5	0	0	0	2.75	0
Fish	Scup (*Stenotomus chrysops*)	10	4	23	4	11	23	0	0	7	15.25	0
	Juvenile Scup (*Stenotomus chrysops*)	18	30	0	0	0	0	23.1	43.3	24	0	33.2
	Cunner (*Tautogolabrus adspersus*) **Estimate**	68.1	230.5	6	11	17	14	0	0	149.3	12	0
	Shorthorn, grubby & longhorn (*Myoxocephalus sp.*)	0	2	0	0	0	0	0	0	1	0	0
	Winter flounder (*Pseudopleuronectes americanus*)	0	0	0	0	0	0	0	0	0	0	0
	Windowpane flounder (*Scophthalmus aquosus*)	0	0	0	0	0	0	0	0	0	0	0
	Summer flounder (*Paralichthys dentatus*)	0	1	0	1	2	0	0	0	0.5	0.75	0
	Black sea bass (*Centropristis striata*)	97.2	79	11	14	14	19	0	3	88.1	14.5	1.5
	Juvenile Black sea bass	75	137	0	0	0	0	20.1	123.4	106	0	71.75
	Tautog (*Tautoga onitis*)	0	7	9	10	7	13	0	0	3.5	9.75	0
	Juvenile Tautog (*Tautoga onitis*)	5	0	0	0	0	0	0	0	2.5	0	0
	Northern Sea Robin (*Prionotus carolinus*)	0	1	0	0	0	1	0	0	0.5	0.25	0
Other												

Table 7. 2020 Sessile Species Monitoring Results

Season / Year								
Location	Natural Rock Reef (RR)		ILF Reef (IR)				RR	IR
Transect (bearing)	1 (0)	2 (260)	1 (80)	2 (135)	3 (230)	4 (300)	Avg % cover / transect	
Brown Algae								
Knotted wrack (*Ascophyllum nodosum*)	0.3	0	0	0	0	0	0.15	0
Shotgun kelp, with holes (*Agarum cribrosum*)	0	0	0	0	0	0	0	0
Common kelp, no mid-rib (*Laminaria sp.*)	0	0	0	0	0	0	0	0
Mid-rib kelp (*Alaria sp.*)	0	0	0	0	0	0	0	0
Unid filamentous browns	0.18	0.27	0.29	0.09	0.09	0.59	0.225	0.265
Red Algae								
Red Filamentous/Foliose	2.79	3.57	0.7	1.2	0.09	0	3.18	0.4975
Red Blade (*Palmaria or Membranoptera)*	0.77	1.18	0	0	0	0.5	0.975	0.125
Red Coralline Crust	0	0	0	0	0	0	0	0
Irish moss *(Chondrus crispus)*	0	0	0	0	0	0	0	0
Unid filamentous reds	0.18	2.3	0	0	0	0	1.24	0
Green Algae								
Green blade (*Ulva lactuca)* drift	0	0	0	0	0	0	0	0
Branching green (*Codium sp.)* drift	0.99	3.19	0	0	0	0	2.09	0
Unid filamentous greens	0	0.09	0	0	0	0	0.045	0
Invertebrates								
Tufted or bushy bryozoan (*Bugula / Crisularia turrita*)	24.1	32.09	0	0	0	0	28.095	0
Palmate sponge *(Isodictya sp.)*	0	0	0	0	0	0	0	0
Crumb Bread Sponge (*Halichondria sp.*)	0	0	0	0	0	0	0	0
Sheath tunicate (*Botrylloides violaceus*)	0	0	0	0	0	0	0	0
Star tunicate (*Botryllus schlosseri)*	0	0	0	0	0	0	0	0
Northern Rock Barnacle (*Balanus balanoides*)	0	0	16	10	0	0	0	6.5
Dead man's fingers (*Haliclona oculata*)	0	0	0	0	0	0	0	0
Pink-hearted hydroid *(Tubularia crocea)*	0	0	0	0	0	0	0	0
Snotty gray tunicate (*Didemnum sp.*)	0	0	0	0	0	0	0	0
Blue mussels (*Mytilus edulis*)	0	0	0	0	0	0	0	0
Sand dollar (*Echinarachnius parma*)	0	0	0	0	0	0	0	0
Yellow Sponge (*Cliona celata*)	0	0.8	1.2	0	0.5	1.6	0.4	0.825

Table 8. 2020 BRUV Species Presence (preliminary)

	September 2020 BRUV Monitoring				October 2020 BRUV Monitoring 1				October 2020 BRUV Monitoring 2			
	Natural Rock Reef	Bare Sand Control	ILF Reef	Tire Reef	Natural Rock Reef	Bare Sand Control	ILF Reef	Tire Reef	Natural Rock Reef	Bare Sand Control	ILF Reef	Tire Reef
Black Sea Bass (*Centropristis striata)*	X		X	X	X		X	X	X		X	X
Juvenile Black Sea Bass (*Centropristis striata)*	X	X	X	X	X	X		X	X	X	X	
Scup (*Stenotomus chrysops*)	X	X	X	X	X	X	X	X	X	X	X	X
Juvenile Scup (*Stenotomus chrysops*)	X	X								X		
Northern Sea Robin *(Prionotus carolinus)*	X											
Summer Flounder (*Paralichthys dentatus*)	X											
Dogfish (spiny and/or smooth)		X				X						
Sand Tiger Shark *(Carcharias Taurus)*			X	X			X				X	X
Cunner (*Tautogolabrus adspersus)*					X				X			
Tautog (*Tautoga onitis*)					X		X	X	X		X	
Butterfish (*Peprilus triacanthus*)										X		
Northern Puffer *(Phoeroides maculatus)*											X	
Spider Crab (*Libinia emarginata)*						X						
Unconfirmed ID (possibly Blue Runner, Bluefish or Weakfish)						X	X			X	X	X

Appendices

A. Yarmouth Artificial Reef Monitoring SOP's for the ILF-funded deployment in 2020

B. File No. NAE-2012-00311, State of Massachusetts In-Lieu Fee Program Instrument, Credit Release, 2019-CS-Artificial Reef Habitat Enhancement, Yarmouth, Massachusetts

Appendix A.

Yarmouth Artificial Reef Monitoring SOP's for the ILF-funded deployment in 2020

Massachusetts Division of Marine Fisheries (MA DMF) Standard Operating Procedure

Yarmouth Artificial Reef Monitoring for the ILF-funded deployment

Updated 12/03/2020

POINT OF CONTACT
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This is a working document that contains the Standard Operating Procedures (SOP) used for data collection and monitoring of the ILF-funded material deployment to the Yarmouth Artificial Reef in Nantucket Sound:

Yarmouth Reef SOP's

Station locations:

	Start Lat	Start Lon	Transect ID	Bearing	
ILF Reef	41.60593	-70.19157	1	80	
			2	135	
			3	230	
			4	300	
Natural Reef	41.56829	-70.24202	1	0	BRUV
			2	100	
Bare Sandy	41.61255	-70.12772	1	90	BRUV
			2	180	
Harwich Reef	41.625972	-70.069944	N/A	N/A	BRUV
Yarmouth Tires	41.60832	-70.19348	N/A	N/A	BRUV*
Yarmouth ILF Deployment	41.605464	-70.192077	N/A	N/A	BRUV
	*original temp monitor / acoustic receiver location (one temp monitor still at this location				

Schedule (criteria from ILF proposal):

Table modified: 011/30/2020								
Monitoring Schedule		Pre-Deploy	Year 0 (2020)		Year 1 and 2 (2021-2022)		Year 3 and 4 (2023-2024)	2025
			May-Oct	Nov-Apr	Summer/Fall	Winter/Spring	Annual	Annual
Permanent transect survey Quadrats (sessile species) and Swath (mobile species) along 50m fixed transects								
	natural reef	x	x	x	x	x	x	x
	artificial reef	x	x	x	x	x	x	x
Camera/ Video survey	natural reef	x	3		3		3	3
	artificial reef	x	3		3		3	3
Side scan survey		x	x					x
Temp / acoustics			x	x	x	x	x	x
completed								

Field Day Preparation (from DMF AR SOP's dated 8/15/2018):

- **a.** Coordinate available divers and topside personnel
- **b.** Reserve any boats and/or vehicles needed
- **c.** File Dive Plans and get approval from DSO
- **d.** Equipment Prep: See Gear Checklist in Reef Notebook

Monitoring Methods:

a. Reef Notebook

Record all monitoring visits in the Artificial Reef notebook. Scan field notes and save electronic copy in W: Drive

b. Stationary time-series monitoring

1. Temperature Monitors and Housings (from DMF AR SOP's dated 8/15/2018)

Temperature monitors remain on-site year-round and are swapped out annually. Bottom temperature data is collected hourly using ONSET Hobo ProV2 data loggers and/or HOBO Pendants. For time-series temperature data see the DMF Bottom Temperature Database.

Temperature loggers need to be changed out annually. Divers access the temperature logger housing (Figure 1) and use a 3/4" wrench to loosen the bolt on one end of the white PVC tube.

Figure 1. Temperature Housing at site

Inside the PVC tube is a white PVC Temperature Logger housing (Figure 2).

Figure 2. Temperature Logger Housing

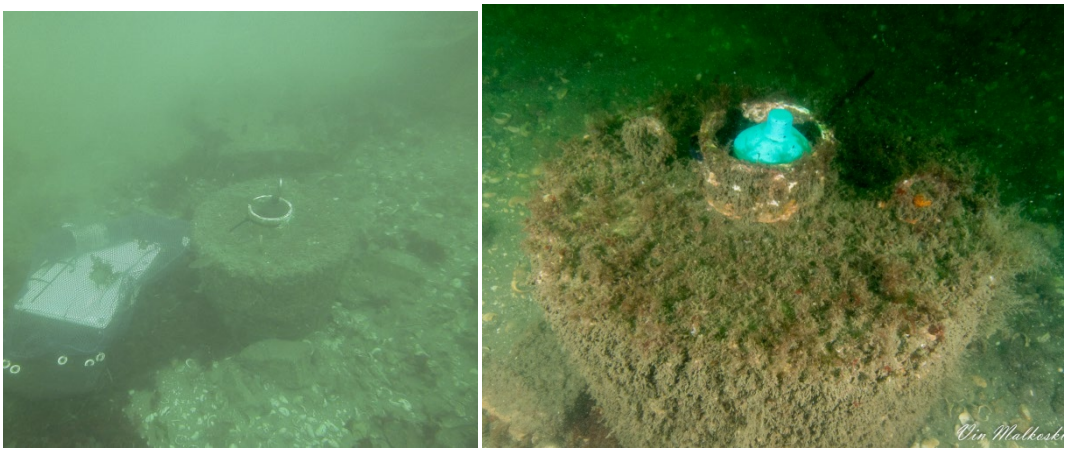
Unscrew the housing and carefully switch out ProV2 and/or Logger. Make sure temperature logger is in a secure location before moving on. WARNING: Loggers are positively buoyant and will ascend to the surface if they are not secured during handling.

2. Acoustic Receivers and Housings (from DMF AR SOP's dated 8/15/2018)

Receivers remain on-site year-round and are swapped out annually.

Changing out acoustic receivers

Make sure receiver is activated prior to deployment. Record the date and time of deployment as well as the serial numbers of the receivers being deployed and recovered. Drop weighted surface buoy on the coordinates and locate the receiver on the bottom. The acoustic receivers are secured via zip ties (14 inch or longer) within concrete housings (Figure 3). Divers locate concrete block and carefully replace the acoustic receiver. (Is gear needed on gear list – or just use dive knife receiver and zip ties?) Receivers need to be activated prior to deployment



There is video from the Harwich reef 11/03/2016 monitoring of acoustic receiver replacement. See YouTube video.

c. Diver Monitoring

Transect setup: At the artificial reef locations, divers descend on fixed station waypoints to the bottom. Divers then search for the transect start point, which varies from a screw anchor to a temp monitor housing depending on the specific location. Here, divers attach a regular transect tape to the start point and head XX degrees (see maps) along the bottom out 50m.

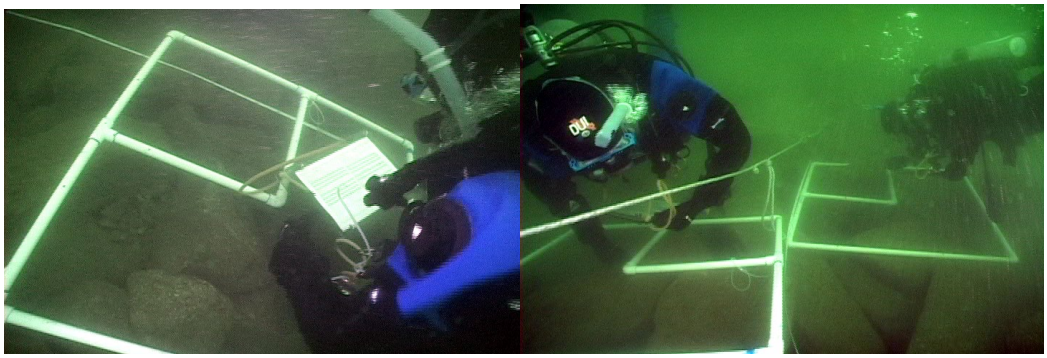


Figure 5. Divers conducting Transect Sampling

Swaths: Two-meter width swath sampling along both sides of each 50m transect. Enumerate mobile species observations every 5 meters.

Quadrats: Ten, one-meter quadrat samples collected along both sides of each 50m transect. Quadrats locations are determined by randomly selecting two quadrats every ten meters using a table of randomly generated numbers (random number table below) for a total of 20 quadrats sampled, 10 on each side. A photo is taken of every quadrat and divers enumerate all life within all odd-numbered quadrats.

d. Stationary Video

Stationary video is used to document species presence. Divers deploy a stationary GoPro video camera on or near the on-site marker or the zero meter transect mark and directed to view the transect tape or other prominent landscape features. Camera is fastened in place using zip ties. Video runs until the battery dies or when it is recovered by divers. Stationary videos are collected on one dive during each monitoring visit if visibility allows.

e. BRUV Stations / BRUV monitoring

Each BRUV is a weighted PVC frame, a solid state sports camera with underwater housing attached to an aluminum bait-pole, a bait box located 0.8 m from the camera and suspended 19.5 in (49.5 cm) from the benthos, and a rope and float system linking the BRUV to a surface buoy. All cameras set to 960 video resolution, 60 frames per second, and a wide field of view to maximize battery life. Video focal width at the bait box is demarcated in 7.6 cm increments using alternating black and white colored tape under the bait box and extending along the bait-pole. Cameras are bolted to the bait-pole such that fish can be viewed in a horizontal orientation to the benthos. Three to four pounds (1.4-1.8 kg) of Atlantic mackerel, *Scomber scombrus*, are inserted into the bait box for each deployment. Two-thirds of the bait is chopped and inserted into a mesh bag within the bait box to ensure fish could not completely consume the bait before the end of a recording period. Additional whole fish were added to the bait box for each deployment.

Sampling is restricted to calm days with ocean swells of one foot or less; all units are deployed during daylight hours between 08:00-16:00 hours to prevent any biases associated with diurnal behavior. BRUVs are consecutively deployed to all sites from a small vessel and retrieved 45 minutes after the last site deployment. This allowed for a 15-minute soak period and at least 30 minutes of overlapping video across all four recordings for comparison. The desired products for analysis were four 30-minute video samples with no differences in field conditions across all sites (time of day, tide, swell, wind, cloud cover, etc).

Maps

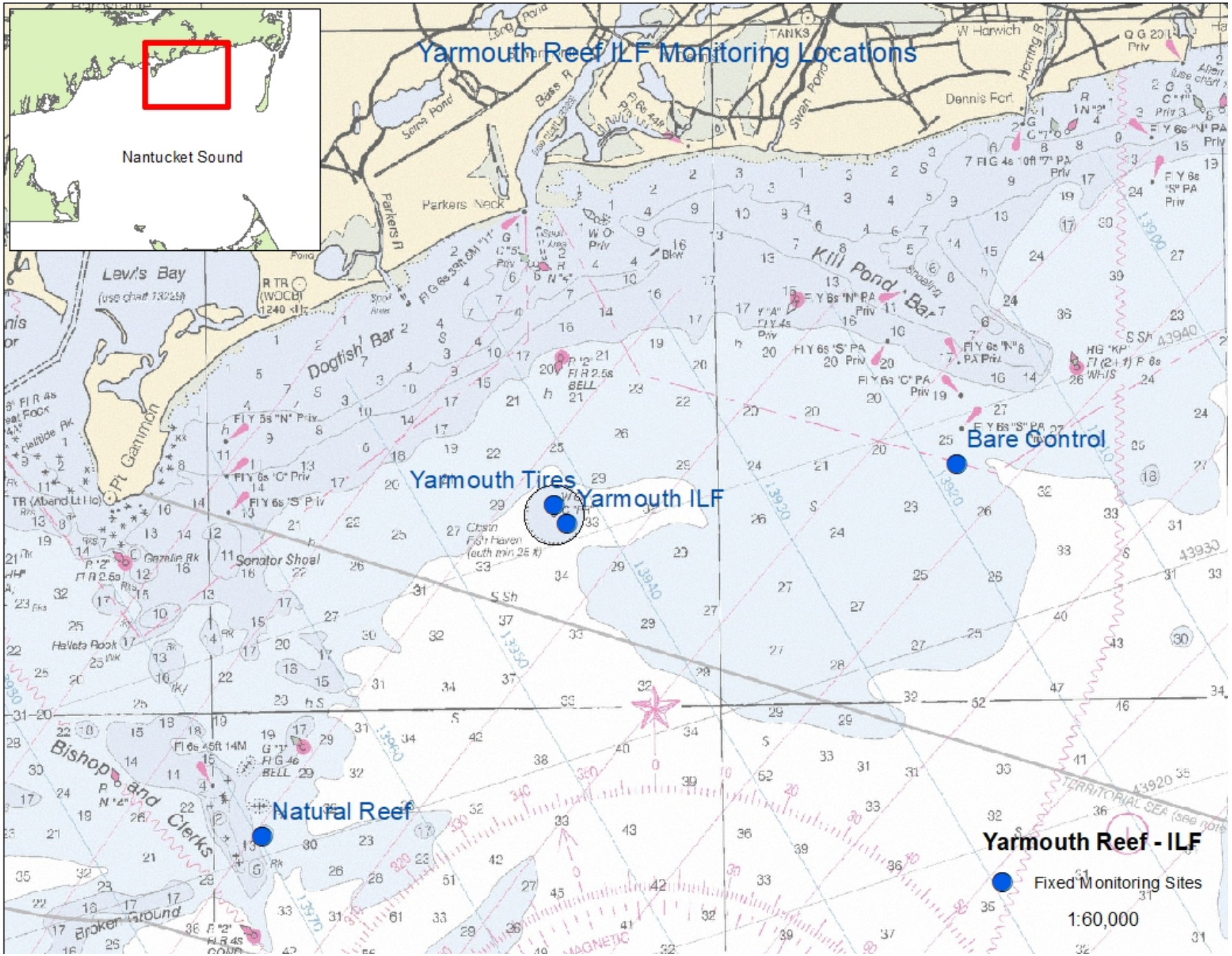
A. Nantucket Sound Monitoring Stations (1:60,000)

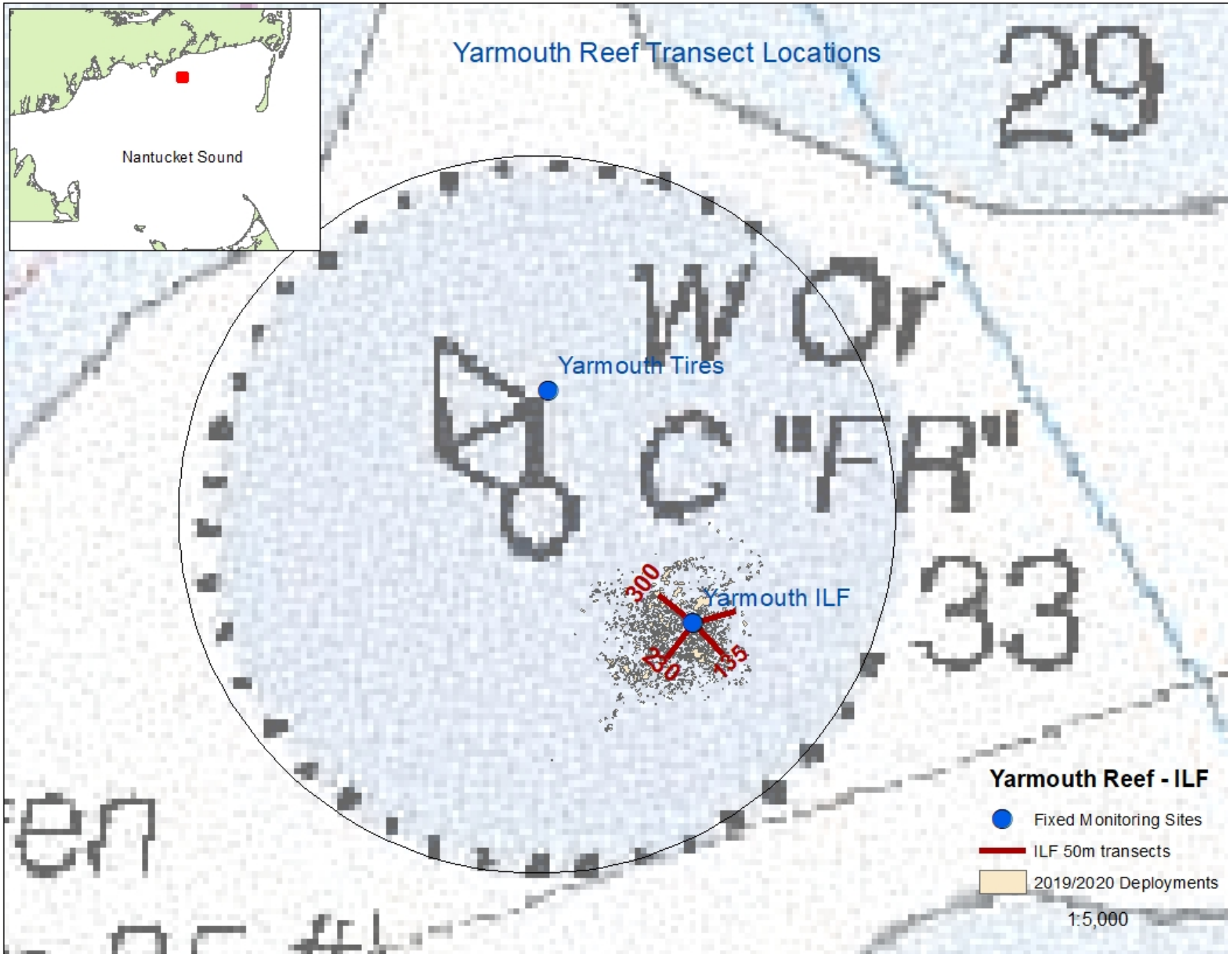
B. Yarmouth Artificial Reef Monitoring Stations (1:5,000)

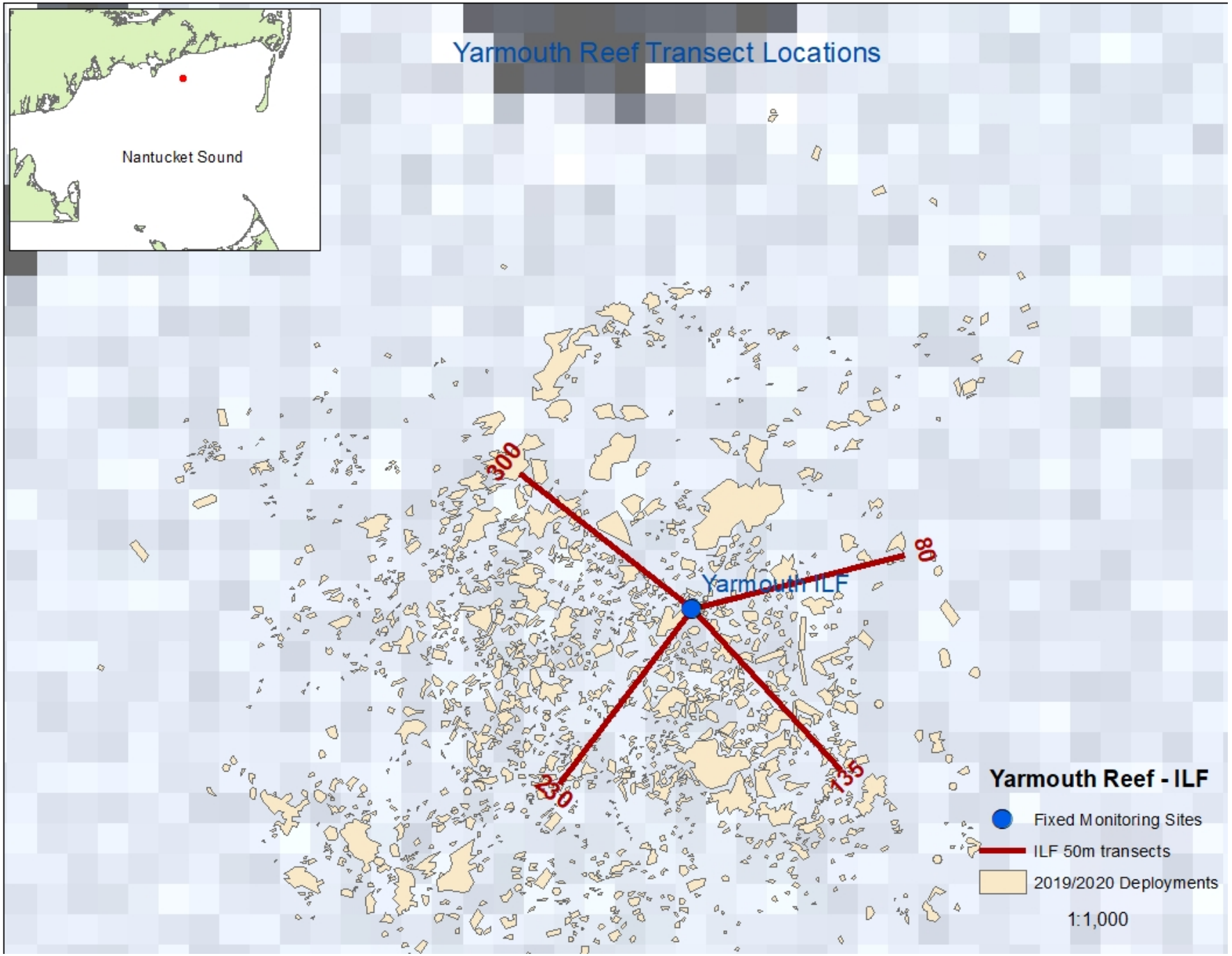
C. Yarmouth Artificial Reef, ILF Deployment Area Monitoring Stations and Transect Directions (1:1,000)

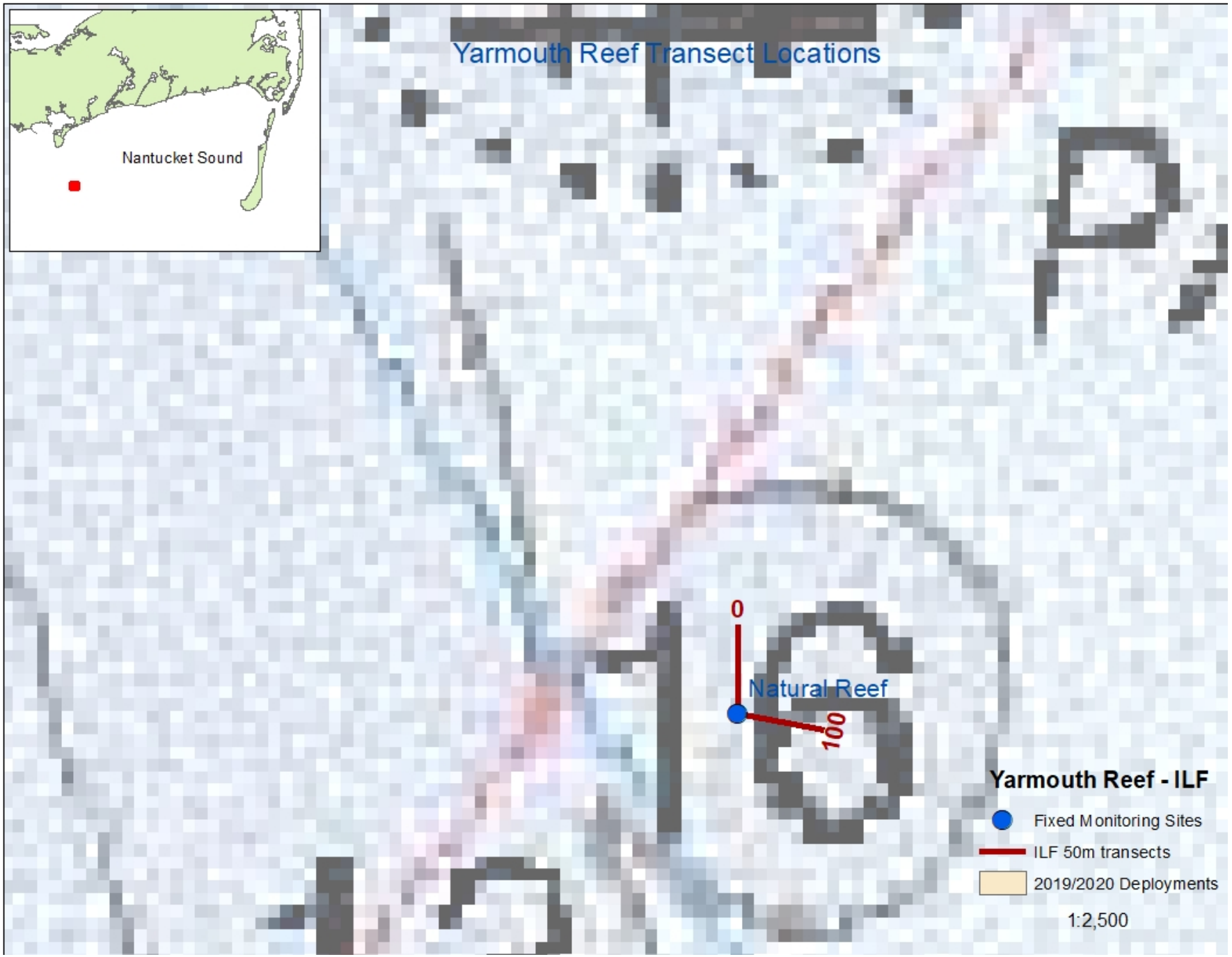
D. Natural Reef Site and Transect Directions (1:2,000)

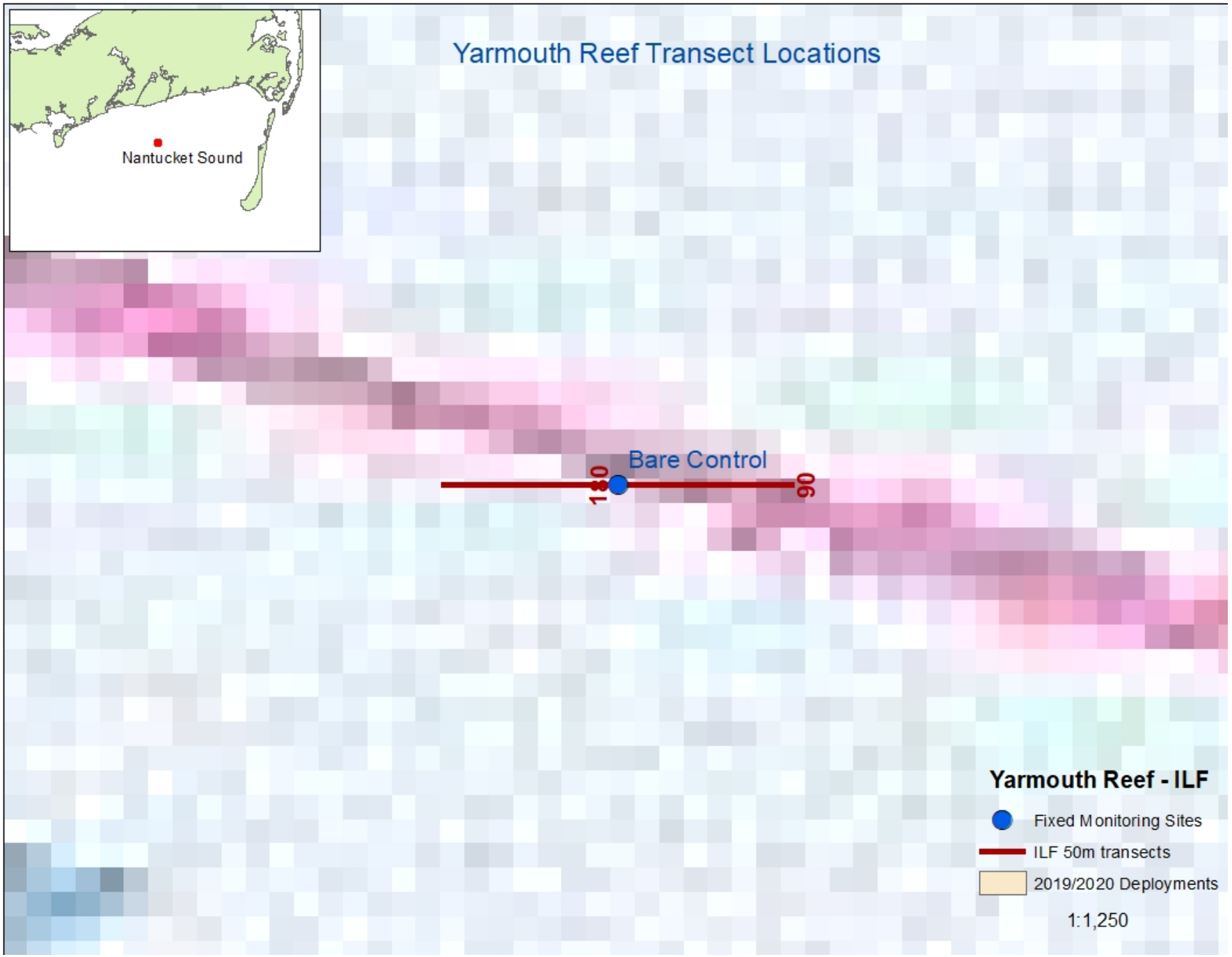
E. Bare Control Site and Transect Directions (1:2,000) – NOT A required monitoring site


Yarmouth Reef ILF Monitoring Locations
Nantucket Sound
Bare Control
Yarmouth Tires
Yarmouth ILF
Natural Reef
Yarmouth Reef - ILF
Fixed Monitoring Sites
1:60,000


Yarmouth Reef Transect Locations
Nantucket Sound
Yarmouth Tires
Yarmouth ILF
300
135
Yarmouth Reef - ILF
Fixed Monitoring Sites
ILF 50m transects
2019/2020 Deployments
1:5,000


Yarmouth Reef Transect Locations
Nantucket Sound
300
80
230
135
Yarmouth ILF
Yarmouth Reef - ILF
Fixed Monitoring Sites
ILF 50m transects
2019/2020 Deployments
1:1,000


Yarmouth Reef Transect Locations
Nantucket Sound
0
Natural Reef
100
Yarmouth Reef - ILF
Fixed Monitoring Sites
ILF 50m transects
2019/2020 Deployments
1:2,500



Not a required monitoring site – center point is also Bare Control BRUV site.

Random number table for assigning quadrat locations for Yarmouth Reef monitoring for ILF Project									
						Two random numbers per 10m. If number is repetitive then move to the next number down the list.			
0-10	11-20	21-30	31-40	41-50	extra				
3	5	4	1	2	9				
9	0	0	6	1	5				
5	8	8	6	6	9				
3	5	1	6	5	5				
2	2	2	7	3	5				
7	5	7	2	3	0				
4	7	1	3	2	2				
4	8	2	1	3	5				
9	8	8	2	0	1				
5	3	8	0	6	5				
3	7	3	6	6	7				
3	1	8	8	1	7				
0	7	5	0	2	7				
7	1	5	3	3	3				
1	4	9	6	1	4				
8	0	4	6	5	4				
8	3	7	0	0	0				
7	9	5	2	6	1				
6	1	4	4	3	8				
4	4	1	1	6	7				
4	7	8	2	9	8				
0	6	3	1	4	2				
2	6	1	0	6	6				
7	0	6	2	5	9				
4	4	9	7	5	3				
1	0	8	3	7	8				
7	8	3	0	8	7				
5	0	7	5	1	6				
8	2	3	0	7	0				
7	2	8	7	6	8				
9	3	4	5	8	7				
4	4	5	2	3	6				
2	5	5	1	3	5				
1	2	1	2	7	8				
9	6	9	5	7	5				
0	0	7	9	2	9				
6	5	7	6	4	6				
4	8	1	2	8	7				
1	6	3	5	3	6				
5	2	7	3	9	3				
9	3	8	3	6	4				
2	6	3	8	1	4				

Data Sheets

A. **Quadrat Data**
B. **Swath Data**
C. **BRUV**
D. **Species Presence**

Date_____ Site ID Transect ID Diver_____ **Yarmouth Reef ILF**

Bearing _____ Left / Right Visibility_____ Buddy_____ Depth _____

Photo Quadrat (**1**m^2) - photograph all quadrats. Estimate % cover every other quadrat (odd #'s).

	Q1	Q2	Q3	Q4	Q5	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*
Quadrat	___( )	___( )	___( )	___( )	___( )	___( )	___( )	___( )	___( )	___( )
Check off										

Substrate

Quadrat (**1** meter^2)	Q1	Q3	Q5	Q7	Q9	
Sampling Start Mark	___( )	___( )	___( )	___( )	___( )	
Primary (>50%)						
Secondary (10-50%)						
Tertiary (<10%)						
Tertiary (<10%)						
Tertiary (<10%)						

SA=Sand; GR=Granule (0.2-0,4cm bb to pea size); PE=Pebble (0,4-0,6cm pea to billiard ball)

CO=Cobble (6-25cm billiard ball to head size); BO=Boulder(> head size)

Notes:

Quadrat (**1**m^2)	Q1	Q3	Q5	Q7	Q9
Sampling Start Mark	___( )	___( )	___( )	___( )	___( )
Brown Algae					
Agarum cribrosum (kelp with holes)					
Laminaria sp. (thick blade)					
Alaria sp. (mid-rib)					
Unid filamentous browns					
Reds					
RedFilamentous/Foliose					
Red Blade (*Palmaria or Membranoptera*)					
Red Coralline Crust					
Chondrus crispus					
Unid filamentous reds					
Greens					
Ulva lactuca (green blade -prob. drift)					
Codium sp. (branching green, prob. drift)					
Unit filamentous greens					
Sessile Inverts					
Bugula (Tufted bryozoan)					
Palmate sponge *(Isodictya sp.)*					
Crumb Bread Sponge (*Halichondria sp.*)					
Botrylloides violaceus (orange, white tunicate)					
Botryllus schlosseri (star tunicate)					
Barnacles					
Haliclona oculata (deadmans fingers)					
Tubularia (hydroid with pink)					
Didemnum sp. (snotty gray tunicate)					
Blue mussels					
Sand dollars					

Date_____ Site ID_____ Diver_____ **Yarmouth Reef ILF**

Hour_____ Depth_____ Left / Right Vis. Buddy Bearing

		0-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m
Arthropods	Homarus americanus (American lobster)										
	Cancer irroratus (Rock crab - sharp point carapace)										
	Cancer borealis (Jonah crab)										
	Family Majidae (Libina/Hyas - spider crabs)										
	Large hermit crabs (width of large chelae >1.5 cm)										
	Lady Crab										
Cnidarian/Tunicates	Metridium senile (frilled anemone)										
	Northern cerianthid (Cerianthus borealis)										
	Ascidiella aspersa (tunicate warty with no yellow rim)										
	Ciona intestinalis (sea squirt with yellow rim)										
	Styela sp. (warty, knobby sea squirt)										
Echinoderms	Stronglyocentrotus droebachiensis (green urchin)										
	Henricia sp. (Blood star)										
	Asterias forbesi (orange madreporite)										
	Asterias vulgaris (white madreporite, row spines down arms)										
	Sand Dollar										
Gastropods	Lunatia heros (Moon snail)										
	Buccinum undatum (waved whelk)										
	Channeled whelk										
Fish	Scup										
	Cunner (estimate)										
	Myoxocephalus sp.(shorthorn, grubby & longhorn)										
	Winter flounder (*P. americanus*)										
	Windowpane										
	BSB										
	Tautog										
	Fluke										
Other											

BRUV Field Data Sheet

Date: | Vessel:
Crew: | Tide @ Time:

Drop Site:	Weather:
Drop # Boats:	Recovered # Boats:
BRUV Name:	SD Card Number:
Drop Time:	Drop Depth:
Recover Time:	Recover Depth:
Lat:	Long:
Notes:	

Drop Site:	Weather:
Drop # Boats:	Recovered # Boats:
BRUV Name:	SD Card Number:
Drop Time:	Drop Depth:
Recover Time:	Recover Depth:
Lat:	Long:
Notes:	

Drop Site:	Weather:
Drop # Boats:	Recovered # Boats:
BRUV Name:	SD Card Number:
Drop Time:	Drop Depth:
Recover Time:	Recover Depth:
Lat:	Long:
Notes:	

Drop Site:	Weather:
Drop # Boats:	Recovered # Boats:
BRUV Name:	SD Card Number:
Drop Time:	Drop Depth:
Recover Time:	Recover Depth:
Lat:	Long:
Notes:	

PHYLUM	CLASS	ORDER	FAMILY	GENUS	SPECIES	COMMON NAME	NATURAL % Cover	ARTIFICIAL % Cover	NATURAL NUMBER (n/m²)	ARTIFICIAL NUMBER (n/m²)
Ochrophyta										
	Class Phaeophyceae		Laminariaceae	*Saccharina*	*latissima*	Sugar Kelp				
				Laminaria	*digitata*	Oarweed				
	Ochrophyta (unspecified)					Filamentous Brown				
	Subtotal									
Rhodophyta										
	Class Florideophyceae		Gigartinaceae	*Chondrus*	*crispus*	Irish Moss				
			Palmariaceae	*Palmaria*	*palmata*	Dulse				
	Rhodophyta (unspecified)					Filamentous Red				
		Corallinales (unspecified)				Encusting Coralline				
	Subtotal									
Chlorophyta										
	Class Ulvophyceae		Ulvaceae	*Ulva*	*lactuca*	Sea Lettuce				
	Chlorophyta (unspecified)					Drift Green				
	Subtotal									
Arthropoda										
	Class Malacostraca	Decapoda	Paguridae	*Pagurus*	*pollicaris*	Hermit Crab				
			Epialtidae	*Libinia*	*emarginata*	Spider Crab				
			Portunidae	*Ovalipes*	*ocellatus*	Lady Crab				
				Carcinus	*maenas*	Green Crab				
			Nephropidae	*Homarus*	*americanus*	American Lobster				
			Cancridae	*Cancer*	*irroratus*	Atlantic Rock Crab				
				Cancer	*borealis*	Jonah Crab				
		Xiphosura	Limulidae	*Limulus*	*polyphemus*	Horseshow Crab				
	Subtotal									
Echinodermata										
	Class Echinoidea		Echinarachniidae	*Echinarachnius*	*parma*	Sand Dollar				
	Subtotal									
Mollusca										
	Class Gastropoda		Busyconidae	*Busycotypus*	*canaliculatus*	Channeled Whelk				
				Busycon	*carica*	Knobbed Whelk				
			Calyptraeidae	*Crepidula*	*fornicata*	Slipper Shell				
				Crepidula	*convexa*	Convex Slippersnail				
	Class Bivalvia	Veneroida	Veneridae	*Mercenaria*	*mercenaria*	Quahog				
			Mactridae	*Spisula*	*solidissima*	Surf Clam				
		Ostreoida	Mytilidae	*Mystilus*	*edulis*	Blue Mussel				
	Subtotal									
Cnidaria										
	Class Anthozoa		Metridiidae (unspecified)			Anemone				
	Subtotal									
Porifera										
	Class Demospongiae	Hadromerida	Clionaidae (unspecified)			Yellow Sponge				
		Halichondrida	Halichondriidae	*Halichondria*	*panicea*	Breadcrumb Sponge				
	Subtotal									
Chordata										
Tunicata										
	Tunicata (unspecified)					Tunicates				
	Class Actinopterygii	Perciformes	Zoardcidae	*Zoarces*	*americanus*	Ocean Pout				
			Labridae	*Tautogolabrus*	*adspersus*	Cunner				
			Serranidae	*Centropristis*	*striata*	Black Sea Bass				
			Moronidae	*Morone*	*saxatilis*	Striped Bass				
		Labriformes	Labridae	*Tautoga*	*onitis*	Tautog				
		Pleuronectiformes	Paralichthyidae	*Paralichthys*	*dentatus*	Summer Flounder				
			Pleuronectidae	*Pseudopleuronectes*	*americanus*	Winter Flounder				
			Scophthalmidae	*Scophthalmus*	*aquosus*	Windowpane Flounder				
		Gadiformes	Gadidae	*Pollachius*	*pollachius*	Pollock				
	Class Chondrichthyes	Rajiformes (unspecified)				Skate				
	Subtotal									

Data Storage – All handwritten data sheets and notebooks are kept on file at DMF Annisquam River Marine Fisheries Station. All paper files are scanned to .pdf files and saved in a secure drive (DMF W:). For acoustic receiver and temperature sensor data, electronic files are uploaded and saved to W: drive. For stationary video/photo data, and BRUV, files are temporarily stored on the W: drive for processing and data analysis. Once per year all project image files are archived to the secure DMF V: drive.

Outreach / Reporting – There is significant public interest in this project, especially recreational anglers on Cape Cod. When conditions allow, DMF will release short videos to the MA Marine Fisheries YouTube channel to provide the public with information from our monitoring efforts. New video links will be added here as they are generated.

MA MarineFisheries YouTube Channel

Harwich Reef Monitoring 11/03/2016 – example of acoustic receiver recovery replacement SOP

Yarmouth Artificial Reef Monitoring 07/01/2020

BRUV Video Analysis

Video files are manually analyzed by reviewer using the open-source VLC™ (VideoLAN Client) media player to ensure video analysis and related bias was consistent across all replicates. Visibility is estimated directly from the video using the bait box (0.8 m from camera) as a guide. Time to first fish sighting is documented. Still frames for analysis are captured from each 30-minute recording in 30-second increments for a total of 60 analyzed frames per recording. Additional examination of up to five seconds before and/or after a given still frame is allotted when water clarity was limited. The identity of each species of fish, an index of its relative abundance (MaxN), and quantitative length estimates of two species of economic significance, black sea bass (*Centropristis striata*) and scup (*Stenotomus chrysops*), are documented within each frame. MaxN is the maximum number of a given species of fish within the field of view at any one frame during a 30-min recording; this index is employed to prevent double counts of individual fish (Cappo et al. 2004; Malcolm et al. 2007). Due to the documented error in estimating exact fish length measurements from mono H-BRUV recordings (Cappo et al. 2004; Folpp et al. 2013), fish of interest were binned by species into size ranges to distinguish between juvenile, undersized adult, and legally fishable adults. Specifically, black sea bass were binned into 0-3, 3-15, and over 15 inches and scup were binned into 0-3, 3-9, and over 9 inches. ImageJ 1.52a NIH software is used to aid fish binning when necessary.

Appendix B.

File No. NAE-2012-00311, State of Massachusetts In-Lieu Fee Program Instrument, Credit Release, 2019-CS-Artificial Reef Habitat Enhancement, Yarmouth, Massachusetts

DEPARTMENT OF THE ARMY
US ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
696 VIRGINIA ROAD
CONCORD MA 01742-2751

November 24, 2020

CENAE-RDP

SUBJECT: File No. NAE-2012-00311, State of Massachusetts In-Lieu Fee Program Instrument, Credit Release, 2019-CS-Artificial Reef Habitat Enhancement, Yarmouth, Massachusetts

Ms. Aisling O'Shea (via email: aisling.oshea@mass.gov)
In Lieu Fee Program Administrator
Massachusetts Department of Fish and Game
251 Causeway Street
Suite 400
Boston, Massachusetts 02114

Dear Ms. O'Shea:

This letter is in response to your credit release request for the Artificial Reef Habitat Enhancement Project. The project site is located 2.2 miles off the coast of Yarmouth in Nantucket Sound, within the Coastal South Service Area. The project was expected to deploy 0.33 acres of granite and repurposed concrete material within a 1.1-acre footprint in order to enhance subtidal habitat. The project deployed 0.70 acres of material within a 2.1-acre footprint. This work was permitted in 2014 under Corps General Permit number NAE-2012-00311. Due to the change in project area, the Corps presented the IRT with two options of credit release:

1. Proceed with the original credit release for deployment of 0.33 acres of material within a 1.1-acre footprint. Credit release for this option will be 40% of the total credit release, which will be 0.1464 credits of the total 0.366 credits.

2. Release credits for the deployment of 0.70 acres of material within a 2.1-acre footprint. Credit release for this option will be 40% of the total credit release, which will be 0.2796 credits of the total 0.699 credits.

According to the Artificial Reef Habitat Enhancement Project final mitigation plan titled "Marine Habitat Enhancement, Yarmouth MA Artificial Reef" and dated "March 28, 2018", 40% of the sites credits generated from the project would be released after materials are deployed to site as specified in design and upon completion of post-construction sonar survey. As a result of the Interagency Review Team coordination it

was determined that the larger credit release was deemed appropriate. Therefore, 40% of the 0.699 project credit, or 0.2796 credit, is proposed to be released.

By receipt of this letter, the Massachusetts Department of Fish and Game is hereby granted the release of 0.2796 wetland mitigation credits. A total of 0.2796 wetland credits will be added to the ledger. If you have any questions, please contact Mr. Taylor Bell by email at taylor.m.bell@usace.army.mil or by phone at 978-318-8952.

Sincerely,

Taylor Bell

Taylor Bell
Mitigation Program Manager
Regulatory Division