KITTERY PORT AUTHORITY
TOWN HALL
200 ROGERS RD.
KITTERY, ME 03904

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Meeting Agenda
October 6, 2022
6:00 P.M.

1. Call to Order / Attendance
2. Pledge of Allegiance
3. Agenda Amendments and Adoption
4. Acceptance of Previous Minutes: August 4, 2022
5. Harbormaster Report and Budget Report
6. All Items involving Town Officials or Invited Guests

   a. Welcome town attorney, Mr. Cameron Ferrante

7. Public Hearing

   a. The Kittery Port Authority moves to hold a public hearing and approve an application from SHM Kittery Point, 48 Bowen Road, Kittery, ME 03904 (Map 17, Lot 10) for the conversion of 28 single point moorings in the Back Channel into twelve (12) 8’ x 80’ floats and one (1) 8’ x 160’ float. Agents is Sandra Guay Archipelago Law, LLP.

8. Piers, Wharves & Floats
9. Public Segment (Three Mins.)
10. Unfinished Business
11. New Business

    a. Election of Acting Vice Chair

12. Committee and Other Reports
13. Communications from the Chairperson
14. Board Member Issues or Comments
15. Executive Session
16. Adjournment

1. Call to Order / Attendance

Vice Chair Patten called the meeting to order at 6:00 P.M.

Members present: Vice Chair Patten, Steve Lawrence, John McCollett, Bryan Bush, Niles Pinkham and Alan Johnston. Members absent: Chair Philbrook.

2. Pledge of Allegiance

3. Agenda Amendments and Adoption

Vice Chair Patten cast one vote to approve the agenda as written.

4. Acceptance of Previous Minutes: July 7, 2022

All were in favor of the July 7, 2022 minutes as written.

5. Harbormaster Report and Budget Report

The Harbormaster assisted a vessel in distress in the area of the 95 Bridge during a strong tide. The vessel was having mechanical issues causing handling issues. He took the family off the boat and escorted the captain to the docks where the boat was hauled for repairs.

Chuck Moran did a check of Brave Boat Harbor, there were 13 boats on the bar and approximately 47 people. Chuck found evidence of clamming but no clams visible among the people or boats.

The Harbormaster did several parking/fishing ordinance overnight checks between 1am and 4am. He found some fishing without licenses, during one of the checks, he found that 2 resident vehicles had squid ink on them. These vehicles were parked in the resident parking areas facing the ramp. The Harbormaster was approached by a mooring holder who last year would park there to spend the night on their boat but would find ink or damage to their vehicle the next morning, so they don't park there any longer. The Harbormaster stated he will request that the KPA change the fishing ordinance to prohibit fishing in the area between the dumpster and the parking spot next to the HM office.

The Harbormaster responded to several floating objects in the river/back channel that were navigational hazards, these hazards include telephone poles, docks, large structural timber among other items.

The Harbormaster responded to a report of a vessel on the rocks at Hicks Rock, he found the vessel had not run aground, but rather got a lobster trap line and buoy wrapped in the propeller. They were able to clear the line and got underway without incident.

The Harbormaster responded to a vessel adrift in the area off Captains Way Gerrish Island, he found a vessel and towed it back to the docks. He also found that the bow line knot had come undone while the vessel was on mooring in Pepperrell Cove. He reported there was no damage and he contacted the owner who brought the vessel back to the mooring.

Deputy Harbormasters Moran/Valenti conducted mooring occupancy inventories of Pepperrell Cove, Chauncey Creek and the lower portion of the Back Channel.

The Harbormaster responded to a sailboat taking on water in the area of 2KR. He found that the 35-foot sailboat had approximately 4 feet of water in it. The wind and seas were increasing so they notified the Coast Guard and TowboatUS that they were going to dewater the boat and tow the vessel in. The Harbormaster towed the boat into safer waters and turned it over to TowboatUS. The Harbormaster wanted to thank the NH Marine Patrol for providing a security zone while they had the vessel in tow and pumping it out.

The 21-foot Harbormaster’s boat had outboard problems while responding to a dock floating down the main river, so the Harbormaster called Gunnar Ek to tow the dock in as well as follow them back to Pepperrell Cove.

The Harbormaster repaired the scuppers in the 21ft Harbormaster’s boat as the flappers were not closing and would not bail properly.

The Harbormaster repaired the safety railing along the wall that was damaged.

The Harbormaster reported that he is getting a new stainless-steel ladder for next to the hoist, it was fabricated, delivered and will hopefully be installed next week.

The Harbormaster reported the total recorded underway hours for patrol on HM boats (not including several in the back channel that he was notified of, but not called into dispatch, to be put in the log during the early part of the month). -122 hours.

FY 2023 YTD EXPENSES

OBJECT	ACCT DESCRIPTION	CURRENT YEAR BUDGET	CURRENT YEAR EXPENSE	CURRENT YEAR REMAINING	PERCENT USED
64010	HARBOR MASTER FULL TIME SALARI	$ 65,162.00	$ 5,233.75	$ 59,928.25	8.03
64020	PART TIME SALARIES	$ 26,967.00	$ 6,771.34	$ 20,195.66	25.11
65010	POSTAGE	$ 250.00	$ -	$ 250.00	0.00
65020	TELEPHONE & INTERNET	$ 2,000.00	$ 111.85	$ 1,888.15	5.59
65200	ELECTRICITY	$ 2,016.00	$ -	$ 2,016.00	0.00
65220	WATER	$ 515.00	$ -	$ 515.00	0.00
65240	DUMPSTERS/TRASH REMOVAL	$ 1,000.00	$ 213.12	$ 786.88	21.31
65305	BOAT EQUIPMENT MAINTENANCE	$ 3,500.00	$ 155.59	$ 3,344.41	4.45
65310	VEHICLE MAINTENANCE	$ 1,000.00	$ -	$ 1,000.00	0.00
65311	GAS, GREASE, & OIL	$ 2,250.00	$ -	$ 2,250.00	0.00
65462	RIGGING	$ 12,000.00	$ 812.48	$ 11,187.52	6.77
65463	SANITATION	$ 2,000.00	$ 331.24	$ 1,668.76	16.56
65470	PROFESSIONAL DEVELOPMENT	$ 1,500.00	$ -	$ 1,500.00	0.00
65480	OTHER PROFESSIONAL/CONTRACTED	$ 3,000.00	$ 1,360.00	$ 1,640.00	45.33
65500	MAIN BLDG/GROUNDS WHARVES/HARB	$ 5,500.00	$ 418.11	$ 5,081.89	7.60
65521	UNIFORMS	$ 1,300.00	$ 626.95	$ 673.05	48.23
66010	OFFICE SUPPLIES	$ 300.00	$ -	$ 300.00	0.00
66040	JANITORIAL SUPPLIES & SERVICES	$ 500.00	$ 85.76	$ 414.24	17.15
TOTAL		**$ 130,760.00**	**$ 16,120.19**	**$ 114,639.81**	**12.33%**

FY 2023 YTD REVENUE

OBJECT	ACCT DESCRIPTION	CURRENT YEAR BUDGET	CURRENT YEAR REVENUE	CURRENT YEAR DIFFERENCE	PERCENT
43147	DINGHY FEES	$ (11,000.00)	$ (100.00)	$ (10,900.00)	0.91
43148	TRANSIENT SLIP RENTAL	$ (8,000.00)	$ (2,631.00)	$ (5,369.00)	32.89
43149	KPA APPLICATION FEES	$ (500.00)	$ -	$ (500.00)	0.00
43150	MOORING FEES	$ (100,000.00)	$ 168.00	$ (100,168.00)	-0.17
43151	LAUNCH FEE	$ (14,000.00)	$ (4,834.00)	$ (9,166.00)	34.53
43152	TRANSIENT MOORING	$ (8,000.00)	$ (1,804.00)	$ (6,196.00)	22.55
43153	WAIT LIST FEE	$ (1,000.00)	$ (80.00)	$ (920.00)	8.00
43156	PIER USAGE FEE	$ (2,400.00)	$ (1,286.00)	$ (1,114.00)	53.58
43157	MOORING LATE FEE	$ (1,000.00)	$ -	$ (1,000.00)	0.00
43159	KAYAK RACK RENTAL	$ (2,700.00)	$ (118.00)	$ (2,582.00)	4.37
TOTAL		**$ (148,600.00)**	**$ (10,685.00)**	**$ (137,915.00)**	**7.19%**

6. All Items involving Town Officials or Invited Guests

7. Public Hearing

a. The Kittery Port Authority moves to hold a public hearing and approve an application from The Brewster Family Irrevocable Trust, 7 Bond Road, Kittery Point, ME 03905 (Map 25, Lot 1-A) for the construction of a 4' x 24' fixed wood pier, a 3' x 30' gangway and a 10' x 20' float secured by two helical moorings. Agent Steve Riker Ambit Engineering.

Steve Riker from Ambit Engineering gave an overview of the project.

Mr. Lawrence moved to approve the application from The Brewster Family Irrevocable Trust, 7 Bond Road, Kittery Point, ME 03905 (Map 25, Lot 1-A) for the construction of a 4' x 24' fixed wood pier, a 3' x 30' gangway and a 10' x 20' float secured by two helical moorings, seconded by Mr. Johnston.

Motion Carried 5-0-1

Mr. Bush recused.

b. The Kittery Port Authority moves to hold a public hearing and approve an application from SHM Kittery Point, 48 Bowen Road, Kittery, ME 03904 (Map 17, Lot 10) for the conversion of 28 single point moorings in the back channel into twelve (12) 8' x 80' floats and one (1) 8' x 160' float. Agents is Sandra Guay Archipelago Law, LLP.

POSTPONED TO SEPTEMBER 1, 2022

8. Piers, Wharves & Floats - None

9. Public Segment (Three Mins.) – None

10. Unfinished Business - None

11. New Business - None

12. Committee and Other Reports - None

a. Communications from the Chairperson

Vice Chair Patten spoke about two items, Chair Philbrook wanted the Vice Chair to bring to the board's attention first was a letter from Allen Bretton, regarding wakes in the back channel and an application the KPA approved at 134 Whipple Road.

13. Board Member Issues or Comments

Mr. Lawrence – None

Mr. Johnston – None

Mr. Bush – None

Mr. Pinkham spoke about the fishing on the Kittery Point bridge.

Mr. McCollett – None

Vice Patten - None

14. Executive Session - None

15. Adjournment

Mr. Lawrence moved to adjourn at 6:00 P.M., seconded by Mr. Johnston.

All were in favor.

Submitted by Kim Tackett

Disclaimer: The following minutes constitute the author's understanding of the meeting. Whilst every effort has been made to ensure the accuracy of the information, the minutes are not intended as a verbatim transcript of comments at the meeting, but a summary of the discussion and actions that took place. For complete details, please refer to the video of the meeting on the Town of Kittery website.

KITTERY MAINE PORT AUTHORITY

FINDINGS OF FACT **UNAPPROVED**

For: 48 Bowen Road, TAX MAP 17, LOT 10
Re: Shoreland Development Plan Review: Piers, Wharfs, Floats and Other Marine-Related Structures

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WHEREAS, Owner and Applicant, SHM Kittery Point, LLC of 48 Bowen Road, Tax Map 17, Lot 10, located in the Commercial Fisheries/Maritime Uses Overlay Zone, submitted an application for Piers, Wharfs, Floats and other Marine-Related Structures, dated June 15, 2022 (the "Application"), requesting to convert 28 single point moorings into Twelve (12) 8' x 80'floats and one (1) 8" x 160' float (hereinafter, the "Development"); and

WHEREAS, pursuant to the procedures set forth in the Town of Kittery Code of Ordinances, the Kittery Port Authority (hereinafter, the "Port Authority") deemed the Application complete at its July 7, 2022 hearing and placed the Application on its agenda for a public hearing on August 4, 2022, the public hearing was continued by agreement of the Applicant until October 13, 2022; and

WHEREAS, the Application and other documents considered to be a part of the Application for review by the Port Authority consist of: (1) an application for Piers, Wharfs, Floats and Other Marine-Related Structures, dated June 15, 2022; (2) agent authorization for Archipelago; (3) a copy of the Town of Kittery Tax Map for Tax Map 17, Lot 10; (4) a list of abutters to 48 Bowen Road; (5) a project narrative; (6) a recorded deed demonstrating the Applicant's right, title or interest in 48 Bowen Road; (7) an aerial site plan; (8) a design showing the Applicant's mooring construction and specifications; (9) an Army Corps of Engineers Authorization Letter, dated April 7, 2022; (10) published studies and surveys related to the environmental impacts of single point moorings; and (11) supplemental materials provided on September 15, 2022, including additional engineering documents for the proposed floats, a Town of Yarmouth mooring plan, letters of support from the community, and a letter authorizing the transfer of the Kittery Point Yacht Yard Corp. U.S. Army Corps of Engineers permit to the Applicant.

NOW THEREFORE, based on the Application and materials before the Port Authority and pursuant to the applicable standards in the Land Use and Development Code and the Port Authority's Rules and Regulations, the Port Authority makes the following factual findings and conclusions:

FINDINGS OF FACT AND CONCLUSIONS

Port Authority Rules and Regulations, Waiver (§ 4.3.3)
§ 4.3.3. The Port Authority may grant a waiver from the specifications of these regulations provided that the Port Authority finds that due to special circumstances of the specific application the granting of a waiver will not adversely impair the public health, safety and general welfare, the use of public waters, navigation, or harm the environment. All such waivers must be supported by sufficient findings of fact.
Findings: The Application requests a waiver from the maximum float dimensions contained in Section 3.12.1.C for the purpose of constructing twelve 8' x 80' moored floats and one 8' x 160' moored float. *C. Float size may not exceed 10' x 24' dimensions for commercial uses and 8' x 24' dimensions for recreational uses, unless otherwise permitted by the Port Authority.* A. Special Circumstances: The Application indicates that the proposed moored floats would replace 28 single-point moorings. The Application indicates that the floats must exceed the maximum size permitted to allow it to moor additional vessels at the floats and recover the capital costs of constructing and installing the floats. B. No Adverse Impact: The Application indicates that the moored floats would not take up any more space than the 28 single-point moorings that will be removed. The Application has provided evidence that the moored floats will enable additional access to vessels by older or disabled boaters; provide a safer platform for vessel maintenance and boaters during adverse weather conditions; will offer more secure mooring locations for numerous vessels; and more clearly define the channel and reduce navigability issues created by swinging vessels, dinghies and launches on the existing single-point moorings. The Application has also provided evidence that the moored floats will be less harmful to the environment than the existing single-point moorings they will replace by reducing disturbances to the bottom and destruction of eelgrass habitats.
Conclusion: The Application has satisfied the standard contained in Section 4.3.3 for the Port Authority to grant a waiver of the maximum float dimensions contained in Section 3.12.1.C for the construction of twelve (12) 8' x 80' moored floats and one (1) 8' x 160' moored float. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

Port Authority Rules and Regulations, Moored Floats (§ 3.12)
§ 3.12.1.A. *Moored floats are authorized only with the expressed permission of the Port Authority and only after receiving an Army Corps of Engineers Permit. Permits are issued in accordance with Section 4 of these Rules and Regulations.*

<u>Findings</u>: The Application demonstrates that the Army Corps of Engineers have issued a permit for the Development. The Port Authority has [approved / denied] a waiver for the maximum size of the moored floats as proposed in the Application.
<u>Conclusion:</u> The Development has obtained the necessary approvals from the Port Authority. **<u>Second:</u>** **<u>Vote:</u>** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
§ 3.12.1.B. *Floats are prohibited in Pepperell Cove.*
<u>Findings</u>: This standard is not applicable to the Application because the Development is not located in Pepperell Cove.
<u>Conclusion:</u> N/A
§ 3.12.1.C. *Float size may not exceed 10' x 24' dimensions for commercial uses and 8' x 24' dimensions for recreational uses, unless otherwise permitted by the Port Authority.*
<u>Findings</u>: The Application requests to install moored floats with dimensions greater than those permitted for moored floats under Section 3.12,1.C and requests a waiver of the maximum moored float dimensions pursuant to Section 4.3.3 of the Port Authority Rules and Regulations. The Port Authority has [approved / denied] the Applicant's request for a waiver. *§ 4.3.3. The Port Authority may grant a waiver from the specifications of these regulations provided that the Port Authority finds that due to special circumstances of the specific application the granting of a waiver will not adversely impair the public health, safety and general welfare, the use of public waters, navigation, or harm the environment. All such waivers must be supported by sufficient findings of fact.*
<u>Conclusion:</u> This standard [has / has not] been met. **<u>Second:</u>** **<u>Vote:</u>** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
§ 3.12.1.D. *All floats are required to have a minimum of two (2) moorings.*
***<u>Findings</u>**: The Application indicates that all floats will be anchored by four granite anchors weighing at least 4,000 pounds.*
<u>Conclusion:</u> This standard has been met. **<u>Second:</u>** **<u>Vote:</u>** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
§ 3.12.1.E. *All shackles and fasteners must be hot dipped galvanized steel and structurally sound and proportional in size to the chain use.*
<u>Findings</u>: The Application indicates that all shackles will consist of ¾ inch hot-dipped galvanized steel and all fasteners on the floats will consist of hot-dipped galvanized steel.

Conclusion: The standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
§ 3.12.1.F. *All floats must be identified with assigned registration numbers on both ends of the float in contrasting colors and be a minimum of three (3) inches in height.*
Findings: The Application indicates that all floats will be appropriately identified, and that the Applicant will comply with this requirement prior to placing any floats.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
§ 3.12.1.G. *All floats must be buoyant so as not to become submerged at any time and must remain above water and visible at all times.*
Findings: The Application indicates that the purpose of the floats is to provide a mooring site for vessels that will at all times remain above water and visible. The Application further indicates that the floats will consist of buoyant 40' x 8' floating platforms constructed using pressure treated lumber.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
§ 3.12.1.H. *All gear, traps, fish and dunnage must be stored or secured so as not to be discharged or fall into the water or to pollute or to create a navigational hazard. All fuel, foul waste, decaying matter and/or hazardous material must be removed promptly from the floats after use and disposed of properly.*
Findings: The Application does not address these requirements; however, the Applicant will ensure future compliance with these requirements.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

Town Code, Performance Standards (Code § 16.9.2(D)). *Development involving piers, wharves, marinas and other uses projecting into water bodies must conform to the following standards:*

(1) In accordance with 38 M.R.S.A. § 435 et seq., mandatory shoreland zoning, all dimensional and other standards (excluding setbacks from water bodies) of this title apply to structures and uses projecting into a water body beyond the highest annual tide. (2) *Boathouses, while convenient to locate near the water, are not considered functionally water-dependent uses and must meet the same setback requirement as principal structures. The State of Maine no longer issues permits for construction of boathouses below the highest annual tide due to the adverse environmental impact; therefore, new boathouses must be located on uplands.*
Findings: These standards are not applicable because the Application does not include a proposal to create any structures projecting beyond the highest annual tide or a boathouse.
Conclusion: N/A
(3) Only functionally water-dependent uses are allowed on, over or abutting a pier, wharf or other structure beyond the highest annual tide.
Findings: The Application proposes to locate moored floats for the mooring of recreational and commercial vessels beyond the highest annual tide. The Port Authority finds that this constitutes a functionally water-dependent use.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
(4) Access from shore must be developed on soils appropriate for such uses and constructed so as to control erosion.
Findings: This standard is not applicable because the Application does not propose development of any access to the moored floats.
Conclusion: N/A
(5) The location must not interfere with existing developed recreational and maritime commerce or natural beach areas.
Findings: The Application indicates that the moored floats will be located within the existing single-point mooring fields and outside of the existing channel. As a result, the moored floats will not interfere with the navigability of the Back Channel or its use for recreational or maritime commerce. The moored floats will be accessed by existing facilities and will not affect access to or use of any natural beach areas. The Applicant has demonstrated that the Development will not interfere with either existing recreational and maritime commerce or natural beach areas.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

(6) The facility must be located so as to minimize adverse effects on fisheries.
Findings: The Application indicates that the moored floats will each be anchored by four granite blocks with connecting chains under tension to minimize disturbance of the bottom. The installation of four anchor chains on each float decreases the risk of gear entanglement and gear loss within the Back Channel and the Applicant has provided evidence of the positive impact that the reduced use of single-point moorings within the Back Channel may have on existing eelgrass beds and associated marine life. These positive impacts outweigh any adverse effects the proposed development may have on fisheries. As a result, the proposed development will minimize adverse effects on fisheries.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
(7) The facility must be a water-dependent use and no larger in dimension than necessary to carry on the activity and must be consistent with existing conditions, use and character of the area.
Findings: The Port Authority has determined that the proposed Development is a functionally water-dependent use. The dimensions of the moored floats, while significantly larger than existing single-point moorings and floats within the area, are consistent with and no larger than necessary to moor multiple vessels, as the Applicant proposes. Additionally, the installation of moored floats is consistent with the existing conditions, use and character of the area as a single-point mooring field.
Conclusion: This standard has been met. **Second:** **Vote:** Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]
(8) No new structure may be built on, over or abutting a pier, wharf, dock or other structure extending beyond the highest annual tide of a water body or within a wetland unless the structure requires direct access to the water as an operational necessity. *(9) No existing structures built on, over or abutting a pier, dock, wharf or other structure extending beyond the highest annual tide of a water body or within a wetland may be converted to residential dwelling units in any district.* (10) *Except in the Commercial Fisheries/Maritime Uses Overlay Zone, structures built on, over or abutting a pier, wharf, dock or other structure extending beyond the highest annual tide of a water body or within a wetland must not exceed 20 feet in height above the pier, wharf, dock or other structures.*
Findings: These standards are not applicable because the Application does not include any structures to be built on, over or abutting a pier, wharf, dock or other structure extending beyond the highest annual tide or within a wetland.
Conclusion: N/A

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(11) Applicants proposing any construction or fill activities in a waterway or wetland requiring approval by the U.S. Army Corps of Engineers pursuant to Section 404 of the Clean Water Act, Section 9 of 10 of the Rivers and Harbors Act, or Section 103 of the Marine Protection, Research and Sanctuaries Act, must submit proof of a valid permit issued.

Findings: The Applicant has provided an authorization from the U.S. Army Corps of Engineers pursuant to Section 10 of the Rivers and Harbors Act for the installation of the Development.

Conclusion: This standard has been met.

Second:

Vote: Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

(12) Proposals for any principal marine structure use, any residential joint- and/or shared-use pier, or any residential-development-use pier require Planning Board approval.

(13) A residential development containing five or more lots in a zone permitting a residential-development-use pier may construct only one residential-development-use pier.

(14) Commercial development of the shorefront must provide for access by the general public as part of a shorefront development plan.

(15) *Only one pier, ramp and float structure is permitted on any noncommercial or nonindustrial lot.*

Findings: These standards are not applicable to the Application because the Application only proposes moored floats located below the highest annual tide and does not propose the construction of any piers or structures falling under the Shorefront Development Plan.

Conclusion: N/A

(16) Marine-related permanent structures located below the mean low-water line require the following permits, leases and approvals:

a. Port Authority approval;
b. Department of Environmental Protection permit pursuant to the Natural Resources Protection Act, 38 M.R.S.A. § 480-C;
c. Army Corps of Engineers permit;
d. Maine State Department of Conservation, Bureau of Parks and Lands, Submerged Land Coordinator approval; and
e. *Building permit.*

Findings: The Application contains the required authorization from the Army Corps of Engineers pursuant to Section 10 of the Rivers and Harbors Act. The Development does not require permits from the Department of Environmental Protection or Submerged Land Coordinator approval. The Applicant will obtain all necessary building permits prior to beginning construction of the Development. The Application [has / has not] been approved by the Port Authority based on its [approval / denial] of the waiver from the maximum dimensions allowed for moored floats under Section 3.12.1.C of the Rules and Regulations.

Conclusion: This standard [has / has not] been met.
Second:
Vote: Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

(17) Any other performance standards as enumerated in the Port Authority's rules and regulations.

Findings: The Application proposed moored floats that are larger than those permitted under Section 3.12.1.C of the Rules and Regulations. The Port Authority has [approved / denied] the Applicant's request for a waiver from the applicable maximum dimensions.

Conclusion: This standard has been met.
Second:
Vote: Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

Port Authority Rules and Regulations, Performance Standards (§ 4.7)

§ 4.7.1. *All applications for permits under this section must comply wholly with the requirements of Title 16, §3.2.17 (Shoreland Overlay Zone), and Title 38 MRS §435-439, and any other applicable federal or state requirements. These requirements apply to all development within 250 feet, horizontal distance, of the normal high-water mark of any river or saltwater body. These requirements also apply to any structure built on, over, or abutting a dock wharf or pier, or any other structure extending beyond the normal high- water mark of a water body or within a coastal wetland shown on the Official Shoreland Zoning Map.*

Findings: The Application has satisfied all applicable standards of Title 16 and any other state or federal requirements. [The Application has not satisfied all applicable standards of Title 16, including those provided by Section 16.9.2(D)(5-7) and (16-17).]

Conclusion: This standard has been met.
Second:
Vote: Vote of ____ in favor; _____ against; ____ abstaining. Motion is [Approved / Denied]

§ 4.7.2. *The construction of any piers, docks, wharves, and other structures and uses extending over or beyond the normal high-water mark of a water body or within a wetland must comply with all applicable requirements of Title 16.*

§ 4.7.3. *Non-commercial private piers may have a maximum width of 6 feet as measured parallel to the shoreline and be limited to the minimum size necessary to accomplish their purpose. Except for temporary ramps and floats, the total length of a ramp, pier and float structure may not extend more than 150 feet beyond the normal high-water mark and piers not extend more than 100 feet beyond the normal high-water mark nor extend below the mean low water mark, whichever is shorter.*

§ 4.7.4. *The maximum height of the pier deck may not exceed six (6) feet above the normal high-water mark, and the handrails not exceed 42" without the specific approval of the Port Authority.*

§ 4.7.5. *Commercial piers are limited to the minimum size necessary to accomplish their purpose. They may not extend beyond the mean low water mark except with credible proof by the applicant that the extension is necessary for the water-dependent use of the pier. The maximum height of the pier deck may not exceed six (6) feet above mean high water mark and the handrails not exceed 42", without a showing of necessity and specific approval of the Port Authority. Documentation required for an application for a commercial pier, in addition to all other*

requirements of these Rules and Regulations, must set forth credible proof of the commercial usage and include at least the following: ***§ 4.7.6.*** *Piers, wharves, and pilings must be set back at least 25 feet from property lines and 50 feet from other structures that are fixed in place below the normal high- water mark and not owned or controlled by the applicant unless a letter of permission is granted by abutting or other controlling property owner. If abutting property owners reach a mutual agreement regarding structures which have a lesser setback, which does not interfere with navigation, is practical and is consistent with the intent of these regulations, that setback may be authorized by the Port Authority if the applicant agrees to record any ensuing permit (which will have that agreement as a condition) and the abutters' letters of no objection, with the Registrar of Deeds, or other appropriate official charged with the responsibility for maintaining records of title to or interest in real property in the Town*
Findings: These standards are not applicable because the Application does not propose the construction of any commercial or non-commercial private piers, docks, wharves or other structures beyond the normal high-water mark or within a wetland.
Conclusion: N/A

MAIN MOTION:
Motion: Based on the foregoing Findings and Conclusions, the Applicant's Piers, Wharfs, Floats and other Marine-Related Structures Application proposing twelve (12) 8' x 80' floats and one (1) 8' x 160' float at 48 Bowen Road (Tax Map 17, Lot 10) is approved, [subject to the following conditions]:

[Conditions of Approval (to be included on the final plan to be recorded):
1)]

Second:
Vote: Vote of __ in favor__ against __ abstaining

APPROVED BY THE KITTERY PORT AUTHORITY ON OCTOBER 13th, 2022.

____
BY: Charles Patten, Chair
Kittery Port Authority

NOTICE OF APPEAL RIGHTS: The Applicant has the right to request reconsideration of this decision within fifteen (15) days of its issuance pursuant to the Kittery Port Authority Rules and Regulations, Section 7.2. The Applicant and any aggrieved party has the right to appeal this decision within forty-five (45) days of its issuance pursuant to the Kittery Port Authority Rules and Regulations, Section 7.3.

Benjamin E. Ford
Partner
bford@archipelagolaw.com
(207) 558-0102

22 Free Street, Ste 403
Portland, Maine 04101

September 15, 2022

Via Fedex and email to cvarao@kitteryme.org

Charles Patten, Vice Chair
Kittery Port Authority
200 Rogers Road
Kittery, ME 03904

RE: Supplemental Information in Support of SHM Kittery Point, LLC's Pending Application

Dear Vice Chair Patten:

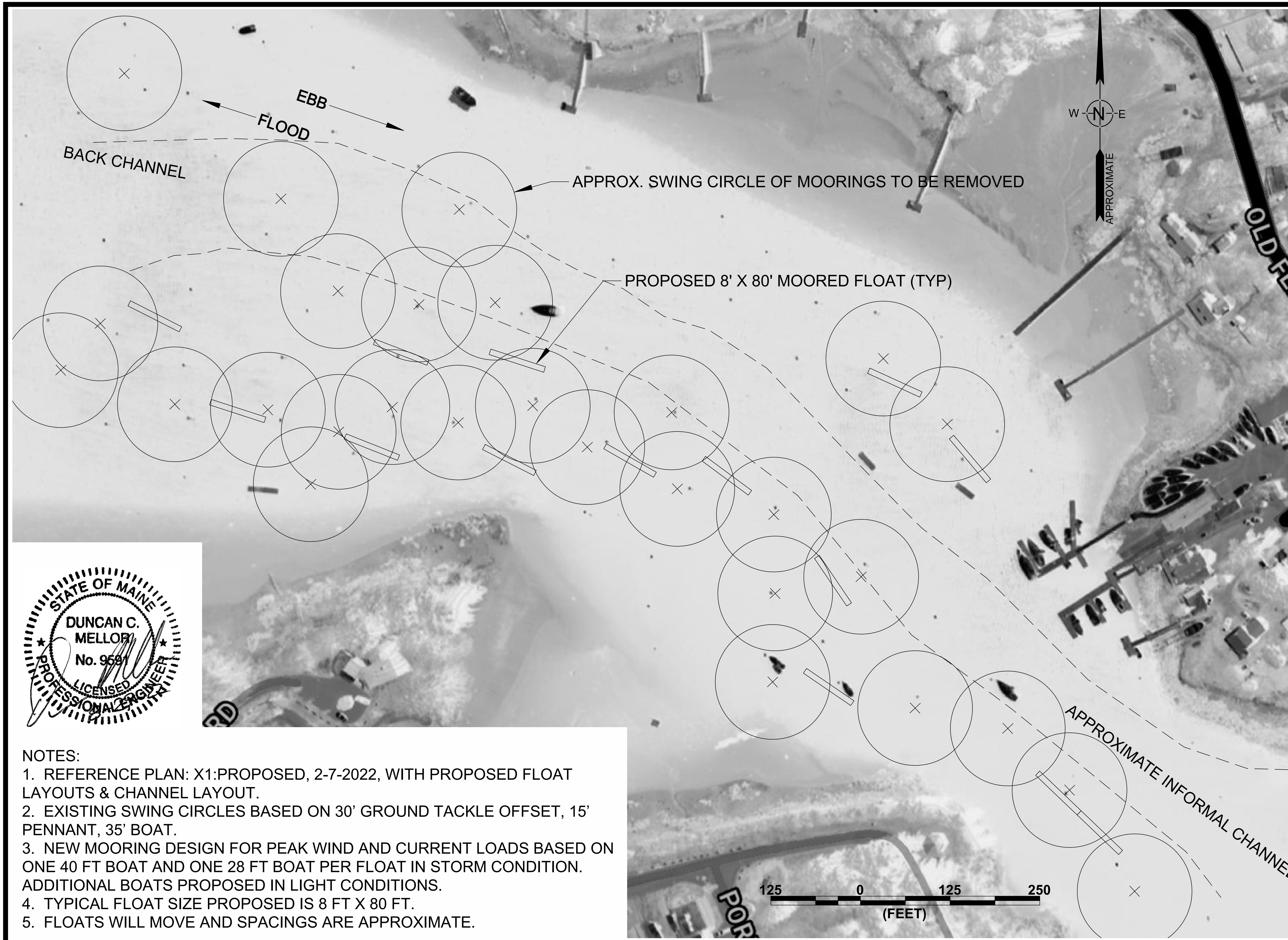
Enclosed please find 10 copies of documents to supplement SHM Kittery Point, LLC's pending application for the installation of floats. Included in this packet are the following documents:

Exhibit A: Additional engineering documents showing the specific design of the floats, the anchoring pattern, a cross section demonstrating the use of sentinel weights, the proximity of each float to the next, and the amount of swing space that will be conserved by the implementation of the float system
Exhibit B: A mooring plan from the Town of Yarmouth showing the town's intent to convert most of the moorings in the Town Landing Basin to floats
Exhibit C: Letters of support from the community
Exhibit D: A letter from Thomas Allen, President of Kittery Point Yacht Yard Corp. authorizing the transfer of the US Army Corp Permit to SHM Kittery Point, LLC

We would appreciate your including these documents in the applicant's file and rescheduling a hearing at the next meeting which we understand to be October 6, 2022.

Sincerely,

Benjamin E. Ford



NOTES:

1. REFERENCE PLAN: X1:PROPOSED, 2-7-2022, WITH PROPOSED FLOAT LAYOUTS & CHANNEL LAYOUT.
2. EXISTING SWING CIRCLES BASED ON 30' GROUND TACKLE OFFSET, 15' PENNANT, 35' BOAT.
3. NEW MOORING DESIGN FOR PEAK WIND AND CURRENT LOADS BASED ON ONE 40 FT BOAT AND ONE 28 FT BOAT PER FLOAT IN STORM CONDITION. ADDITIONAL BOATS PROPOSED IN LIGHT CONDITIONS.
4. TYPICAL FLOAT SIZE PROPOSED IS 8 FT X 80 FT.
5. FLOATS WILL MOVE AND SPACINGS ARE APPROXIMATE.

FLOAT PLAN & MOORINGS TO BE REMOVED

NOT FOR CONSTRUCTION

CIVILWORKS NEW ENGLAND
CIVIL & WATERFRONT ENGINEERING
181 Watson Road, PO Box 1166
Dover, New Hampshire 03821
603.749.0443

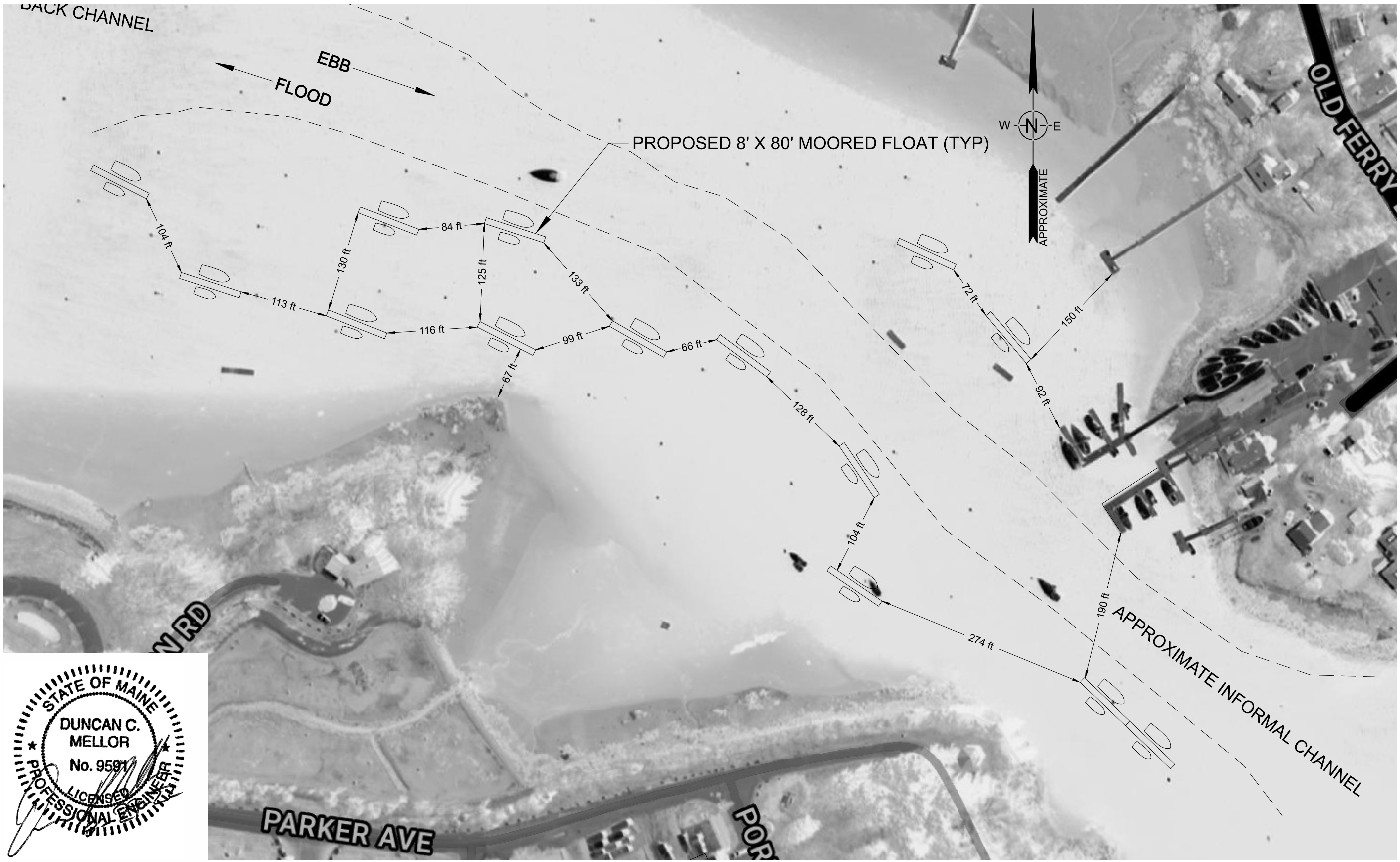
NO.	REVISION	APP'D	DATE

SHM, KITTERY POINT LLC
48 Bowen Road
Kittery, ME 03904
TAX MAP 17, LOT 10

DATE: 8–15–22
SCALE: AS SHOWN
DRAWN BY: DCM
DESIGN BY: DCM
APPROVED BY:
PROJECT NO:
FILE:

MOORED FLOATS
SAFE HARBOR KITTER POINT
KITTERY, ME
YORK COUNTY
BACK CHANNEL

WF - 1



NOTES:

1. REFERENCE PLAN: X1:PROPOSED, 2-7-2022, WITH PROPOSED FLOAT LAYOUTS & CHANNEL LAYOUT.
2. MOORING DESIGN FOR PEAK WIND AND CURRENT LOADS BASED ON ONE 40 FT BOAT AND ONE 28 FT BOAT PER FLOAT IN STORM CONDITION. ADDITIONAL BOATS PROPOSED IN LIGHT CONDITIONS.
3. TYPICAL FLOAT SIZE PROPOSED IS 8 FT X 80 FT.
4. FLOATS WILL MOVE AND SPACINGS ARE APPROXIMATE.

125 0 125 250
(FEET)

NOT FOR CONSTRUCTION

CIVILWORKS NEW ENGLAND
CIVIL & WATERFRONT ENGINEERING
181 Watson Road, PO Box 1166
Dover, New Hampshire 03821
603.749.0443

NO.	REVISION	APP'D	DATE

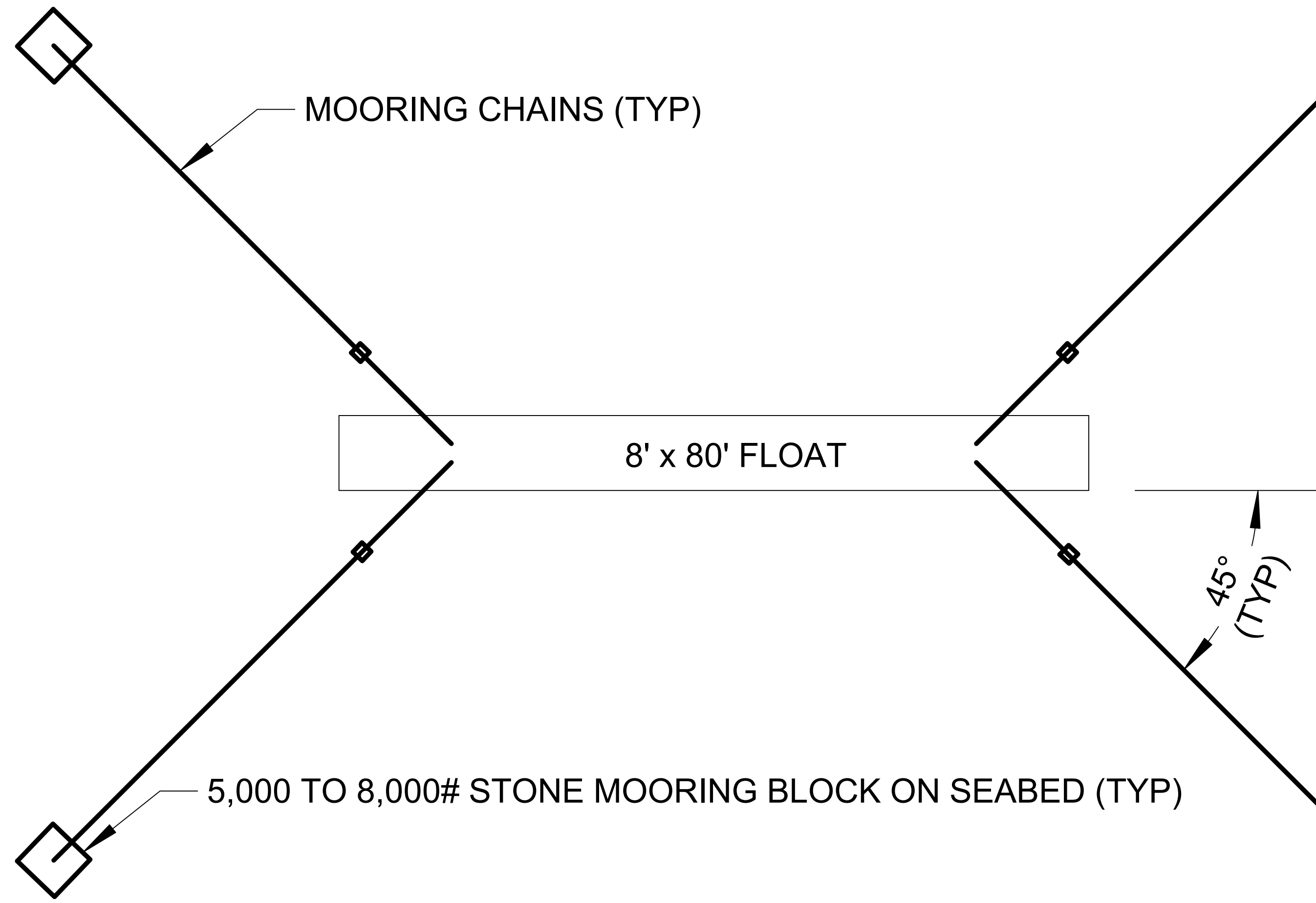
DATE: 8-15-22
SCALE: AS SHOWN
DRAWN BY: DCM
DESIGN BY: DCM
APPROVED BY:
PROJECT NO:
FILE:

SHM, KITTERY POINT LLC
48 Bowen Road
Kittery, ME 03904
TAX MAP 17, LOT 10

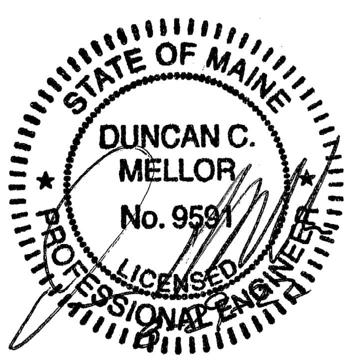
FLOAT PLAN

MOORED FLOATS
SAFE HARBOR KITTER POINT
KITTERY, ME
YORK COUNTY
BACK CHANNEL

WF - 2



FLOAT MOORING PLAN (TYP)



NOTES:
1. MOORING DESIGN FOR PEAK WIND AND CURRENT LOADS BASED ON ONE 40 FT BOAT AND ONE 28 FT BOAT PER FLOAT IN STORM CONDITION.
2. MOORING LAYOUT BASED ON AVERAGE WATER DEPTH AND ASSUMES SENTINEL BLOCKS ARE USED TO REDUCE CHAIN LENGTHS BELOW CHAIN ONLY CATENARY LENGTHS.

20 0 20 40 60
(FEET)

NOT FOR CONSTRUCTION

CIVILWORKS NEW ENGLAND
CIVIL & WATERFRONT ENGINEERING
181 Watson Road, PO Box 1166
Dover, New Hampshire 03821
603.749.0443

NO.	REVISION	APP'D	DATE

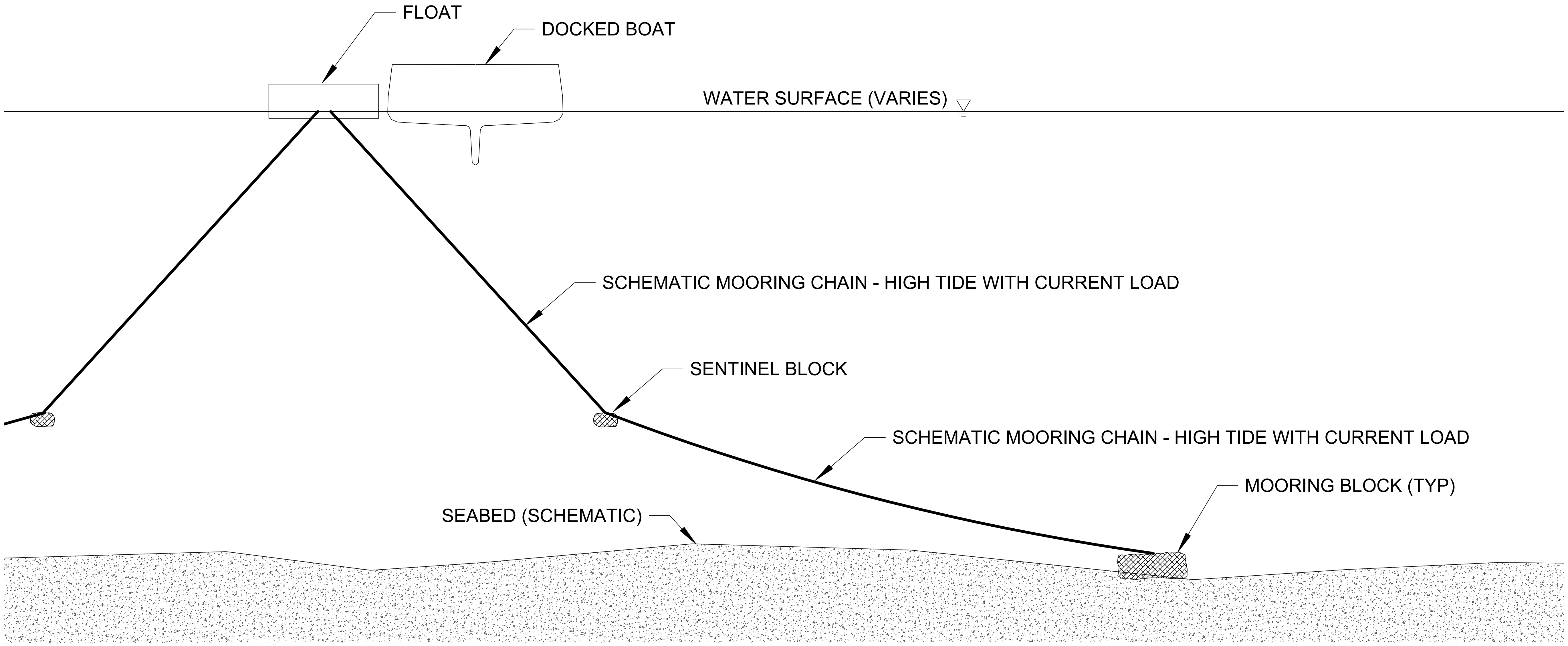
DATE: 8-15-22
SCALE: AS SHOWN
DRAWN BY: DCM
DESIGN BY: DCM
APPROVED BY:
PROJECT NO:
FILE:

SHM, KITTERY POINT LLC
48 Bowen Road
Kittery, ME 03904
TAX MAP 17, LOT 10

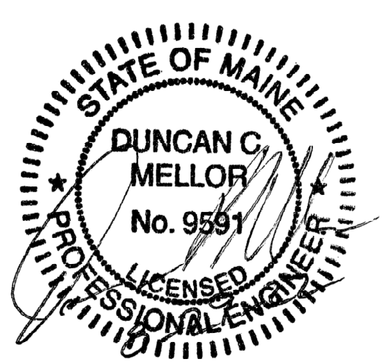
MOORED FLOATS
SAFE HARBOR KITTER POINT
KITTERY, ME
YORK COUNTY
BACK CHANNEL

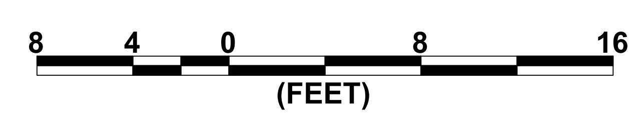
MOORING DETAILS

WF - 3



FLOAT MOORING SECTION (TYP)





NOT FOR CONSTRUCTION

CIVILWORKS NEW ENGLAND
CIVIL & WATERFRONT ENGINEERING
181 Watson Road, PO Box 1166
Dover, New Hampshire 03821
603.749.0443

DATE: 8–15–22
SCALE: AS SHOWN
DRAWN BY: DCM
DESIGN BY: DCM
APPROVED BY:
PROJECT NO:
FILE:

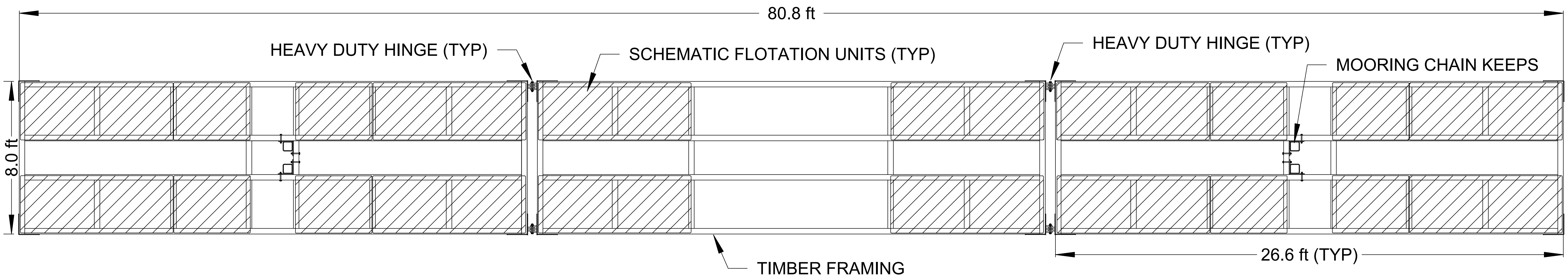
NO. | REVISION | APP'D | DATE

SHM, KITTERY POINT LLC
48 Bowen Road
Kittery, ME 03904
TAX MAP 17, LOT 10

MOORING SIDE VIEW

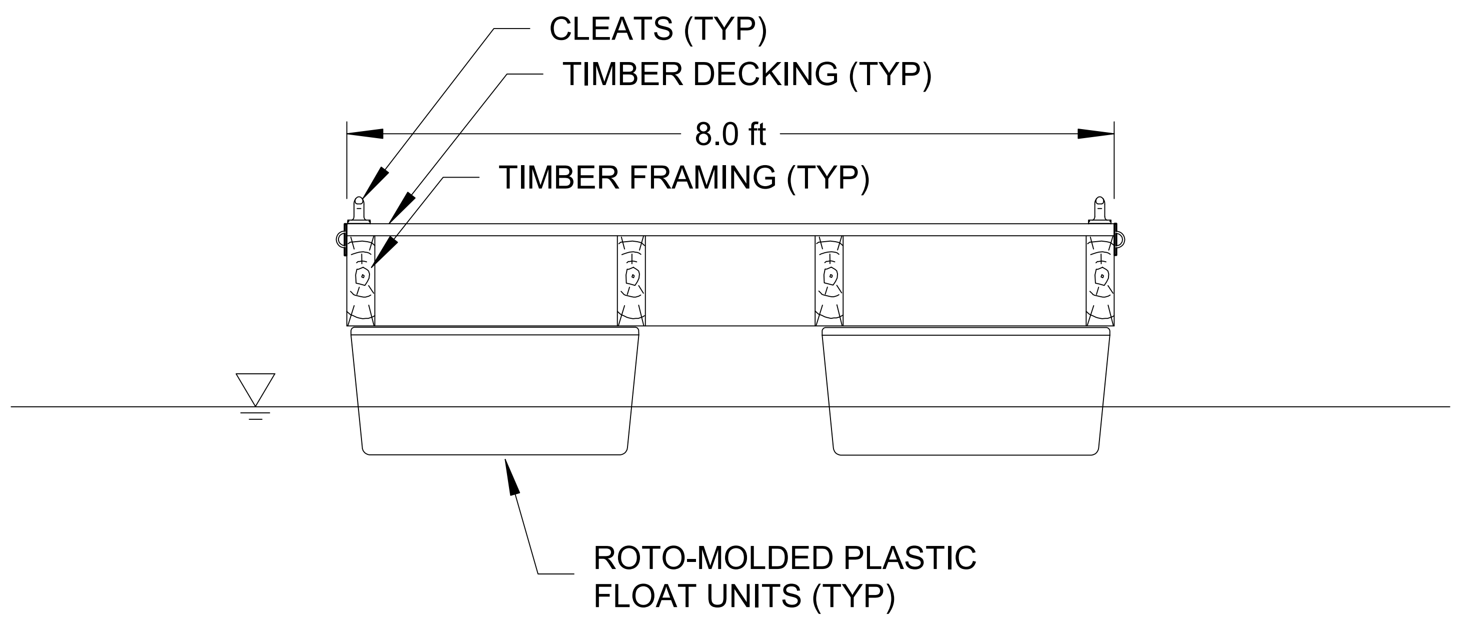
MOORED FLOATS
SAFE HARBOR KITTER POINT
KITTERY, ME
YORK COUNTY
BACK CHANNEL

WF - 4



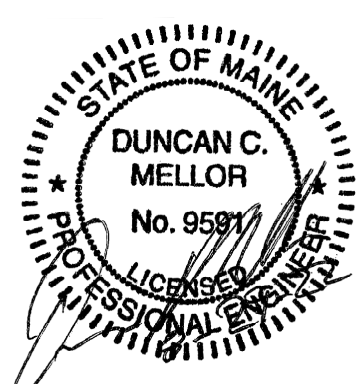
FLOAT PLAN DETAILS (TYP)

4 0 4 8 16
(FEET)



FLOAT SECTION DETAILS (TYP)

2 0 2 4 8
(FEET)



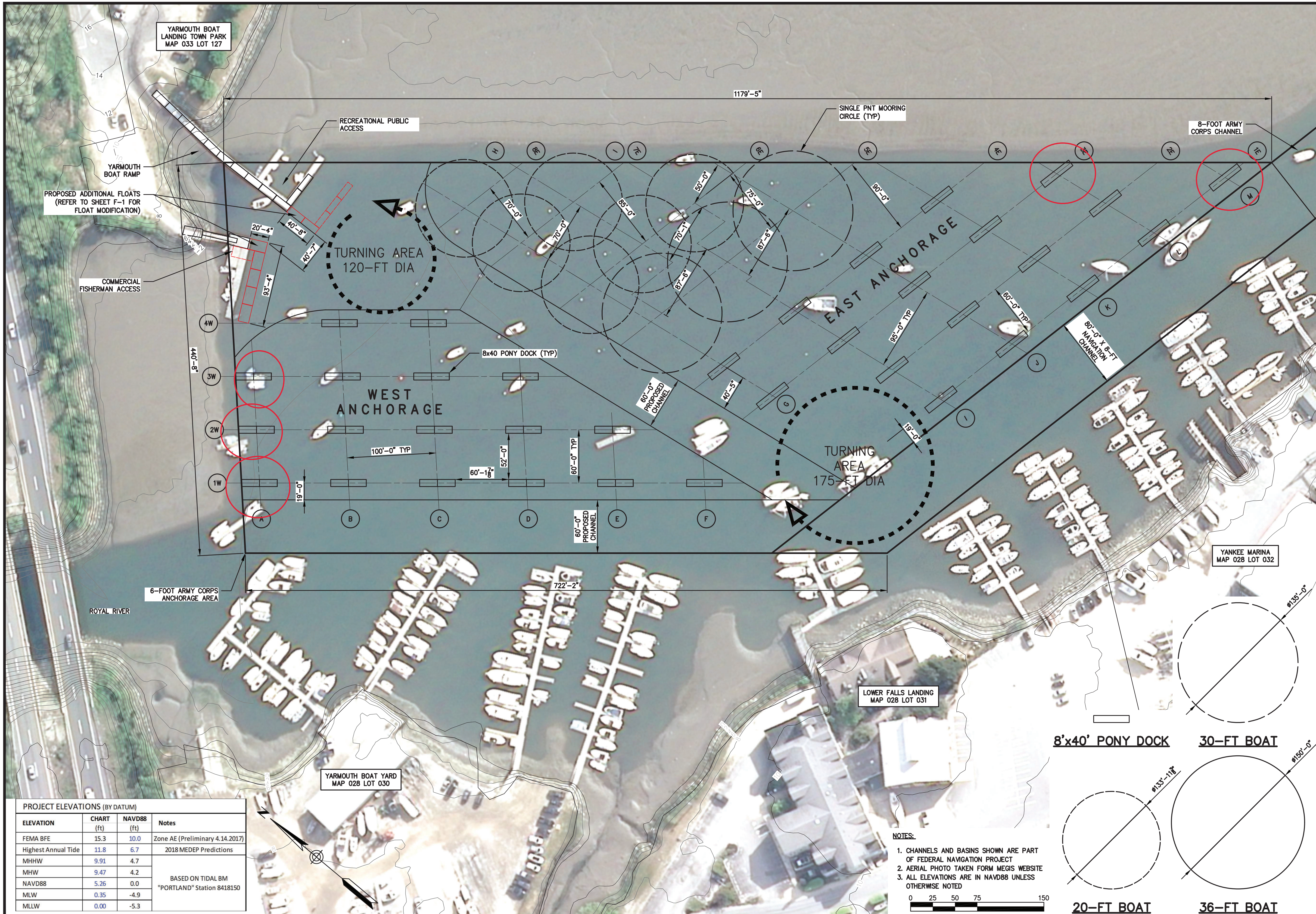
FLOAT DETAILS

MOORED FLOATS SAFE HARBOR KITTER POINT KITTERY, ME YORK COUNTY BACK CHANNEL	SHM, KITTERY POINT LLC 48 Bowen Road Kittery, ME 03904 TAX MAP 17, LOT 10	DATE: 8-15-22 SCALE: AS SHOWN DRAWN BY: DCM DESIGN BY: DCM APPROVED BY: PROJECT NO: FILE:	NO.	REVISION	APP'D	DATE

CIVILWORKS NEW ENGLAND
CIVIL & WATERFRONT ENGINEERING
181 Watson Road, PO Box 1166
Dover, New Hampshire 03821
603.749.0443

NOT FOR CONSTRUCTION

WF - 5



PROJECT ELEVATIONS (BY DATUM)

ELEVATION	CHART (ft)	NAVD88 (ft)	Notes
FEMA BFE	15.3	10.0	Zone AE (Preliminary 4.14.2017)
Highest Annual Tide	11.8	6.7	2018 MEDEP Predictions
MHHW	9.91	4.7	BASED ON TIDAL BM "PORTLAND" Station 8418150
MHW	9.47	4.2	
NAVD88	5.26	0.0	
MLW	0.35	-4.9	
MLLW	0.00	-5.3	

NOTES:

1. CHANNELS AND BASINS SHOWN ARE PART OF FEDERAL NAVIGATION PROJECT
2. AERIAL PHOTO TAKEN FORM MEGIS WEBSITE
3. ALL ELEVATIONS ARE IN NAVD88 UNLESS OTHERWISE NOTED

0 25 50 75 150

x:\20\20-43 2020 waterfront masterplan-yarmouth\cad\20-43_yarmouthtownlanding_civil.dwg 2/26/2021

BAKER DESIGN CONSULTANTS
Civil, Marine, and Structural Engineering
7 Spruce Road • Freeport • Maine • 04032 • 207-846-9724 • info@bakerdesignconsultants.com

NO.	SUBMISSION	DATE	INT.
B	REGULATORY REVIEW	2.26.21	BJB
A	PRELIMINARY REVIEW	1.18.21	BJB

DESIGNED BY: MMC
DRAWN BY: MMC
CHECKED BY: BJB
SCALE: AS SHOWN

SHEET TITLE: BASIN MOORING PLAN

PROJECT: YARMOUTH TOWN LANDING
YARMOUTH, MAINE

DATE: DEC 2020
CONTRACT NO. 20-43
SHEET NO. M-1
REV. B

FROM THE DESK OF
Captain Mark Lechner
28 Folcutt Road
Kittery Point, Maine 03905

August 5, 2022

Kittery Point Yacht Yard
48 Bowen Road
Kittery, ME, 03904

Dear Tom and Jason,

Thank you for updating me on the ACOE approval for pending improvements to the Back Channel. I believe the investment in creating a defined channel and added navigation space by converting 14 swinging moorings to fixed floats will be well received by the boating community, as will any additional berthing capacity it may provide. Also, your sensitivity to improvements that have an ecological benefit is appreciated. As a sailboat owner who moored my sailboat with KPYY for many years I witnessed nothing but concern for your neighbors in any decisions made. Preservation of this resource and the boatyard and marina are important to us. Good luck.

Warm regards,

Mark Lechner
Captain, Isles of Shoals Steamship Co.

From : Mike MacKenzie

To: Tom and Jason

Ref: Back Channel Improvements

Dear Tom and Jason,

Thank you for updating me on the ACOE approval for pending improvements to the Back Channel. I believe the investment in creating a defined channel and added navigation space be converting 14 swinging moorings to fixed floats will be well received be the boating community, as will any additional berthing capacity it may provide. Also, your sensitivity to improvements that have an ecological benefit is appreciated. Preservation of this resource and the boatyard and marina are important to us. If there is anything that I can do to support this effort please let me know.

Regards,

Mike MacKenzie

Owner of “Just One More V”

July 31, 2022

From: Peter Mocklis <pmocklis@gmail.com>
Sent: Thursday, August 4, 2022 12:41 PM
To: Jason Tittle <jtittle@shmarinas.com>
Subject: [External] Moorings

August 4, 2022

Dear Tom and Jason,

Thank you for updating me on the ACOE approval for pending improvements to the Back Channel. I believe the investment in creating a defined channel and added navigation space by converting 14 swinging moorings to fixed floats will be well received by the boating community, as will any additional berthing capacity it may provide. Also, your sensitivity to improvements that have an ecological benefit is appreciated. Preservation of this resource and the boatyard and marina are important to us. Good luck.

Regards,

Peter Mocklis

Alexa

September 14, 2022

Thomas Allen
Kittery Point Yacht Yard Corp.
48 Bowen Road
Kittery, Maine 03904

United States Army Corp of Engineers
Maine Project Office
442 Civic Center Drive, Suite 350
Augusta, Maine 04330

Re: Corps Permit No. NAE -2015-01134-MOD

To whom it may concern:

I am the owner and principal of Kittery Point Yacht Yard Corp. Kittery Point Yacht Yard Corp. holds the General Permit described above. Kittery Point Yacht Yard Corp. operated on the property and submerged lands described in the permit. As of May 1, 2022 the property on which Kittery Point Yacht Yard operated was sold to SHM Kittery Point, LLC. I will continue to operate the property as the General Manager for the new owners. The purpose of this letter is to affect the transfer of this permit from Kittery Point Yacht Yard Corp. to SHM Kittery Point, LLC.

The name, address and phone number of the transferee will be as follows:

SHM Kittery Point, LLC
Attention Thomas Allen
48 Bowen Road
Kittery, Maine 03904
(207) 439-9582

Pursuant to Section 39 of the General Permits for the State of Maine:

> "When the structures or work authorized by these GPs are still in existence at the time the property is transferred, the terms and conditions of these GPs, including any special conditions, will continue to be binding on the new owner(s) of the property."

Thomas Allen
General Manager
SHM Kittery Point, LLC

(signature)

Please transfer the permit accordingly. If you have any question, please do not hesitate to contact me.

Sincerely,

Thomas Allen
Kittery Point Yacht Yard Corp.

charliepatten@comcast.net

From: Harbor Master <kpa@kitteryme.org>
Sent: Wednesday, September 28, 2022 4:53 PM
To: Charles Patten
Subject: Fwd: Safe Harbor Pony Floats

Flag Status: Flagged

FYI

John Brosnihan
Harbormaster
Town of Kittery
Ph. 207-451-0829
or
Ph. 207-332-2656

Begin forwarded message:

> **From:** Robert Hendrickson
> **Date:** September 28, 2022 at 4:50:08 PM EDT
> **To:** Harbor Master <kpa@kitteryme.org>
> **Cc:** Robert Hendrickson
> **Subject: Safe Harbor Pony Floats**
>
> John,
> I had a chance to review Safe Harbor's plan to convert moorings to pony floats in the back channel. As someone who has many times navigated the channel in low visibility conditions due to fog and/or darkness, I can say it is a welcome change.
>
> I believe the plan will allow for a more consistently defined channel (as the floats do not swing). The resulting definition (as viewed via radar) will be well defined and consistent allowing for safer transit and less potential damage to transiting and moored vessels.
>
> Some may view this as progress that is unwelcome; I do not see it that way. Many communities have seen a loss of available dock and mooring space when ownership has changed. Here we see increased access to the water resource here in Kittery as a result of this plan. Gentrification of the waterfront is a theme seen all too often in transiting the waters of New England. The investment in the expansion of water-related uses is refreshing, and frankly necessary, to keep alternative development from occurring.
>
> I am in favor of the plan and wish to express that support to the Kittery Port Authority. If this email can serve in that regard I would appreciate your passing it on and making it part of the record. If not, your advice as to how to support the plan would be greatly appreciated.
>
> Kindest regards,
>
> Bob Hendrickson
> 7 Keene Terrace

TOWN OF KITTERY

APPLICATION FOR PIERS, WHARFS, FLOATS AND OTHER MARINE-RELATED STRUCTURES

Applicant: **SHM Kittery Point, LLC**

Property: **48 Bowen Road**
Kittery, Maine

Agent: **Sandra L. Guay, Esq.**
Benjamin E. Ford, Esq.
Archipelago
22 Free Street, Suite 403
Portland, ME 04101

DATE: **June 15, 2022**

Index

Application for Piers, Wharf, Floats and other Marine Related Structures

Authorization Appointing Archipelago as Agents for Applicant

Town Tax Map of Lot

List of Abutters within 150 ft of Applicant's shorefront property line

Project Narrative

Exhibit 1 – Recorded Deed

Exhibit 2 – Site Plan

Exhibit 3 – Construction and Mooring Specifications

Exhibit 4 – Army Corps of Engineers Authorization Letter Dated April 7, 2022

Exhibit 5 – Lobster Use of Eelgrass Habitat in the Piscataqua River on the New Hampshire/Maine Border, USA, Estuaries and Coasts, April 2001, F.T. Short, K. Matso. H.M. Hoven, J. Whitten, D.M. Burdick, and C.A. Short.

Exhibit 6 – Maine Eel Grass Survey 1997 and 2010.

Exhibit 7 – *Disturbances of Intertidal Soft Sediment Assemblages Cause by Swinging Boat Moorings,* Hydrobiologia, June 2009, J.H. Herbert, T.P. Crow, S. Bracy, M. Sheader.

Exhibit 8 – A Simple Mooring Modification Reduces Impacts on Seagrass Meadows, Scientific Reports, 2019, Anna L. Luff, Emma V. Sheehan, Mark Parry, Nicholas Higgs.

Map: 17
Lot: 10
Date Submitted: June 15, 2022

TOWN OF KITTERY
KITTERY PORT AUTHORITY

Application for
PIERS, WHARFS, FLOATS AND OTHER MARINE-RELATED STRUCTURES

Contact: kpa@kitteryme.org Website: kitteryme.gov

NOTE: Ten (10) sets of plans, applications, maps and other necessary information are required atsubmittal.

The following application is submitted for the construction, modification, reconstruction of a:
Conversion of 28 single point moorings in the Back Channel operated by Safe Harbors Kittery Point into 13 floating docks configured as (12) 80'x8' long floats and (1) 160'x8' long float along the narrower part of the BC.

1. This project is an in-kind repair/replacement, **which will not** expand, move, or modify the style of the existing structure:
   [ ] Yes, it is in-kind repair [X] No, there will be modifications
2. Property Owner(s): SHM Kittery Point LLC.
3. Property Address: 48 Bowen Road, Kittery, ME 03904
4. Telephone Number: 207-439-9582 (REQUIRED) Email: toallen@shmarinas.com (REQUIRED)
5. Property Size (Acres/SF): +/-1.3acres/ 57,500s.f. Zoning District(s): R/U Maritime Overlay
6. The shore frontage of this property is +/-500' feet, measured at the high water line in a straight line, stake to stake.
7. This is my first Kittery Port Authority application **for this property**: Yes [ ] No [X]
   If No, please explain: (See attached narrative)
8. LEGAL INTEREST: The applicant demonstrates a legal interest in the property by including a copy of the following: Deed, Purchase and Sale Agreement
   (See Recorded Deed attached as Exhibit 1)
9. CONSTRUCTION PLAN: Provide a description of the property showing all proposed construction showing the lot lines and exact positions of the proposed structure with dimensions and elevations from readily identifiable reference points. (See Site Plan attached Exhibit 2)

Applicant Signature: [signature] General Manager Date: 6/14/2022

Property Owner Signature: [signature] General Manager Date: 6/14/2022

Agent Name: Sandra Guay Agent Firm: Archipelago Law, LLP

Agent Phone: 207-558-0102 (REQUIRED) Agent Email: sguay@archipelagona.com (REQUIRED)

APPLICATION FEE ($125). Include a check payable to the Town of Kittery. Additional fees may be charged for direct costs (i.e. legal notices, engineering review, etc.) necessary to complete the review of the application per Town Code, Title 3, Chapter 3.3

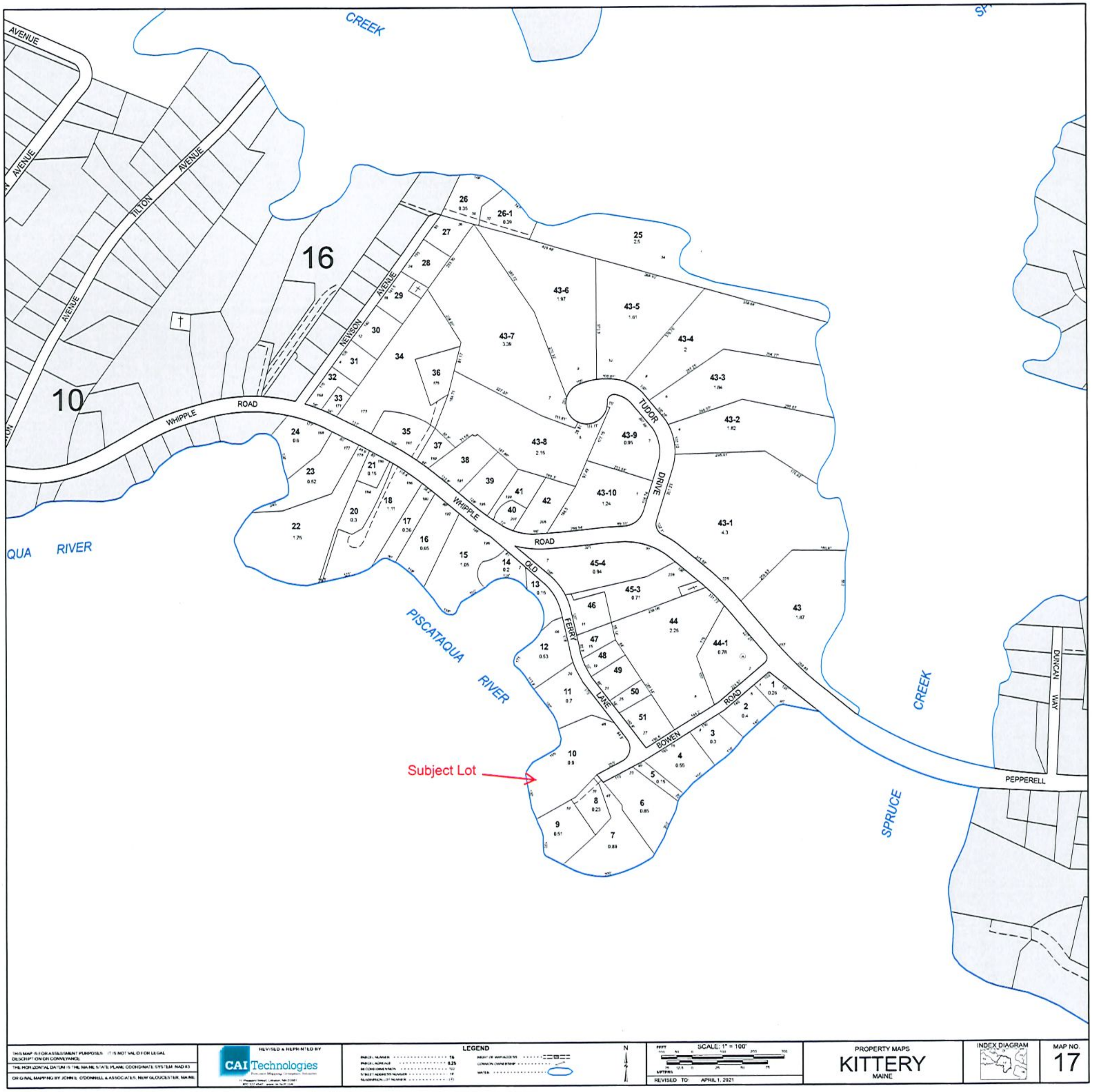
Fee Paid, Amount:________________ Date: ________________

AUTHORIZATION

I, Thomas J. Allen, as General Manager of SHM Kittery Point, LLC, hereby authorize Sandra Guay and Benjamin Ford of firm of Archipelago in Portland, Maine, to sign any and all State of Maine or Town of Kittery permit and appeal applications on our behalf with regard to our property located at 48 Bowen Road, Kittery, Maine (Tax Map 17 Lot 10). We further authorize any member of that firm to appear on our behalf and to represent us before any department, board, committee, or agency of said State or town, including, but not limited to, the Kittery Port Authority, the Kittery Planning Board, and the Kittery Board of Appeals.

DATED: June 14, 2022

Thomas J. Allen
General Manager
SHM Kittery Point, LLC



CREEK
SPRUCE
CREEK
16
10
WHIPPLE ROAD
NEWSON AVENUE
TILTON AVENUE
AVENUE
TUDOR DRIVE
WHIPPLE ROAD
OLD FERRY LANE
BOWEN ROAD
PEPPERELL
DUNCAN WAY
PISCATAQUA RIVER
QUA RIVER
Subject Lot
LEGEND
SCALE: 1" = 100'
REVISED TO APRIL 1, 2021
CAI Technologies
PROPERTY MAPS
KITTERY
MAINE
INDEX DIAGRAM
MAP NO.
17

Abutter's List

(150 ft from Applicant's shorefront property line)

Abutter	Mailing Address	Lot Address	Map	Lot
Sanidas, John & Carol	7 Amberwood Ln Boxford, MA 01921	20 Old Ferry Lane	17	11
Hall, Michael & Rebecca	140 State Rd Kittery, ME 03904	51 Bowen Road	17	9
Anderson, Lee Richards	6029 E Old West Way Scottsdale, AZ 85262	31 Bowen Road	17	8

INTRODUCTION

SHM Kittery Point, LLC (the "Applicant") is a marina operating in the Back Channel. The Applicant currently leases and maintains 41moorings and two existing 28' x 6' floating docks in the harbor that it then leases out to its customers. In the summer, the Applicant's service customers are a mix or recreational and commercial boaters. In the winter, the Applicant's on-the-water customers are almost exclusively commercial. The Applicant is proposing to replace 28 of their single-point moorings with 13 fixed-position floating docks. Most docks will consist of two 40' X 8' floating platforms joined end to end. One dock will consist of four 40' x 8' platforms. See **Exhibit 2**.

For several years, members of the Kittery Port Authority have discussed replacing some moorings in the Back Channel with fixed floating docks. Compared to single-point moorings, fixed floating docks provide enhancements to safety, environmental impacts, and public access to the waterway. In the Back Channel, the proposed floating dock arrangement would better define the center channel and allow boats to navigate the harbor more easily, especially in conditions with low visibility.

While a floating dock arrangement provides many benefits over single point moorings, those benefits come with capital costs associated with building the docks and installing the anchors, chain, and tackle. This proposal would offset the increased capital costs by granting the Applicant a waiver to build floating platforms larger than the maximum size specified in the Kittery Port Authority Rules. The increased size would allow the Applicant to recoup its investment by slightly increasing the number of boats moored in the same space. This proposal would not increase the size of the space currently allocated to the Applicant; it would only increase the size of the floats and allow the Applicant to slightly increase the number of boats moored in the same space.

LEGAL STANDARD

The Kittery Port Authority has the authority to permit the installation of floating docks and to grant waivers to permit the construction of floats exceeding the maximum size defined by the rules. Kittery Port Authority Rules state that:

> No wharf, pier, float, or any other marine-related structure may be erected, moved, or otherwise altered without a Building Permit therefor, issued by the Code Enforcement Officer after plan approval is obtained from the Port Authority and in compliance with all requirements of the applicable local, State and Federal requirements.

Port Authority Rules and Regulations Pertaining to Harbor, Port, and Channels, Within the Town of Kittery, Maine, Amended January 2, 2020 (the "Rules") § 4.2.1. The Rules further state that:

> Moored floats are authorized only with the expressed permission of the Port Authority and only after receiving an Army Corps of Engineers Permit. Permits are issues in accordance with Section 4 of these rules.
>
> …

> Float size may not exceed 10' X 24' dimensions for commercial uses and 8' 24' dimensions for recreational uses, unless otherwise permitted by the Port Authority.

Rules § 3.12.1 (A, C). The Rules also specify minimum standards for floats specifically requiring the floats to have "a minimum of two (2) moorings," that each float be identified with registration numbers, and that each float use the proper chain size and include "hot dopped galvanized steel for all shackles and fasteners." *Id.* (D-F).

The Port Authority may grant a waiver from the specifications defined by the regulations provided that "the Port Authority finds that due to special circumstances of the specific application, the granting of a waiver will not adversely impair the public health, safety and general welfare, the use of public waters, navigation, or harm the environment." Rules § 4.3.3.

The proposed installation includes four granite anchors, each weighing at least 4,000 pounds, 5/8" chain, sentinel weights to maintain chain tension, and ¾" hot dipped galvanized steel shackles. **Exhibit 3**; see also Rules § 3.12.1 (D-F). Each float will be identified with an assigned registration number on both ends of the float, in contrasting colors, and with numbers that are at least three inches high. *Id.* The proposed installation is already approved by the Army Corp of Engineers. *Id.* (A); see **Exhibit 4**. The only waiver the Applicant is requesting is to the maximum size requirements found in section 3.12.1 (C). As discussed below, the waiver should be granted because the installation of floating docks will enhance, rather than impair each of criteria specified in the Rules.

1. Enhancements to Public Health

The proposed floating docks will float lower in the water compared to most of the vessels tied to them. To access the vessel, boaters will transfer first from the dingy or launch to the float, and then from the float to the boat itself. The lower float makes it easier and safer for people to transfer between vessels since they will not need to scale the freeboard of a larger boat or manage stability issues with a smaller boat. This benefit is especially pronounced for the elderly and boaters with mobility issues.

2. Enhancements to Public Safety

Floating docks allow vessels to remain in a fixed location. This prevents the vessels from oscillating horizontally in the wind and current and lessens the risk of dangerous collisions between dinghies or launches, and their intended vessels. The fixed location also provides a safer platform for workers as they commission, de-commission, and prepare vessel for adverse weather such as hurricanes.

In the winter, the use of floats will allow increased capacity for the Back Channel to serve as a safe harbor for the in-water commercial fleet during storms.

While experienced operators pride themselves on their ability to land on small docks in tight locations, a larger float will allow a new boater more room to make mistakes thereby lessening the chance of dangerous collisions between boats, docks, and people.

Unlike single point moorings, floating docks allow multiple points of attachment between the vessel and the float and between the float and the anchors. This eliminates the danger of a single point failure and makes it significantly less likely an equipment failure will allow boats to break free in adverse weather.

3. Enhanced Access to the Public Waters

The proposed improvements will increase access for the local boating community by allowing approximately 20-25 additional vessels to moor in the same amount of space. Because the proposed installation will not take up more space in the harbor, the waitlist for moorings will not be lengthened and may even be reduced as some of the additional spaces may be used by those already on the list.

Because the floats are easier to use and access, the use of floats will also allow elderly boaters to use their vessel later in life and the larger landing space will allow for new boaters to use their vessels in a greater range of weather conditions.

4. Enhanced Navigation

Unlike most harbors, the Back Channel currently lacks a clearly defined navigation channel. As vessels are free to swing around their moorings in the wind and current, the navigable channel can be obscured which greatly increases the risks of collisions, especially at night and in low visibility conditions. As the plan shows, most of the single-point moorings on the west side of the center channel will be removed and replaced with floats. See **Exhibit 2**. The floats and the vessels tied to them will be fixed thereby clearly defining the center channel and easing navigation for vessels entering and leaving the harbor.

By eliminating the swing associated with single point moorings, the use of floats will have a significantly smaller impact on the harbor surface. With the swing associated with single-point moorings, the current area of impact is estimated at 170,000 square feet based on an average vessel length of 38' LOA. The proposed converson to fixed floats would reduce that impact to an estimated 26,000 square feet.[1]

While each float will have four anchors as opposed to a single anchor in a traditional system, if four boats are tied to one float, there will not be any additional ground tackle per boat. In other words, under a traditional system, four boats would require four anchors and four chains. In the proposed system, those same four boats will still only require four anchors and four chains. The advantage of the proposed system is that the chains and the boats do not move, thereby allowing people to fish in very close proximity to the floats.

---

[1] 88' diameter= 44' radius squared x 3.14 x 28 moorings= 170,213sf versus float and additional boat area of ((12) x 80 x 8) + (1) x 160 x 8)) x 3 = 26,880sf].

5. Enhanced Environmental Benefits

Eelgrass provides critical habitat for many spawning and juvenile fish species. In 2001, a study by the University of New Hampshire showed that adolescent lobsters in the vicinity of Seavey Island burrow into the eelgrass beds and use those eelgrass beds to overwinter. See **Exhibit 5**. In 1997 and again in 2010, the Maine Department of Marine Resource documented the presence of eelgrass habitat in the Back Channel. See **Exhibit 6**. Researchers have documented negative environmental effects from single point moorings. See **Exhibit 7**. As the chain between anchor and the mooring ball is allowed to rest on the harbor floor, it scours the bottom as the vessel swings in the changing wind a current. *Id.* Researchers have noted a significant environmental benefit when mooring chains are lifted off the bottom thereby eliminating bottom scouring. See **Exhibit 8**.

This proposal would eliminate bottom scouring thereby promoting a healthier ecosystem in the Back Channel. The float, mooring tackle, and anchor will remain in a fixed single line should any chain contact the bottom, it would do so in only one direction. However, because the anchors are offset, the mooring tackle will remain under tension with each sentinel weight pulling against its opposite anchor. Because of this arrangement, the mooring chains will remain suspended and will not touch the bottom.

CONCLUSION

The Applicant is a historic boatyard that provides incomes for 22 local families and has been part of this community for 60 years. Past investments in infrastructure to control runoff and mitigate other negative environmental effects demonstrate the Applicant's sincere commitment as a steward of this important public resource.

From increased tax revenue from visitors to increased quality of life for residents, the Town of Kittery has much to gain from expanded use of the Back Channel. This proposal will allow the town to realize those benefits while at the same time making the Back Channel a safer and more welcoming harbor.

NANCY E HAMMOND, REGISTER OF DEEDS
E-RECORDED Bk 19017 PG 753
Instr # 2022019520
05/04/2022 02:23:05 PM
Pages 6 YORK CO

DLN: 1002240192344

After recording return to:
SHM Kittery Point, LLC
c/o Safe Harbor Marinas
14785 Preston Road, Suite 975
Dallas, TX 75254
Attn: John Ray

Space Above This Line For Recording Data

Maine R.E. Transfer Tax Paid

WARRANTY DEED

KNOW ALL MEN BY THESE PRESENTS that **MGX, LLC,** a Maine limited liability company with a principal place of business in Kittery, County of York and State of Maine, in consideration of one dollar and other valuable consideration, grants to **SHM KITTERY POINT, LLC**, a Delaware limited liability company with a place of business in Dallas, County of Dallas, and State of Texas, whose mailing address is 14785 Preston Road, Suite 975, Dallas, TX 75254, with WARRANTY COVENANTS, a certain lot or parcel of land, together with any improvements thereon, situated in the Town of Kittery, County of York and State of Maine, and described on the attached **Exhibit A**, which is made a part hereof for all purposes, together with all and singular the rights, benefits, privileges, easements, tenements, hereditaments and appurtenances thereon or in anywise appertaining thereto, and together with all improvements located thereon and any right, title and interest of Grantors in and to adjacent streets, alleys and rights-of-way (said land, rights, benefits, privileges, easements, tenements, hereditaments, appurtenances, improvements and interests being hereinafter referred to as the "**Property**").

This conveyance is made and accepted subject to those certain matters all as more particularly described on **Exhibit B** attached hereto and incorporated herein by this reference (the "**Permitted Exceptions**"); provided, however, that the reference to the Permitted Exceptions shall not be deemed to reimpose same.

TO HAVE AND TO HOLD the Property, subject to the Permitted Exceptions, as aforesaid, unto the Grantees, and the Grantees' legal representatives, successors and assigns forever; and Grantors do hereby bind themselves and their heirs, executors, legal representatives, successors and assigns, to WARRANT AND FOREVER DEFEND all and singular the Property unto Grantees and Grantees' legal representatives, successors and assigns against every person whomsoever lawfully claiming or to claim the same, or any part thereof.

[*Signature page follows*]

IN WITNESS WHEREOF the said MGX, LLC has caused this instrument to be executed by

Thomas Allen, its Manager, duly authorized, this 2nd day of May, 2022.

MGX, LLC

WITNESS

By: ______________________
Thomas Allen, its Manager

STATE OF MAINE
York, ss.

May 2nd, 2022

Then personally appeared the above-named Thomas Allen, Manager of MGX, LLC and acknowledged the foregoing instrument to be his free act and deed in his said capacity, and the free act and deed of said limited liability company,

Before me,

~~Notary Public~~ / Attorney at Law

Print Name: Benjamin E. Ford Benjamin E. Ford

My Commission Expires: Bar No. 4528 Bar No. 4528

EXHIBIT A

A certain lot or parcel of land, together with any buildings or improvements located thereon, situated on Old Ferry Lane and at 48 Bowen Road in the Town of Kittery, County of York and State of Maine, and being more specifically bounded and described as follows:

Beginning at a rebar found flush with the ground on the southwesterly side of said Old Ferry Lane at the intersection with Bowen Road, and thence proceeding South 52° 13' 55" West a distance of 260.59 feet along said Bowen Road and land now or formerly of Milton E. Hall to a one and one-half (1 ½) inch iron pipe found 6 inches high; thence proceeding South 61° 10' 14" West a distance of 114.46 feet along a chain link fence and land now or formerly of said Milton E. Hall to a one (1) inch iron pipe found 3 inches high; thence proceeding South 61° 39' 55" West a distance of 11.00 feet, more or less, to the mean high water mark of the Piscataqua River, and thence proceeding in the same direction to the low water mark; thence proceeding in a generally northeasterly, westerly, northwesterly and northeasterly direction along the Piscataqua River to a point at the low water mark found by extending the line shown on the plan hereafter referenced as the "Proposed Property Line" between other land now or formerly of Elmer L.J. Dion and Shirley I. Dion and the parcel herein conveyed to the low water mark of the Piscataqua River; thence turning and proceeding along said extended boundary line North 59° 06' 41" East to the high water mark, and thence continuing in the same direction a distance of 20.00 feet to a one-half (1/2) iron rod; thence North 59° 06' 41" East along the southerly boundary of other land now or formerly of said Elmer L.J. Dion and Shirley I. Dion fifty (50) feet to a two (2) inch iron pipe; thence proceeding North 76° 09' 26" East a distance of 50.73 feet still along other property now or formerly of Elmer L.J. Dion and Shirley I. Dion; thence turning and proceeding South 55° 01' 55" East a distance of 67.07 feet to a point in the southwesterly sideline of said Old Ferry Lane; thence proceeding South 27° 11' 00" East a distance of 12.81 feet along the sideline of said Old Ferry Lane to a point; thence proceeding South 30° 38' 00" East a distance of 60.09 feet still along said Old Ferry Lane to a point; thence proceeding South 33° 25' 00" East a distance of 20.64 feet along said Old Ferry Lane to a rebar found flush with the ground, and being the place of beginning.

Meaning and intending to convey the premises shown as "Tax Map 17 Lot 10" on a plan entitled "Lot Line Revision & Driveway Easement Plan for Property Off Old Ferry Lane, York County, Kitty, Maine for Elmer L.J. Dion & Shirley Dion", dated November 16, 1999 and last revised November 18, 1999, by Easterly Surveying, Inc., and recorded in Plan Book 251, Page 42 with the York County Registry of Deeds.

Also conveying at all the grantor's right, title and interest in and to the right of way for access and utility services along the southeasterly sideline of the property hereinabove conveyed over land shown on said plan as land of Milton E. Hall and shown as Tax Map 17, Lot 9 on the aforementioned plan. Also conveying all the grantor's right, title and interest in an easement from Milton E. Hall to Elmer L.J. Dion and Shirley I. Dion dated November 19, 1999 and recorded at said Registry of Deeds at Book 9788, Page 306, for maintenance of an existing overhead transmission line, underground water line and other utilities and access to the driveway to the premises conveyed above as shown on the aforementioned plan.

The premises are conveyed subject to an easement for access, ingress and egress from Old Ferry Lane for the benefit of other land of Elmer L.J. Dion and Shirley I. Dion shown as Tax Map 17, Lot 11 on the aforementioned plan over the following described property:

The starting point for the easement may be found by beginning at a rebar found flush with the ground on the northwesterly side of said Old Ferry Lane at its intersection with Bowen Road, and thence proceeding on the following courses and distances: North 33° 25' 00" West a distance of 20.64 feet, North 30° 38' 00" West a distance of 60.09 feet, and North 27° 11' 00" West a distance of 12.81 feet to a point and being the starting point for the easement reserved herein; thence proceeding North 59° 14' 08" West a distance of 71.87 feet to point at land of Elmer L.J. Dion and Shirley I. Dion; thence turning and proceeding North 76° 09' 26" East a distance of 7.0 feet to a point; thence turning and proceeding South 55° 01' 55" East a distance of 67.07 feet along said land of Elmer L.J. Dion and Shirley I. Dion to a point in the sideline of said Old Ferry Lane, and being the place of beginning.

The reserved easement is shown on the foregoing plan as "Driveway Easement Inset".

Meaning and intending to convey the same premises conveyed to MGX, LLC by deed of Dion's Yacht Yard Corp., dated June 17, 2004, and recorded in the York County Registry of Deeds in Book 14127, Page 576.

EXHIBIT B

Permitted Exceptions

1. Taxes and assessments for the year 2022 and subsequent years, a lien not yet due and payable.

2. Subject to the State of Maine Submerged Land Lease between the Bureau of Public Lands, State of Maine Department of Conservation, and Dion's Yacht Yard, Inc. dated July 24, 1986.

3. Such state of facts as set forth on a plan entitled "Lot Line Revision & Driveway Easement Plan for Property of Off Old Ferry Land, York County, Kittery, Maine for Elmer L. J. & Shirley Dion" dated November 15, 1999, prepared by Northeasterly Surveying, Inc. and recorded in Plan Book 251, Page 42.

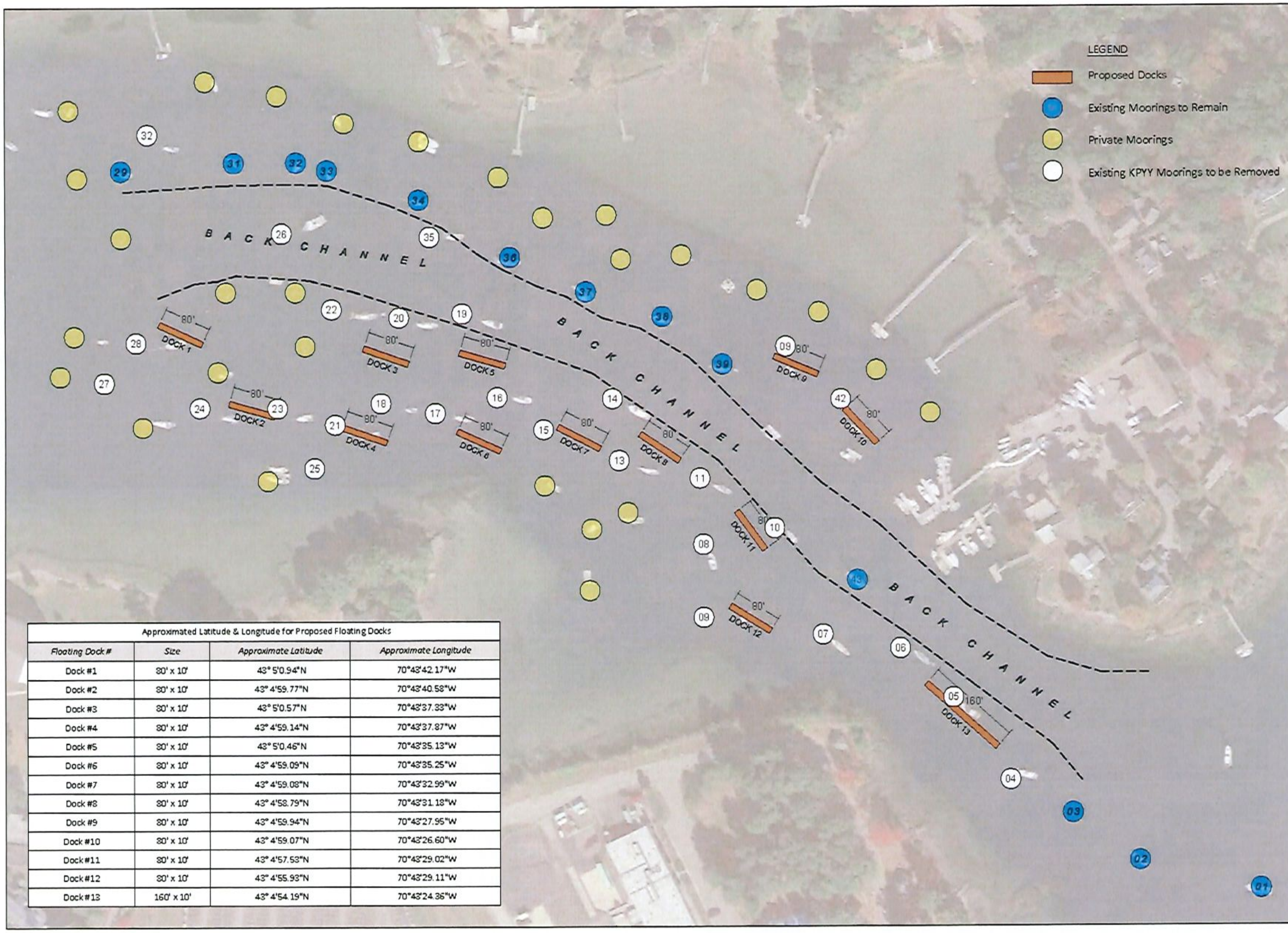
4. Conditions and restriction relative to an appurtenant easement from Milton E. Hall to Elmer L.J. Dion and Shirley I. Dion dated November 19, 1999 and recorded in Book 9788, Page 306, and as shown on the ALTA/NSPS survey of the property prepared by Earl N. Strom, PLS 2224, last revised February 18, 2022 , Surveyor Drawing No. 21-09-026 (the "Survey").

5. Easements and rights as reserved in Warranty Deed from Dion's Yacht Yard Corp. to MGX, LLC dated June 17, 2004 and recorded in Book 14127, Page 576, and as shown on the Survey.

6. Such state of facts as set forth on a plan entitled "Site Plan Showing Activity & Use Restriction Area for Property at 48 Bowen Road, Kittery, York County, Maine Owned by: MGX, LLC" dated September 29, 2005, prepared by Northeasterly Surveying, Inc. and recorded in Plan Book 312, Page 30.

7. Such state of facts as set forth in a Department Order from the State of Maine Department of Environmental Protection in the Matter of Dion's Yacht Yard Corporation dated June 5, 2006 and recorded in Book 14895, Page 216.

8. Such state of facts as set forth in a Declaration of Environmental Covenant by MGX, LLC (successor in interest to Dion's Yacht Yard Corporation) and the Maine Department of Environmental Protection dated June 28, 2006 and recorded in Book 14895, Page 220.



Approximated Latitude & Longitude for Proposed Floating Docks			
Floating Dock #	*Size*	*Approximate Latitude*	*Approximate Longitude*
Dock #1	80' x 10'	43° 5'0.94"N	70°43'42.17"W
Dock #2	80' x 10'	43° 4'59.77"N	70°43'40.58"W
Dock #3	80' x 10'	43° 5'0.57"N	70°43'37.33"W
Dock #4	80' x 10'	43° 4'59.14"N	70°43'37.87"W
Dock #5	80' x 10'	43° 5'0.46"N	70°43'35.13"W
Dock #6	80' x 10'	43° 4'59.09"N	70°43'35.25"W
Dock #7	80' x 10'	43° 4'59.08"N	70°43'32.99"W
Dock #8	80' x 10'	43° 4'58.79"N	70°43'31.18"W
Dock #9	80' x 10'	43° 4'59.94"N	70°43'27.95"W
Dock #10	80' x 10'	43° 4'59.07"N	70°43'26.60"W
Dock #11	80' x 10'	43° 4'57.53"N	70°43'29.02"W
Dock #12	80' x 10'	43° 4'55.93"N	70°43'29.11"W
Dock #13	160' x 10'	43° 4'54.19"N	70°43'24.36"W

[redacted]

KITTERY POINT

Eliot, Maine

DRAWING TITLE:

Kittery Point

DRAWING INDEX:

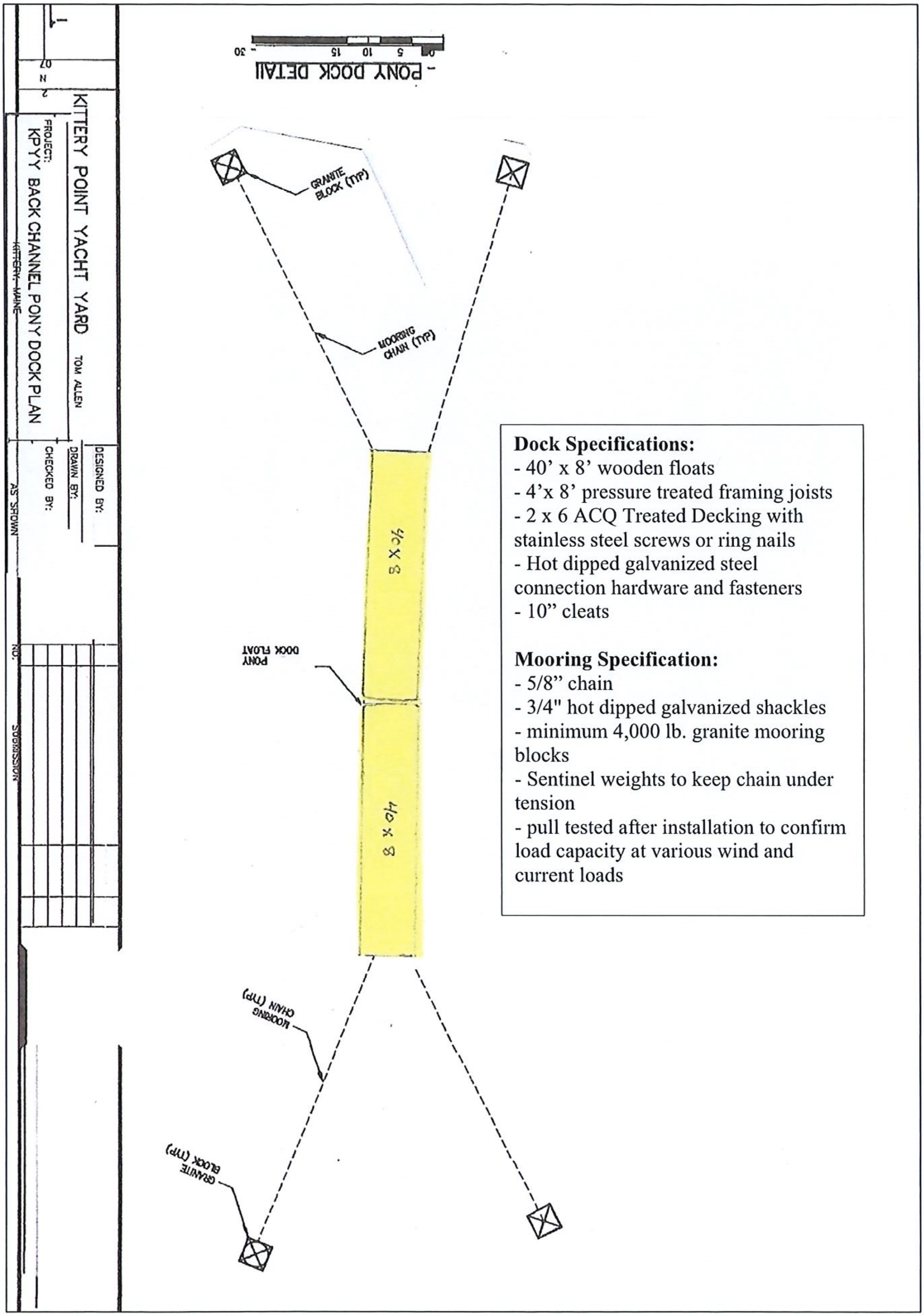
X1 : Proposed

SCALE

0' 150'

N

X1



Dock Specifications:
- 40’ x 8’ wooden floats
- 4’x 8’ pressure treated framing joists
- 2 x 6 ACQ Treated Decking with stainless steel screws or ring nails
- Hot dipped galvanized steel connection hardware and fasteners
- 10” cleats

Mooring Specification:
- 5/8” chain
- 3/4" hot dipped galvanized shackles
- minimum 4,000 lb. granite mooring blocks
- Sentinel weights to keep chain under tension
- pull tested after installation to confirm load capacity at various wind and current loads

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

REPLY TO ATTENTION OF

MAINE GENERAL PERMITS (GPs)
AUTHORIZATION LETTER AND SCREENING SUMMARY

THOMAS ALLEN
KITTERY POINT YACHT YARD CORP.
48 BOWEN ROAD
KITTERY, MAINE 03904

CORPS PERMIT # NAE-2015-01134-MOD
CORPS GP# 3
STATE ID# exempt

DESCRIPTION OF WORK:
Install and maintain 13 floats below the mean high water mark of the Piscataqua River (Back Channel) at Kittery, Maine. Each of twelve 8-ft. wide x 80-ft. long floats will be comprised of twin 8-ft. wide x 40-ft. long floats and one 8-ft. wide x 160-ft. long float will be comprised of quadruple 8-ft. wide x 40-ft. long floats. Each float will be moored with four, 4,000-lb. granite blocks or equivalent. Approximately 26 commercial single-boat moorings will be removed upon installation of floats. This work is shown on the attached plans entitled "Approximated Latitude & Longitude for Proposed Floating Docks" and "PONY DOCK DETAIL" in two sheets undated. ***See GENERAL CONDITIONS attached.***

LAT/LONG COORDINATES: 43.082801° N -70.724969° W **USGS QUAD:** KITTERY, ME

I. CORPS DETERMINATION:
Based on our review of the information you provided, we have determined that your project will have only minimal individual and cumulative impacts on waters and wetlands of the United States. **Your work is therefore authorized by the U.S. Army Corps of Engineers under the Federal Permit, the Maine General Permits (GPs) which can be found at:** https://www.nae.usace.army.mil/Missions/Regulatory/State-General-Permits/Maine-General-Permit/ Accordingly, we do not plan to take any further action on this project.

You must perform the activity authorized herein in compliance with all the terms and conditions of the GP [including any attached Special Conditions and any conditions placed on the State 401 Water Quality Certification including any required mitigation]. Please review the GPs, including the GPs conditions beginning on page 5, to familiarize yourself with its contents. You are responsible for complying with all of the GPs requirements; therefore you should be certain that whoever does the work fully understands all of the conditions. You may wish to discuss the conditions of this authorization with your contractor to ensure the contractor can accomplish the work in a manner that conforms to all requirements.

If you change the plans or construction methods for work within our jurisdiction, please contact us immediately to discuss modification of this authorization. This office must approve any changes before you undertake them.

Condition 45 of the GPs (page 19) provides one year for completion of work that has commenced or is under contract to commence prior to the expiration of the GPs on October 14, 2025. You will need to apply for reauthorization for any work within Corps jurisdiction that is not completed by October 14, 2026.

This authorization presumes the work shown on your plans noted above is in waters of the U.S. Should you desire to appeal our jurisdiction, please submit a request for an approved jurisdictional determination in writing to the undersigned.

No work may be started unless and until all other required local, State and Federal licenses and permits have been obtained. This includes but is not limited to a Flood Hazard Development Permit issued by the town if necessary.

II. STATE ACTIONS: PENDING [ ], ISSUED [ ], DENIED [ ] DATE________

APPLICATION TYPE: PBR:___, TIER 1:___, TIER 2:___, TIER 3:___, LURC:___ DMR LEASE:___ NA: X

III. FEDERAL ACTIONS:

JOINT PROCESSING MEETING: 18JUN2015 LEVEL OF REVIEW: SELF-VERIFICATION:___ PRE-CONSTRUCTION NOTIFICATION: X

AUTHORITY (Based on a review of plans and/or State/Federal applications): SEC 10 X, 404___ 10/404___, 103___

EXCLUSIONS: The exclusionary criteria identified in the general permit do not apply to this project.

FEDERAL RESOURCE AGENCY OBJECTIONS: EPA NO, USF&WS NO, NMFS NO

If you have any questions on this matter, please contact my staff at 978-318-8676 at our Augusta, Maine Project Office. In order for us to better serve you, we would appreciate your completing our Customer Service Survey located at: http://corpsmapu.usace.army.mil/cm_apex/f?p=136:4:0

[signature]
COLIN M. GREENAN
PROJECT MANAGER
MAINE PROJECT OFFICE

Richard Kristoff Jr.
Digitally signed by Richard Kristoff Jr.
Date: 2022.04.07 08:42:54 -04'00'
FOR FRANK J. DEL GIUDICE
CHIEF, PERMITS & ENFORCEMENT BRANCH
REGULATORY DIVISION

US Army Corps
of Engineers®
New England District

PLEASE NOTE THE FOLLOWING GENERAL CONDITIONS FOR DEPARTMENT OF THE ARMY MAINE GENERAL PERMIT 3 PERMIT NO. NAE-2015-01134-MOD

GENERAL CONDITIONS

11. Navigation. a. There shall be no unreasonable interference with general navigation by the existence or use of the activity authorized herein, and no attempt shall be made by the permittee to prevent the full and free use by the public of all navigable waters at or adjacent to the activity authorized herein. b. Work in, over, under, or within a distance of three times the authorized depth of an FNP shall specifically comply with GC 10. c. Any safety lights and/or signals prescribed by the U.S. Coast Guard, State of Maine or municipality, through regulations or otherwise, shall be installed and maintained at the permittee's expense on authorized facilities in navigable waters of the U.S. d. The permittee understands and agrees that, if future operations by the U.S. require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the U.S. No claim shall be made against the U.S. on account of any such removal or alteration.

31. Storage of Seasonal Structures. Seasonal or recreational structures such as pier sections, floats, aquaculture structures, etc. that are removed from the waterway for a portion of the year shall be stored in an upland location and not in wetlands, tidal wetlands, their substrate, or on mudflats. These seasonal structures may be stored on the fixed, pile-supported portion of a structure that is waterward of the mean high water mark or the ordinary high water mark, e.g. the storage of a ramp or gangway on the pile-supported pier. Seasonal storage of structures in navigable waters, e.g., in a protected cove, requires prior Corps approval and local harbormaster approval.

33. Permit(s)/Authorization Letter On-Site. The permittee shall ensure that a copy of the terms and conditions of these GPs and any accompanying authorization letter with attached plans are at the site of the work authorized by these GPs whenever work is being performed and that all construction personnel performing work which may affect waters of the U.S. are fully aware of the accompanying terms and conditions. The entire permit authorization shall be made a part of any and all contracts and subcontracts for work that affects areas of Corps jurisdiction at the site of the work authorized by these GPs. This shall be achieved by including the entire permit authorization in the specifications for work. The term "entire permit authorization" means all terms and conditions of the GPs, the GPs, and the authorization letter (including its drawings, plans, appendices and other attachments) and subsequent permit modifications as applicable. If the authorization letter is issued after the construction specifications, but before receipt of bids or quotes, the entire permit authorization shall be included as an addendum to the specifications. If the authorization letter is issued after receipt of bids or quotes, the entire permit authorization shall be included in the contract or subcontract. Although the permittee may assign various aspects of the work to different contractors or subcontractors, all contractors and subcontractors shall be obligated by contract to comply with all environmental protection provisions contained within the entire GP authorization, and no contract or subcontract shall require or allow unauthorized work in areas of Corps jurisdiction.

34. Inspections. The permittee shall allow the Corps to make periodic inspections at any time deemed necessary in order to ensure that the work is eligible for authorization under these GPs, is being, or has been performed in accordance with the terms and conditions of these GPs.

Lobster Use of Eelgrass Habitat in the Piscataqua River on the New Hampshire/Maine Border, USA

Article *in* Estuaries and Coasts · April 2001

DOI: 10.2307/1352951

6 authors, including:

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University of New Hampshire

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Estuaries Vol. 24, No. 2, p. 249–256 April 2001

Lobster Use of Eelgrass Habitat in the Piscataqua River on the New Hampshire/Maine Border, USA

F. T. SHORT[1,*], K. MATSO[1], H. M. HOVEN[2], J. WHITTEN[1], D. M. BURDICK[1], and C. A. SHORT[1]

[1] *Department of Natural Resources, Jackson Estuarine Laboratory, University of New Hampshire, 85 Adams Point Road, Durham, New Hampshire 03824*

[2] *SWCA, Inc. Environmental Consultants, 230 South 500 East, Suite 230, Salt Lake City, Utah 84102*

ABSTRACT: The relationship between lobsters and eelgrass beds was investigated in the Piscataqua River, which constitutes the lower portion of the Great Bay Estuary, New Hampshire and Maine. The goals of the study were to assess the numbers, size distribution, and sex distribution of lobsters in eelgrass beds, to determine whether lobsters in the eelgrass beds were transients or residents, and to investigate eelgrass density preferences among adolescent lobsters. Eighty percent of the lobsters collected from eelgrass beds were adolescents, measuring > 40 to 70 mm carapace length (CL). Of the 295 lobsters collected at four different eelgrass beds, we found an average male-to-female ratio of 1.2. Tag/recapture efforts in eelgrass beds (1.5 to 4 mo interim period) yielded an average recapture of 5.5%. Twenty transects, each 10 m in length, sampled at two eelgrass sites revealed a lobster density of 0.1 m^{-2}. In mesocosm experiments, lobsters (53–73 mm CL) showed a clear preference for eelgrass over bare mud. Our investigations showed that adolescent lobsters burrow in eelgrass beds, utilize eelgrass as an overwintering habitat, and prefer eelgrass to bare mud.

Introduction

The underwater habitat created by the seagrass *Zostera marina* L. (eelgrass) has been identified as critical for the reproduction and development of commercially, recreationally, and ecologically important shellfish and finfish species (see reviews by Thayer et al. 1984; Heck et al. 1989). The importance of other seagrass habitats to epibenthic shellfish has been documented in Florida Bay, with observations of commercially important pink and brown shrimp populations congregating within seagrass beds (Stoner 1980; Lewis and Stoner 1983). Working in Australia, O'Brien (1994) and Loneragan et al. (1994) demonstrated that seagrass provides critical nursery grounds for tiger prawns (*Penaeus esculentus*). Specifically regarding eelgrass, researchers working in the Chesapeake Bay have shown that the commercially important blue crab (*Callinectes sapidus*) is more abundant in eelgrass habitats than in adjacent unvegetated areas and that eelgrass is an important settlement habitat for post-larval blue crabs (Penry 1982; Montane et al. 1995).

The commercially important American lobster (*Homarus americanus* Milne Edwards) is known to be dependent on shelter for its survival during its early benthic life (Wahle and Steneck 1991). Wahle and Steneck (1991) designated the term early benthic phase (EBP) to describe the developmental stage of lobsters 25–40 mm CL. During this period, lobsters are known to inhabit areas that provide shelter, such as cobble (Wahle and Steneck 1991, 1992; Wahle 1993) or salt-marsh peat reefs (Able et al. 1988). As a lobster matures, however, it exhibits an ontogenetic shift from a post-settlement, shelter-based state to a more mobile existence. According to Wahle and Steneck (1991), the adolescent stage includes lobsters that are greater than 40 mm CL but not yet reproductive.

The onset of the reproductive phase in lobsters differs between males and females and also varies according to water temperature (Aiken and Waddy 1980). Female lobsters south of Cape Cod become reproductive at approximately 65 mm CL, whereas females in the Bay of Fundy become reproductive at 110 mm CL (Wahle and Steneck 1991). For the purposes of this paper, we will use the term adolescent to refer to lobsters > 40 to 70 mm CL. We assume that most lobsters in the Piscataqua River larger than 70 mm CL are either reproductive or nearly reproductive and therefore behaviorally distinguishable from smaller lobsters.

Studying substratum constraints on lobster recruitment, Wahle and Steneck (1991) censused adolescent lobsters in Pemaquid, Maine, and found 0.2 lobsters m^{-2} in eelgrass and 3.8 m^{-2} in cobble. Also in mid-coast Maine, it was shown that cobble habitat was used by adolescent lobsters at densities of 0.3–0.4 m^{-2} as well as EBP lobsters (Wahle and

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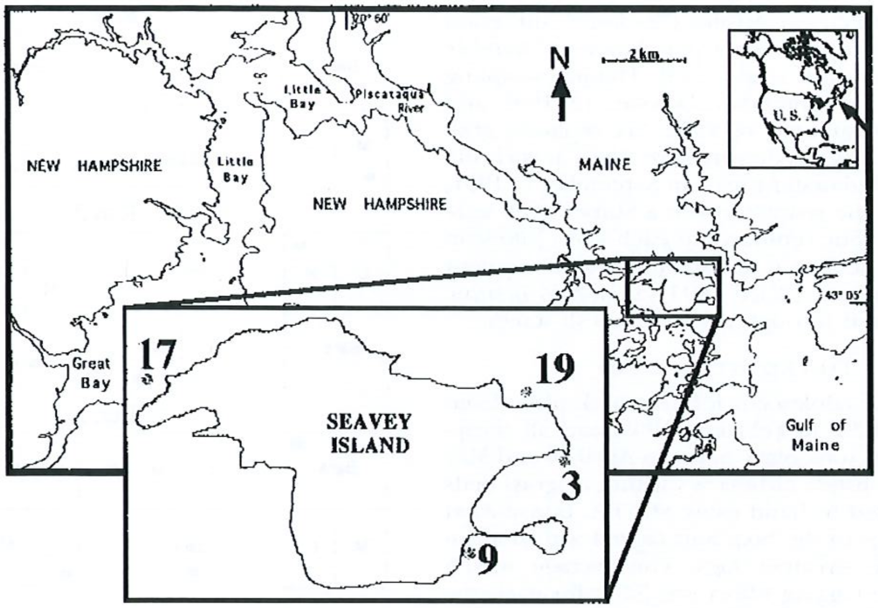


Fig. 1. Location of the lobster collection sites in eelgrass beds around Seavey Island (zoom) in Portsmouth Harbor, lower Piscataqua River, New Hampshire/Maine.

Incze 1997). Karnofsky et al. (1989) found transient and resident lobsters (mostly adolescent) in eelgrass beds in a shallow cove near Woods Hole, Massachusetts, with half the lobsters measuring 50–59 mm CL and the largest lobster measuring 92 mm CL; lobsters smaller than 50 mm CL were not recorded. In the Gulf of St. Lawrence, Hudon and Lamarche (1989) found fewer lobsters in eelgrass beds than in rocky areas, but the eelgrass beds contained more lobsters than adjacent areas of bare sediment. The lobsters they found in the eelgrass were all between 31.2 and 92.3 mm CL, predominantly adolescents.

Barshaw and Bryant-Rich (1988) found that EBP lobsters in eelgrass had a lower mortality rate than those in rock and mud when studied for an 8-mo period in 0.03 m^2 (surface area) aquaria. The authors attributed the lower mortality rate to the higher food resources and increased physical structure associated with eelgrass beds. They reported that lobsters in eelgrass spent much less time maintaining their burrows than lobsters in bare mud. Barshaw and Lavalli (1988), working with 0.33 m^2 (surface area) seawater tables, noted that when preying upon EBP lobsters, cunner (*Tautogolabrus adspersus*) were able to collapse lobster burrows made in bare mud by fanning their tails over the substrate, but in eelgrass this tactic was less successful.

While sampling eelgrass biomass around Seavey Island (Fig. 1) as part of the Portsmouth Naval Shipyard Ecological Risk Assessment (Short 1994), we were surprised to find many lobsters, mostly adolescent, in the eelgrass root-rhizome mass brought up by our modified oyster tong samplers. The present study investigates the population structure of lobsters in these eelgrass beds. We also sought to determine if lobsters were remaining in eelgrass beds for more than 1 mo in winter. Finally, using mesocosm experiments, we examined whether lobsters preferred eelgrass to bare fine-grained substratum and whether lobsters differentiated between low and moderate density eelgrass.

Study Location

Four sites located around Seavey Island (43°05′N, 70°44′W) in Portsmouth Harbor were examined for this study; stations 3, 9, 17, and 19. Portsmouth Harbor is located at the mouth of the Piscataqua River, which forms the border between New Hampshire and Maine along the lower portion of the Great Bay Estuary (Fig. 1). The main navigation channel passes south of Seavey Island. The Piscataqua drains the Salmon Falls and Cocheco Rivers as well as Little Bay, a fairly narrow L-shaped bay connecting to Great Bay. Lobsters have been documented moving in a seasonal migratory pattern into and out of this well-mixed macrotidal estuary (Watson and Howell 1991).

Materials and Methods

As part of the Ecological Risk Assessment, we studied habitat parameters including eelgrass density, sediment characteristics (% clay, % silt, grain size, and % organic), and populations of benthic infauna (Johnston et al. 1994). Habitat sampling took place in September/October of 1991 and again in the summer of 1992. Six replicate grab samples for eelgrass density were made at each site using modified oyster tongs. In September of 1991, we sampled the sediment with a Shipek grab sampler, taking four replicates at each site (Johnston et al. 1994); sediment texture and organic content were determined (Ward 1994) as well as benthic infauna, sieved through a 0.5-mm mesh screen.

Tag/Recapture Study

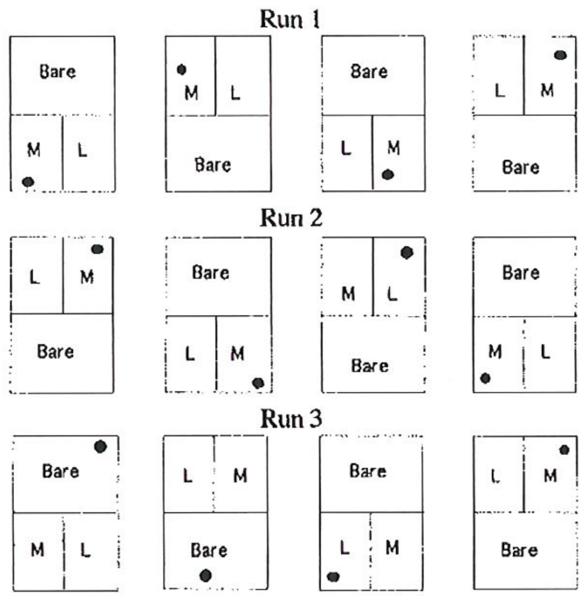
Tagging of adolescent lobsters took place from December 1992 to February 1993, and all recapturing efforts took place between April 16 and May 18, 1993. Lobsters in burrows within eelgrass beds were collected by hand using SCUBA, transported in mesh bags to the boat and tagged with fluorescent orange streamer tags. The average search time for the tagging effort was 5.3 h for each station. Tagging was accomplished by inserting the plastic streamer tag into the lobster flesh between the carapace and the tail so that the lobsters would retain the tags through the molting process (Landsburg 1991). A minimum of 60 lobsters were collected and tagged at each station. Lobsters were returned to the stations where they were initially collected (although not to their specific burrows), and these stations were surveyed again after a range of 1.5 to 4 mo. The recapture period was sufficient to visit each of the sites several times; once a given site yielded no new recaptures, we did not visit the site again. All recaptured lobsters were sexed and measured for carapace length. The search time for the recapture effort was 1.8, 3.3, 1.8, and 1.6 h for stations 3, 9, 17, and 19, respectively. Lobsters were considered to be residents if they were recaptured at the same station after a period of one month or more.

SCUBA Transect Surveys

Transect surveys of lobsters at station 9 on April 19, 1993 and at station 17 on March 29, 1993 were conducted by SCUBA. Transects 10 m long (10 per station) were laid out using line on the bottom within existing eelgrass beds of various plant densities; divers then swam the length of the transect line, recording observations of lobster burrows and lobsters within 1 m on either side of the line. All transects were located in water depths 1–2 m below mean low water.

Habitat Preference Mesocosm Study

Outdoor mesocosm experiments at the Jackson Estuarine Laboratory were conducted during the fall of 1992 to determine if adolescent lobsters preferentially selected eelgrass habitats over unvegetated mud bottom, and if they preferentially selected certain densities of eelgrass. Four mesocosm tanks of 1.5 m^2 surface area each were set up with three different regions: an unvegetated region, a region with low eelgrass density (37 shoots m^{-2}), and a region with moderate eelgrass density (287 shoots m^{-2}). In each mesocosm, the unvegetated zone occupied 50% of the total area; the low and moderately vegetated zones each occupied 25% of the total area. Four replicate tanks were set up with the location of the three habitat types randomly distributed within the replicates (Fig. 2). Each flow-through tank (800-l volume) received 1,000 l



Chi-square Comparison

Lobster Burrow Location (Count)	Chi-square	Confidence Interval ($P < 0.05$)
Vegetated vs. Bare (10 vs. 2)	4.1	($0.05 > P > 0.025$)
Moderate vs. Low (8 vs. 2)	2.5	($0.25 > P > 0.10$)

Fig. 2. Diagrammatic design of three runs of the habitat preference mesocosm study with Chi-square comparison. Moderate (M) indicates an eelgrass density of 287 shoots m^{-2}. Low (L) indicates an eelgrass density of 37 shoots m^{-2}. (Bare) indicates unvegetated mud substrate. Lobsters were introduced into the tanks, and the locations of their burrows (denoted by black dot) were recorded.

of ambient sea water d^{-1}, and all tanks were covered with screening to prevent disturbance by birds and to keep the tanks cool. Sixty percent ambient sunlight reached the water surface.

Lobsters for the mesocosm experiments were collected using SCUBA in Portsmouth Harbor, transported to the Jackson Estuarine Laboratory, and maintained in the flowing seawater system for at least 24 h prior to the experiment. Lobsters ranging in size from 53–73 mm CL were selected at random from the holding facility and one was introduced into each tank. Lobsters were placed into the tanks at night to avoid phototactic bias. After 2 wk, we recorded the area in which the burrow was located. The lobsters were then removed from the tanks and returned to the holding facility. The burrows were filled, the bottom surface restored to its original condition, and the tanks allowed to sit for 5 d to let the system stabilize before repeating the experiment. Two experiments were run with the first set of lobsters, and a third experiment was run with a second set of lobsters for a total of three experimental runs.

Chi-square tests were performed for the habitat preference mesocosm experiments and significance levels were set at 0.05. Vegetated habitat (low density and moderate density combined) was compared with bare substrate, and low density eelgrass was compared with moderate density eelgrass. Thus, the expected ratio for any comparison was 1:1, testing the null hypothesis that lobsters had equal preference for constructing burrows in either habitat treatment. Since $v = 1$ in these tests, we used the Yates Correction for Continuity.

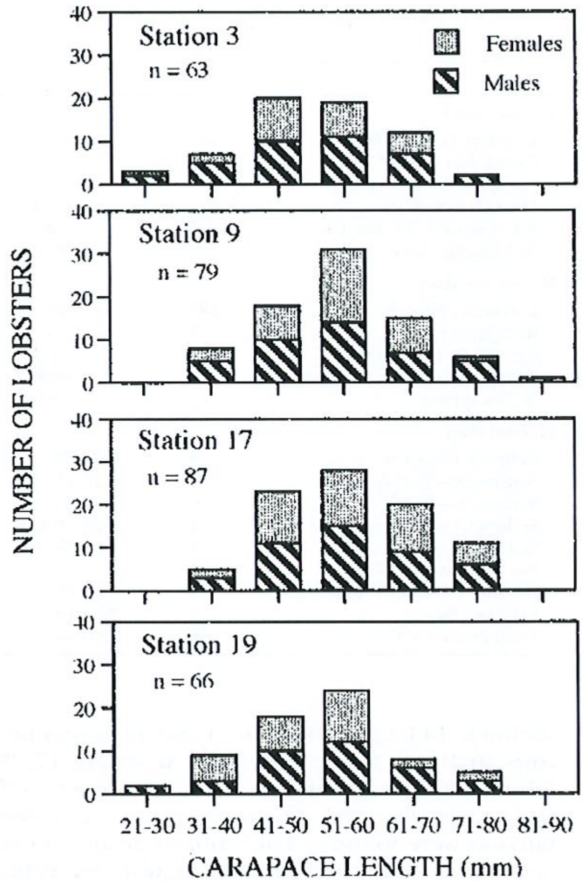


Fig. 3. Lobster size and sex distributions at the four stations around Seavey Island, Portsmouth Harbor. Lobsters were collected between December 1992 and March 1993.

Results

Population Assessment

Of the lobsters inhabiting the eelgrass beds around Seavey Island in Portsmouth Harbor, 11.5% were EBP (between 25 and 40 mm CL), 80% were adolescents (> 40 to 70 mm CL), and 8.5% were adults (> 70 mm CL). Size distributions for all stations were similar (Fig. 3). Station 17 had the highest collection rate, and stations 9 and 17, both close to the main channel, had more adult lobsters than stations 3 and 19 (Fig. 3). The mean CL at each of the four stations ranged from 51 to 56 mm. The average male-to-female ratio of all four stations was 1.2 (Table 1). Of the 25 lobsters over 70 mm CL, only 8 were female (male-to-female ratio = 2.1). Stations 9, 17, and 19 had 26%, 18%, and 15% injured lobsters (missing a claw), respectively, while at station 3, 49% were injured (Table 1).

Tag/Recapture Study

We measured and sexed 295 lobsters during the tag phase of the study. During the recapture phase, we counted 380 lobsters and measured and sexed 9 lobsters at each station. Recapture of the tagged lobsters between April 16 and May 18, 1993, showed resident populations at 3 out of the 4 stations. The average time between tagging and recapture was 95 d (Table 2). Of the 295 lobsters tagged, 15 lobsters were recaptured, with an average size of 57.3 mm CL (Table 1). Recapture was over 9% at stations 3 and 19, 3.4% at station 17, and no lobsters were recaptured at station 9 for an average recapture of 5.5% (Table 1). Of the 15 recaptured lobsters (Fig. 4), 10 were male and 5 were female (Table 2). All the lobsters that were recaptured were found in the beds where they were originally marked; no cross-bed movement of adolescent lobsters was seen.

SCUBA Transect Surveys

Ten transects (10 × 2 m, for a total area of 200 m^2) were searched at both stations 9 and 17. At

TABLE 1. Lobster capture/recapture and habitat data for stations sampled in Portsmouth Harbor. Means (SE) included where relevant.

	n	Station 3	Station 9	Station 17	Station 19	Study Average
Lobster data						
Lobsters tagged (#)	295	63	79	87	66	—
Collection rate (# h^{-1})	—	11.5	14.4	15.5	14.3	13.9
Carapace length (mm)	—	51 (1)	55 (1)	56 (1)	51 (1)	53
Male-to-female ratio	—	1.4	1.1	1.0	1.2	1.2
# Lobsters > 70 mm CL	25	2	7	11	5	—
% Missing claws	—	49.2	25.7	17.7	14.9	—
Recapture data						
Lobsters collected (#)	380	183	81	39	77	—
Recaptures	15	6	0	3	6	—
Recapture rate (# h^{-1})	—	3.3	0	1.6	3.8	2.2
Recapture CL, mean (mm)	—	62.0	—	53.8	54.3	57.3
% Recapture	—	9.5	0	3.4	9.1	5.5
Habitat data						
Eelgrass (shoot m^{-2})	6	401 (27)	237 (41)	341 (70)	285 (36)	316
Sediment—% clay	4	17 (1)	16 (2)	20 (2)	20 (2)	18.3
Sediment—% silt	4	35 (3)	18 (2)	30 (1)	39 (3)	31
Sediment grain size (phi)	4	5.23 (0.13)	4.28 (0.24)	5.23 (0.19)	5.58 (0.25)	5.08
Sediment—% organic	4	4.9 (0.3)	4.2 (0.4)	4.3 (0.2)	5.9 (0.7)	4.8
Benthic infauna (# spp.)	4	58	73	69	62	66
Benthic infauna (# $grab^{-1}$)	4	17,438	15,075	71,181	67,181	42,719
Salinity (‰)	2	26.4 (0.2)	28.1 0.3	28.1 (0.3)	26.5 (0.2)	27.3
Temperature (°C)	2	2.6 (0.2)	0.95 0.0	1.2 (0.1)	1.8 (0.1)	1.6

station 9, 14 lobsters (0.07 m^{-2}) and 42 lobster burrows (0.21 m^{-2}) were observed. At station 17, 28 lobsters (0.14 m^{-2}) and 74 lobster burrows (0.37 m^{-2}) were observed. On some transects, lobster burrows were found to have subterranean connections, but counts did not distinguish individual burrows from burrows with such connections. In some instances, more than one lobster was observed in a connected burrow.

Habitat Preference Mesocosm Study

In the mesocosm study (Fig. 2), lobsters showed a clear preference for creating burrows in vegetated habitat over unvegetated habitat (10 choices for eelgrass, 2 for bare substrate; $0.05 > p > 0.025$). Lobsters chose moderate-density eelgrass more often than low-density eelgrass, but the difference was not statistically significant (8 choices for moderate, 2 for low; $0.25 > p > 0.10$).

TABLE 2. Profiles of recaptured lobsters. No lobsters were recaptured at station 9.

Date Tagged	Initial CL (mm)	Date Recaptured	Second CL (mm)	Tag to Recapture (d)	Sex
Station 3					
30Dec92	64	18Apr93	64.1	109	M
30Dec92	58	18Apr93	57.1	109	F
5Feb93	59.7	18Apr93	60.3	72	F
19Feb93	58.6	18Apr93	58.8	58	M
30Dec92	61.1	30Apr98	61.3	121	M
30Dec92	70.1	18May93	70.1	139	M
Station 17					
11Feb93	40	21Apr93	38.3	69	M
30Dec92	70.5	21Apr93	70.7	112	M
4Mar93	52.8	21Apr93	52.3	48	M
Station 19					
30Dec92	51.1	16Apr93	51.2	107	M
30Dec92	52.5	16Apr93	52.8	107	F
30Dec92	58.7	5May93	59.2	126	F
30Dec92	50	5May93	50.3	26	M
26Feb93	62.8	5May93	62.6	68	F
26Feb93	50	5May93	49.7	68	M

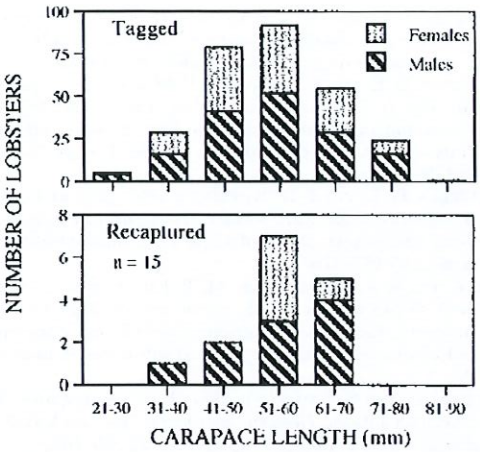


Fig. 4. Size and sex distributions for tagged and recaptured lobsters. Lobsters were tagged between December 5, 1992 and March 4, 1993, and recaptured between April 16 and May 18, 1993. Total SCUBA search time for the recapture effort was 8.5 h.

Discussion

Most of the lobsters inhabiting eelgrass beds around Seavey Island were adolescents. Only 34 of the 295 lobsters collected during the tag phase were less than 40 mm CL, and only 25 lobsters were over 70 mm CL with one lobster, a male found at station 9, greater than 80 mm CL. Our population assessment reinforces the previously observed pattern of primarily adolescent lobsters residing in eelgrass beds (Hudon and Lamarche 1989; Karnofsky et al. 1989). Karnofsky et al. (1989) suggested that the vegetated shallow cove (0.3–1.5 m MLW) studied in Woods Hole served as a lobster refuge, especially for injured males. This was based on a male-to-female ratio of lobsters > 50 mm CL of 1.8 and a high occurrence (26%) of resident males with missing claws. Sampling the eelgrass beds of the Piscataqua River, we also found that 26% of the lobsters we captured were missing claws, with 43% of the injured lobsters female and 57% male. In our sampling, we pulled lobsters from their burrows, which could have caused some of the observed injuries. Injury rates varied widely between sampling locations, ranging from 15% to 49%.

For the lobsters we collected around Seavey Island, the male-to-female ratio was 1.2; this number is consistent whether looking at all the lobsters in our study or just at those lobsters > 50 mm CL. However, when we looked at only those lobsters > 70 mm CL, the male-to-female ratio increased to 2.1. Others (Atema and Cobb 1980; Karnofsky et al. 1989; Estrella and Morrissey 1997) have noted that the onset of sexual maturity occurs in male and female lobsters at different sizes. Aiken and Waddy (1980) stated that females between 58 and 70 mm CL are in a transitional state where reproduction is only sometimes successful. Males, on the other hand, are physiologically mature as small as 45 mm CL. However, since males usually have to be larger than their chosen females for successful mating, they are not functionally mature until much later. Males must also be large enough to defend their mates and their shelters from other males. Females, in comparison, have the advantage of being protected by males when they mate and while they are vulnerable due to molting (Aiken and Waddy 1980). We conclude that the majority of the lobsters we collected were immature females and functionally immature males.

Our stations closer to the main channel of the Piscataqua River (stations 9 and 17) were slightly colder and more saline, had more lobsters > 70 mm CL, had no lobsters < 30 mm CL, and had fewer recaptures overall than the other two stations (Table 1 and Fig. 4). Not one of the 79 lobsters tagged at station 9 was recaptured. At the shallower eelgrass sites more distant from the main channel (stations 3 and 19), the lobsters were smaller and more were recaptured.

None of the recaptured lobsters molted between tagging and recapture; the small size differences are attributed to variation in measurement (Table 2). Aiken (1980) noted that lobsters do not normally molt while overwintering (~ 180 d), and that the molting cycle does not begin until the water temperature reaches approximately 10°C. Studies in Nova Scotia and Prince Edward Island, Canada, found that the molting cycle began in late May or June and ended between September and October (Landsburg 1991; Maynard 1991; Tremblay and Eagles 1997). Based on the time of year and the water temperature during our recapture effort (April 16 to May 18; 6.4°C to 11.0°C), it seems that our sampling took place just prior to the molting season.

The recapture of 15 of the 295 tagged lobsters demonstrates that lobsters do overwinter in eelgrass beds. Most recaptured lobsters were adolescents; all but 3 measured in the 40 to 70 mm CL range, with 2 of those 3 less than 71 mm CL (Table 2). The transect surveys indicated that lobster density was 0.1 m^{-2} in the eelgrass beds. Also, approximately one third of the identified burrows in eelgrass beds were occupied, with lobster-to-burrow ratios of 38% and 33% for stations 17 and 9, respectively. The pattern noted in this limited sampling is that lobster and burrow densities were proportional in eelgrass beds.

Our mesocosm experiments agree with results from previous studies comparing eelgrass to other substrata as lobster habitat. Working in the field, Hudon and Lamarche (1989) found more lobsters in eelgrass beds than in nearby unvegetated mud. In aquaria, Barshaw and Bryant-Rich (1988) found that eelgrass offered EBP lobsters increased physical structure and food resources compared to unvegetated mud. In our mesocosm study, with no difference in food resources between eelgrass of two densities and unvegetated mud, adolescent lobsters still preferred eelgrass, indicating a response to structure. Also, lobsters in the mesocosm experiments exhibited a strong, though not statistically significant, preference for burrowing in moderate-density eelgrass (8 burrows) over low-density eelgrass (2 burrows).

The experimental mesocosm results, coupled with our findings that the lobsters with an average CL of 53 mm resided in eelgrass beds at a density of 0.1 m^{-2}, indicate that the eelgrass habitat surrounding Seavey Island in the Piscataqua River serves as a significant refuge for adolescent lobsters. Based on our studies to date, it is impossible to assess the overall importance of eelgrass beds to adolescent lobster populations in the region. We do know that eelgrass in the U.S. Gulf of Maine covers an area of 20,000 hectares (Barker, Costello, Short unpublished data), providing a substantial potential habitat resource. Studies of the habitat requirements of early benthic phase and adolescent lobsters have demonstrated the importance of cobble (Wahle and Steneck 1991; Wahle 1993; Wahle and Incze 1997). For the adolescent lobsters we studied, habitat preferences are not fully known but do include eelgrass.

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Disturbance of intertidal soft sediment assemblages caused by swinging boat moorings

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PRIMARY RESEARCH PAPER

Disturbance of intertidal soft sediment assemblages caused by swinging boat moorings

R. J. H. Herbert · T. P. Crowe · S. Bray · M. Sheader

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Abstract The impact of swinging boat moorings on intertidal benthic assemblages was investigated in a small estuary on the south coast of England. Mooring buoys fixed near low water mark on a muddy shore were attached to 5 m of galvanised steel chain and had not been let for 12 months. Core samples for macro-invertebrates and sediments were taken both within and outside the chain radius of each buoy. The assemblage structure, biomass and abundance of selected bird prey species were examined at a range of scales. The study revealed variation in the impact of mooring buoys relative to control areas at two different times of sampling. Prior to the removal of buoys, the assemblage structure within areas affected by the buoys was found to be significantly different from unaffected areas. The abundance of the amphipod *Corophium volutator*, an important bird prey species, was significantly less in the areas affected by the buoys. In the second sampling programme (15 months after removal of buoys), the impact of extant buoys remaining in commission was not detectable. Assemblage structure in areas from which buoys had been removed was distinct from control areas which had never had buoys. The removal of mooring buoys clearly affected the assemblage, yet convergence with control areas, indicative of recovery, was not complete after 15 months. It is suggested that the effect of swinging mooring chains scraping over the mud surface may modify sediments favouring the greater prominence of larger particles such as gravel and shell fragments. The ecological impact of swinging moorings on estuarine benthic assemblages in designated protected areas is discussed in the context of other spatial and temporal disturbances.

Keywords Disturbance · Estuaries · Boating · Intertidal macrofauna · Recreation · Coastal management

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Introduction

Recreational boating is increasing worldwide (Cicin-Sain et al., 1998; Widmer & Underwood, 2004). The disturbance it may cause to aquatic habitats is perceived to be of conservation concern (Davenport & Davenport, 2006). Research has focussed on issues concerned with marina developments (Turner et al., 1997), water quality (Langston et al., 1994; Matthiessen et al., 1999), disturbance to benthic habitats and sea grass meadows by permanent subtidal moorings and anchoring (Walker et al., 1989; Creed & Amado, 1999; Francour et al., 1999; Backhurst & Cole, 2000; Milazzo et al., 2004), propellers (Uhrin & Holmquist, 2003) and disturbances caused by boat movements (Eriksson et al., 2004). In Europe, much boating activity falls within marine protected areas, yet there have been few ecological studies that have investigated this impact, especially upon intertidal estuarine habitats. Understanding the responses of marine ecosystems to disturbance is a key to predicting their spatial and temporal dynamics (Pickett & White, 1985). The extent of disturbance is known to influence the diversity and composition of benthic assemblages (Connell, 1978; Probert, 1984; Hall et al., 1994; Hall 1994).

The Solent, on the south coast of England, is one of the most popular sailing areas in the world and has seen a growth in moorings of 27% in the past 30 years to currently stand at approximately 24,000 (Solent Forum, 2008). While many vessels are harboured in marinas or deep-water moorings, a large number of boats on swinging moorings 'dry-out' at low tide in estuaries. Boats aground on intertidal mud and sand flats occupy potential bird feeding areas, and in some harbours and estuaries this collective footprint may be large. Moreover, moored boats and associated chains may cause scour and mechanical damage to the mud surfaces as they swing around their anchor point, and potentially impact upon the size and composition of invertebrate populations and assemblages that form important bird prey resources.

Although boats could be attached to moorings for considerable time, most swinging moorings will be subject to periods when boats have left the mooring and are out sailing. In the UK, many leisure craft are lifted out for 4–6 months during the winter, and numerous un-let or visitor moorings can normally be found in harbours and estuaries. Additionally, moored navigation marks may cause similar disturbances. The unseen, yet permanent, impact of the mooring is not the boat attached, which may be away for long periods, but the ground tackle and chain that moves over the sea bed in response to changes in wind and tide.

The aims of this investigation were to determine the extent to which swinging moorings impact upon estuarine soft sediment assemblages and to assess recovery following the removal of the moorings. In addressing these aims, we focussed on variation at a range of scales in assemblage structure, total biomass and the abundance of selected species considered important as food for birds.

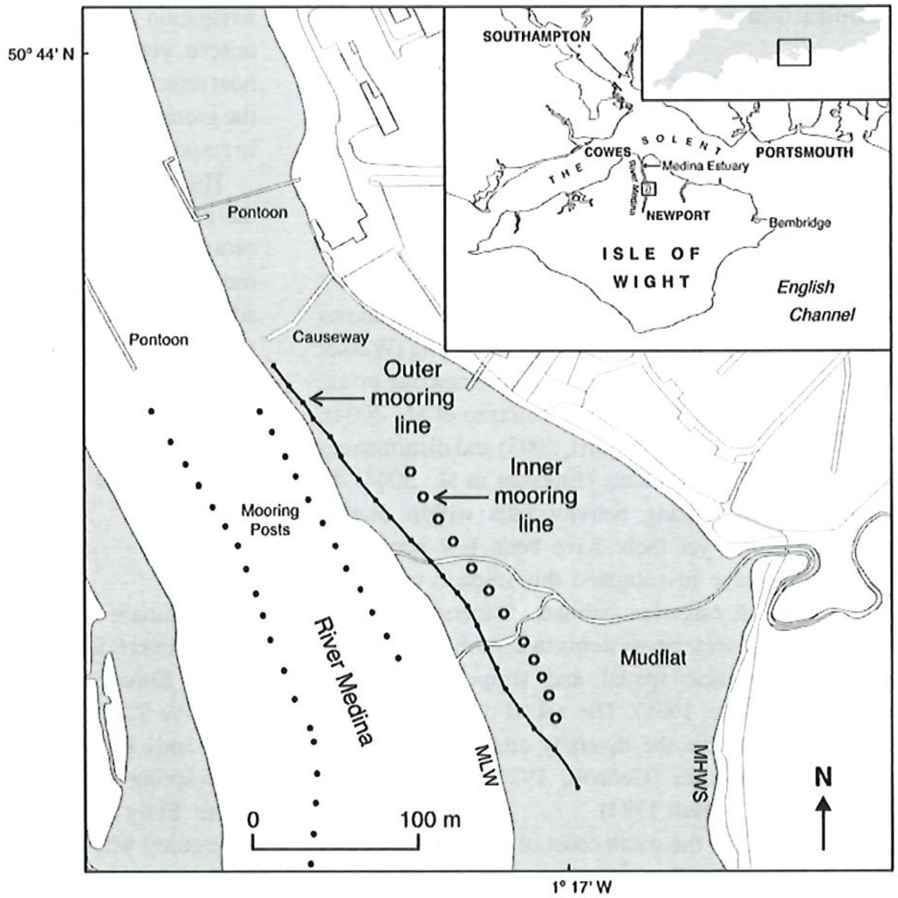
Materials and methods

Study area

The Medina is a narrow, linear estuary 7.5 km in length with an intertidal area of 66 ha. It is a component of the Solent European Marine Site (European Habitats Directive 92/43/EEC and EU Birds Directive 79/409/EEC) and a Ramsar Site. Tides are semi-diurnal and the mean spring tide range is 3.6 m. The study area known as the 'Folly' (Fig. 1) is approximately halfway along the estuary where it is at its widest (0.5 km). Peak ebb currents here are 0.4 m s^{-1}. Surface salinity is 31–34 and there is seasonal dilution to 26 (Withers, 1979). Salinity at the water–sediment interface at High Water is 33–34. The surface water temperature range is between 6 and 20°C.

At the mouth of the Medina is the internationally famous yachting town of Cowes where there are large marinas and deep-water swinging moorings. Pile moorings, whereby boats are tied between posts, and pontoons for local and visiting craft occupy each side of the narrow channel along the lower 4 km of the estuary. In July 2004, 44 boats of between 5.5 and 8.0 m occupied swinging moorings between mean tide level (MTL) and low water spring tide level (LWS). Collectively, these craft, with an average of 6 m of chain attached, are estimated to scour 3% of the mudflat area as they swing with tide and wind. The duration of scour is dependent on mooring height above low tide and the length of chain. It is estimated that over a 12-h tidal cycle during a spring tide, these chains could scrape the mud surface for 7 h. At high tide, relatively little chain would be on the bottom,

Fig. 1 Location of study area on the Medina Estuary, Isle of Wight. Samples were taken from two buoys along the 'inner mooring line'



whereas just prior to the buoy grounding as the tide recedes, most chain could be scraping over the mud.

Other potential disturbances from bait digging and clam collecting were not observed to occur in the immediate vicinity of the study area, although do occur on the estuary.

Fieldwork and sample processing

Two buoys were selected from an 'inner mooring line' of 12 small-craft (<6 m length) moorings that dried out between MTL and mean low water neap tide level in the Medina Estuary (Fig. 1). The buoys, 70 m apart, were attached to 2 m of rope (15 mm) and approximately 5 m of galvanised 8 mm steel chain that was attached to concrete blocks buried in the mud. The moorings had not been let during the year immediately prior to the fieldwork but had continued to swing around their anchor point with changes in tide and wind direction.

In September 2000, two separate random patches of five core samples were taken within the chain radius of each buoy and also within a control area 3–4 m beyond the chain radius of each buoy. Patch diameter was 1.5 m; core diameter was 10 cm and sampling depth 15 cm. The distance between patches was at least 3 m. This hierarchical sampling design was chosen so that any difference found between areas with and without buoys could be more confidently attributed to the buoys rather than small-scale variation in assemblage structure (Thrush, 1991; Winer et al., 1991; Underwood, 1997). Samples were processed using a 0.5-mm sieve and the animals preserved in 5% formaldehyde in seawater. Prior to sorting, samples were stained with Rose Bengal and macrofauna were identified to species where possible. Bryozoans were not identified to species level and, being colonial, were not easy to quantify. Where present in a core, usually on the shell of a bivalve, they were given an abundance of 1 for that core. Subsampling was carried out for abundant species such as small oligochaete worms.

Following removal of the mooring buoys and ground tackle in July 2001, the sites were revisited in October 2002 utilising the same procedures to determine whether changes consistent with 'recovery' (convergence of the benthic assemblages) had taken place. In addition, to ensure that any evidence for recovery was due to decommissioning and not a reflection of temporary changes in assemblage structure, samples were also obtained from two moorings that had remained in commission. Finding that decommissioned sites were similar to unimpacted control sites yet different from sites subject to ongoing impact would provide clearer evidence for recovery (Chapman, 1998).

Estimation of sample biomass

A contractual requirement to preserve specimens necessitated a non-destructive estimation of sample biomass utilising mean dry-weight values for taxa held on a database (Medina Valley Field Centre, Isle of Wight). These measurements were obtained from material dried at 80°C for 48 h.

Sediment analysis

A core of 10 cm diameter was used to obtain samples for particle size analysis from each of the two 'Buoy sites' and two 'Control sites'. Samples were sieved wet over a stack of Wentworth sieves. The finer clay fractions (below 0.063 mm diameter) were not quantified. The organic content of the sediments was determined by placing 10 g sub-samples in a muffle furnace at 450°C for 8 h and measuring loss in mass on ignition. This was the most practical method available to help avoid overestimation of organic content due to loss of structural water in clays (Schulte & Hopkins, 1996; Cambardella et al., 2001).

Statistical analysis of biological data

Differences in assemblage structure

Non-metric mulitdimensional scaling (MDS) was used to produce a graphical representation of the data using the software package PRIMER (Clarke and Warwick, 1994). MDS plots were based on Bray–Curtis similarity measures calculated using square-root transformed data. Permutational multivariate analysis of variance (PERMANOVA) was used to test hypotheses of difference in community structure among groups of samples from different patches, sites and treatments (Anderson, 2001, 2005; McArdle and Anderson, 2001). Two analyses were done: one for data collected prior to removal of moorings and the other for data collected after removal. Prior to removal of moorings, the factors were: Treatment (fixed, 2 levels: buoy versus control); Site (random, 2 levels, nested in Treatment) and Patch (random, 2 levels, nested in the Treatment × Site interaction). After removal of moorings, the factors were the same, but there was an additional level for the factor Treatment (see above).

The PRIMER routine similarity of percentages (SIMPER) was used to identify which species were important in discriminating among samples from the different treatments.

Differences in abundance of individual taxa and total biomass

Variation in sample biomass and abundance of the more common invertebrate species (*Tubificoides* spp. *Cirriformia* and *Corophium*) known to be important prey items for birds (Prater, 1981) was tested separately using hierarchical ANOVA. A separate analysis was done for each variable. Two sets of analyses were done: one for data collected prior to removal of moorings and the other for data collected after removal. The factors involved were the same as those described above for multivariate analyses. There were five replicates. Heterogeneity of variance was tested using Cochran's test and where necessary, data were transformed.

Results

Prior to removal of moorings

A visual assessment of the mudflats in the vicinity of the moorings showed no obvious evidence of disturbance of the mud surface within the chain radius of each buoy. All samples contained coarser sediments, including small gravel, within a matrix of fine silt and clay. Below the top 10 mm sediments were anoxic.

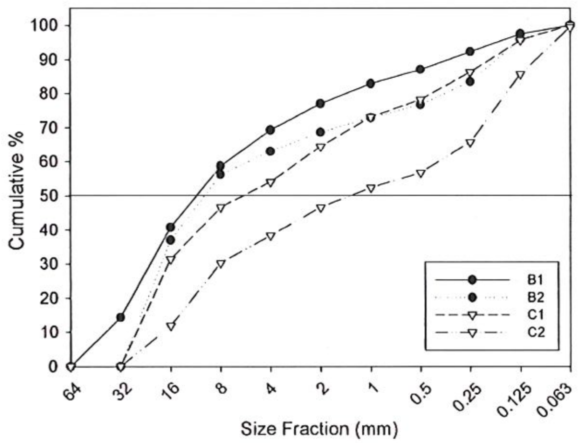


Fig. 2 Cumulative percentage weight of each sediment size class for samples from within the chain radius of buoys 1 & 2 and the two control sites. Samples sieved over a Wentworth sieve stack; largest diameter (64 mm). The median sediment size class (D^{50}) is indicated by *horizontal line*. See text for further details

Particles included shells of cockles and other molluscs. The median sediment size class (D^{50}) and interquartile range (IQR) were determined for each sample (Fig. 2). These were larger from samples affected by the buoys (D^{50} 11.2 and 10.1 mm; IQR 21.7 and 19.3 mm) than the unaffected control areas (D^{50} 5.84 and 1.34 mm; IQR 17.64 and 9.76 mm). The mean organic content of samples obtained from buoys was 2.85% (SE ± 0.05) and 2.65% (SE ± 0.35) from control areas.

The fauna was typical of that found previously at lower tidal levels within this part of the Medina Estuary (Withers, 1979). A total of 21 taxa were identified in the samples; 19 species occurred in the areas scraped by buoy chains and 15 occurred in the control areas (Table 1a). Epifaunal species attached to stones and shells including the barnacle *Elminius modestus* and chiton *Lepidochitona cinereus* were found only in the areas affected by the buoys.

Prior to removal of buoys, samples from different patches within a site and different sites within a treatment (i.e. buoy versus control) were intermingled, indicating no strong spatial patterns of community structure at either of those scales (Fig. 3, Table 3a). There was, however, a significant separation ($P < 0.024$) between samples from areas with buoy chains and samples from control areas (Fig. 3, Table 2a). It should be noted, however, that the stress value associated with this 2D representation is >0.2. Care should therefore be taken interpreting the figure (Clarke, 1993).

SIMPER analysis revealed 90% of variation among groups of samples collected near buoys and from control areas were caused by differences in abundance of *Tubificoides* sp., *Tubificoides benedii*, *Cirriformia tentaculata*, *Elminius modestus*, *Neanthes virens*, *Macoma balthica* and *Cerastoderma edule* which occurred in greater abundance among buoys than in control areas and by *Corophium volutator* and *Anaitides mucosa* which occurred in greater abundance in control areas than among buoys.

There were no significant differences between patches, sites or treatments for total biomass or densities of *Cirriformia tentaculata* or *Tubificoides* spp. (Fig. 4a, b, d; Table 3a, b, d). However, *Corophium volutator* was significantly more abundant at control sites than at sites with buoys (Fig. 4c, Table 3c; Student–Newman–Kuels (SNK) procedure, $P < 0.05$). The mean density of *Corophium* was reduced by 40% from 4,624 m^{-2} in control sites to 2,752 m^{-2} in sites with buoys.

After removal of moorings

In October 2002, 15 months after removal of selected moorings, 15 species occurred in the control sites, 19 in sites from which buoys had been removed (decommissioned) and 18 species occurred in areas that were still being scraped by buoy chains (Table 1b). Generally, percentage occurrences and average densities of most species were comparable at sites in the three treatments. There were however differences in the densities of single species. The burrowing anemone *Cereus pedunculatus* was found only in decommissioned sites where it attained a mean density of 35 m^{-2} (Table 1b). Although cockles, *Cerastoderma edule*, were on average two to three times more abundant at decommissioned sites compared to controls or extant moorings (Table 1b), significant variation was at the scales of Patches and Sites, rather than among treatments (Treatment: $F_{2,3} = 1.33$, $P > 0.38$). Of the common species considered important as food for birds, there were no differences among treatments in the abundances of *Tubificoides* spp. (Treatment: $F_{2,3} = 2.05$, $P > 0.47$) or *Cirriformia tentaculata* (Treatment: $F_{2,3} = 0.14$, $P > 0.87$). The burrowing amphipod *Corophium*

Table 1 Summary of mean densities of species present and the percentage of samples in which they occurred (a) prior to removal of mooring buoys and (b) after removal of mooring buoys

Taxon	Buoys present			Control areas		
	Occurrence (% samples)	Mean density (m^{-2})	95% CI	Occurrence (% samples)	Mean density (m^{-2})	95% CI
(a)						
Sagartia troglodytes	20	25.48	22.91	15	31.85	35.66
Nemertea						
(*Lineus* sp.)	10	12.74	17.18	5	12.74	24.97
Anaitides mucosa	0	0	0	30	261.15	288.39
Ampherete sp.	5	6.37	12.48	10	12.74	17.18
Cirriformia tentaculata	100	3974.57	1260.40	100	2770.73	1065.32
Nereis (Neanthes) virens	85	248.41	77.86	90	229.30	58.97
Nephtys hombergii	10	12.74	17.18	5	6.37	12.48
Tubificoides benedii	100	5687.96	1233.79	95	3681.57	1252.21
Tubificoides sp.	100	8019.20	4062.49	100	7445.95	3798.74
Carcinus maenas	5	6.37	12.48	5	6.37	12.48
Corophium volutator	100	2751.62	660.95	100	4624.26	675.36
Cyathura carinata	5	6.37	12.48	0	0	0
Elminius modestus	25	783.45	1444.28	0	0	0
Gammarus sp.	5	6.37	12.48	0	0	0
Melita palmata	5	6.37	12.48	0	0	0
Cerastoderma edule	40	63.70	38.43	25	31.85	24.80
Hydrobia ulvae	0	0	0	10	38.22	54.64
Lepidochitona cinereus	15	19.11	20.45	0	0	0
Littorina littorea	5	6.37	12.48	0	0	0
Macoma balthica	55	76.43	33.40	20	25.48	22.91
Bryozoa indet.	10	12.74	17.18	0	0	0

Table 1 continued

Taxon	Buoys present			Control areas			Buoys removed		
	Occurence (% samples)	Mean density (m^{-2})	95% CI	Occurence (% samples)	Mean density (m^{-2})	95% CI	Occurence (% samples)	Mean density (m^{-2})	95% CI
(b)									
Cereus pedunculatus	0	0	0	0	0	0	10	35.37	47.71
Nematoda	15	70.74	81.09	20	61.89	57.75	50	335.99	221.93
Nemertea	0	0	0	5	17.68	34.66	15	53.05	56.79
Ampharete acutifrons	0	0	0	5	17.68	34.66	40	159.15	93.75
Anaitides mucosa	5	17.68	34.66	0	0	0	10	53.05	75.85
Tubificoides benedi	80	1167.14	605.79	80	592.41	258.92	95	3713.62	1458.86
T. pseudogaster	90	5110.64	2367.12	85	2749.84	1343.86	95	3890.45	3824.07
Cirriformia tentaculata	100	15066.67	3981.67	100	14169.21	3846.86	100	12767.76	2770.05
Caulleriella sp.	100	2581.85	609.95	70	618.94	300.43	100	1768.39	548.61
Nereis (Neanthes) virens	10	35.37	47.71	0	0	0	5	17.68	34.66
Mediomastus fragilis	5	17.68	34.66	0	0	0	5	17.68	34.66
Cossura longocirrata	5	17.68	34.66	5	17.68	34.66	0	0	0
Capitella capitata	5	17.68	34.66	10	22.10	35.28	0	0	0
Streblospio shrubsolli	35	141.47	92.73	65	579.15	251.29	0	0	0
Carcinus maenas	10	35.37	47.71	0	0	0	35	123.79	75.85
Melita palmata	0	0	0	0	0	0	25	212.21	221.51
Ampharete baltica	0	0	0	5	35.37	69.32	0	0	0
Magelona mirabilis	5	17.68	34.66	0	0	0	0	0	0
Melinna palmata	10	35.37	47.71	5	17.68	34.66	0	0	0
Cerastoderma edule	35	371.36	268.36	80	477.46	161.69	90	1131.77	364.74
Macoma balthica	10	35.37	47.71	20	84.00	82.90	5	17.68	34.66
Abra tenuis	10	35.37	47.71	0	0	0	5	17.68	34.66
Lepidochitona cinerea	0	0	0	0	0	0	10	35.37	47.71
Hydrobia ulvae	90	1697.65	536.01	95	2055.75	536.50	95	2723.32	1030.77
Crepidula fornicata	0	0	0	0	0	0	5	17.68	34.66

Data based on a total of 20 samples taken from patches and sites in each treatment. Densities converted to m^2

CI confidence interval

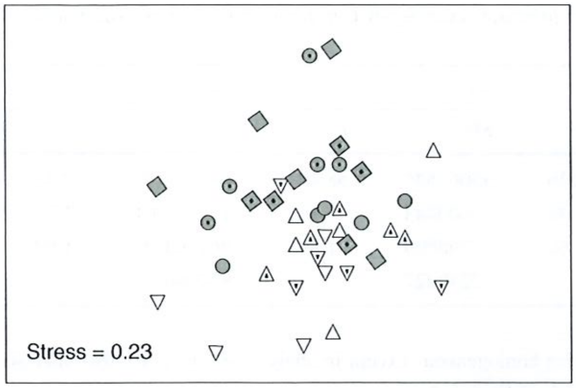


Fig. 3 MDS ordination of assemblages in all samples collected prior to removal of moorings. Each point represents a single sample. White *triangles* and *inverted triangles* represent samples from buoys 1 and 2, respectively. *Grey circles* and *diamonds* represent samples from control sites 1 and 2, respectively. *Symbols* with and without *black centres* distinguish samples from different patches within each site. See text for further details

Table 2 PERMANOVA analyses of differences between patches, sites and treatments: (a) prior to removal of moorings (Treatments = buoys versus controls) and (b) after removal of moorings (Treatments = extant buoys versus controls versus buoy removal areas)

Source of variation	df	MS	Pseudo-*F*	*P*(MC)
(a)				
Treatments = Tr	1	1622.6	4.04	0.024
Sites = Si(Tr)	2	401.7	0.88	0.554
Patches = Pa(Si(Tr))	4	454.2	1.09	0.378
Residual	32	415.2		
Source of variation	df	MS	Pseudo-*F*	*P*
(b)				
Treatments = Tr	2	5194.9	2.47	0.033
Sites = Si(Tr)	3	3172.5	1.03	0.469
Patches = Pa(Si(Tr))	7	7211.7	2.38	0.001
Residual	47	20,333		

Data were square-root transformed. Analyses were done on Bray–Curtis similarity matrices using 999 permutations of residuals under a reduced model. In analysis (a), Monte Carlo tests (MC) were used given the limited number of unique permutations for factor 1

volutator, which was less abundant in areas affected by the original moorings in September 2000, was not recorded at any site during this sampling.

After removal of moorings, there was considerable variation in assemblage structure at the scale of

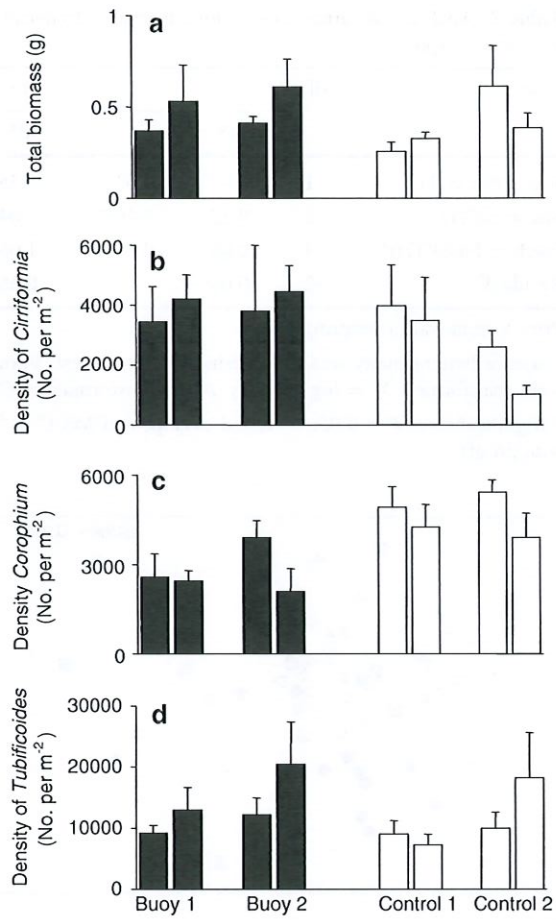


Fig. 4 **a** Mean total biomass of macrofauna per core, **b** density of *Cirriformia tentaculata*, **c** density of *Corophium volutator* and **d** density of *Tubificoides* spp. at the sites sampled prior to the removal of mooring buoys. In each graph, each site is represented by two *bars*. Each *bar* represents a single patch at which five replicate cores were taken. Mean + SE shown. Note different scales on the *y* axes

Patches and among Treatments (Fig. 5, Table 2b), although the stress is again >0.2, so the specific placement of the points should be interpreted with caution (Clarke, 1993). Assemblages in areas from which moorings had been removed were distinct from those in control areas in which buoys had never been present (PERMANOVA post hoc pairwise comparisons). SIMPER analysis indicated that this difference was underpinned by reduced abundances of *Cirriformia tentaculata* in areas from which moorings had been removed and increased abundances of *Tubificoides benedi*, *T. pseudogaster*, *Caulleriella* sp. and *Hydrobia ulvae*. Assemblages in control areas and

Table 3 Analyses of variance of (a) total biomass, (b) density of *Cirriformia*, (c) density of *Corophium volutator* and (d) density of *Tubificoides* spp.

Source	df	(a)		(b)		(c)		(d)	
		MS	*F*	MS	*F*	MS	*F*	MS	*F*
Treatment = Tr	1	0.07	0.62	2.35	2.26	35067544	58.40*	66545812	0.42
Site = Si(Tr)	2	0.12	1.46**	1.04	0.98	600443	0.16	1.57×10^8	1.78***
Patch = Pa(Si(Tr))[a]	4	0.08	0.97	1.06	1.60	3790099	1.69	96140391	1.09
Residual[b]	32	0.08		0.66		2249027		87498057	

Prior to removal of mooring buoys

Variance heterogeneity was tested using Cochran's test. Variances were homogeneous except in analysis (b). Data for that analysis were transformed, $X' = \log(X + 1)$. After transformation, Cochran's $C = 0.25$, n.s.

* Significance at $P < 0.05$; ** tested over pooled MS ($^a + ^b = 0.08$ with 36 df); *** tested over pooled MS ($^a + ^b = 88458316$ with 36 df)

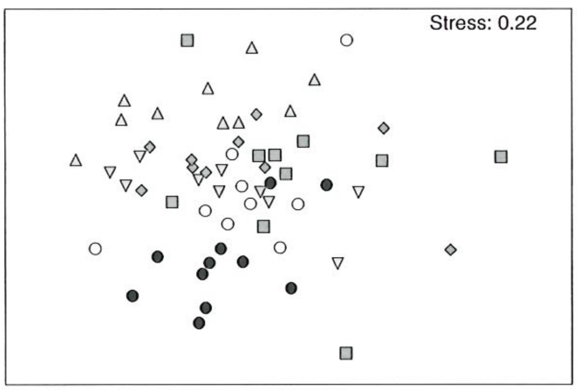


Fig. 5 MDS ordination of assemblages in all samples collected after removal of moorings. Each point represents a single sample. *Pale grey triangles* and *inverted triangles* represent samples from extant buoys (P1 and P2); *dark grey squares* and *diamonds* represent samples from control sites (C1 and C2); *black circles* and *open circles* represent samples from sites from which buoys had been removed (R1 and R2)

areas with buoys still in place were not distinguishable from each other.

Biomass of macrofauna varied significantly from patch to patch and from treatment to treatment (Patch: $F_{6,48} = 5.59$, $P < 0.001$; Treatment: $F_{2,3} = 19.58$, $P < 0.05$). Mean biomass at decommissioned sites was significantly greater than at control sites and sites at which buoys were still present (78.5 g m^{-2} v 13.3 g m^{-2} v 14.6 g m^{-2} respectively; SNK procedure, $P < 0.05$). In control areas, densities of several species, notably *Cerastoderma edule*, *Hydrobia ulvae*, *Cirriformia tentaculata* and *Tubificoides* spp., were considerably different to the initial survey in September 2000 prior to removal of buoys.

Discussion

This study has revealed variation in the impact of mooring buoys relative to control areas at two different times of sampling. In the first sampling programme (prior to removal of buoys), there were clear differences between areas with and without mooring buoys. In the second sampling programme (15 months after removal of buoys), the impact of the buoys was not detectable. After the removal of buoys, the total biomass in areas from which buoys had been removed was far greater than in control areas which had never had mooring buoys and from extant mooring buoys. Assemblage structure in areas from which buoys had been removed also diverged from that in other areas and was statistically distinct from control areas which had never had buoys. The removal of mooring buoys has clearly affected the assemblage. At the time of sampling, however, the assemblage had not converged with control areas, suggesting that if recovery is underway it was not complete after 15 months.

For individual species and assemblage structure, variability was evident at a range of spatial scales, from individual cores separated by tens of centimetre, through patches separated by metres to sites separated by tens of metre. Such variation is common in sedimentary habitats (Morrisey et al., 1992; Hall et al., 1994; Kendall & Widdicombe, 1999). In some cases variation was related to the presence, absence or removal of buoys and in others it was not. Mooring buoys clearly have some impact on the macrofauna of the Medina Estuary, but there are other sources of spatial and temporal variation which sometimes have a greater impact (Summers, 1980; Thistle, 1981; Savidge & Taghon, 1988; Cadée, 1990; Raffaelli et al., 1990). Moreover, deposition and erosion of sediment are likely to vary over at least annual time scales. Although the number of sediment samples was limited, it is suggested that the effect of the swinging mooring chains scraping over the mud surface may modify sediment composition favouring the greater prominence of larger particles such as gravel and shell fragments. These were certainly more evident in the sediment samples obtained from within the chain radius of the buoys.

Some larger polychaete and bivalve species may have been undersampled with a 10-cm diameter corer. Because of this potential size-bias, densities of some species may have been calculated as significantly higher or smaller than those commonly found in UK estuaries. The abundance of many species, e.g. *Tubificoides* spp., *Nereis (Neanthes) virens*, *Cirriformia tentaculata*, which are likely to be important prey items for wading birds (Prater, 1981), tends to be greater amongst the buoys. However, the tube dwelling amphipod *Corophium volutator*, a filter and deposit feeder on the upper 2 cm of mud surface (Meadows & Reid, 1966; Mermillod-Blondin et al., 2005), was significantly less abundant amongst the buoys compared to control areas. It is possible that frequent scraping by chains could damage burrows or modify sediments preventing adequate construction. *Corophium* was not recorded at any sampling site after removal of buoys; vagaries of life cycle are probably responsible for what it is likely to be only a temporary absence of this generally common species, although interactions with other species and/or changes in background sediment composition are also possible (Hughes & Gerdol, 1997; McCurdy et al., 2005). Differences in the abundance of particular species may be due to changes in the chemical and physical properties of the mud, such as the degree of anoxia and drainage, caused by particle size variability. They could also be due to competition between and within species or to differential predatory activity by birds and fish (Cadée, 1990; Raffaelli et al., 1990). For example, populations of some species may be higher due to reduced predation: fish may be deterred by the movement of chains and some birds may avoid the brightly coloured mooring buoys. Within the chain radius of the buoy, there may be temporal variability in the extent of disturbance and rate of recovery due to the interaction of wind direction, tidal movement and use of the mooring. More complex interactions may be occurring whereby localised small-scale disturbances on mudflats, caused by foraging by predators within areas of high prey density, accentuate the degree of patchiness (Hall et al., 1994). However, in the initial analyses, small-scale patchiness is approximately similar in the vicinity of both buoys and controls: there were no significant differences in the abundance of particular species between sites or patches within either of the treatments. Prior to the cessation of use of these moorings, disturbances of the mud surface may have affected benthic assemblages within control areas outside the chain radius of the buoys and it is possible that these areas may still be recovering.

Although convergence between areas from which buoys had been removed and control areas was not apparent 15 months after decommissioning, there was evidence that assemblages are changing in areas from which buoys had been removed. It is not clear whether convergence will occur or within what time frame. In a study of the recovery of soft sediment assemblages, following physical disturbances of different intensity (Dernie et al., 2003), the fauna within experimental plots took between 64 and 208 days to converge to that of surrounding control areas. The Medina appears to be on a slower trajectory. Given the high level of temporal variation in the system, indicated by the changes observed in the control areas over the two year period, it would be necessary to collect data on a number of occasions prior to and after removal of buoys over an extended period to generate clear-cut evidence of recovery (Chapman, 1998).

Many of the invertebrate species found in this study are important prey items for wading birds (Prater, 1981). The amphipod shrimp *Corophium volutator* and oligochaete worms (*Tubificoides* spp.) are especially favoured by smaller waders such as Redshank and Dunlin. Polychaetes, such as *Cirriformia tentaculata*, *Nereis* (*Neanthes*) *virens* and *Nepthys hombergii*, and molluscs, *Cerastoderma edule* and *Macoma balthica*, are also regarded as essential prey items for larger species such as Oystercatchers, Curlew and Godwits (Burton, 1974; Prater, 1981). A 40% reduction in abundance of *Corophium* in the vicinity of moorings reduces the potential food resource for various species within the marine protected area. Personal observations suggest that foraging does occur in close proximity; Turnstone (*Arenaria interpres*) was observed feeding both within and beyond areas affected by mooring buoys. In September, when the samples were obtained, there were intermittent large flocks of wading birds on passage in the vicinity. Prater, (1981) suggests depletion of invertebrate stocks occurring from July onwards; however, it would be surprising if significant reduction in prey density within these areas had occurred so early when bird numbers were still relatively low.

The scope of this study was limited to the immediate vicinity of the buoys. The overall ecological impact of chain-scouring on the quality of designated habitat is difficult to quantify without more detailed sediment maps, and there could be interactions with a variety of other disturbances. Even if the locally exaggerated disturbances caused by chain-scouring result in habitat modification, these habitat types may be commonplace in undisturbed parts of the Medina Estuary and elsewhere in the marine protected area. If this is the context, then the impact of the buoys may be considered to be negligible. However, human-induced disturbances of the kind examined may not be acceptable in terms of maintaining favourable habitat or for the protection of scarce species. For example, while these habitats may encourage some birds, they may not be attractive to Black-tailed godwits (*Limosa limosa*), for which the Solent and Medina Estuary have been specially designated, that require a variety of food items including *Corophium* (West et al., 2007).

Scouring caused by anchor chains is just one of several possible impacts of a swinging mooring. The disturbance impact caused by movement of the hull and keel of tethered boats has not been examined and will vary considerably depending on vessel size, hull shape and keel type. The type of impact will also depend on substrate and tidal regime. With increasing pressure for space within designated conservation areas, the impact of different boat mooring configurations may need to be examined and mitigation approaches considered. On the Medina, six intertidal swinging moorings from the inner mooring line and three from the outer mooring line (Fig. 1) were re-laid below extreme low water spring tide mark to offset reclamation of mudflat and dredging disturbances in the upper estuary. In areas where swinging moorings are scattered throughout the intertidal region, zoning schemes that concentrate moorings within defined areas would create larger areas of undisturbed mudflats. Holding boats in line between fixed buoys or 'trot' type moorings would significantly reduce scour effects where this might be considered a problem.

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A simple mooring modification reduces impacts on seagrass meadows

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Moorings can have a detrimental impact on seagrass, fragmenting the meadows, resulting in the habitat degradation. To reduce contact of the moorings with the seabed we attached small floats along the chain of a traditional swing mooring and monitored the ecological impacts of this modified mooring, with reference to a standard swing mooring, in a seagrass meadow under high tidal influence. After three years, seagrass density surrounding the modified mooring was over twice as high as that of the standard mooring, with blade length surrounding the modified mooring also found to exceed that of the standard mooring. Seagrass-associated epifaunal species richness was twice as high surrounding the modified mooring compared to the standard mooring. Sediment composition was considerably finer at the modified mooring, indicative of increased disturbance surrounding the standard mooring. A simple modification to existing swing moorings can mitigate some of the impacts of moorings on seagrass meadows, whilst accommodating for tidal fluctuations. The scale of the differences observed between the mooring types demonstrates the susceptibility of seagrass meadows to damage from swing moorings. Given the ecological importance of these habitats, it is crucial that action is taken to reduce further degradation, such as that demonstrated here.

Shallow, sheltered coastal bays provide ideal conditions for the growth of temperate seagrass meadows, but are also attractive mooring and anchorage sites for boating communities. Anchoring and mooring causes physical disturbance to the seagrass that has a number of deleterious consequences. However, the ecological importance of seagrass habitat is widely recognized, and seagrasses are protected by law in many countries[1]. Therefore, it is often problematic for environmental managers to balance the needs of the maritime leisure industry and conservation obligations, especially when maritime safety is paramount. The most common solution is to provide fixed moorings that negate the need for anchoring, but moorings also cause lasting damage to seagrass[2].

The most commonly used mooring system is the swing mooring, a system that consists of a sinker block on the seafloor, and a heavy chain reaching a surface buoy, on which the boat is secured. The buoy and chain pivot as the boat moves with the changing tide and wind, dragging the chain across the seafloor, resulting in scouring and the creation of 'mooring scars', circular areas of bare ground surrounding the mooring, which can be seen in satellite imagery. Impacts from mooring infrastructure on seagrass meadows have been widely studied, although few studies are undertaken in areas of increased tidal fluctuation, or focus on the seagrass species *Zostera marina*[2].

Seagrass meadows provide key ecological services, these include sediment stabilization and natural coastal defenses during extreme weather, carbon sequestration, nutrient cycling, the provision of fish nurseries and enhancement to biodiversity[3]. Anthropogenic activities including anchoring, mooring, propeller scaring, vessel grounding and dredging have been found to negatively affect the rhizomes and bury seeds thus inhibiting germination and reduce the provision of these ecological services[3]. Impacts to seagrass can also result from extreme weather, invasive species, overgrazing and algal blooms[3]. Physical impacts to seagrass bed substrates can influence microbial communities within the sediments, often leading to the release of CO_2 from blue carbon sinks in the meadow, acting as a contributor to global warming[4]. In addition to this, sediment disturbance can also result in the loss of seagrass meadow stability, leading to increased fragmentation of the meadow, erosion, and a reduction in sedimentation, often resulting in the decline of seagrass cover and a loss of resilience, leaving the seagrass meadows prone to impacts from other stressors[2,5]. Seagrass loss has also been found to effect associated fauna, with negative impacts observed on species density and richness, alongside changes to species assemblage[6,7].

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Impacts on seagrass ecosystems are also expected to have an effect on local fisheries dependent on the high diversity of commercial species supported by seagrass meadows[5,8]. A study by Jackson *et al.*[9] estimated that seagrass associated species contributed approximately 30–40% to the value of commercial fisheries landings, highlighting the economic value of seagrass meadows.

As an approach to reduce anthropogenic impacts on seagrass, various 'environmentally friendly moorings' or 'eco-moorings' have been designed to reduce the detrimental impacts of mooring chains on seagrass meadows. Eco-moorings are primarily designed to reduce chain abrasion on the seafloor, whilst ensuring a secure mooring for vessels in prevailing conditions. The moorings typically consist of two common features; a rode and buoy system designed to reduce contact and scouring of the seafloor, and an anchorage; both features vary in design across different moorings. The rode is often either rope, chain or an elastic tether, a preferred option in areas of increased tidal range. The anchorage can be a concrete block such as those used in swing moorings, or a substrate embedment anchor, which is often preferable due to its reduced ecological impact[10].

A frequently used eco-mooring system is the Ezyrider design, this consists of a chain rode with an elastic riser system, and a displacement buoy that moves up and down a stainless-steel shaft with movement of the vessel. The system also uses ground weights as anchorage, although can be installed with an alternative 'Offset Anchor System' (a three-pronged structure) for more sensitive habitats such as seagrass meadows[10].

An alternative eco-mooring system is the Seaflex mooring buoy, an elastic mooring system that can be used in conjunction with any anchorage, and if used alongside a seagrass friendly anchor could reduce scouring of the seafloor. An example of a seagrass friendly anchor is the Helix anchor, a corkscrew type substrate embedment anchor which boasts minimal disturbance during deployment and use[11]. To date, few eco-mooring trials have been conducted, with limited peer reviewed literature available on the subject, highlighting the novelty of the designs. Furthermore, few are undertaken in areas with large tidal ranges which pose additional threats to trials, and further stressors to the ecosystems; these include seabed exposure during low tide increasing the likelihood of seagrass entanglement and UV degradation of the meadows[10].

Trials of eco-mooring systems undertaken in the UK are typically of Seaflex moorings, due to Seaflex already being an established UK provider and because of the design's reported ability to endure variable tidal conditions. The trials have provided mixed results; with a Seaflex mooring installed in the waters surrounding Lundy island, showing positive results (although their effectiveness was deemed dependent on wave exposure and water depth)[10], and in Mylor Harbour, Falmouth, UK, showing no improvement in the reduction of mooring scars, which was concluded a result of tidal influence[10]. Collectively, these studies emphasize the need for condition specific eco-moorings specifically designed for use in areas with a high tidal range.

To date most eco-mooring trials have been undertaken in Australia, in *Posidonia australis* meadows. These trials have had an overall higher success rate than those in the UK, which may reflect the reduced tidal ranges in the trial locations. A range of eco-mooring designs were tested and showed positive results against their traditional swing mooring counterparts. Screw moorings in Jervis Bay[12], Ezyrider and Seaflex mooring systems all showed a considerable reduction in seagrass meadow scaring. The only design that showed negative results was a Cyclone seagrass friendly mooring, installed in Jervis Bay; which did little to reduce mooring scars[12].

One downside associated with eco-moorings is the potential difficulty of finding an insurance policy to cover the system; a recent report by Amec Foster Wheeler Environment & Infrastructure UK Limited[13] investigated the feasibility of using eco-moorings as management options for Marine Protected Areas (MPAs) in the UK. The study highlighted the lack of an established insurance market for the moorings. It was suggested that eco-moorings would fall under the definition of a swing mooring, and become insured under an existing policy, however the moorings may be assigned a premium for 'new technology' that insurers could be reluctant to cover or charge higher rates for.

In contrast to previous studies detailed above that assessed whether swing moorings could be replaced with new mooring designs, this study examines the effectiveness of simply modifying existing moorings. The study was designed to compare the impacts of a standard swing mooring and a modified swing mooring ("Stirling Mooring", Community Seagrass Initiative) on seagrass density and blade length, species richness, species density, assemblage composition and sediment composition. The study was conducted in a dense seagrass meadow situated in the Salcombe ria, with seagrass typically growing to approximately 1.5 m in length in deeper parts of the channel, with shorter blades in shallower areas of the ria. We hypothesized that increased seagrass shoot density and blade length will be apparent proximal to the modified mooring, compared with the standard mooring, with recovery in areas absent of mooring chain disturbance over time. Significant differences in species assemblage between the moorings was predicted, with increased species richness and density apparent surrounding the modified mooring. Sediment composition was expected to reflect disturbance surrounding the standard mooring, with coarser particles sizes present. The development of this study, which demonstrates a viable mooring modification and quantifies the associated seagrass ecosystem recovery is fundamental in the evolution of seagrass conservation and management.

Results

Cost comparison for installation and maintenance. The mooring was modified at a total cost of £740 (£120 for modifications, £620 for new mooring tackle), which is considered to be a substantially lower cost than alternative eco-mooring designs on the market (cost model estimates of £1,620–£3,200 for components, and installation costs of £600[13]). There would be no anticipated additional maintenance costs for the modified mooring design than for a standard swing mooring, with annual checks required to monitor chain thickness and corrosion, with only additional buoy attachments to check and maintain. The modified mooring design also met the criteria of the existing insurance policy held by the Salcombe Harbor Authority[13].

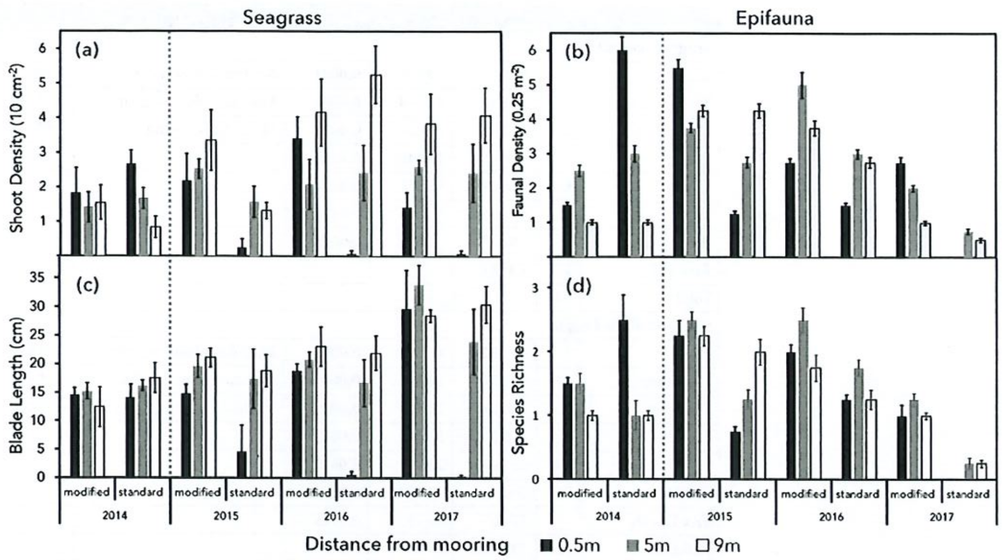

Figure 1. Seagrass (**a**,**c**) and epifauna (**b**,**d**) indicators before (2014) and after (2015–2017) installation of standard and modified moorings in a seagrass meadow, measured at increasing distance from the sinker block: (**a**) seagrass shoot density; (**b**) epifaunal abundance; (**c**) seagrass blade length; (**d**) epifaunal species richness

Seagrass Shoot Density. The average number of shoots in a 10×10 cm quadrat ($0.01\,m^2$) surrounding the standard mooring increased with distance from the sinker block across all years following installation (2015–2017). In the baseline year of 2014, the average number of shoots 0.5 m from the standard mooring sinker block was 2.16 ± 0.39 in $0.01\,m^2$ ($216 \pm 39\,m^{-2}$), with 1.66 ± 0.3 shoots in $0.01\,m^2$ ($166 \pm 30\,m^{-2}$) 5 m from the sinker block. Following the deployment of the standard mooring, the number of shoots at 0.5 m declined to 0.083 ± 0.08 in $0.01\,m^2$ ($8.3 \pm 8\,m^{-2}$) in 2017 and showed a slight increase 5 m from the block to 2.41 ± 0.8 shoots in $0.01\,m^2$ (241 ± 84 shoots m^{-2}) (Fig. 1a).

In comparison, the density of shoots surrounding the modified mooring showed some fluctuation, however, as expected no association with distance can be made. In the baseline year, the average number of shoots 0.5 m from the sinker block was 1.83 ± 0.7 shoots in $0.01\,m^2$ ($183 \pm 72\,m^{-2}$), with 1.41 ± 0.4 shoots in $0.01\,m^2$ ($141 \pm 43\,m^{-2}$) 5 m from the block. After the mooring installment, little change can be observed with 1.42 ± 0.4 ($142 \pm 44\,m^{-2}$) shoots 0.5 m from the mooring, and 2.58 ± 0.2 shoots in $0.01\,m^2$ ($258 \pm 20\,m^{-2}$) 5 m from the mooring in 2017.

At 9 m from the sinker blocks of both moorings, treatments showed a slight incline in seagrass density over time; the standard mooring treatment increased from 0.83 ± 0.3 shoots in $0.01\,m^2$ ($83 \pm 32\,m^{-2}$) in 2014 to an average of 4.08 ± 0.79 shoots in $0.01\,m^2$ ($408 \pm 79\,m^{-2}$) in 2017, with the modified mooring treatment rising from 1.42 ± 0.5 shoots in $0.01\,m^2$ ($142 \pm 50\,m^{-2}$) to 3.83 ± 0.9 shoots in $0.01\,m^2$ ($383 \pm 90\,m^{-2}$).

Differences in seagrass density between treatments ($p = 0.0068$), distances ($p = 0.0001$) and years ($p = 0.0001$) were all statistically significant (Table 1). Pairwise tests conducted on the significant factors revealed a significant difference between the moorings 0.5 m from the sinker block ($p = 0.0004$), with an average shoot density of 0.64 ± 0.3 in $0.01\,m^2$ ($64 \pm 30\,m^{-2}$) 0.5 m from the standard mooring, and 2.21 ± 0.4 shoots in $0.01\,m^2$ ($221 \pm 40\,m^{-2}$) 0.5 m from the modified mooring.

Seagrass Blade Length. At the standard mooring treatment, there was a general increase in blade length with distance from the sinker block; in the baseline year of 2014 (prior to mooring deployment), the mean blade length measured 14.02 ± 2.3 cm at a distance of 0.5 m from the sinker block, and 16.15 ± 0.9 cm at 5 m from the block. Three years after the deployment of the standard mooring, the mean blade length had dropped to 0.25 ± 0.3 cm at 0.5 m from the block and increased to 23.95 ± 5.8 cm at 5 m from the sinker block (Fig. 1c).

The modified mooring treatment blade length remained relatively stable across all distances, whilst showing an increase in blade length over time (2014–2017). In the baseline year of 2014, the mean blade length measured 14.5 ± 1.2 cm at 0.5 m, and 15.18 ± 1.4 cm 5 m from the sinker block. 3 years after deployment, the average blade length of the modified mooring measured 29.72 ± 6.8 cm 0.5 m from the sinker block and 33.9 ± 3.4 cm 5 m from the block (Fig. 1c). Quadrat samples 9 m from the sinker block (away from influence from the chain) remained relatively stable over time, with an increase observed in 2017 in both conditions. Within the standard mooring treatment, 9 m from the sinker block, a mean blade length of 17.51 ± 2.9 cm was observed in 2014, which increased to 30.5 ± 3.2 cm in 2017, and a blade length of 12.41 ± 3.5 cm in 2014 was observed in the modified mooring treatment, which increased to 28.47 ± 1.1 cm in 2017.

Observed differences in blade length between the treatments ($p = 0.0001$), distances ($p = 0.0001$) and over time ($p = 0.0002$) were significant (Table 1). Pairwise tests between the significant factors revealed a significant difference between the moorings 0.5 m from the sinker block, with an average blade length of 4.86 ± 1.9 cm 0.5 m from the standard mooring and 19.46 ± 2.3 cm 0.5 m from the modified mooring.

Source	d.f	MS	F	P	Pairwise Comparison	F	P		
Seagrass Density									
Year (Yr)	3	8.481	5.8947	**0.0001**	Modified Mooring, 0.5 m	4.4474	**0.0004**		
Treatment (Tr)	1	10.845	7.5379	**0.0068**	Modified Mooring, 5 m	0.33883	0.7418		
Distance (Di)	2	20.81	14.464	**0.0001**	Modified Mooring, 9 m	0.62402	0.5304		
Yr x Tr	3	2.8841	2.0046	0.1208					
Yr x Di	6	8.0529	5.5971	0.0001					
Tr x Di	2	4.8466	3.3686	0.0392					
Yr x Tr x Di	6	2.9637	2.0599	0.0685					
Residual	72	1.4388							
Total	95								
Seagrass Blade Length									
Year	3	446.53	11.273	**0.0002**	Modified Mooring, 0.5 m	6.6133	**0.0001**		
Treatment	6	817.37	20.635	**0.0001**	Modified Mooring, 5 m	1.55	0.1342		
Distance	2	864.58	21.827	**0.0001**	Modified Mooring, 9 m	0.47481	0.6359		
Yr x Tr	6	216.31	5.461	**0.0022**					
Yr x Di	72	91.096	2.2998	**0.0418**					
Tr x Di	95	506.9	12.797	**0.0001**					
Yr x Tr x Di		75.005	1.8935	0.0943					
Residual	72	29.611							
Total	95								
Sediment Particle Size									
Treatment	1	14.143	12.196	**0.0042**	Modified Mooring, 0.5 m	6.4589	**0.0286**		
Distance	2	6.5242	5.626	**0.0156**	Modified Mooring, 5 m	1.3583	0.2522		
Tr x Di	2	4.2924	3.7015	**0.0444**	Modified Mooring, 9 m	0.35731	0.7974		
Residual	18	1.1597							
Total	23								
Epifauna Diversity									
Year	3	7.2877	9.1573	**0.0001**					
Treatment	1	10.714	13.463	**0.0005**					
Distance	2	0.36905	0.46372	0.6363					
Yr x Tr	3	1.0258	1.289	0.2862					
Yr x Di	6	0.83532	1.0496	0.3983					
Tr x Di	2	0.46429	0.5834	0.5638					
Yr x Tr x Di	6	0.35913	0.45126	0.8473					
Residual	60	0.79583							
Total	83								
Abundance									
Year	3	7.2877	9.1573	**0.0001**					
Treatment	1	10.714	13.463	**0.0005**					
Distance	2	0.36905	0.46372	0.6363					
Yr x Tr	3	1.0258	1.289	0.2862					
Yr x Di	6	0.83532	1.0496	0.3983					
Tr x Di	2	0.46429	0.5834	0.5638					
Yr x Tr x Di	6	0.35913	0.4126	0.8473					
Residual	60	0.79583							
Total	83								
Assemblage					**SIMPER Test**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum %**
Year	3	5691	5.5277	**0.0001**	*Pagurus bernhardus*	39.26	1.27	51.32	51.32
Treatment	1	8118.4	7.8854	**0.0007**	*Gibbula umbilicalis*	22.76	0.91	29.75	81.07
Distance	2	1008.1	0.97919	0.4377	*Tritia reticulata*	7.86	0.5	10.27	91.34
Yr x Tr	3	1935.2	1.8796	0.0608	*Echinus esculentus*	3.36	0.35	4.4	95.74
Yr x Di	6	1151	1.1179	0.3323	*Macropodia spp*	1.4	0.22	1.83	97.58
Tr x Di	2	1293.2	1.2561	0.2862	*Pomatoschistus minutus*	0.61	0.22	0.8	98.37
Yr x Tr x Di	6	695.67	0.6757	0.8198	*Maja brachydactyla*	0.6	0.21	0.78	99.15
Residual	60	1029.5			*Calliostoma zizyphinum*	0.32	0.15	0.42	99.58
Total	83								

Table 1. PERMANOVA examining differences in biological and physical parameters with year, mooring treatment, and distance from mooring, with pairwise tests for mooring treatments and distances where the main test showed a significant interaction. Simper analysis of species contribution to dissimilarity is also included. Bold type denotes a significant result.

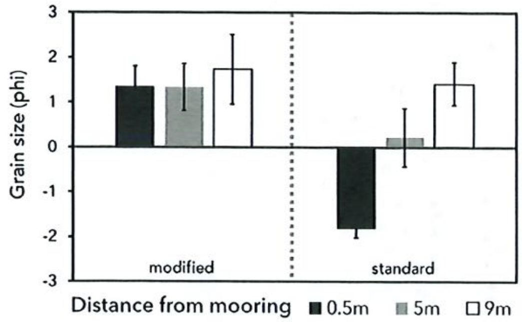

Figure 2. Sediment particle sizes (phi) at increasing distances from each mooring treatment (Udden-Wenworth scale).

Sediment Particle Size. Grain size distribution at the standard mooring was very poorly sorted, dominated by medium to fine sand (53.3%) and fine to coarse gravel (40.8%) (Fig. 2). Mean grain sizes were shown to decrease with distance from the sinker block; samples taken at 0.5 m had a mean phi grain size of −1.807 φ, (very fine to fine gravel on the Udden-Wentworth scale), which decreased to 0.221 φ (coarse sand) 5 m from the block.

The modified mooring treatment was poorly sorted, with the sample dominated by fine to medium sand (72.8%) (Table 1; Fig. 2). The samples showed minimal fluctuations in grain size with distance, with grain sizes of 1.357 φ at 0.5 m and 1.339 φ 5 m from the block (medium sand, medium sand).

Quadrats located away from chain abrasion (9 m) showed similar grain sizes; with an average grain size of 1.415 φ (medium sand) 9 m from the standard mooring, and 1.739 φ (medium sand) 9 m from the modified mooring.

These differences in grain size distribution between treatments were statistically significant ($p = 0.0042$, $p = 0.0156$) (Table 1). Pairwise testing between the significantly different factors showed a significant relationship between the modified and standard mooring treatments 0.5 m from the sinker block ($p = 0.0286$), with the standard mooring having a mean grain size of -1.807 ± 1.8 φ (very fine to fine gravel), and the modified mooring with 1.357 ± 0.5 φ (medium sand) 0.5 m from the sinker block.

Faunal Density. Epifaunal density surrounding the standard mooring increased with distance from the mooring sinker block and showed an overall decline over time (2015–2017).

Prior to the deployment of the moorings (2014), the standard mooring had an average abundance of 6 ± 0.4 individuals 0.5 m from the sinker block, and 3 ± 0.2 5 m from the block. Following the deployment of the standard mooring, the average number of individuals per 0.25 m2 quadrat declined to 0, 0.5 m from the mooring sinker block in 2017, and 0.75 ± 0.08 5 m from the block (Fig. 1b).

The average number of individuals per quadrat surrounding the modified mooring also showed variation over time, although little relationship with distance can be observed. In the baseline year of 2014 the modified mooring had an average abundance of 1.5 ± 0.09 individuals 0.5 m from the sinker block, and 2.5 ± 0.2 5 m from the block. After the deployment of the modified mooring the species abundance increased in the years 2015 and 2016, peaking in 2015 0.5 m from the block at 5.5 ± 0.2 individuals, followed by a decline in 2017 to 2.75 ± 0.2 individuals 0.5 m from the sinker block, and 2 ± 0.09 individuals 5 m from the block (Fig. 1b). Despite this, the average faunal density remained consistently higher surrounding the modified mooring than the standard mooring post deployment.

Quadrat samples 9 m from the sinker block (away from influence of the chain) showed low faunal density in 2014 for both treatments (standard, modified, 1 ± 0.08, 1 ± 0.08), followed by an increase in faunal density with both samples peaking in 2015 (standard, modified, 4.25 ± 0.2, 4.25 ± 02), and declining in 2017 (standard, modified, 0.5 ± 0.1, 1 ± 0.1) (Fig. 1b).

Species Richness. The number of species surrounding the standard mooring treatment was shown to fluctuate over time following the deployment of the moorings (2015–2017), with the average number of species 0.5 m from the sinker block remaining consistently lower than quadrats 5 m and 9 m from the sinker block.

Prior to the deployment of the moorings (2014), the standard mooring had an average species richness of 2.5 ± 0.4 species per quadrat 0.5 m from the sinker block, and 1 ± 0.2 species 5 m from the block. Following the deployment of the moorings, the average species richness surrounding the standard mooring dropped to 0 species 0.5 m from the mooring sinker block in 2017, and 0.25 ± 0.08 species 5 m from the block (Fig. 1d).

The average species richness surrounding the modified mooring also fluctuated over time, whilst remaining consistently higher than the standard mooring across all distances.

In the baseline year of 2014, the modified mooring had an average species richness of 1.5 ± 0.09 per quadrat, 0.5 m from the block, and 1.5 ± 0.2, 5 m from the mooring sinker block. Three years after the mooring deployment (2017), the average number of species at 0.5 m from the sinker block had declined to 1 ± 0.2 species per quadrat, and 1.25 ± 0.1 species at 5 m from the block (Fig. 1d).

The average species richness 9 m from the standard mooring sinker block (away from chain disturbance) showed a slight decline over time, from 1 ± 0.08 species per quadrat in 2014, to 0.25 ± 0.05 species in 2017.

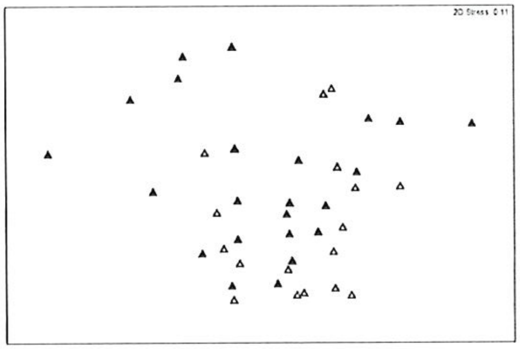

Figure 3. Multidimensional scaling plot based on Bray-Curtis similarity resemblance matrix of epifaunal assemblages around the standard (filled) and modified (unfilled) mooring treatments.

The species richness 9 m from the modified mooring peaked at 2.25 ± 0.2 species in 2015, then dropped to 1 ± 0.06 species in 2017.

Assemblage. The assemblage composition significantly differed between mooring Treatment ($p = 0.0007$) and Year ($p = 0.0001$) (Table 1). The assemblage composition was more dispersed for the standard mooring than the modified mooring (MVDISP: Standard 1.091, Modified 0.909, Fig. 3). The species driving the differences between treatments were *Anemonia viridis, Pagurus* spp. and *Gibbula umbilicalis. G. umbilicalis* and *Calliostoma zizyphimum* were the only species with greater abundance in the standard mooring compared to the modified mooring, two species were found in similar abundances between treatments (*Tritia reticulata, Pomatoschistus minutus*), while the majority (six species: *Anemonia viridis, Pagurus bernhardus, Echinus esculentus, Macropodia* spp, *Maja brachydactyla*) were found in greater abundances in the modified mooring.

Discussion

This study confirms the negative impacts that standard swing moorings can have on sensitive seagrass ecosystems[2], but also shows that these impacts can be mitigated through simple modification of existing moorings. A new and relatively simple modification to a swing mooring has proven successful in the reduction of chain contact with the seafloor, leading to reduced environmental impacts across multiple biological and physical parameters. The study was conducted within an established dense seagrass meadow in the Salcombe ria; the data collected indicates the Salcombe ria seagrass meadow to be a typical dense meadow, with species density, richness and assemblage characterizing the typical ecology representative of a seagrass meadow in the UK.

The mooring modifications and installation costs were considered substantially lower than for alternative designs, costing a minimum of 67% less than alternative eco-mooring designs on the market (cost model estimates of £1,620 - £3,200 for components, and installation costs of £600[13]). The modified mooring design also met the criteria for the existing insurance policies[13] suggesting that a modified swing mooring design may instill increased confidence in insurance companies, due to their confidence in the traditional swing mooring. It is suggested, that alongside a targeted educational program directed towards regulators and the public, reduced costs and the availability of insurance policies for the moorings, the public would be encouraged to modify traditional swing moorings to reduce mooring impacts on seagrass beds.

The study found that seagrass density and blade length both increase with distance from the standard mooring as hypothesized, with a weaker correlation observed in the modified mooring treatment. This indicated substantially reduced scouring impacts on seagrass in the modified mooring treatment, compared to the standard mooring. An increase with distance in both parameters was still evident in the modified mooring treatment, however to a significantly lessened extent. Seagrass recovery was evident over time (2014–2017) in the modified mooring treatment (after modification of a swing mooring) in blade length and faunal density, indicating that the replacement of current swing moorings could reduce fragmentation of seagrass meadows caused by moorings, and encourage recoverability of the ecosystem.

The highest degree of impact across both parameters (density, blade length) was observed 0.5 m from the standard mooring sinker block, as hypothesized. A lessened degree of disturbance 5 m from the block was also observed, with minimal disturbance at 9 m indicating that any acute impacts on the seagrass meadows from the standard mooring were localized. These results are reflected in a study by Unsworth, *et al.*[2], who observed a similar linear gradient with 79% of quadrats located 0 m from a swing mooring containing no seagrass. Unsworth, *et al.*[2] documented impacts up to 20 m from the mooring in the study, suggesting a larger impact area beyond the extent of the mooring chain and scarring area. However, despite this, seagrass degradation as a result of mooring impacts appears to occur on a localized scale, this is considered substantial due to damage occurring in the center of the seagrass meadows, often resulting in habitat fragmentation reducing the resilience of seagrass to additional stressors.

Sediment grain size distributions supported the hypotheses suggesting significantly different sediment compositions between treatments (S.D $p < 0.05$); the sample closest to the standard mooring showed coarser grain sizes, with finer grains in locality to the modified mooring as predicted. Disturbance from mooring chains scouring the seafloor has the potential to resuspend small grains, modifying the sediment composition favoring larger grain sizes such as shell fragments and gravel[6]. The resuspension of fine particles can also increase water turbidity, reducing sunlight and consequently seagrass photosynthesis and growth[14].

Changes in sediment composition can also be linked to seagrass density, with reduced density resulting in a lack of sediment trapping and retention, leading to coarser sediment compositions[15]. In the present study, the sediment particle sizes 0.5 m from the standard mooring in 2017, in areas of low seagrass density were coarser than in quadrats 9 m from the mooring sinker block in areas of increased density, suggesting seagrass density may have had an influence on sedimentation rates. A similar relationship was also observed between sediment size and seagrass blade lengths 0.5 m from the moorings, with finer sediment particle sizes and longer blade lengths local to the modified mooring, compared to the standard mooring, suggesting that long seagrass blades may trap fine sediment particles, leading to an increase in sedimentation in the area. Increased sediment deposition in seagrass meadows, encourages the sequestration of organic carbon, contributing to the reduction of greenhouse gases[15,16].

It is important to note that factors such as coastal development and land use changes can also influence sediment sizes and composition, and the extent of influence would need further research. However, the current study appears to show strong correlations between mooring disturbance, sediment changes and seagrass density and blade length.

Overall, the findings indicate a high degree of disturbance surrounding the standard mooring, compared with the modified mooring, which showed little impact on the surrounding sediment. Species richness, density and assemblage were found to be statistically different between treatments as hypothesized, suggesting a difference in habitat or ecological features of the sites. Increased species richness and abundance surrounding the modified mooring were evident, implying greater biodiversity supported by increased density and blade length of seagrass surrounding the modified mooring.

Similar findings were found by McClosky and Unsworth[6], who reported increased faunal density and species richness in areas of high seagrass cover. Bowden *et al.*[17] and Collins *et al.*[18] also found a decline in species richness and density in unvegetated mooring scars.

A decline in species richness and density surrounding the standard mooring may be a result of species preference for high density seagrass, which offers increased cover from predators; McClosky and Unsworth[6] suggested that species such as Plaice were found to prefer bare substrate, due to difficulty locating prey in dense seagrass meadows.

Moreover, the effects of interspecies and intraspecies competition must be acknowledged as an influential factor in changes in species richness, this could be emphasized as a result of increased species concentration in seagrass meadow fragments[19].

Species habitat preferences may also have influenced the observed differences in species compositions between the mooring treatments. McClosky and Unsworth[6] suggested independent species preferences for bare or vegetated substratum, with observations of Sand Gobies and Plaice preferring to inhabit areas of bare substratum, whereas many juvenile commercial fish species showed a preference for dense seagrass meadows.

It is worth noting that this study was conducted in a single seagrass bed, with only one experimental unit of each mooring type, therefore it is recommended that further spatially replicated experiments are undertaken, in order to confirm the results of the current study. The challenge now is to convince managers and boat owners to modify their swing chain moorings to enable damaged seagrass meadows to recover and restore their associated ecosystem services. Local targeted education programs for regulators and the public could help to raise awareness about the importance of seagrass meadows, the damage that is being caused and how a simple modification to moorings can result in positive recovery for this important habitat. In addition, statutory legislation should be implemented to reduce further human induced degradation of seagrass meadows worldwide.

Conclusion

The current study demonstrates a cost-effective approach to reduce mooring impacts in seagrass meadows and highlights the destructive potential of traditional swing mooring systems.

In contrast to previous studies describing new 'eco-mooring' designs, this paper has offered a low-cost approach through the modification of an already existing swing mooring. The modified mooring successfully reduced chain abrasion of the seafloor, using floats to lift the mooring chain off the seabed at low tide, and greatly reduced the associated negative impacts on the seagrass ecosystem without compromising the integrity of the mooring.

Methods

The study site was situated in the Salcombe ria, UK, chosen because of its combination of established dense seagrass meadows skirting the channel, and intense boating activity all year round. The site has a strong tidal influence, with a tidal range of 5.5 m and a depth of 10 m in the deeper parts of the channel. The experimental treatments, a modified swing mooring and a standard swing mooring, were located 76 m from the shore, and 60 m apart, and installed at low tide on the 18th April 2014. The alterations to the mooring cost £120, in addition to this, mooring tackle was replaced at a maximum cost of £620. Maintenance requirements for the mooring include monitoring chain thickness, corrosion and buoy attachments, with associated costs predicted to align with those for standard swing mooring designs.

Treatment Descriptions. The first treatment comprised of a standard swing mooring, reinstalled in 2014. The mooring consisted of a 1 tonne tyre sinker block and eye, placed on the seafloor, with 1 m of 25 mm stainless-steel chain leading off it. The chain was shackled to a light 19 mm chain, which reached 12.5 m from the sinker block, and was shackled to a 90 cm surface mooring buoy (Fig. 4).

The second treatment was a swing mooring, modified to reduce impact on the seafloor from the stainless-steel chain. The mooring was configured of a 1 tonne tyre block and eye, with 0.5 m of 32 mm Old Jump that rests on

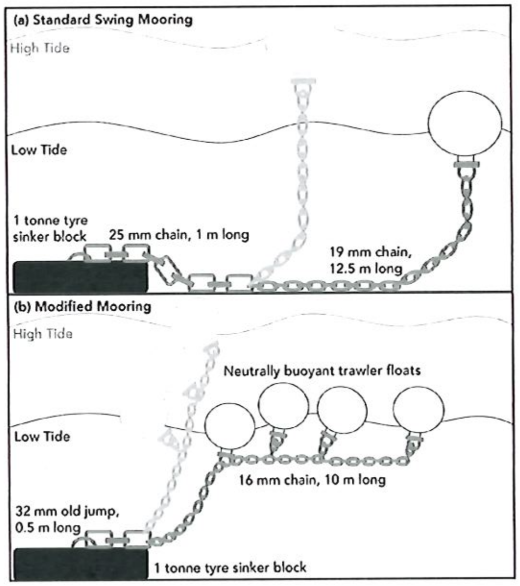

Figure 4. Diagram of a standard mooring **(a)** and modified mooring **(b)** treatments, showing position of the mooring floats and chains at high tide (light grey) and low tide (dark grey).

top of the block. Leading off this was 10 m of 16 mm chain, shackled to which were trawler floats, which kept the chain elevated during high and low tides (Fig. 4).

Sampling Procedure. Data for this study were collected through the citizen science project, the Community Seagrass Initiative[20]. To limit potential inconsistencies between divers, all Community Seagrass Initiative volunteers were subject to training beforehand.

Measurements of seagrass shoot density, blade length, and faunal density were collected around each mooring by a team of 5 dive pairs. Measurements of each variable were taken at three distances along a transect from the sinker block: 0.5 m, 5 m and 9 m. Each transect was replicated across four bearings of NE, SE, SW and NW, providing four replicates at three distances from each mooring. Data were collected from 2014 to 2017 in March of each year (to eliminate seasonal influence) except for 2017, when collections were delayed until May because of poor diving conditions. The distance of 0.5 m represented a zone of direct impact, 5 m the near impact zone, and 9 m, an area away from any influence from the chain.

At each sampling location, a 0.25 m^2 quadrat was placed over the transect line, and photographed after any disturbed sediment had settled, using a Gopro Hero 4 camera.

The following parameters were recorded in the field:

1. The length of 10 haphazardly selected seagrass blades (cm) within a 0.25 m^2 quadrat.
2. The number of seagrass shoots in 3 random 0.01 m^2 squares of the quadrat.

In 2017, additional parameters were investigated through the collection of sediment samples; samples were collected in 125 ml sample pots from the center of the quadrat, which were then sealed and chilled in a lab at 4 °C for further analysis.

Sediment Sample Particle Size Analysis. Sediment particle size analysis was undertaken in accordance to the NMBAQC's Best Practice Guidance for Marine Sediments[21]. Samples were mixed thoroughly, and subsamples of approximately 5 ml of the sample obtained with a spatula. Material >1 mm and <1 mm was separated using a 25 mm diameter 1 mm sieve, a vial funnel and a 12 ml vial. A pressurized water spray was used to aid this process.

For each sample, 5 replicate vials were made, and placed methodically in a sampling rack, with the vial locations noted. The sampling rack was then placed in the Malvern Mastersizer 2000 (general analysis model with irregular particle shape and enhanced sensitivity, reference index of 1.53) for laser diffraction. The instrument was set to run 5 replications on each sample.

Samples were refrigerated until settlement had occurred, and any excess surface water was drained from them. For each sample, a 250 ml and a 100 ml beaker were assigned labels by proxy. The 250 ml beakers were weighed to 2 dp and noted. Approximately 30 ml of the sample was sieved through a 1 mm mesh into a funnel held over the 250 ml beaker. A small sieve brush and a fine water spay were used to aid the sieving process, depositing material <1 mm into the 250 ml beaker. Any sediment >1 mm left on the surface on the sieve was deposited into the 100 ml beaker. Both beakers (250 ml and 100 ml) were then dried in an oven for 48 hours at 105 °c.

Following this, the 250 ml beaker was then reweighed, to determine the weight of the material <1 mm. The material in the 100 ml beakers was dry sieved using 16 mm to 1 mm sieves, at half phi intervals, and the weights recorded.

Epifaunal Analysis. Images taken of the quadrats were analyzed alongside diver observations, and epifaunal species identified to the lowest taxonomic level. Both sessile and mobile epifauna were recorded, and the species richness and density per quadrat noted.

Statistical Analysis. Statistical analysis was conducted using PRIMER 7 with PERMANOVA[22,23]. The threshold for determining statistical significance was set at $P < 0.05$. Variability of the data is reported as standard error about the mean.

The data for variables seagrass blade length, shoot density, and sediment composition were first calculated and arranged into a resemblance Euclidian distance matrix to show the similarity or dissimilarity between each pair of data, as coefficients. Permutational multivariate analysis of variance (PERMANOVA) was used to determine differences in variables. Pairwise tests were then conducted on the statistically significant variables to identify where the differences occurred.

The epifaunal data were subject to resemblance testing, for faunal density, species richness and assemblage variables, using the Bray Curtis technique. A dummy variable of 1 was assigned to the data to aid distinction between the treatment groups. Multivariate dispersion (MVDISP) was then used to assess dispersion of the significant factors, and the resemblance matrix data visualized in an nMDS (non-metric Multi-Dimensional Scaling) plot, providing a graphical representation of how the variables relate to one another. Next PERMANOVA tests were then performed on the resemblance data, to determine the statistical significance of the data. The statistically different ($P \leq 0.05$) factors were then further analyzed with SIMPER tests, to identify the discriminating species between the treatment (modified mooring and standard mooring) and year (2014, 2015, 2016, 2017) factors.

Data availability

The datasets generated during and analyzed during the current study will be archived in the Marine Biological Association repository (DASSH, The Archive for Marine Species and Habitats Data), and made available via the MEDIN (Marine Environmental Data and Information Network) portal (https://portal.medin.org.uk/portal/start.php).

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Author contributions
Nicholas Higgs, Mark Parry and Emma Sheehan designed the study. Mark Parry and Anna Luff collected data. Anna Luff, Nicholas Higgs and Emma Sheehan analyzed the data and wrote the manuscript.

Competing interests
The authors declare no competing interests.

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