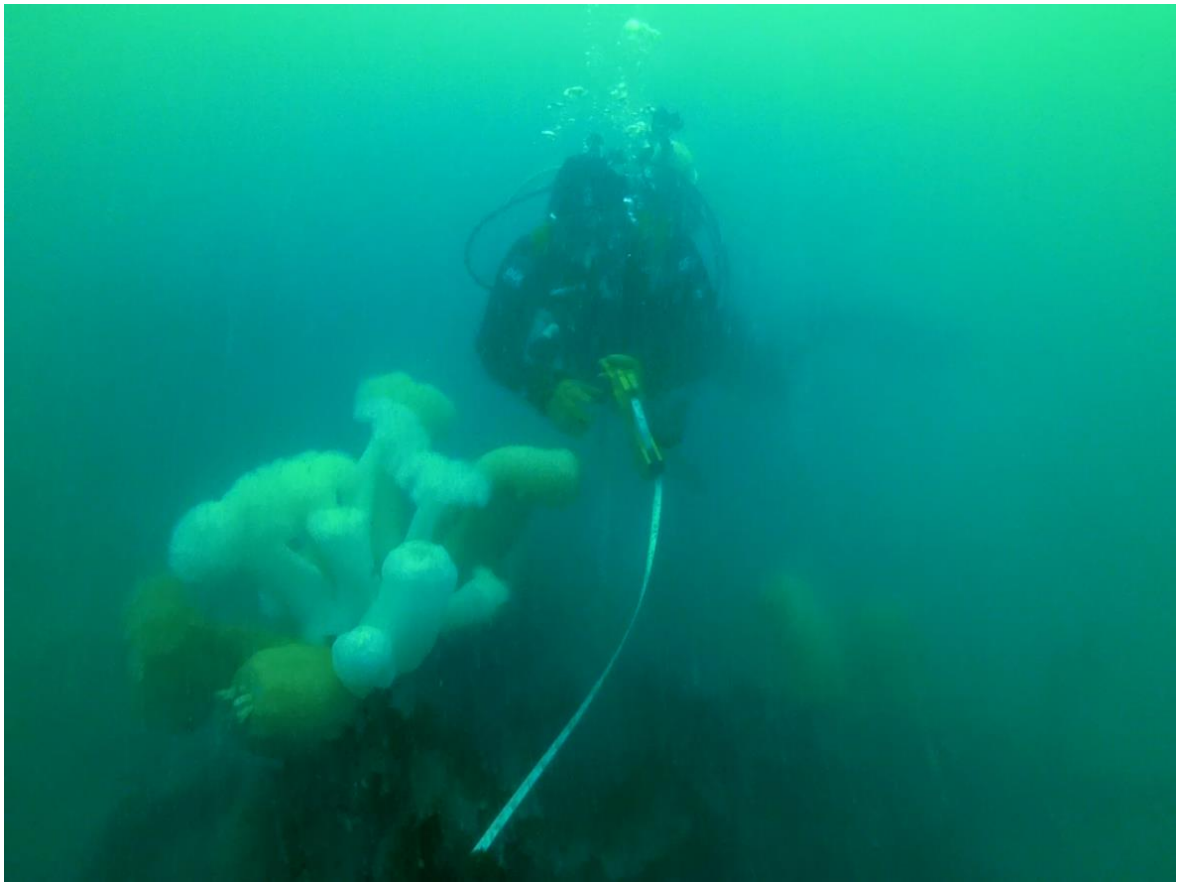
NATURAL RESOURCES

Technical Report

Supplemental Material - Mapping Puget Sound's Artificial Reefs

August 16, 2023



WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES

Cover Photo: DNR diver measuring tire bundle morphology. Photo by DNR dive team.

Supplemental Material - Mapping Puget Sound's Artificial Reefs: Identifying Automobile Tires for Removal

August 16, 2023

Aquatic Assessment and Monitoring Team
Aquatic Resources GIS Team
Aquatic Lands Restoration Program

WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES

Contents

1 Purpose

This supplemental document is intended to be used in combination with the Washington Department of Natural Resources (DNR) 2023 tire reef report "Mapping Puget Sound's Artificial Reefs: Report Prepared for DNR Aquatic Lands Restoration Team (ALRT)". The tire reef technical report provides a thorough introduction and explanation of the methods behind many of the metrics presented in this supplemental document. Rather than duplicating this information here, the current document provides a detailed survey record of each of 14 mapped reefs. We urge readers to reference the DNR tire reef technical report, which is linked in the references of this document for a more complete summary.

2 Background

Artificial reefs can successfully provide habitat for certain species of fish, invertebrates, and algae and allow interesting bottom features for recreational scuba divers to enjoy. A number of artificial reefs have been constructed in Puget Sound to do just this - many of these reefs being built in the late 1980's or later using quarry rock and scrap concrete.

Aside from these more recent reefs, there are other artificial reefs built prior to 1980, however, which were constructed as part of an effort to increase bottom fish habitat and boost recreational bottom fishing opportunities in Puget Sound. Some of these early reefs were built with quarry rock and scrap concrete; however, less environmentally friendly materials were included in the constriction process such as scrap automobile tires.

Scrap automobile tires pose a risk to aquatic organisms, and are a priority for Washington Department of Natural Resources (DNR) as well as other Washington State agencies to clean up. The installation of the majority of these early reefs was never well documented, and to date, there has not been detailed information on the location, size, and quantity of automobile tires or other scrap material in reefs built prior to the 1980's. This list of unknown metrics has made planning for tire removal from these artificial reefs difficult.

Between 2019 and 2021, DNR's Aquatic Assessment and Monitoring Team (AAMT) surveyed 20 different sites for the presence of artificial reefs using a multibeam sonar (R2Sonic 2020) and a towed video camera. The purpose of this project was to identify and locate intentionally reef placed automobile tires for their eventual removal. Figure 1 is a map of all 20 reefs that were surveyed.

Tires were found at 14 of 20 sites. A detailed survey record for each of these 14 sites is included in this supplemental report. There were vast differences in the footprint, number of tires, depth, and condition of the tires within this sample of 14 reefs. These differences are described for each site in the supplemental material presented here, but more holistically in DNR's 2023 tire reef report (DNR 2023).

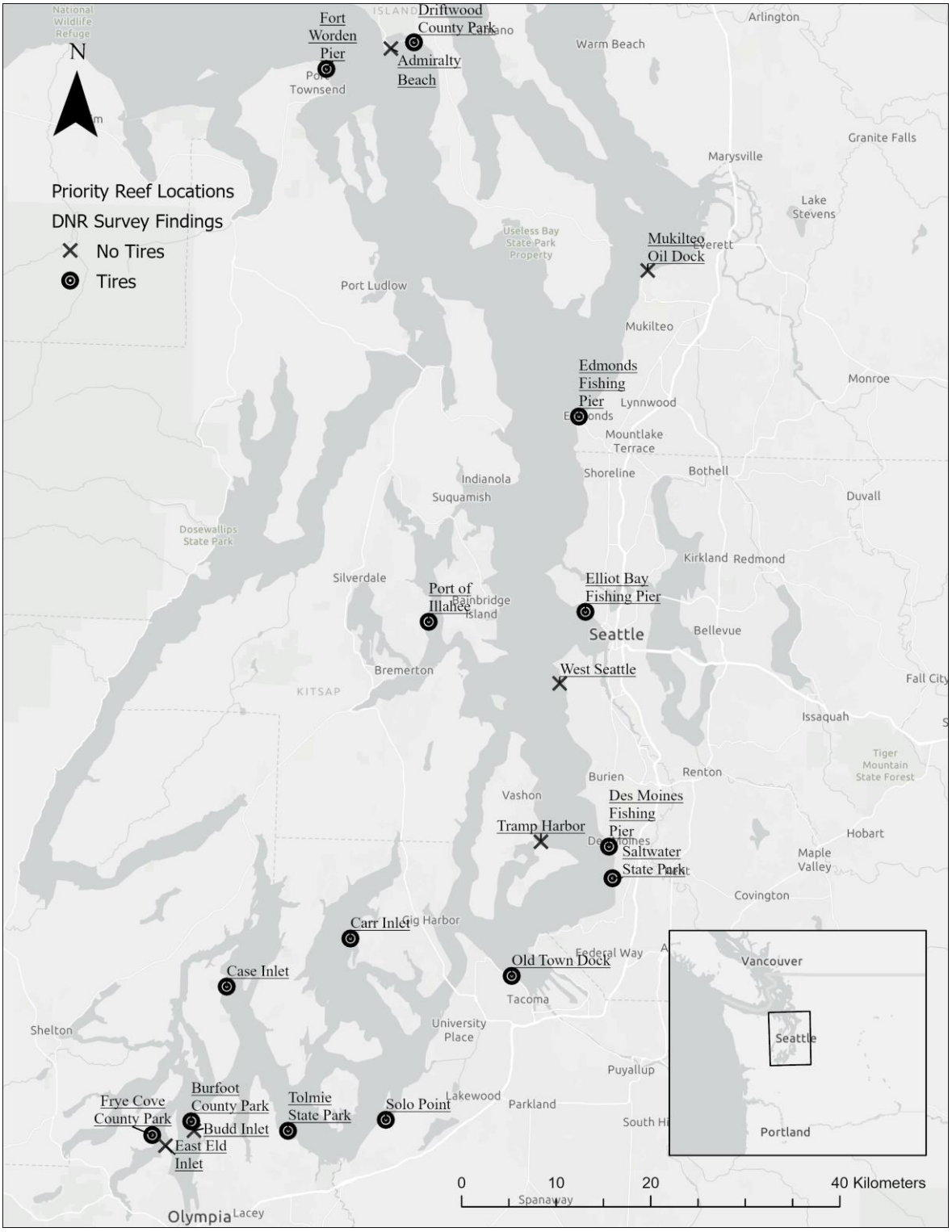


Figure 1. Tire presence and absence for sites surveyed.

3 Information Included in Site Reports

3.1 Report Format

The site-specific documents in this report are presented in a standard format. They each include:

1. General overview of survey

2. Reef Location
    - Description of the location of the reef.

3. Reef Attributes
    - Footprint size
    - Condition of tires
    - Condition of banding materials
    - Description of burial
    - Description of substrate

4. Habitat Characteristics
    - Species observations from video surveys
    - Proximity of reef structure to Pacific geoduck beds, forage fish spawning zones, salmon bearing streams, adult herring spawn, and Washington Department of Fish and Wildlife (WDFW) designated priority habitat (WDFW 2023).

5. Tables and Figures
    - Table of footprint corner coordinates
    - Table of tire reef attributes including minimum and maximum values for depth, distance from shore, tire number, reef footprint size, tire node buffer footprint, and the approximate weight of tires. A description of how these metrics have been calculated is available in the Technical Report: Mapping Puget Sound's Artificial Reefs, a Report Prepared for the WA DNR Aquatic Lands Restoration Team (DNR 2023).
    - Figures such as a master reef map and habitat map. Some sites that are located partly on private land may have an additional aquatic land boundary map.
    - Relevant photos taken during the video survey

3.2 Terminology

A number of tire reef terms are used in the following site reports, which are specific to this supplemental DNR report. Please refer to the appendix in section 5.

3.3 Data and Units

3.3.1 Data

Information that is not the product of DNR sonar or video surveys has been compiled from the DNR Aquatics' Quick Data Loader (QDL) via ESRI ArcGIS Pro. This data may include internal records such as encumbrance footprints and ownership data or alternate agency habitat information from the WDFW or the Washington Department of Health (DOH) (WDFW 2021, WDFW 2022, WDFW 2023, DOH 2023, and WA DNR 2023).

3.3.2 Units

The data in this report is presented with both imperial and metric units. Generally, all information presented in maps and figures will be in meters (m), whereas the information provided in tables will be in feet (ft.), US survey acres (acre), pounds (lb.), or decimal degrees (dd.). Multibeam surfaces, contour lines, and reported depths are all in reference to the NAVD88 vertical datum (m), and the NAD83 (m) horizontal datum.

4 Site Specific Reports

4.1 Port Townsend

Port Townsend- Fort Worden Pier Tire Reef

Overview

On 03/18/2021, AAMT surveyed 68.9 acres of marine waters east of Fort Worden Historical State Park. This is close to where Puget Sound meets the Strait of Juan de Fuca. The survey was focused on the area surrounding the Fort Worden Pier - home to the Port Townsend Marine Science Center Aquarium. The pier is constructed of creosote logs reinforced with galvanized metal. Both the pier and the nearby state park are popular destinations for tourists.

No tires were found at this site, but a large quantity of other reef building materials were identified by DNR. These generally sit to the northeast of the pier, and extend to the southeast. Concrete blocks and pillars, rock mounds, and metal pipes were identified with multibeam sonar and confirmed with towed video. Although tires were not identified with towed video footage, analysis of multibeam sonar data suggests that a small number of tires may be present at this site – these are identified in Figure 3 and Figure 4 with a 1.5m tire node buffer layer. Further video footage is needed to confirm an accurate estimate of tires at this site. Unidentified eelgrass species, as well as intermixed kelp species were seen in multibeam sonar data and confirmed with towed video footage (Figure 3).

Reef Location

General Description of Location:

The Port Townsend-Fort Worden reef is located approximately 538 feet from the Fort Worden Park east beachfront parking lot. The largest portion of the reef extends from approximately 615 ft. north of the northeast corner of the Fort Worden pier to directly in front of the middle portion of Fort Worden pier. The closest public boat launch is located at Port Townsend Boat Haven Marina and has year-round access. The state parks holds a lease (# 22-A02246) on SOAL that resides within the bounds of the reef found at this site (Figure 5).

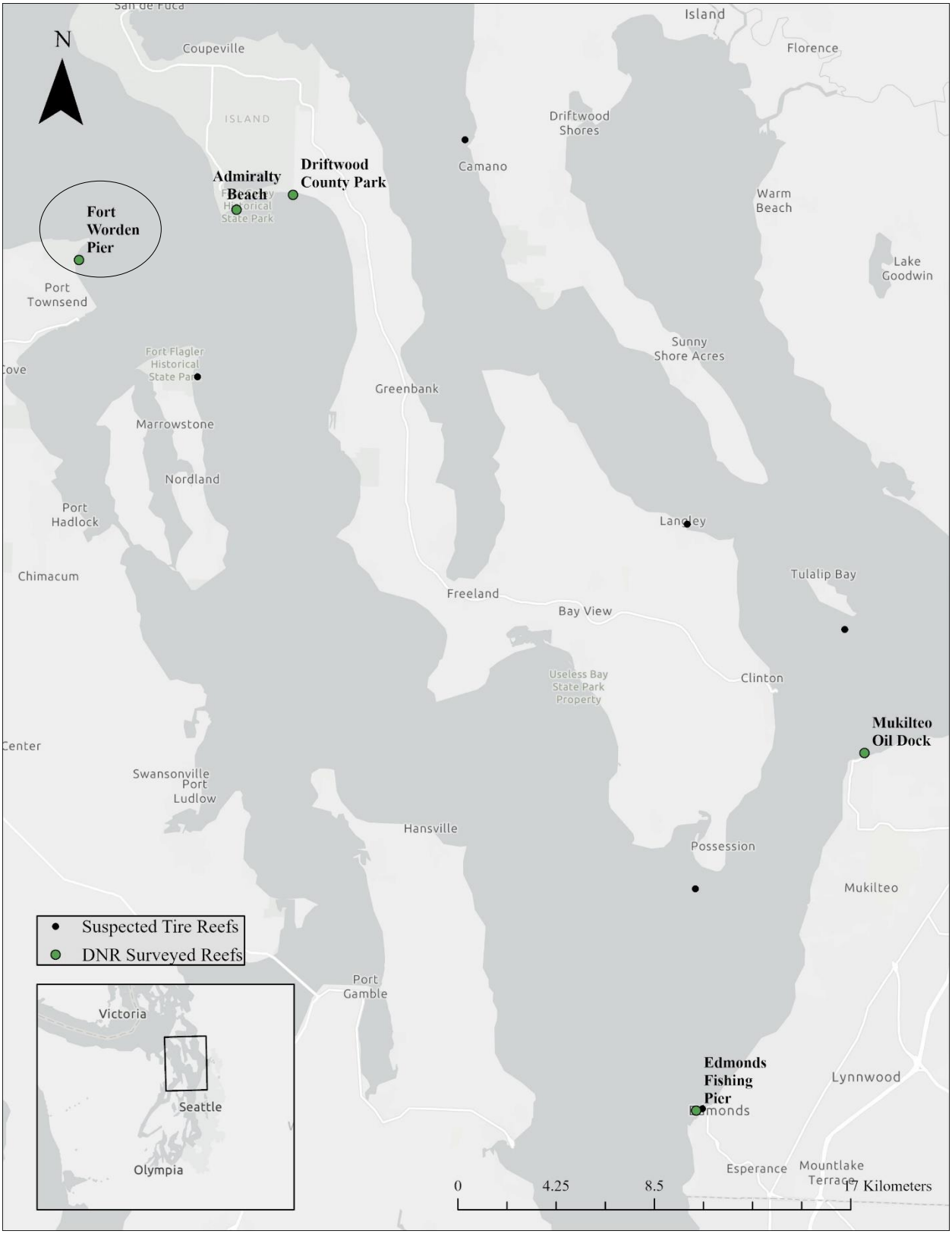


Figure 2. North Sound artificial reef sites. The Fort Worden site is circled.

Table 1. Coordinates for corners of Fort Worden Reef.

	Latitude	Longitude
Center	48.137522 N	-122.759696 W
NW Corner	48.138226 N	-122.759426 W
NE Corner	48.137933 N	-122.759112 W
SW Corner	48.135505 N	-122.760219 W
SE Corner	48.135973 N	-122.75948 W

Reef Attributes

General Description of Reef

The Port Townsend-Fort Worden reef footprint is 3.45 acres in area with a large concentration of materials located in the northern portion of the reef. The substrate observed in the towed video survey indicates there is mud and sand along the shallow portions of the reef in the western portion of the surveyed area. Sand, mixed cobble and shell were observed throughout the middle and deeper portions of the reef.

Tires

There were no tires seen or identified in the towed video footage. The analysis of multibeam sonar data suggests that there is likely a small number of tires interspersed within the bounds of the delineated reef, however this cannot be confirmed without additional video, ROV, or diver surveys.

Non – Tire Reef Features

The reef consists primarily of large concrete structures, ranging from concrete blocks measuring 12 feet long by 6 feet wide, to concrete pillars measuring anywhere from 10 to 85 feet long by 3 to 7 feet wide. The concrete structures are seen throughout the extent of the reef, but are more concentrated and numerous in the northern portion (Figure 4). Many concrete structures are exposed and extend out of the sediment, while other structures are buried. All concrete structures were delineated and marked as linear concrete structures (Figure 4). Some of the linear features surrounding the Fort Worden Pier may be wooden pilings and other debris that has fallen from the pier. While these were marked as concrete, it is possible that they are actually wooden debris (Figure 4).

The second most numerous material found at this site were rock piles situated throughout the extent of the delineated reef. The majority of these rock piles were found in the northern portion, where concrete structure was the most abundant. Rock piles ranged in size, from 5 ft. by 5 ft. to 40 ft. by 30 ft. The boulders found in these piles are likely 1-2 person sized or larger (Figure 4 and Figure 5). A few metal poles interspersed within the rock mounds and concrete structures, were observed in the towed video survey, as seen in Figure 7.

Natural boulders were identified and marked with a 1.5 rock node buffer; however, these lie outside the artificial reef footprint (Figure 3).

Habitat Characteristics

The Fort Worden reef lies within critical nearshore habitat for rockfish species (NMFS 2015). The reef is located within the boundaries of a subtidal geoduck tract (id # 04000) (Figure 5). Sand lance spawning habitat has been found just inshore of the reef footprint (Figure 5).

Crab (sp. unidentified), anemone (sp. unidentified), and sea star (sp. unidentified) were all observed in towed video, while numerous kelp species were present *(Alaria*, *Saccarina*, and *Pterygophera spp*.) attached to the concrete structures and rock piles. Eelgrass (spp. unidentified) was also seen in the southwestern portion of the survey area closer to the shore (Figure 5).

Figures and Tables

Table 2. Fort Worden Tire Reef Estimates.

Reef Attribute	**Minimum**	**Maximum**
Depth at NAV88 (ft.)	-24.45 ± 1.49	-34.97 ± 1.81
Distance from Shore (ft.)	275	875
Reef Footprint Area (acres)	3.45	
Reef Node 1.5 Buffer Area (acres)	0.03	
Number of Tires	152 ± 25	252 ± 112
Tire Weight (lb.)	3045	5059

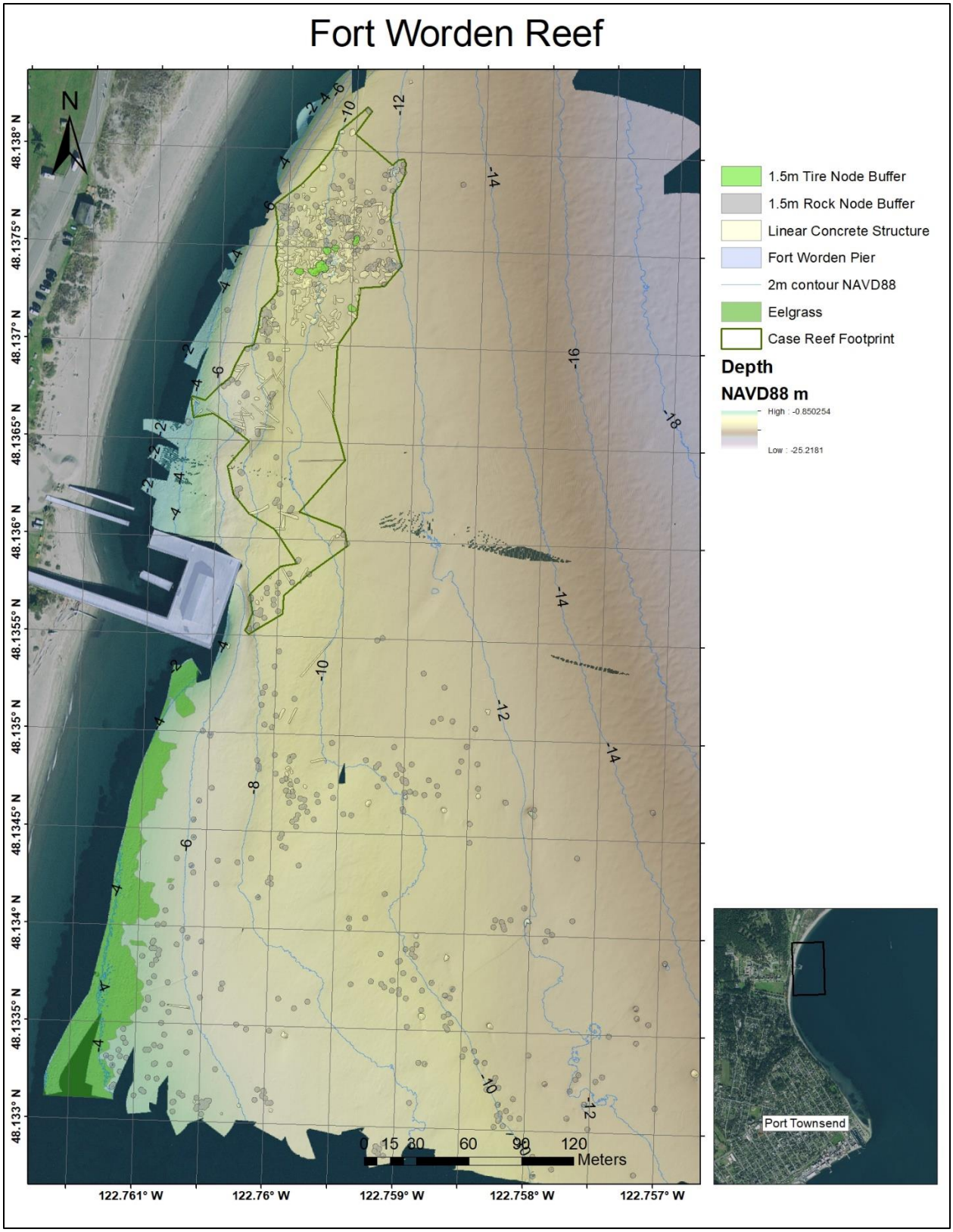


Figure 3. Overview of the surveyed reef footprint at Fort Worden State Park

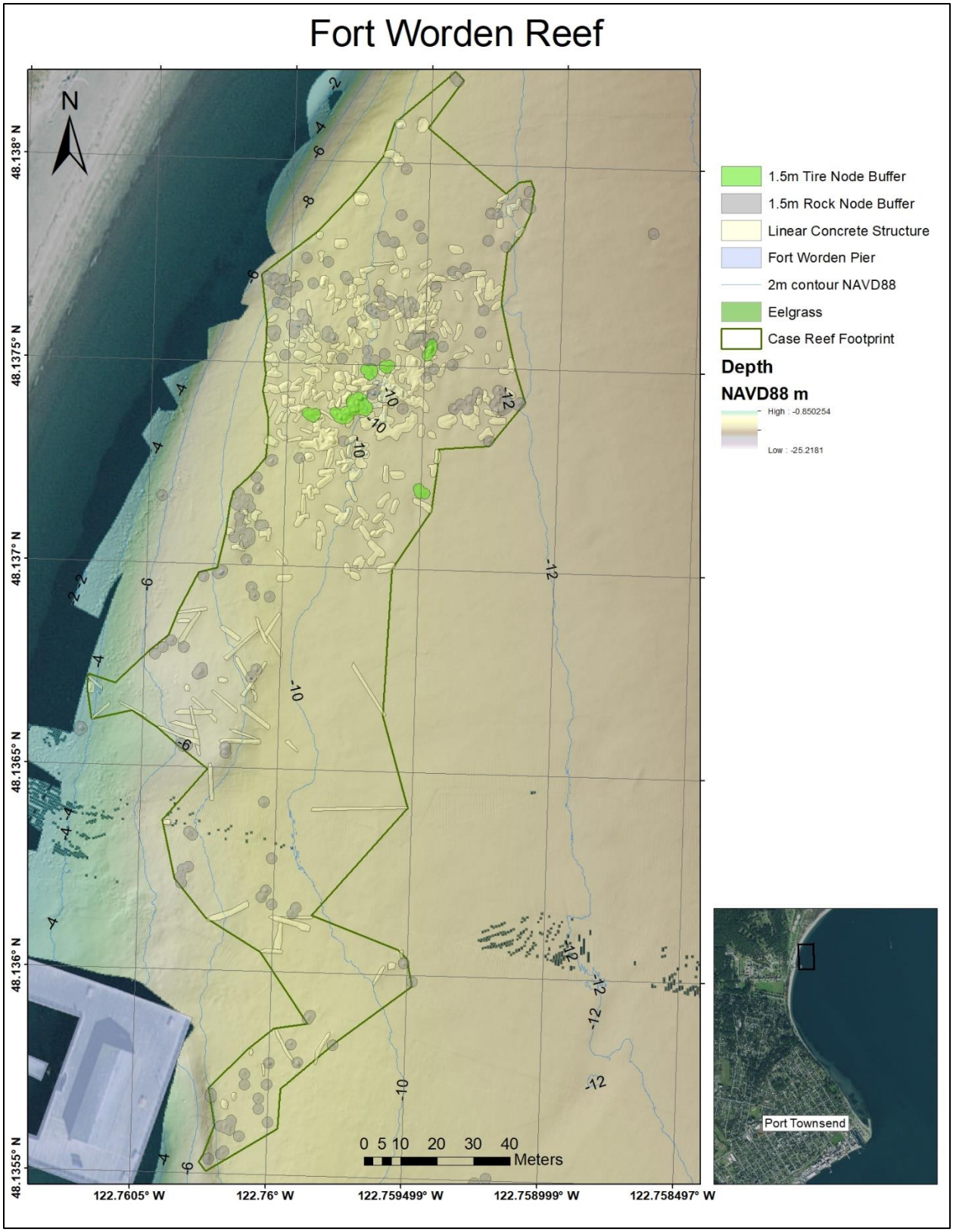


Figure 4. Focused view of the Fort Worden Reef.

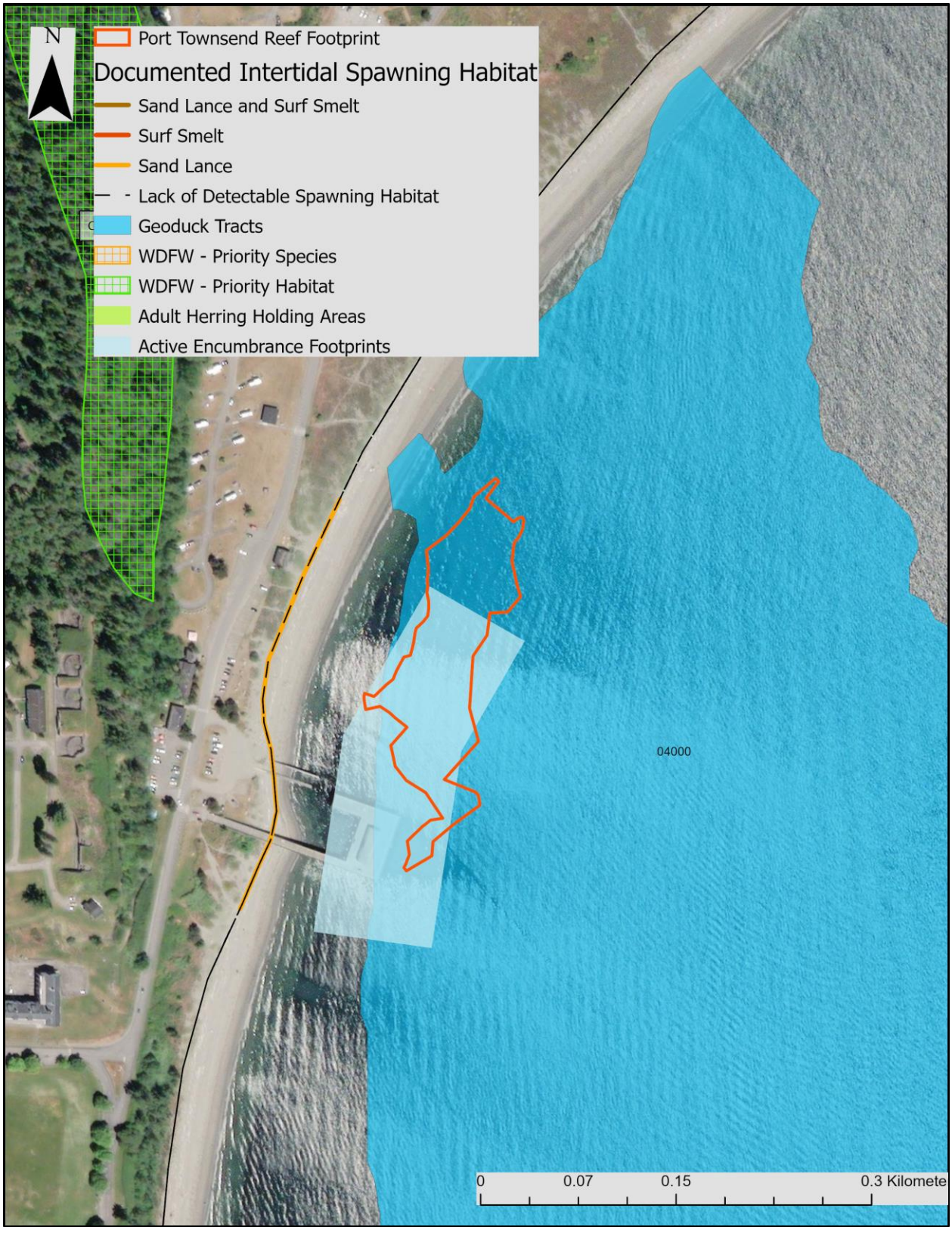


Figure 5. Habitat and species information within proximity to the Port Townsend (Fort Worden) Reef.

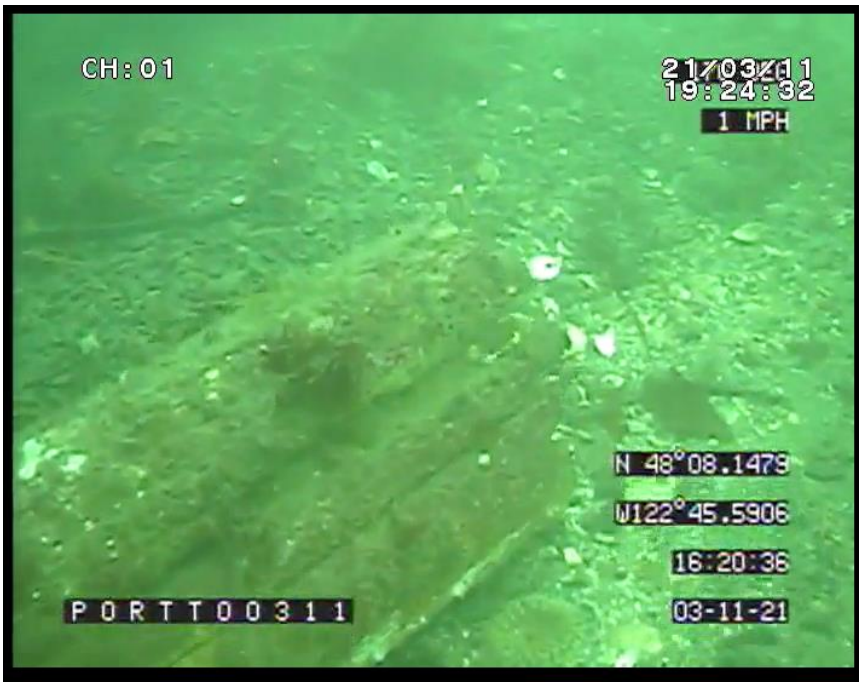


Figure 6. Wooden piling found lying on side at PT Reef.

Figure 7. Metal pipe found lying on sediment.

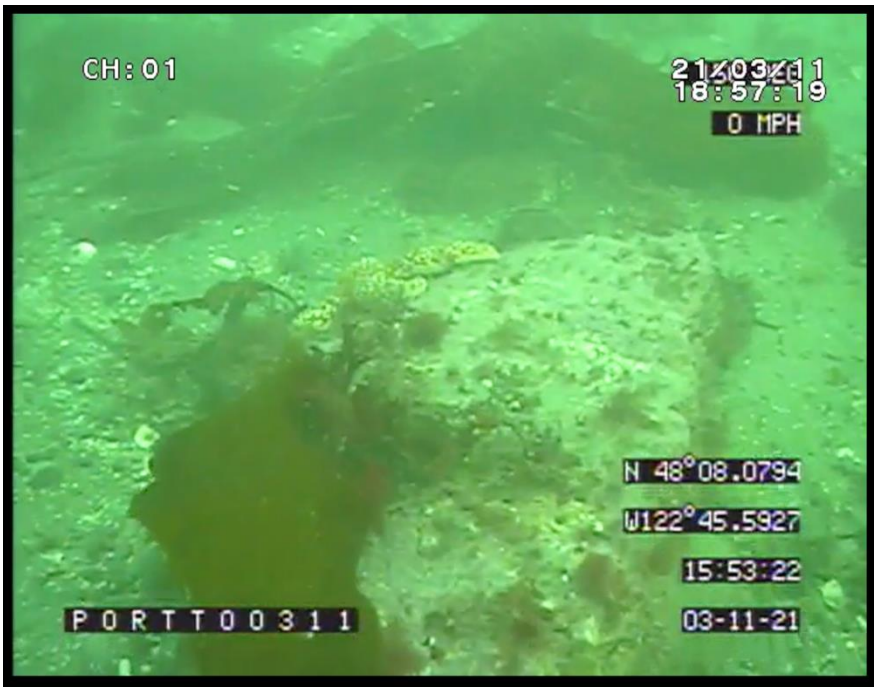


Figure 8. Kelp found among structure at the PT reef site.

Figure 9. Large rocks found among reef piles at the northern end of the PT Reef.

Figure 10. Concrete piling buried in sediment at reef site

4.2 Driftwood Beach

Driftwood County Park Tire Reef

Overview

Fifty-two acres were surveyed on 6/21/2021 at Driftwood County Park on Whidbey Island. Driftwood County Park is located just east of the Coupeville Ferry Terminal. Since the site is at the mouth of Admiralty Inlet, it experiences short slack tide windows, and swift tidal currents. A small reef was identified and mapped with the use of multibeam sonar. Video of the reef was not collected due to damaged equipment on this day; however, ALRT confirmed that the structures observed in multibeam data are tires with the use of a submersible ROV. Other than tires, there were two linear features identified which are expected to be logs.

Reef Location

General Description of Location:

The center of the Driftwood Park tire reef is located approximately 256 feet off the southwestern corner of the Driftwood Beach gravel parking lot at 48.163122 N, -122.637847 W. The closest boat launch to the site is at the Coupeville Ferry Terminal. This launch is accessible at most tides, includes a dock, and has a wide concrete pad that is in good shape. The reef is located within a mitigation and enhancement lease (# 20-009655) held by state parks (Figure 13).

Figure 11. North Sound tire reef sites. Driftwood Beach is circled.

Table 3. Coordinates of the Driftwood Park Tire Reef.

	Latitude	Longitude
Center	48.163122 N	-122.637847 W
NW Corner	48.163265 N	-122.638578 W
NE Corner	48.163291 N	-122.637697 W
SW Corner	48. 162928 N	-122.638689 W
SE Corner	48.162916 N	-122.637088 W

Reef Attributes

Tires

The Driftwood Park tire reef is small (.97 acres) and is located within steep sloping bathymetry. A distinct clump of what are likely tires at the site were found as well as a few periphery features which were marked as potential tire clumps (Figure 12). While we were unable to confirm with video footage, the two linear features identified in Figure 12 are expected to be wooden logs.

Habitat Characteristics

The Driftwood reef lies within critical nearshore rockfish habitat (NMFS 2015). Video footage was not collected on 6/21/2021, so organisms were not identified for presence or absence within the vicinity of the reef

Table 4. Driftwood Park artificial reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	**Minimum**	**Maximum**
Depth at NAV88 (ft.)	-38.76 ± 7.17	-54.32 ± 0.12
Distance from Shore (ft.)	136	302
Reef Footprint Area (acres)	.97	
Reef Node 1.5m Buffer Area (acres)	.018	
Number of Tires	41 ± 5	166 ± 34
Tire Weight (lb.)	823	3328

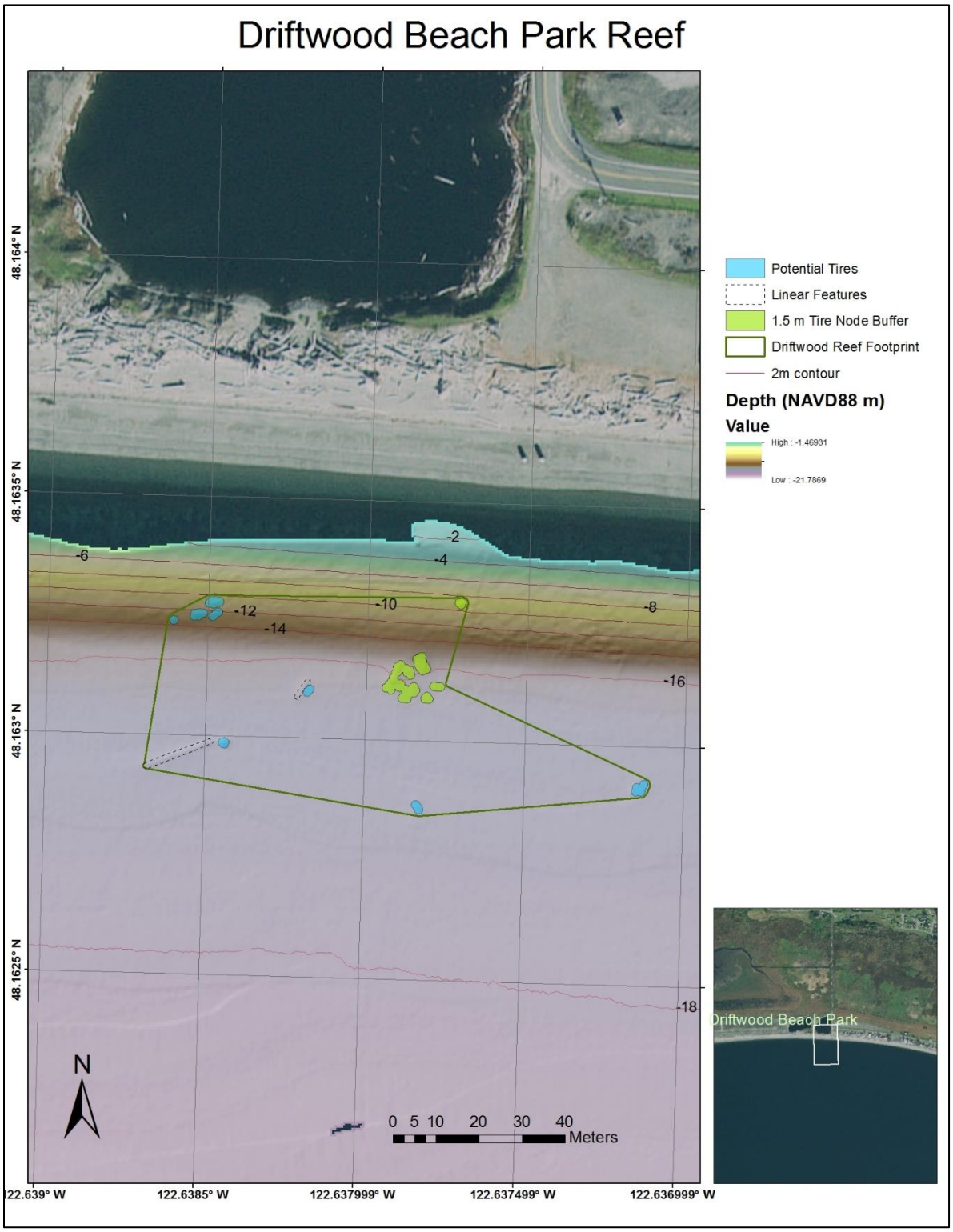


Figure 12. Driftwood Beach Park artificial reef located off the west side of Whidbey Island in Admiralty Inlet.

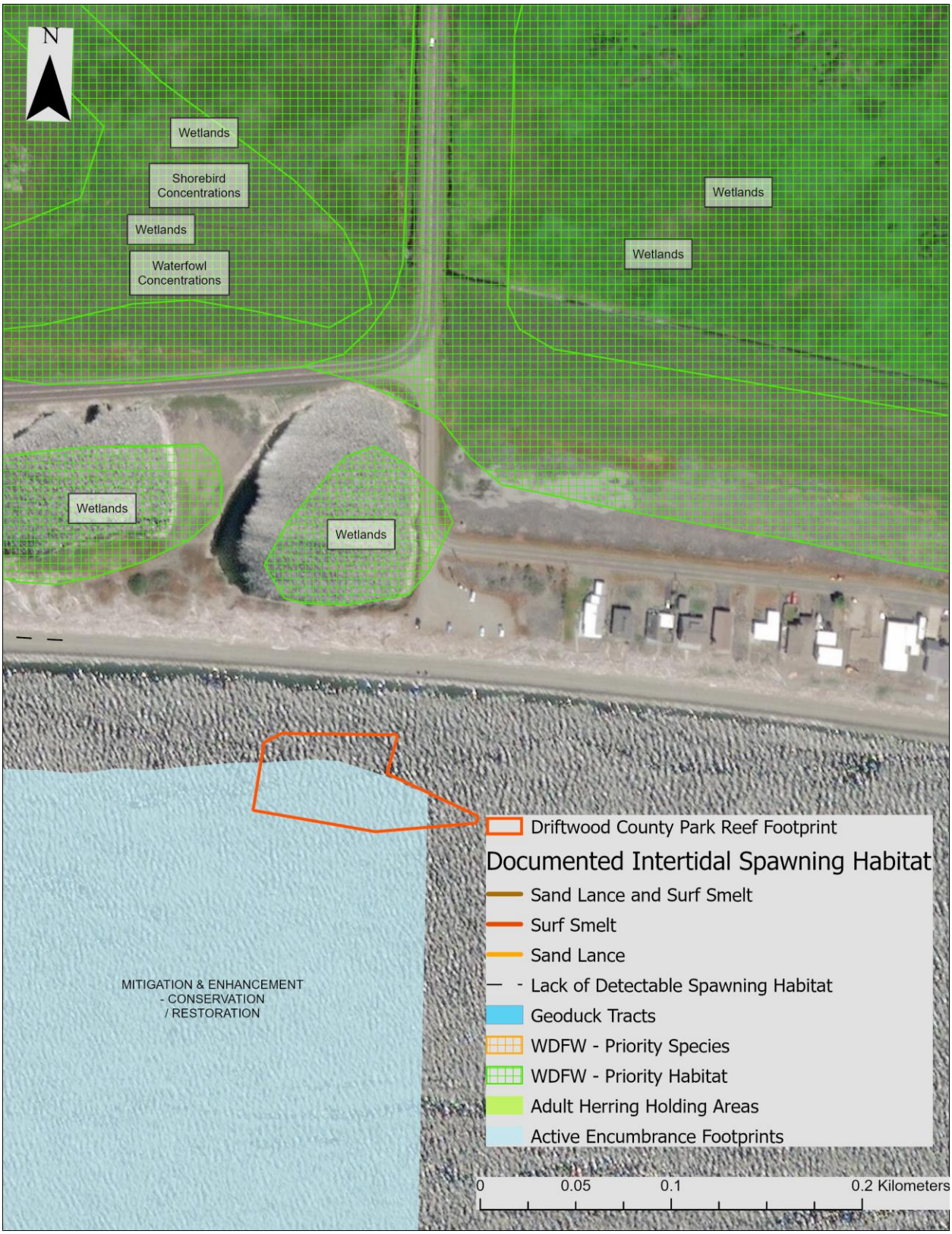


Figure 13. Habitat map for the Driftwood Beach reef.

Edmonds Fishing Pier Reef

Overview

Fifty-six acres were mapped on 3/03/2021 off the Edmonds Fishing Pier in Edmonds, WA. This site is just north of the Edmonds Marina and south of the Edmonds ferry terminal. It is not a part of the Edmonds Underwater dive park, which is located to the north of the Edmonds ferry terminal. Tidal exchange at the site averages 3.4 m daily and maximum current at the site rarely exceeds .9 km/hr. (Walton 1982). A large tire reef (footprint = 370 m long and 40 m wide) with uniquely shaped features was found and mapped. This reef is well documented in the literature and was constructed by the Marine Fisheries Enhancement Division of the Washington Department of Fisheries starting in 1976. It has been the site of multiple fish presence and foraging studies primarily taking place within the first few years after the reef was established in 1976 (Huekel and Stayton 1982, Walton 1982).

Reef Location

General Description of Location:

The center of the Edmonds tire reef is located approximately 218 m (715 ft.) offshore of the high tide line, and 34 m (112 ft.) off the center of the Edmonds fishing pier at 47.811603 N, -122.389692 W. The closest commercial ramp in the area is in Mukilteo. This ramp is wide and is sufficient for the launching of large vessels.

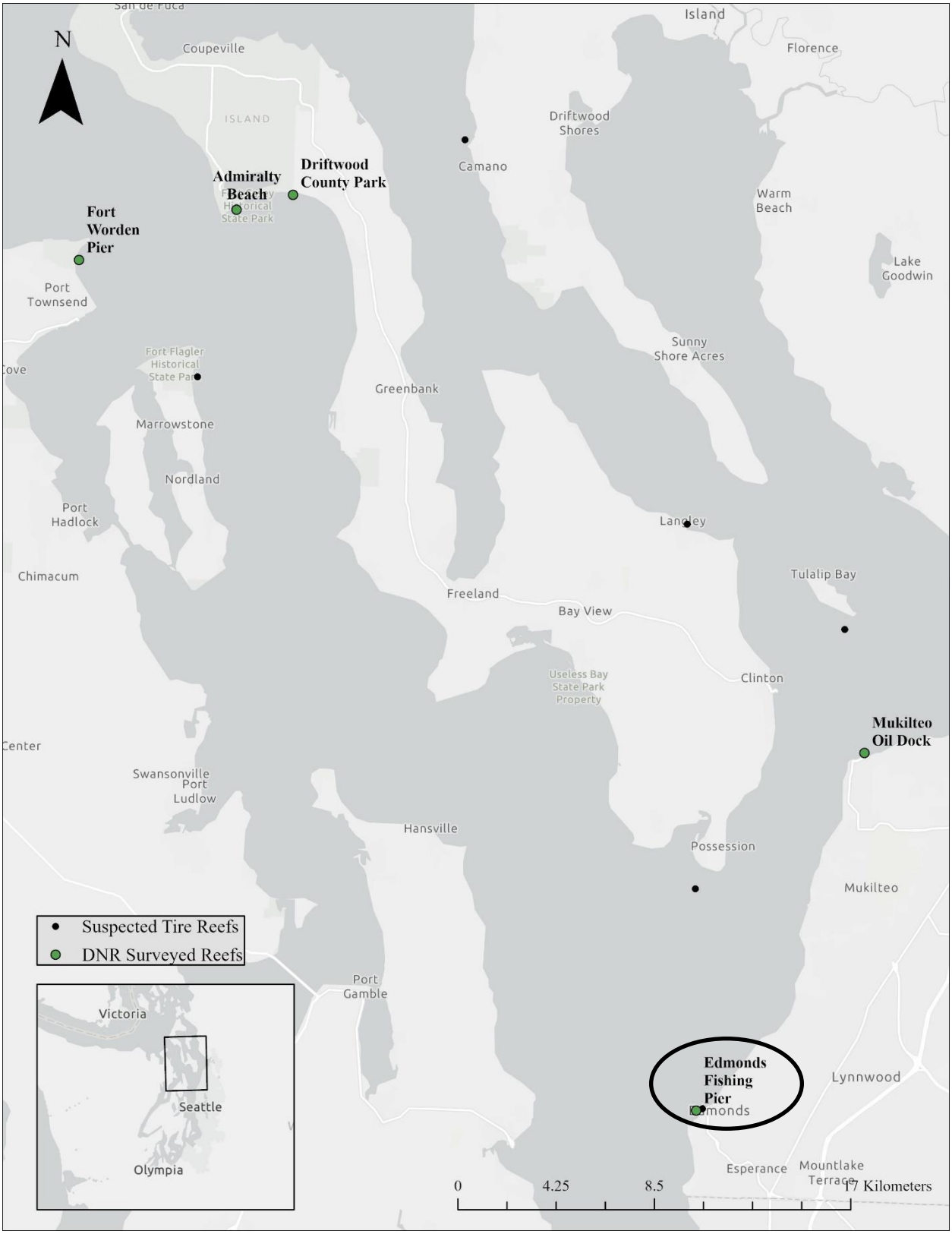


Figure 14. North Sound tire reef sites. The Edmonds site is circled.

Table 5. Coordinates of the Edmonds Fishing Pier Tire Reef Footprint.

	Latitude	Longitude
Center	47.811603 N	-122.389692 W
NW Corner	47.812802 N	-122.38839 W
NE Corner	47.812458 N	-122.388111 W
SW Corner	47.810276 N	-122.391736 W
SE Corner	47.810263 N	-122.391092 W

Reef Attributes

General Description of Reef

Construction of the Edmonds tire reef began in 1976 by the Marine Fisheries Enhancement Division. The first tire feature installed was a grid-designed structure approximately 1000 sq. meters in area, built by joining nearly 10,000 tires into 80 separate daisy shaped modules connected together with polypropylene line. This feature can be seen in multibeam bathymetry at the northern end of the reef (Figure 16). Walton (1982) included a diagram of the method by which this grid is built (Figure 19B). The footprint of the Edmonds fishing pier reef is approximately 3.43 acres in area. A large and organized main tire reef is centered on the -16m NAVD88 contour, oriented from north to south. The prevailing substrate here is soft mud and cobble in certain areas.

Tires

The Edmonds reef includes a variety of different tire features and forms that run approximately 370 meters long and 40 meters wide in front of the Edmonds fishing pier (Figure 15). Many different configurations of tire features have been added over time at this location. Other than the documented grid feature, we found tire feature types at the Edmonds Reef to include loose stacked, horseshoe, and barrel all joined with polypropylene line. The majority of the tires used in this reef appear to be standard passenger car tires. A very large loosely stacked grouping of tires to the north of the gridded feature was composed of tires raised only 10 cm off the surface (likely partially buried) with a footprint of ~400 m^2 (Figure 15 and Figure 16). There were also seven large piles of tires organized in stacks within the middle of the reef which are raised up to 2 m above the seafloor (Figure 16). It is possible that these piles could be stacked 3 to 4 tires high. In addition to these more organized features, it appears that a number of tires have been haphazardly arranged on the seafloor within the larger reef footprint. Features at the south end of the footprint are more spread out and have a higher chance of being mixed within large boulders from the marina jetty (Figure 15). Many of the bottom tires within larger features are partially (up to 50%) or entirely buried (Figure 25 and Figure 28). While some tires remain whole and in good shape, many are cut through the sidewall and tread (Figure 27).

Non – Tire Reef Features

A wooden structure, concrete pilings, and thin metal structure were all identified within the reef in video footage, but to a much lesser extent. Large anchor chain was identified with video

interspersed within some of the tires (Figure 21). Two different wastewater outfalls from the Edmonds wastewater treatment plant also diffuse into the mid to northern portions of the reef (Figure 20 and Figure 15). The concrete piping for these outfalls lies exposed and raised above the seafloor by approximately 0.75 m (cobble surrounds the base of outfall piping). In addition to these exposed features, an encumbrance (Quest Corporation) bisects a northern portion of the site, running perpendicular to shore. This is for a buried cable utility line (Figure 15).

Habitat Characteristics

The Edmonds Tire Reef lies within critical nearshore habitat for rockfish (NMFS 2015). Shelleburger Creek – which empties into the Edmonds Marina, was designated for presence and migration of Coho salmon and resident cutthroat by WDFW in 2006, and the wetland area upstream is designated as priority habitat (Figure 18). The deep edge of the reef is located within a subtidal geoduck tract (id # 0600) (Figure 18).

Sea stars, white anemones, and rockfish (*Sebastes caurinus*) were observed on and around tires in towed video. Eelgrass (sp. Unidentified) was observed in the immediate vicinity of the reef on the shore-side of tire pile features (47.811567, -122.389363) (Figure 29). Vegetation (likely both red seaweeds and kelp) was also observed growing on and around tires. This survey occurred at the beginning of the growing season, so confirmation of kelp was not possible from video footage.

Figures and Tables

Table 6. Edmonds Fishing Pier artificial reef attributes determined from multibeam sonar analysis.

Reef Attribute	**Minimum**	**Maximum**
Depth at NAVD88 (ft.)	-52.99 ± 4.60	-66.08 ± 6.51
Distance from Shore (ft.)	670	830
Reef Footprint Area (acres)	3.43	
Reef Node 1.5m Buffer Area (acres)	0.56	
Number of Tires	4,461 ± 512	12,219 ± 861
Tire Weight (lb.)	89,217	244,389

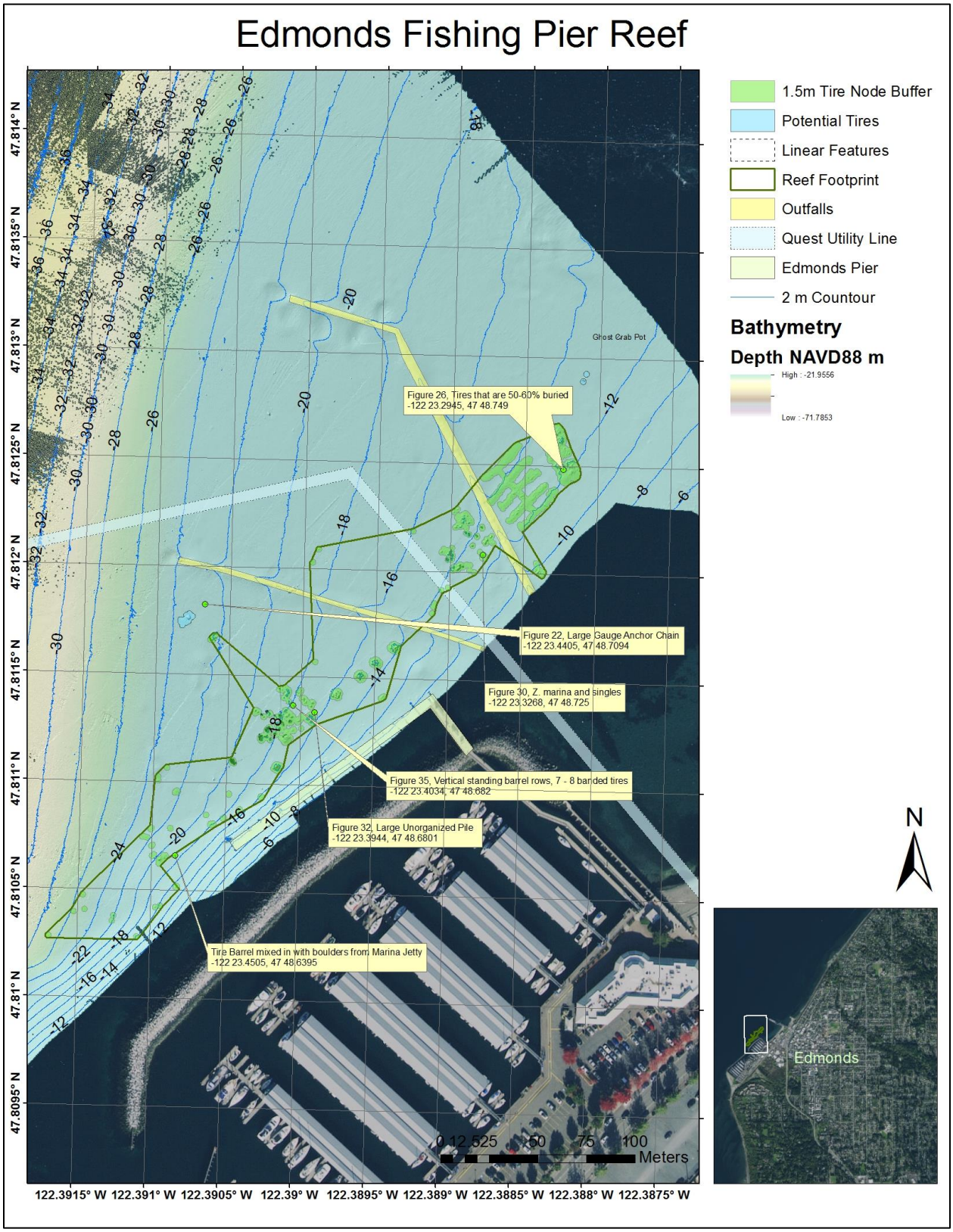


Figure 15. Edmonds Fishing Pier Reef

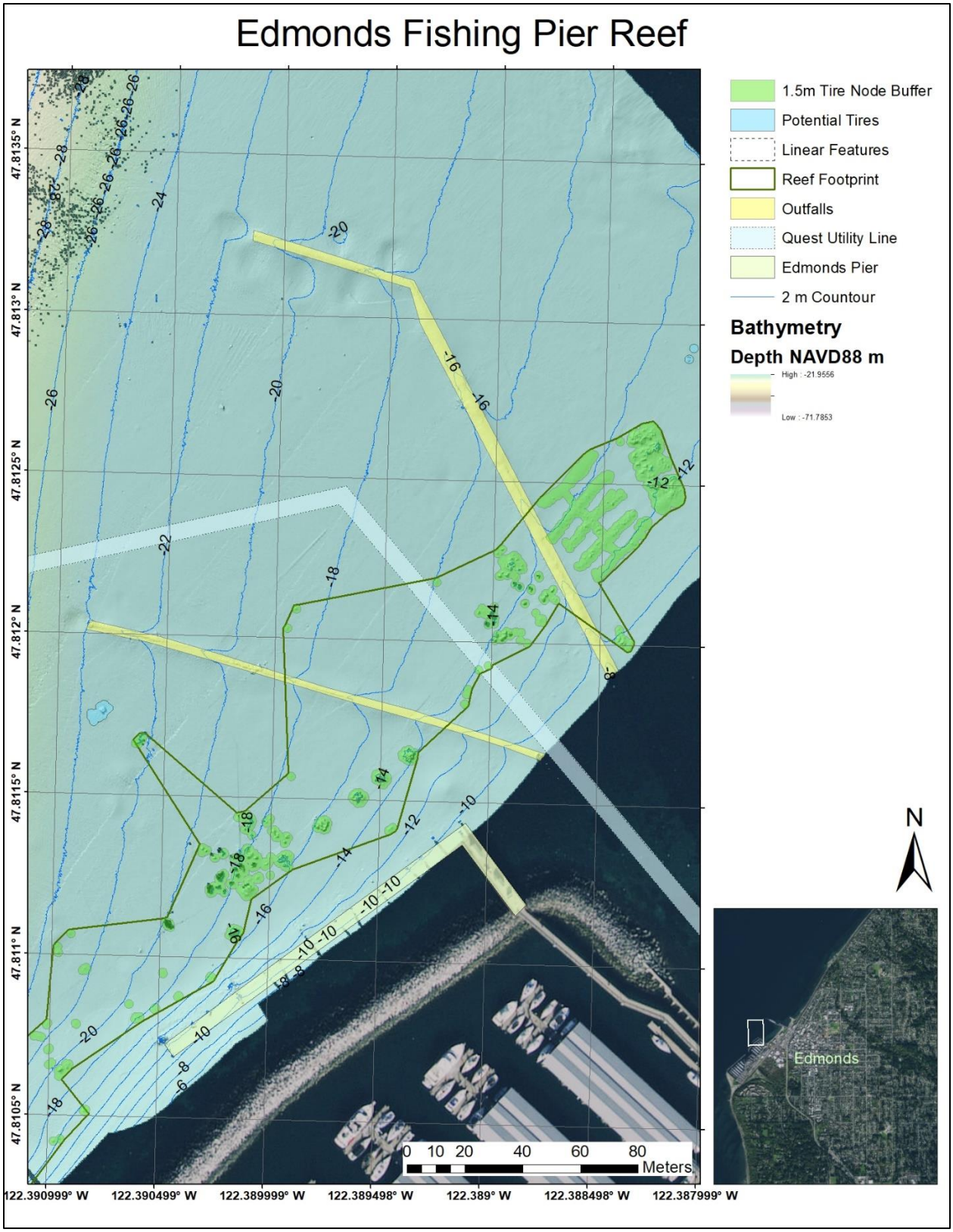
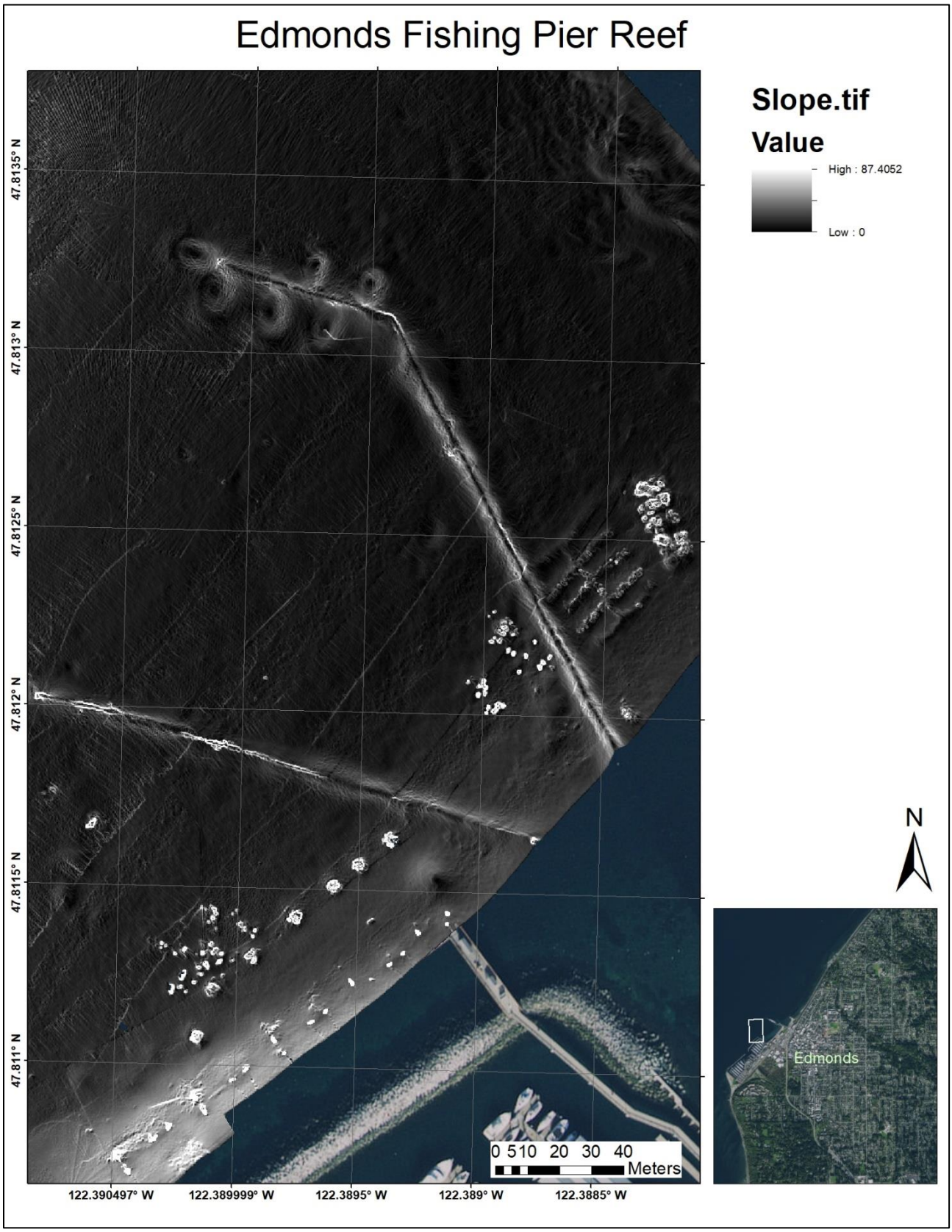


Figure 16. Focused view of main Edmonds Reef


Edmonds Fishing Pier Reef
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122.389999° W
122.3895° W
122.389° W
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0 5 10 20 30 40
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Figure 17. Slope layer generated from multibeam sonar data – this layer helps to identify features from a flat bottom.

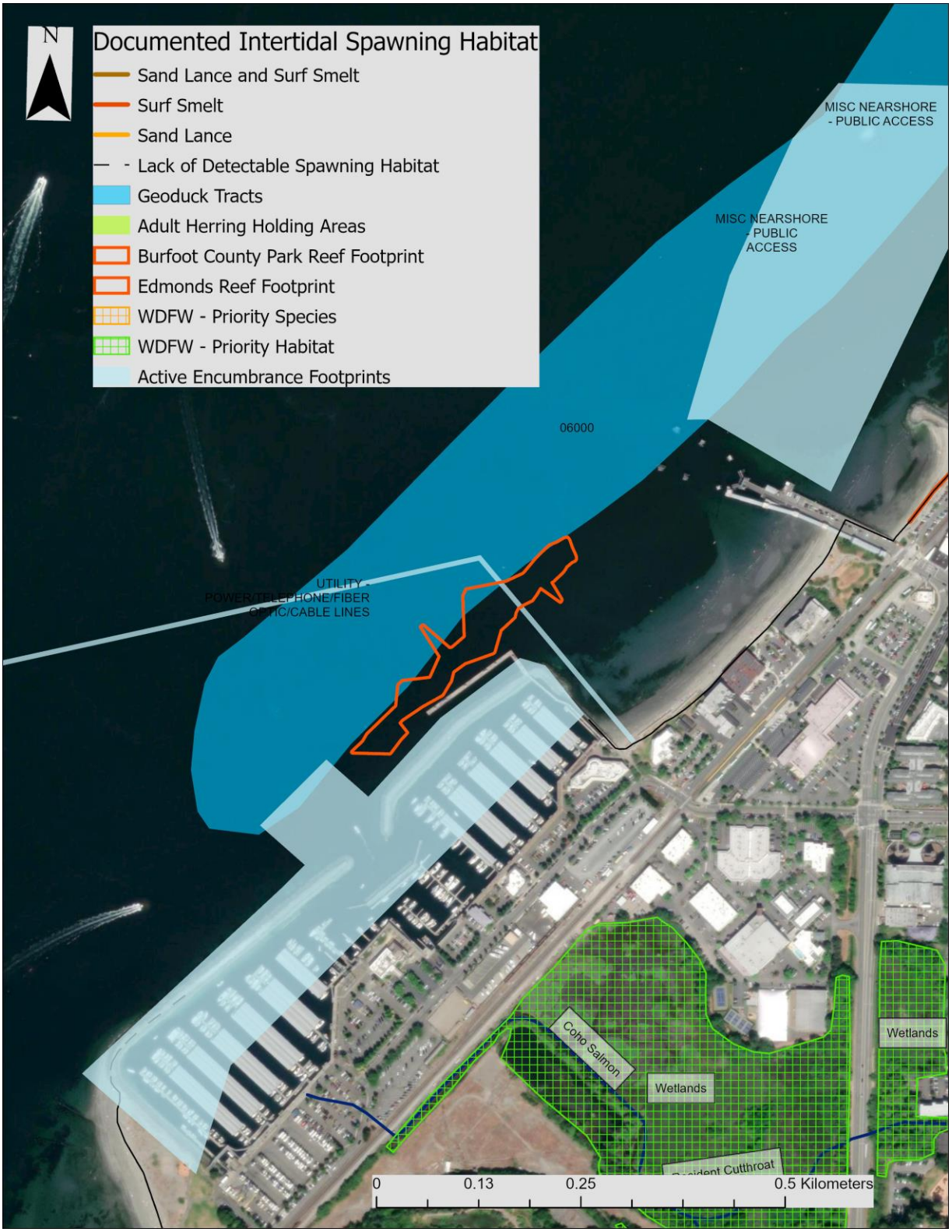

Figure 18. Habitat and species map of area surrounding the Edmonds reef.

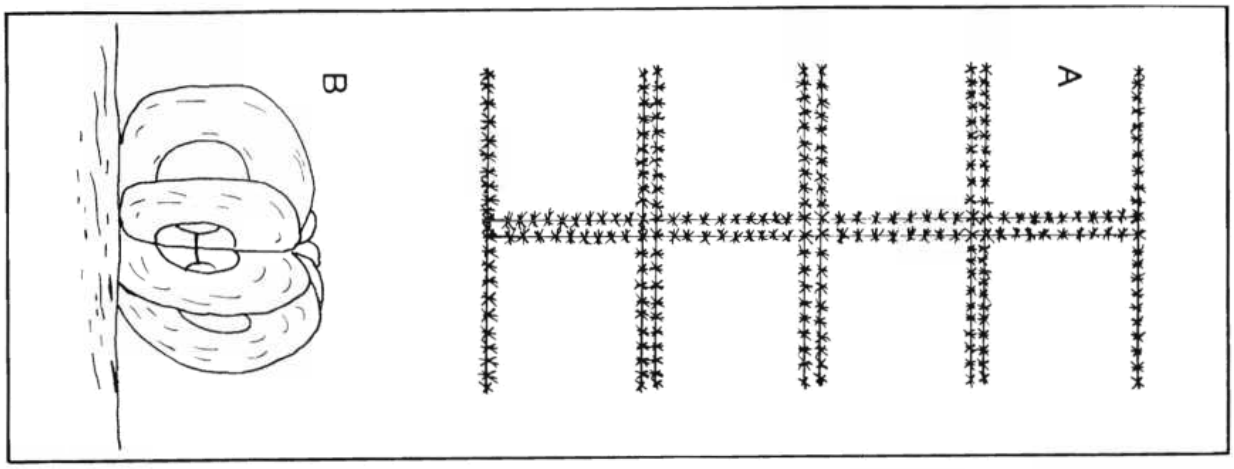

Figure 19. Figure from Walton, 1982. Showing (B) banding of individual tire "daisy formations" that compose the gridded feature to the north end of the reef, and (A) an aerial view of the gridded tire feature.

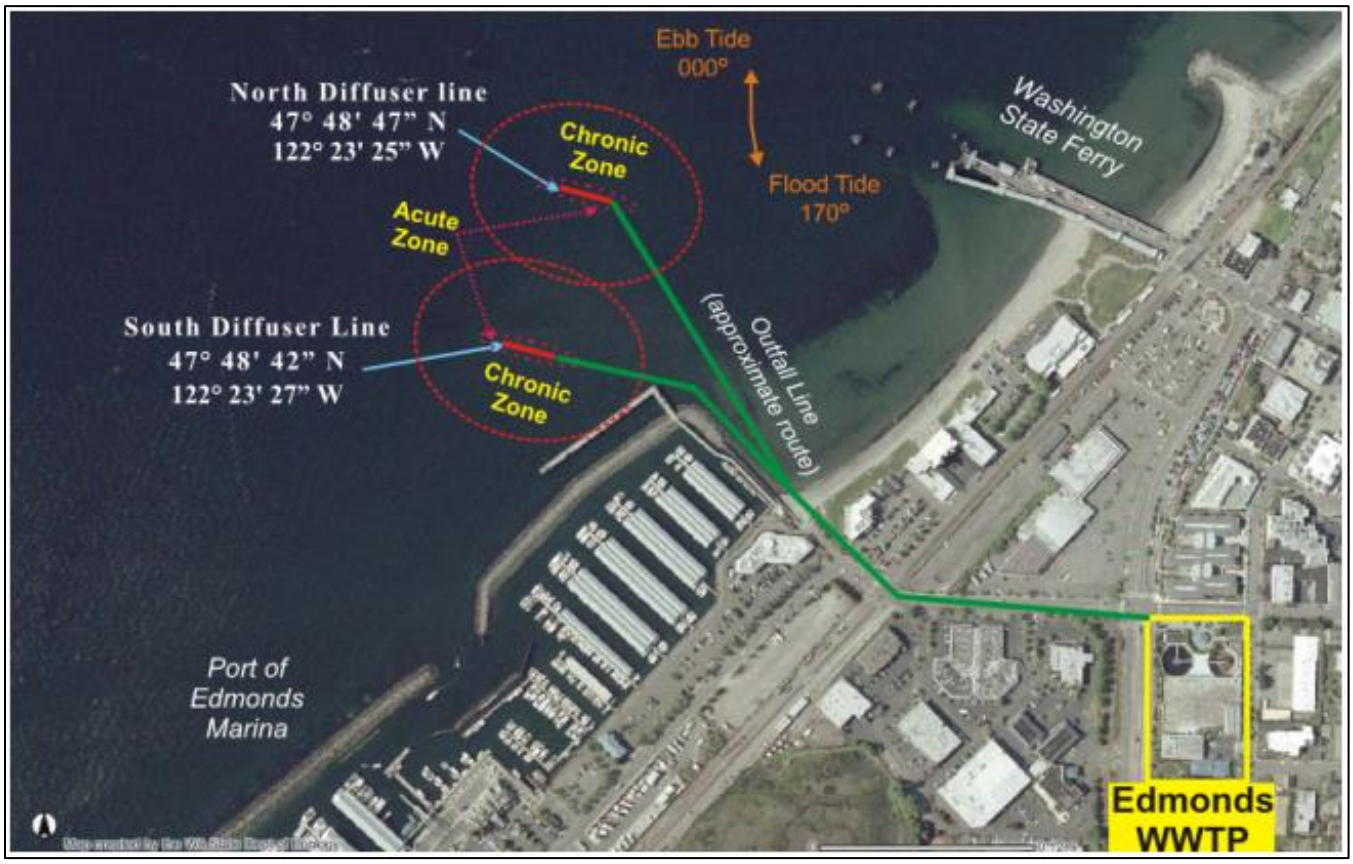

Figure 20. Location of outfalls that bisect the Edmonds Fishing Pier Reef. Figure taken from myedmondsnews.com

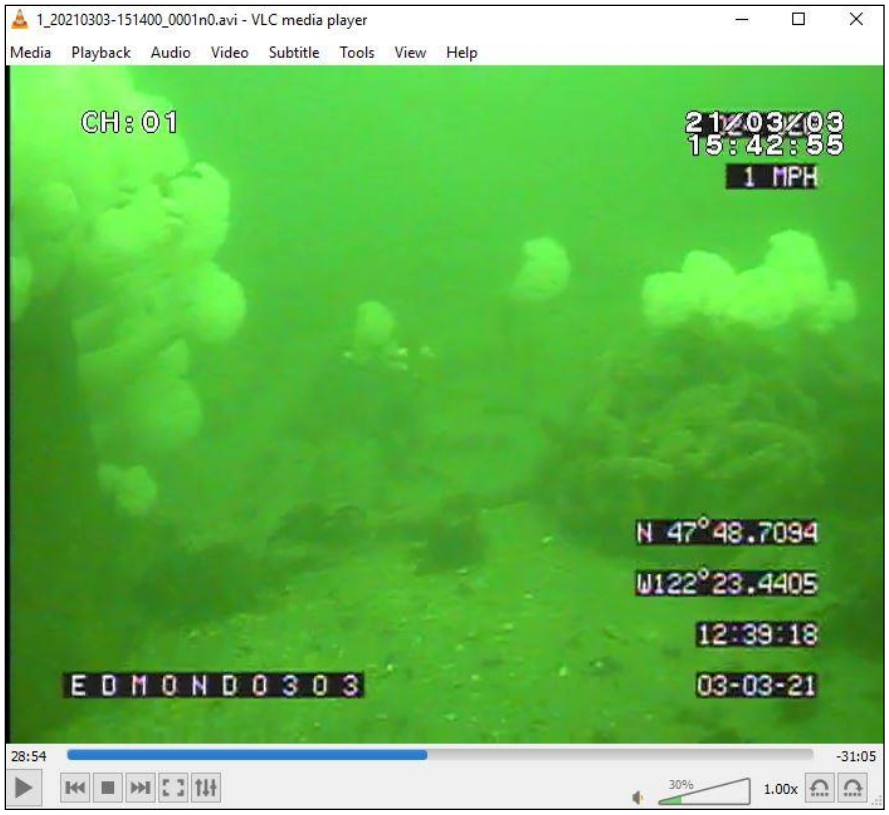

Figure 21. Large gauge anchor chain piled nearby tire features. It is unclear whether this chain is used to band tires.

Figure 22. White anemones growing on barrel banded tires.

Figure 23. Copper rock fish (*Sebastes caurinus*) among loose piled tires

Figure 24. Anemones and rockfish among tires

Figure 25. Tires 50-60% buried into mud and shell.

Figure 26. Barrel joined tires in background, standing upright.

Figure 27. Pile perch observed swimming amongst tires at the site. Air slits are present in many of the tires at the site.

Figure 28. Tires almost completely buried at the Edmonds reef.

Figure 29. Tires have separated from original banding and are lying flat on the sediment. These tires appear to be half buried in sediment with sparse eelgrass (*Zostera marina*) surrounding them.

Figure 30. Large loose piled tire feature within the Edmonds tire reef. See Figure 1 for position within the reef.

Figure 31. Unorganized tire pile at the Edmonds site. The tires in the bottom row in this feature are buried up to 50% into the sediment.

Figure 32. Tires buried more than 50% in sediment.

Figure 33. Unorganized tires buried up to 50% in sediment.

Figure 34. Organized barrel groupings of 6 to 7 tires per row for an overall tire count of 18 to 21 tires in frame.

Elliott Bay Fishing Pier Reef

Overview

Fifty-six acres were mapped around the Elliott Bay fishing pier (Pier 86) at Centennial Park in Seattle, WA on 2/26/2021. A large tire reef was found interspersed between boulder piles approximately 30 to 40 feet off the fishing pier. Tires at the site are bundled into barrel and pyramid formations with approximately seven to eight tires per band joined with polypropylene line. The condition of the tires and line banding barrel formations together is poor, as examples of broken rope were found throughout the site. Based on analysis estimates, between 5,069 and 8,848 tires are expected to be at this site, however many more tires may exist hidden among the boulder piles that separate two main tire groupings. Some tires at this site appear buried up to 20% in soft, muddy sediment. A few linear features were found in the reef and surrounding area, but the reef appears mainly composed of large boulders and tires.

Reef Location

General Description of Location:

The Elliott Bay fishing pier reef is located just offshore from the Elliott Bay fishing pier. It is in the northern most portion of Centennial Park, which is a large park running from Pier 90 to Pier 70 along the Seattle waterfront. The park is in an industrial location where both large passenger cruise ships and shipping tankers frequent to pick up passengers and cargo. The reef starts approximately 164 ft. offshore from the high tide mark and its center is located approximately 21 m (70 ft.) off the SE corner of the Elliott Bay Fishing Pier at 47.625612 N, -122.373892 W. The pier and reef are located with Port Management Agreement Number 22-080031 between the Port of Seattle and DNR (Figure 37). The closest public boat launch is located at the Don Armeni Boat Ramp in West Seattle, by Alki Beach.

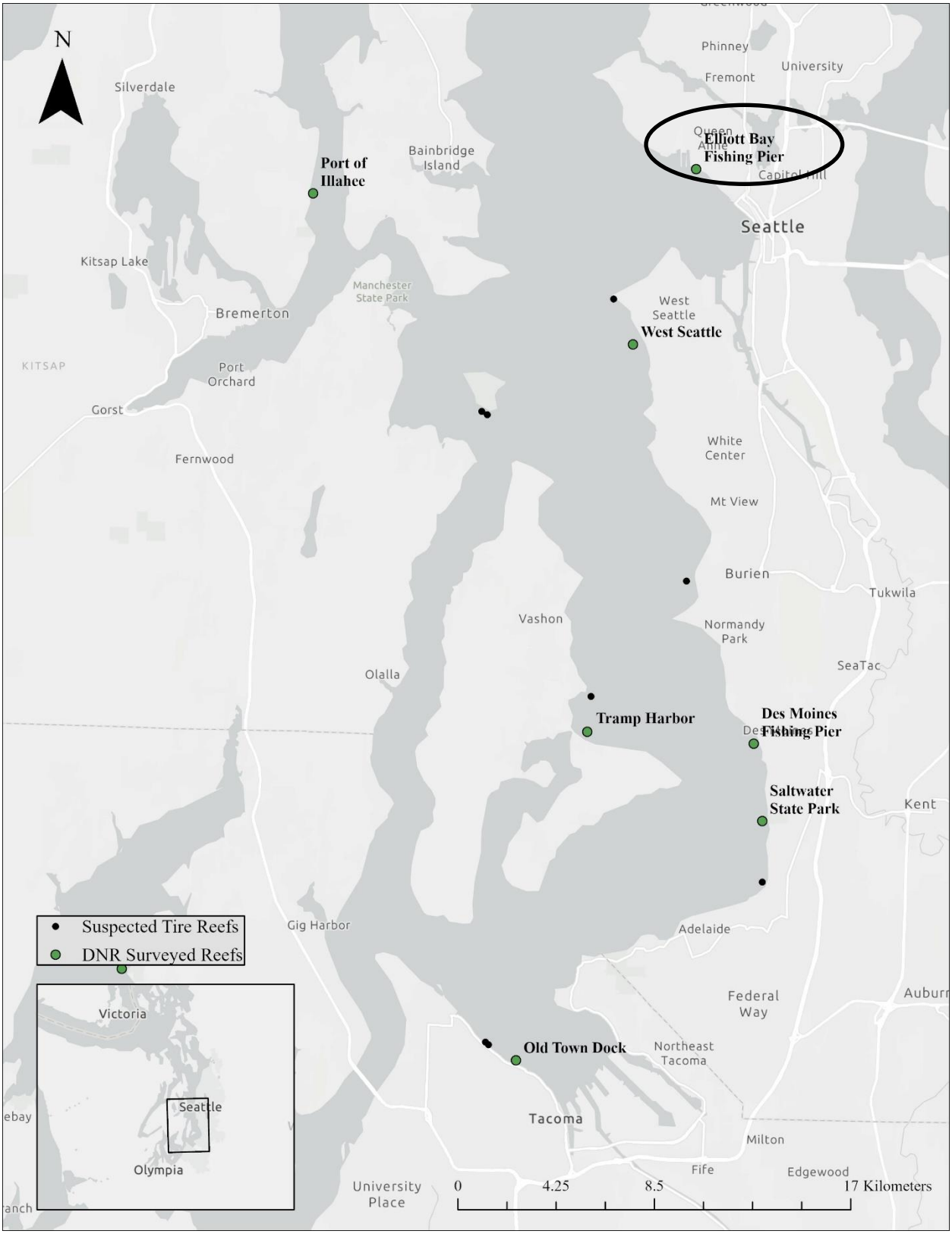

Figure 35. Middle Sound reef sites. The Elliott Bay site (Seattle Fishing Pier) is circled.

Table 7. Coordinates of the Elliott Bay fishing pier tire reef footprint.

	Latitude	Longitude
Center	47.625612 N	-122.373892 W
NW Corner	47.626083 N	-122.375694 W
NE Corner	47.625034 N	-122.371556 W
SW Corner	47.625919 N	-122.376211 W
SE Corner	47.624754 N	-122.371838 W

Reef Attributes

General Description of Reef

Construction of the Elliott Bay reef began in 1974 with the establishment of the fishing pier at Centennial Park. In 2017, public access was closed due to the poor and hazardous condition of the dilapidated pier (Dolan, 2020). The Elliott Bay reef runs parallel (west to east) adjacent to the pier, and is 365 m (1200 ft.) long and 42.6 m (140 ft.) wide. The reef is composed of tire and boulder features and covers a total footprint of 3.23 acres. The 1.5 m buffer footprint of tires at the site covers half an acre while the 1.5 m buffer footprint covered of boulders at the reef is roughly one acre. Due to the proximity of confirmed tire features to boulder features in the reef, our confidence that tires are accurately delineated from boulders within multibeam data is low for this site. To increase this confidence, additional diver, video, or ROV surveys are needed.

Tires

The majority of tire features at the Elliott Bay fishing pier reef are barrel joined into rows of 7 to 8 tires and stacked into pyramid configurations with 21 to 24 tires per pyramid. These tires appear in poor condition - many tires have been sliced open upon placement, and tires within barrel groupings have been compressed together over time becoming thinner Figure 42 and Figure 45). Two main tire groupings to the west and east are separated by a large boulder zone between them (Figure 36). The east grouping of tires is more spread out than the west (Figure 36). Many of the tires at the site were found no more than 10% buried into fine sediment, but some – like those at the bottom of pyramid or barrel features – were found buried up to 20% into the sediment (Figure 38).

Non -Tire Reef Features

A few linear features were identified – possibly logs or cement pilings laying horizontal within boulder piles (Figure 36) as well as a few unidentified features that were deeper than the reef footprint.

Habitat Characteristics

The Elliott Bay Fishing pier reef lies within critical nearshore habitat for rockfish species. The water to the deep edge of our survey is also classified as deep-water critical habitat for rockfish (NMFS 2015). It lies within WDFW priority estuarine zone habitat (Figure 37).

Red algae were observed growing on tires at the Elliott Bay fishing pier reef in video survey. Kelp (likely *S. latissima*) was also observed growing amongst structure at the site. Sea cucumber (*A. californicus*) were observed among the rocks at the site.

Figures and Tables

Table 8. Elliott Bay Fishing Pier artificial reef attributes determined from multibeam sonar analysis.

Reef Attribute	**Minimum**	**Maximum**
Depth at NAVD88 (ft.)	-26.63 ± 5.96	-64.59 ± 1.62
Distance from High Tide Line (ft.)	164	264
Reef Footprint Area (acres)	3.23	
Reef Node 1.5m Buffer Area (acres)	0.53	
Number of Tires	5,070 ± 188	8,849 ± 1,654
Tire Weight (lb.)	101,394	176,980

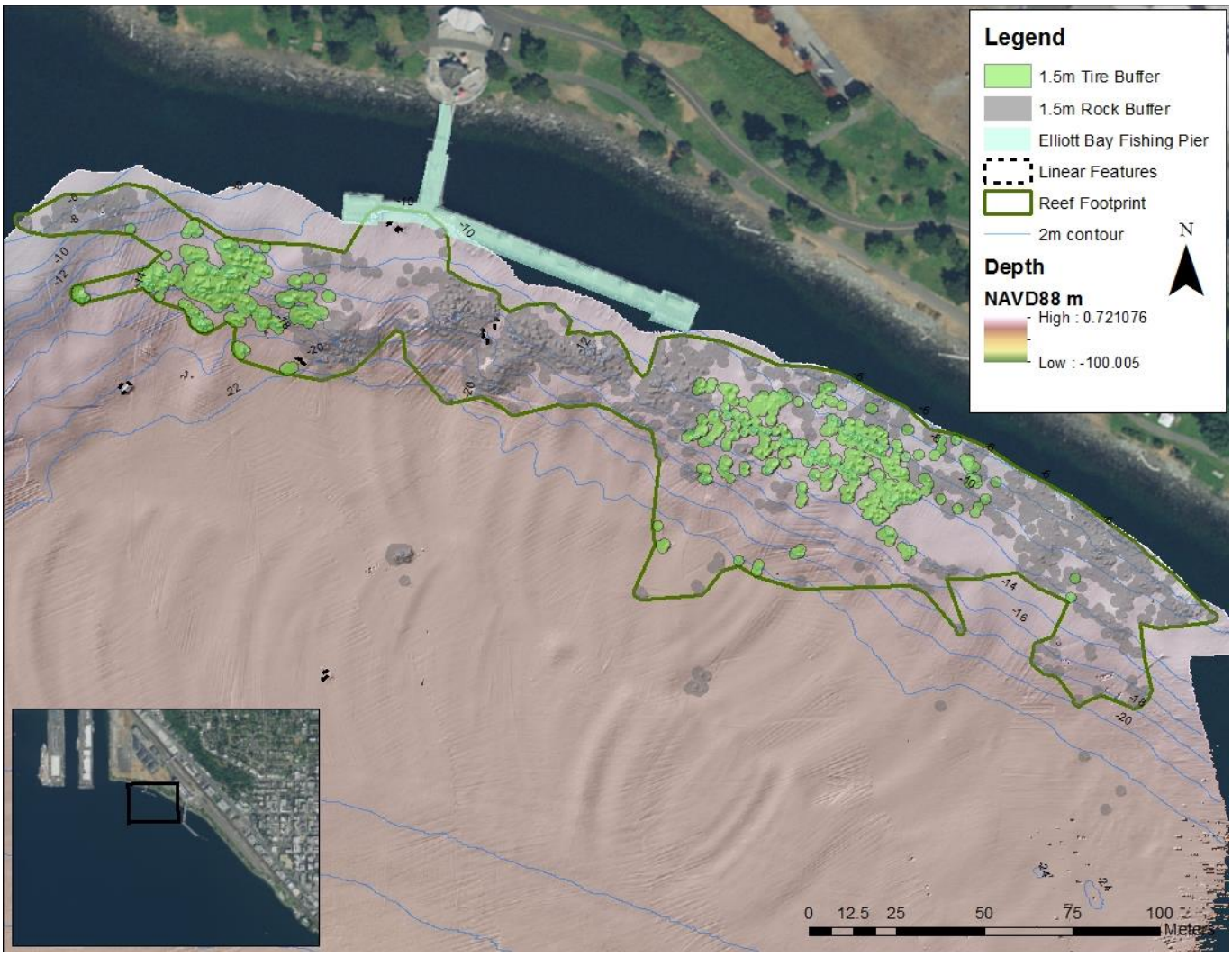

Figure 36. The Elliot Bay Fishing Pier Reef.

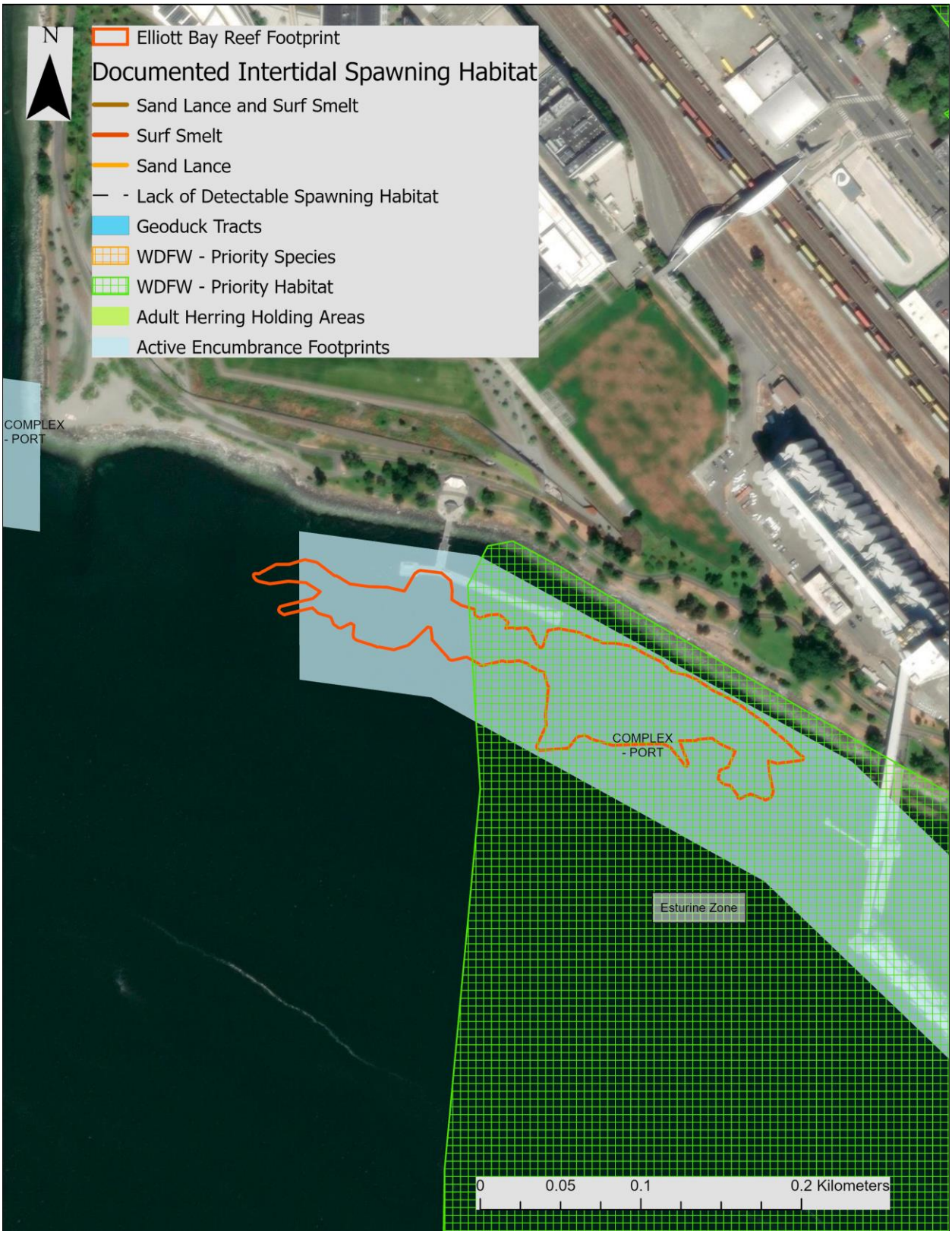

Figure 37. Habitat and species map of the area surrounding the Elliott Bay reef.

Figure 38. Pyramid - stacked tires present at the Elliott Bay Site. Pyramids are created from 8 - 10 tire barrel rows. Two barrels are connected to a "peak" barrel with polypropolene line. Tires on bottom row appear to be buried up to 1/4 into the sediment.

Figure 39. Tires banded in a pyramid formation are banded with multiple sections of polypropylene line.

Figure 40 . Tires at this site have been sliced to allow air bubbles to escape during placement.

Figure 41. Bundles of barrel laced tires at the Elliott Bay site.

Figure 42. Tires at the Elliott Bay reef are a mix of tires. At left appears what may be a military vehicle tire banded to a row of standard passenger vehicle tires. Bundled rows appear to include 8 to 10 tires.

Figure 43. Pyramid of tires at the Elliott Bay site. Line that bands the tires is broken around the tires within this bundle.

Figure 44. A closer view of broken line around the tire bundles at the site.

Figure 45. ROV footage form the Department of Fish and Wildlife. A barrel of eight tires in present in foreground.

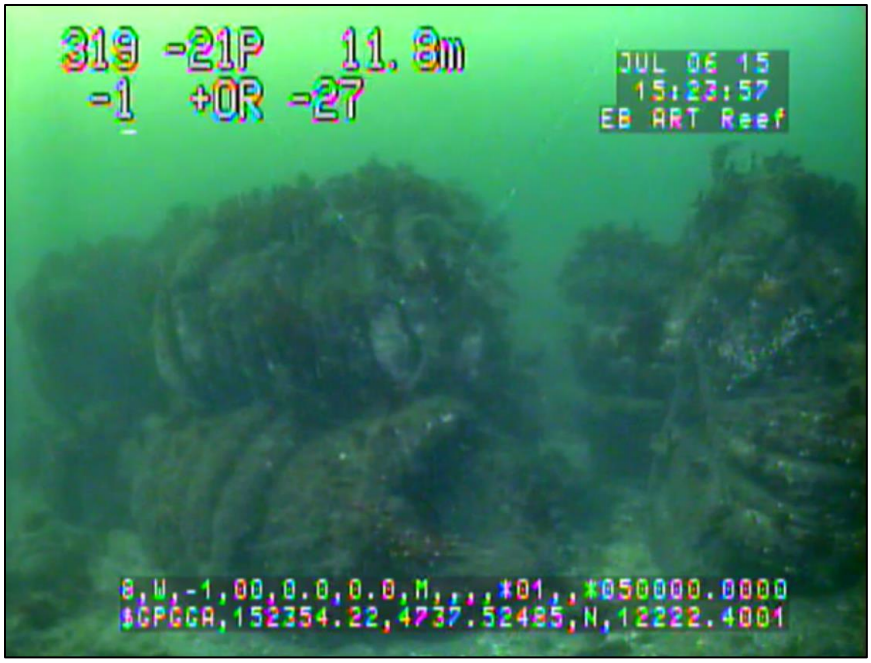

Figure 46. Footage collected by the WDFW. Tire pyramids stacked three rows high.

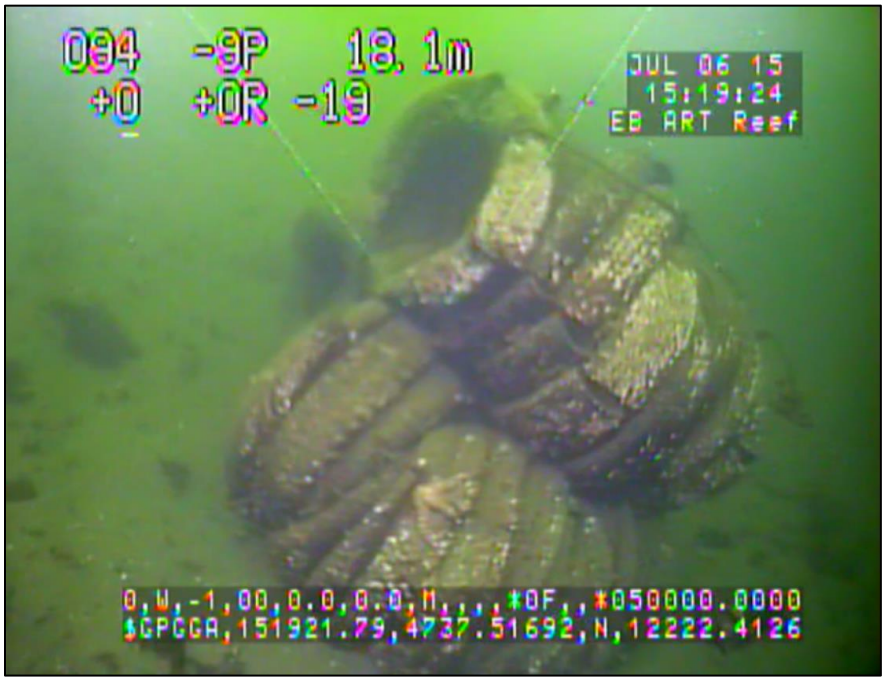

Figure 47. Additional WDFW footage of tire bundle.

Figure 48. Bundles stacked vertical at the Elliott Bay Site (WDFW footage).

4.5 Illahee

Port of Illahee Dock Tire Reef

Overview

Thirty-eight acres were surveyed on 5/13/2021 off the Illahee Dock. The site lies between Illahee and the west side of Bainbridge Island and is offshore of the Port of Illahee dock – a port owned structure in Illahee, Washington that is used for recreational fishing and boating. A moderately sized tire reef was found at this site and mapped with mutlibeam sonar. The reef runs along the east side of the Illahee Dock, centered approximately along the -7 m NAVD88 bathymetric line.

Visibility was poor on 5/13/2021 due to phytoplankton blooms, and WDFW ROV footage from 2016 has supplemented for video analysis (Robert Pacunski Pers. Comm.). Despite poor visibility, tires appear loose stacked in groups of 10 to 30, with the bottom layer of tires buried up to 50% in fine sediment. Individual piles within the reef are connected with thick rope.

Reef Location

General Description of Location:

The center of the Illahee tire reef is located approximately 354 feet off the beach, and 122 feet to the northeast from the southeast corner of the Port of Illahee dock at 47.612987 N, -122.594735 W. The closest commercial ramp in the area is in Port Orchard. This ramp is inaccessible at low

tide. A SOAL lease held by the Port of Illahee covers the very south end of the tire reef (Figure 52).

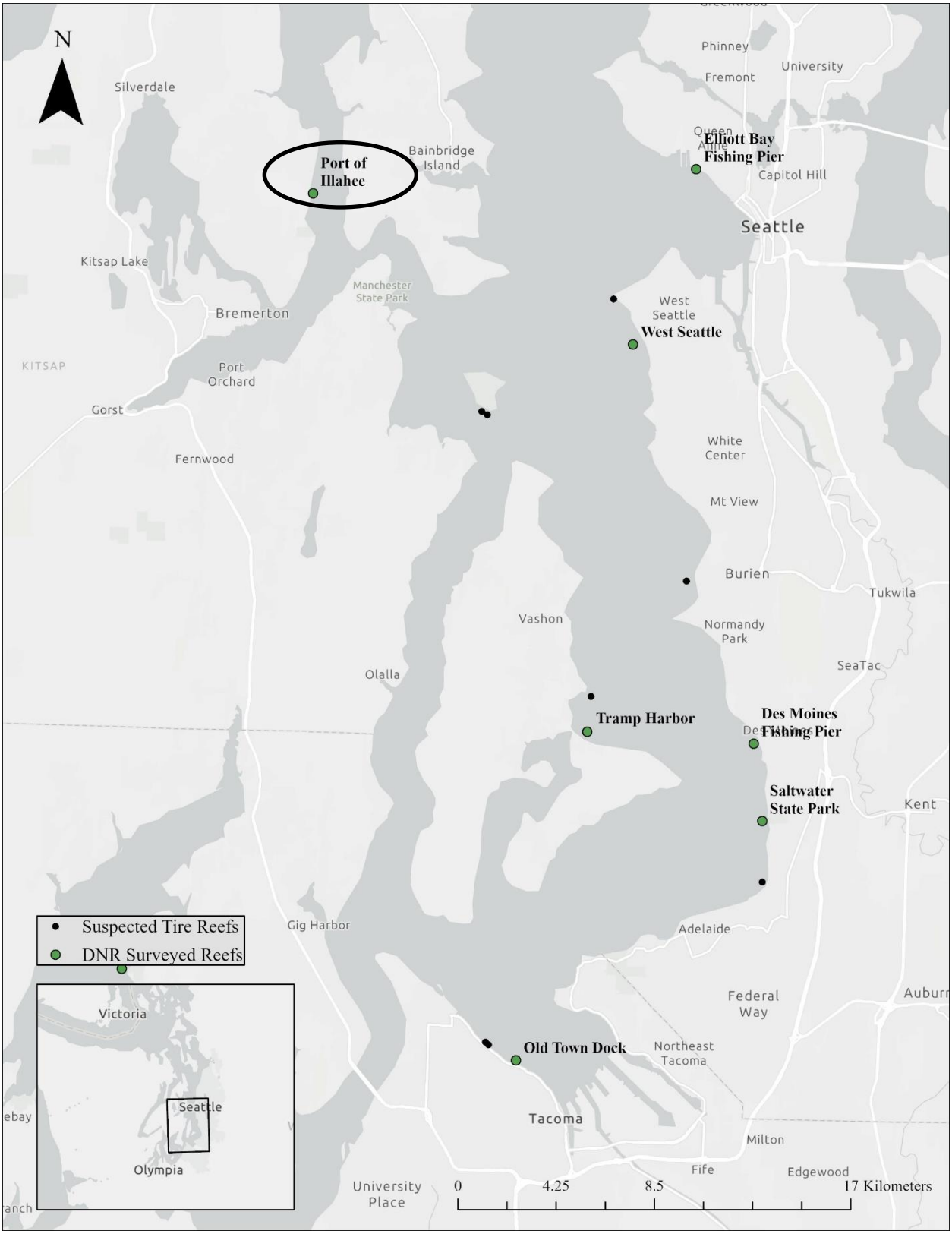

Figure 49. Port of Illahee Dock Reef Location is circled.

Table 9. Coordinates of the Illahee Dock Tire Reef Footprint. Potential reef features to the North of confirmed tires elongate this footprint (Fig. 1).

	Latitude	Longitude
Center	47.612987 N	-122.594735 W
NW Corner	47.614033 N	-122.595013 W
NE Corner	47.623756 N	-122.594587 W
SW Corner	47.612488 N	-122.594824 W
SE Corner	47.594491 N	-122.612507 W

Reef Attributes

The footprint of the Port of Illahee dock reef is approximately 1.34 acres in area. The survey confirmed a large and organized main tire reef centered on the -7 m NAVD88 contour, which is oriented north to south. The prevailing substrate here is soft mud with some shell.

Tires

The reef is primarily composed of tires and is approximately 80 feet wide and 350 feet long (Figure 50). Three organized rows of loose stacked tires appear to have been placed running parallel to each other from north to south (Figure 51). In addition to this confirmed grouping, potential tire features were identified as far as 64 m (211 feet) to the north from the north edge of the main reef (Figure 50). The condition of tires at this site are poor, and many are buried up to 50% in fine sediment. The tires appear to be of different sizes (standard passenger and of thinner dimension – (Figure 61)), and have either broken apart from organized stack formations or were originally placed haphazardly in loose stacked piles (Figure 57). Many of these tires have slashes through the sidewall for air escapement (Figure 60). Tires and tire piles appear connected together with bridles of thick line. This line was observed suspended horizontally off the bottom between piles (Figure 62).

Non – Tire Reef Features

In addition to tires, a concrete piling was found at the southern end of the reef at (47.61256633 N, -122.5944867 W). This is identified as a linear feature at the southern end of the main reef (Figure 51). Although this object was not captured on video footage, it is likely that this feature is an additional concrete piling.

Habitat Characteristics

A stream approximately 222 m (730 ft.) to the south of the Illahee dock is documented for presence and migration of Coho salmon, fall chum, and resident cutthroat (WDFW 2010). The reef also lies within critical nearshore habitat for rockfish, and is designated inshore of an adult herring holding area (NMFS 2015) (Figure 52). In 2006, there was documented intertidal spawning on the beach approximately 1,280 m to the north of the reef footprint for smelt (WDFW 2006). The reef sits on the edge of footprints for the Illahee and Illahee North Geoduck

Tracts (Tract codes 07350 and 07360) (WDFW 2005) (Figure 52). There is WDFW designated priority estuarine habitat to the south of the Illahee tire reef surrounding the mouth of this stream (WDFW 2021) (Figure 52).

Hundreds of sea cucumber (*Apostichopus californicus*) and red seaweed (sp. Unidentified) were observed in video footage within and covering the tire reef. Slender sea pens (*Stylatula elongata*) were also abundant in the soft substrate on the east edge and deeper than the reef between -10 and -14 m contours (from 0 to 40m in distance from the deep edge of the reef). No eelgrass was observed in the immediate vicinity of the reef, however, it was present approximately 100ft away on the shallower regions of the shelfed delta to the south.

Figures and Tables

Table 10. Port of Illahee dock artificial reef attributes determined from multibeam sonar analysis. Note: Due to the loose stacking of tires and the poor video conditions on the day of survey, it was difficult to estimate the number of tires per mound. Due to these factors, the estimate of tire maximum may be lower than what is actually there.

Reef Attribute	Minimum	Maximum
Depth at NAVD88 (ft.)	-18.68 ± 2.46	-29.37 ± 3.04
Distance from Shore (ft.)	307	389
Reef Footprint Area (acres)	1.34	
Reef Node 1.5m Buffer Area (acres)	0.40	
Number of Tires	2,307 ± 243	9675 ± 3903
Tire Weight (lb.)	49,154	80,620

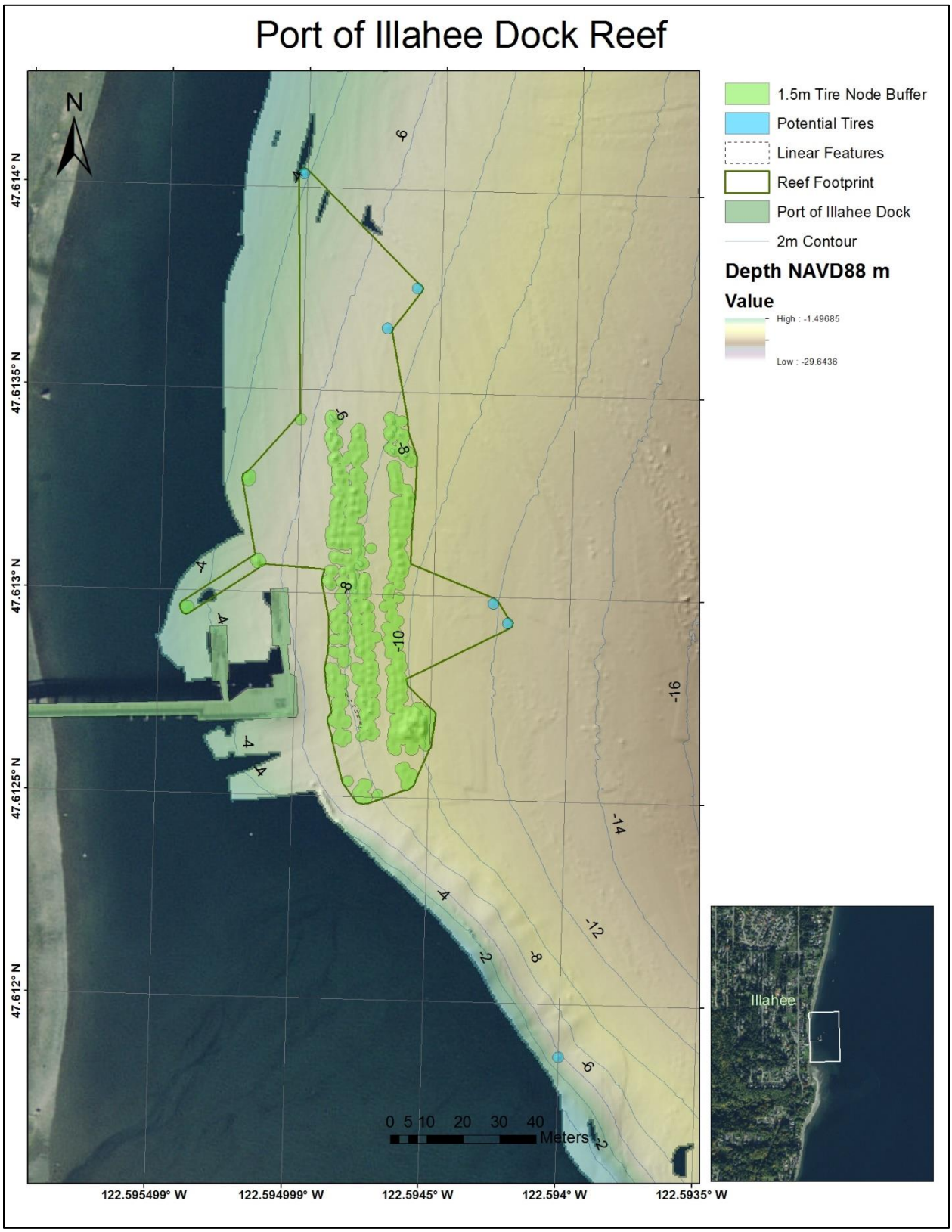

Figure 50. Extended view of Port of Illahee Dock Tire Reef

Figure 51. Focused view of Illahee Dock Reef

Figure 52. Habitat and species maps for the area surrounding the Illahee Reef.

Figure 2. Rope bridal (indicated with arrows) observed attached to a grouping of tires. The nearest tire is delineated with a hashed line.

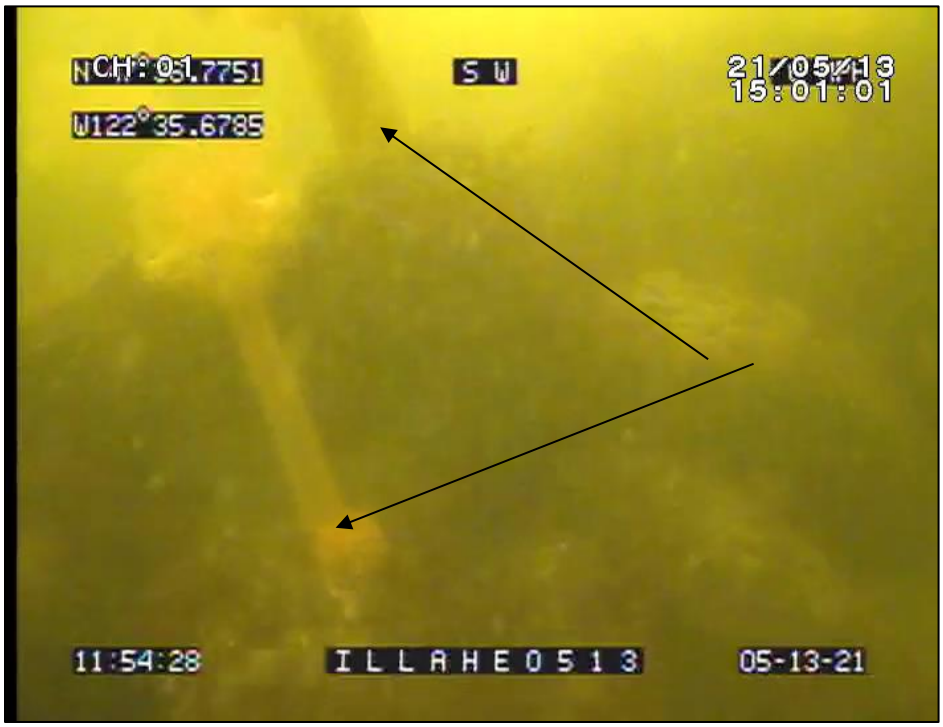

Figure 53. Loose stacked tires. White anemones were observed attached to the outer walls of tires.

Figure 54. Sea cucumber (*Apostichopus californicus*) were observed inside and on top of tires at the Illahee Dock tire reef.

Figure 55. Red seaweeds observed covering tires at the Illahee Dock tire reef.

Figure 56. Sea pens were found in the soft sediments surrounding the Illahee tire reef.

Figure 57. Image from 2016, captured with WDFW ROV. Tires at the site appear to be buried up to 1/2 in fine sediment and strewn haphazardly in loose piles.

Figure 58. Image from 2016, captured with WDFW ROV. Tires ½ buried in fine sediment. Rope in forefront of image appears to tie loose bundles together. Also evident from the image are tires with slashes through them at forefront left.

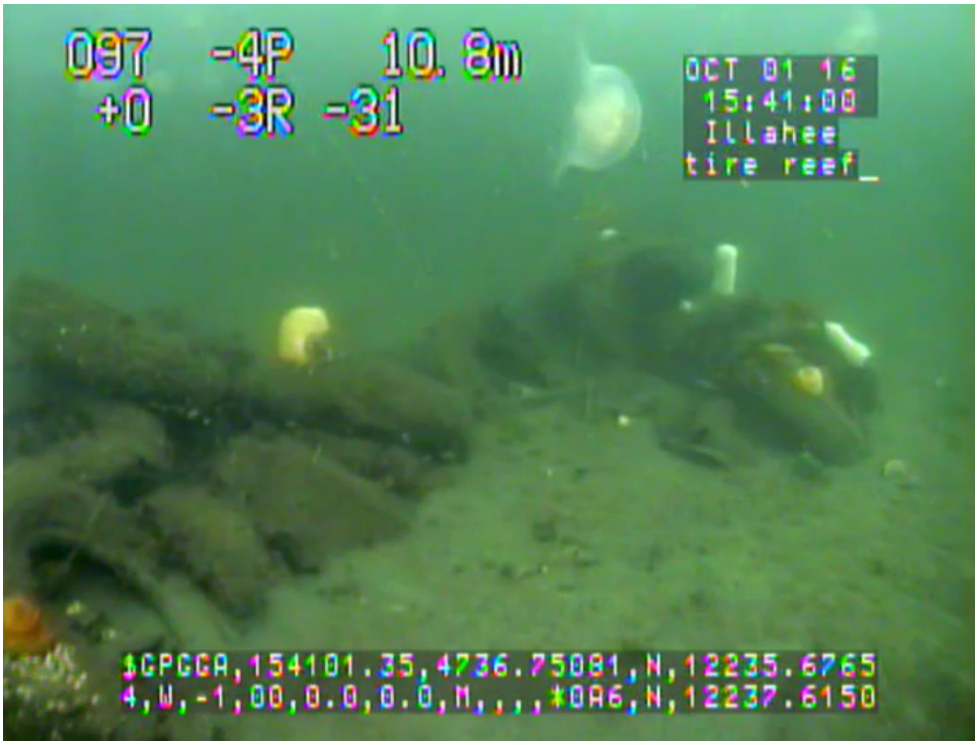

Figure 59. Image from 2016, captured with WDFW ROV. Single layers of tires buried up to 1/2 were present throughout the Illahee reef.

Figure 60. Image from 2016, captured with WDFW ROV. Tires were likely placed in haphazard loose piles at the Illahee reef.

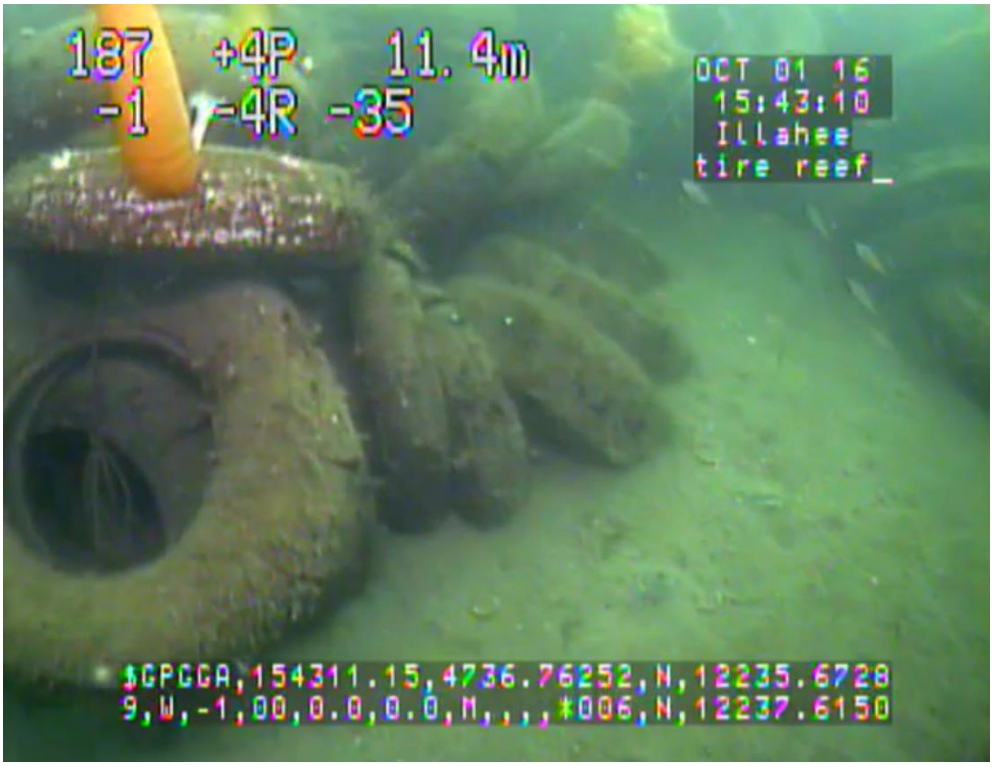

Figure 61. Image from 2016, captured with WDFW ROV. Tires of various sizes are present at the Illahee reef.

Figure 62. Image from 2016, captured with WDFW ROV. Thick ropes that likely tie the reef together run along three main rows of the reef.

Figure 63. Image from 2016, captured with WDFW ROV. A different view of ropes that connect the Illahee reef.

4.6 Des Moines

Des Moines Pier Tire Reef

Overview

Roughly 20.9 acres were surveyed on 3/8/2020 at the Des Moines Fishing Pier in Des Moines, WA. The pier at this site is built of concrete pilings, galvanized metal, and extends into the main basin of Puget Sound. The site is a popular fishing location. Nearby and to the South is the Des Moines marina. A very large reef was identified and mapped by DNR AAMT staff. Many different materials were found to make up the reef. These were identified with multibeam sonar and confirmed with towed camera/ ROV video. The reef materials included tire mounds (both loose and barrel stacked), unidentified metal structures, large concrete blocks, large hills of two-person sized boulders, toilets, bathtubs, and other miscellaneous refuse. Interspersed brown macro algae (possibly Sacharinna latissima) and green algae (Ulva lactuca) were found within portions of the reef with video.

Reef Location

General Description of Location

The city of Des Moines has lease number 20-A09080 with DNR for a rock breakwater, publish fishing pier, parking lot, restroom, open and covered moorage, and a vessel access channel to the marina. The center of the Des Moines tire reef is located approximately 781 feet to the West of this parking lot and lies at the very end of the fishing pier (Figure 65). Two outfalls empty at the northern extent of the tire reef footprint. The first (an agreement between the Des Moines Creek Basin Committee and DNR (# 51-075748)) is for a pipeline that discharges excess stream flow. The second is an easement held by the Midway Sewer District (# 51-071144) for a submarine outfall and diffuser located on bed lands north of the fishing pier as well on the northern edge of the Des Moines reef.

Two additional easements are located outside the Des Moines tire reef footprint – the first is for a sewer outfall pipe that extends onto state-owned aquatic lands from S. 2227th Street. This easement is held by the Des Moines Sewer District (agreement number 51-025261). A second easement for a utility cable that runs from the southern end of the Des Moines marina across the Sound to Maury Island is held by Puget Sound Energy (# 51-027510 with DNR) (Figure 67). While both this outfall and utility cable are outside the main portion of the reef footprint, they should be noted for barges and other equipment during any tire structure removal activity (Figure 67).

The closest boat launch to the site is at the Des Moines Yacht club and is private. There is a public launch located to the South in Redondo. This launch is exposed to inclement weather from the southeast, and does not have walkable docks during winter months.

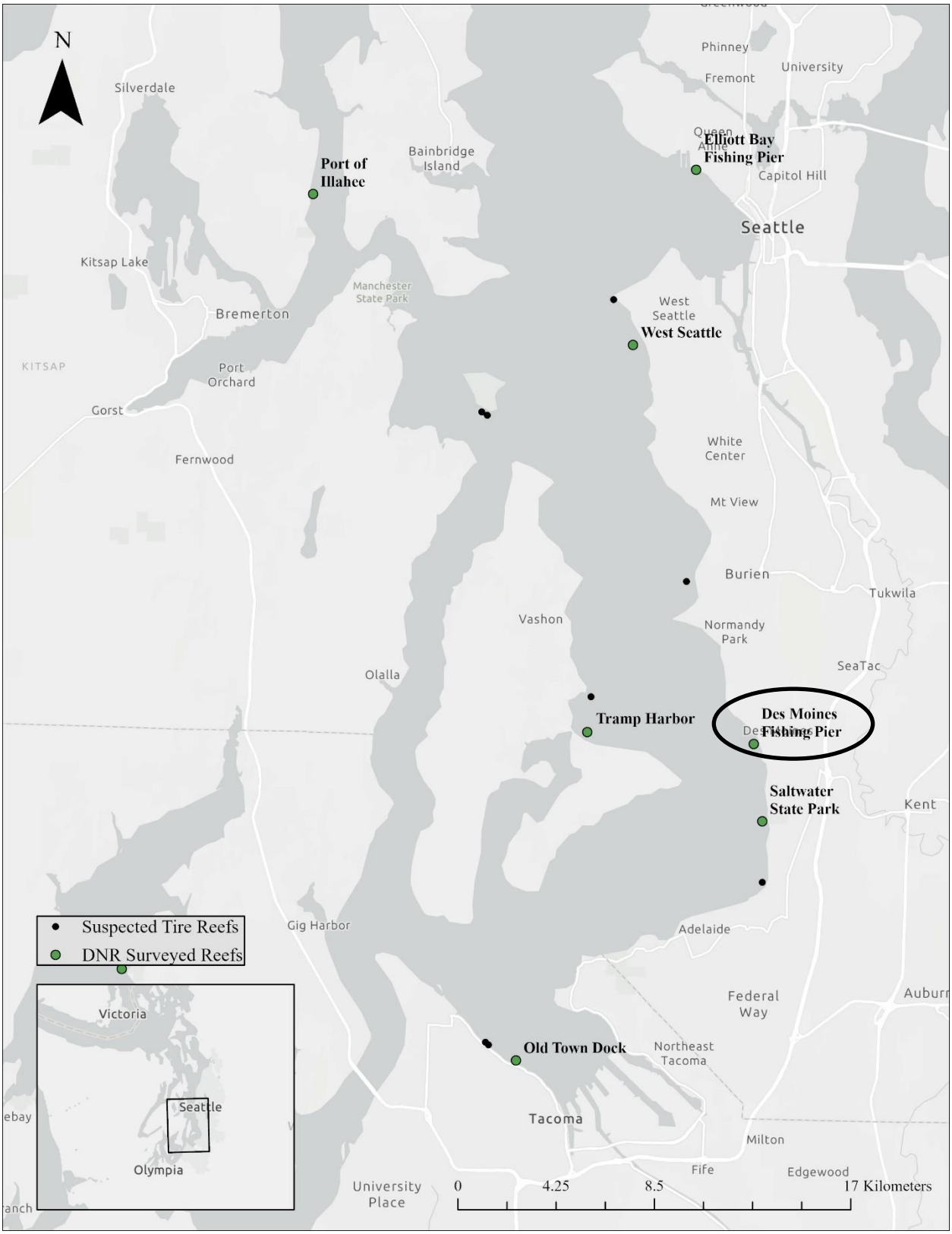

Figure 64. Mid Sound tire Reef sites, the Des Moines Site is circled.

Table 11. Coordinates of the Des Moines Pier Tire Reef.

	Latitude	Longitude
Center	47.402351	-122.334529
NW	47.402844	-122.335712
NE	47.403395	-122.334346
SW	47.401295	-122.333941
SE Corner	47.402074	-122.332828

Reef Attributes

Tires

The Des Moines reef is large (5.7 acres) and "intact", meaning many automobile tires are still barrel laced with polypropylene rope. Bundles typically hold 8 to 10 standard passenger car tires, but this can vary ±2 tires. Most of the barrel-laced bundles lay horizontal and are stacked in pyramids of three barrels (two at base and one at the top ~ 24 to 30 tires per bundle), however some are also vertically stacked. Tire bundles are held together with three strand polypropylene line, and some may also have steel rebar entangled within them. There also appears to be line or anchor chain lying on the bottom in between bundles. This may suggest that the tire pyramids are connected. For some bundles, the polypropylene line keeping them together appears to have failed, allowing tires to be separated (Figure 69). Most tires in the bottom level of tire bundles are buried no more than 10% into the sediment. The sediment at this site is characterized by mixed cobble, sand, and shell at the shallow reaches of the survey, which changes to fine sand further out.

Non- Tire Reef Features

In addition to tires, there are many large (12 by 6 by 6 ft. (L, W, and H)) concrete blocks interspersed throughout the site. These blocks may be sewer septic vaults and are generally found at the north and south extremes of the reef (Figure 65 and Figure 66). There are also five large rectangular structures of concrete, metal, or both in the northeast section of the reef. It is unclear if these are old sections of dock or something else. The structures measure approximately 65 ft. long and are 9 ft. wide. They are raised approximately 4 to 5 ft. off the bottom. These figures are delineated as linear features in Figure 65, and were captured in Figure 77, which is a top down camera photo of one such structure. In addition to concrete and metal I – beam material, it appears that these linear features may incorporate corrugated metal as well.

A number of large rock piles also contribute to the artificial reef at the Des Moines site (Figure 65). The largest of these is a mound that rises roughly 38 ft. off the bottom. The boulders in these mounds are two person sized or larger. Metal rebar was also identified within or lying on top of some of these boulder mounds (Figure 74).

Habitat Characteristics

The shoreline surrounding the Des Moines Tire Reef site is within the nearshore critical Habitat for rockfish (NMFS). There are also two nearby streams – Massey and Des Moines Creek, where Coho salmon spawn. The location is also along a Coho migratory route (WDFW). There has been documented surf smelt spawn on the beach inshore of the Des Moines tire reef (Figure 67).

Giant California sea cucumber (*Apostichopus californicus*) were observed in the towed video survey where they were found attracted to hard structures in the reef (concrete blocks and boulders in rock piles). Rockfish (sp. unknown), and lingcod were observed in the towed video survey surrounding the largest boulder pile at the West side of the reef. Tunicates were found on concrete, rock, and tire structures dispersed throughout the reef.

Figures and Tables

Table 12. Des Moines Fishing pier artificial reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	**Minimum**	**Maximum**
Depth at NAVD88 (ft.)	-12.48 ± 1.13	-77.01 ± 6.05
Distance from Shore (ft.)	460	900
Reef Footprint Area (acres)	5.67	
Reef Node 1.5m Buffer Area (acres)	1.37	
Number of Tires	9,891 ± 1,315	22,117 ± 5,153
Tire Weight (lb.)	197,829	442,359

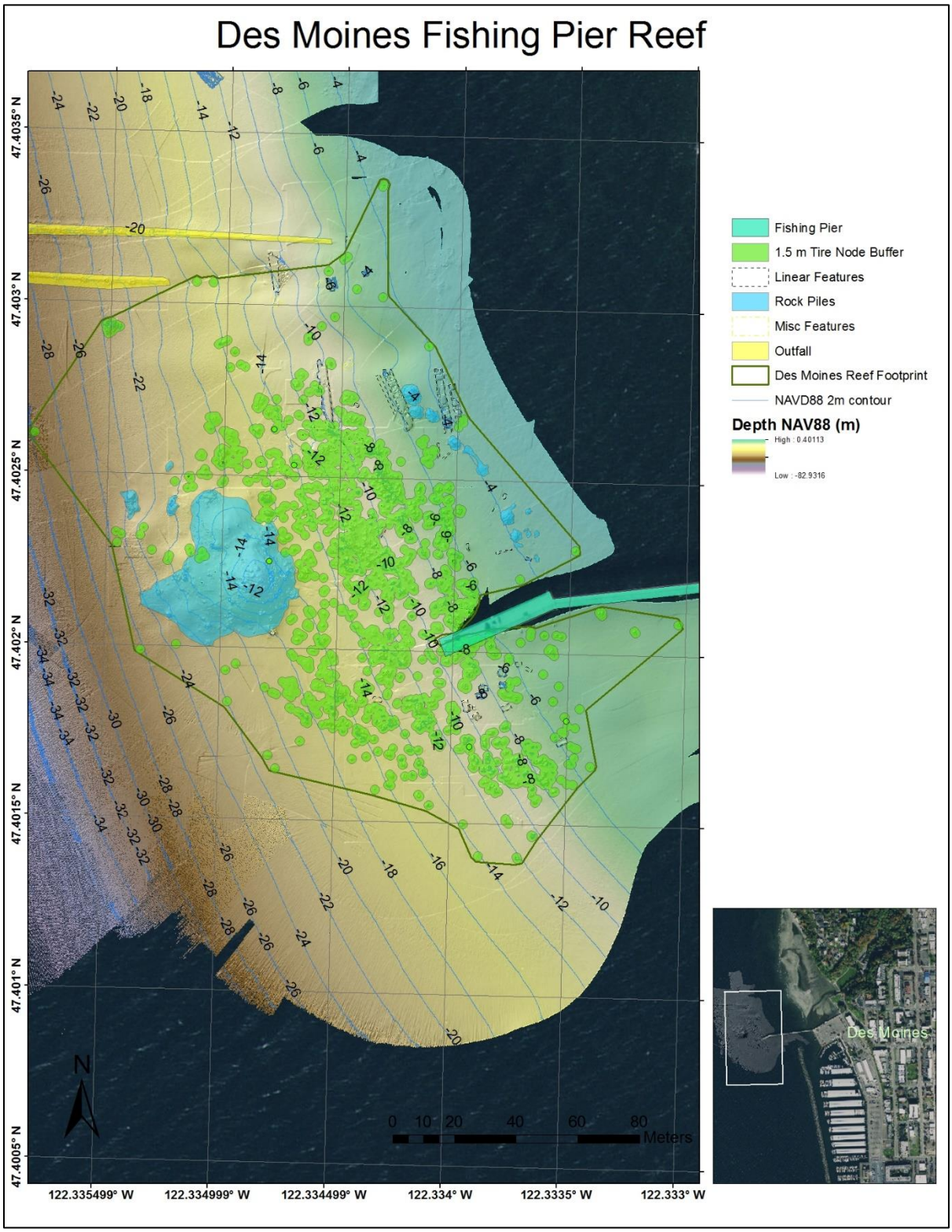

Figure 65. Des Moines artificial reef located off the Des Moines fishing pier in Central Puget Sound.

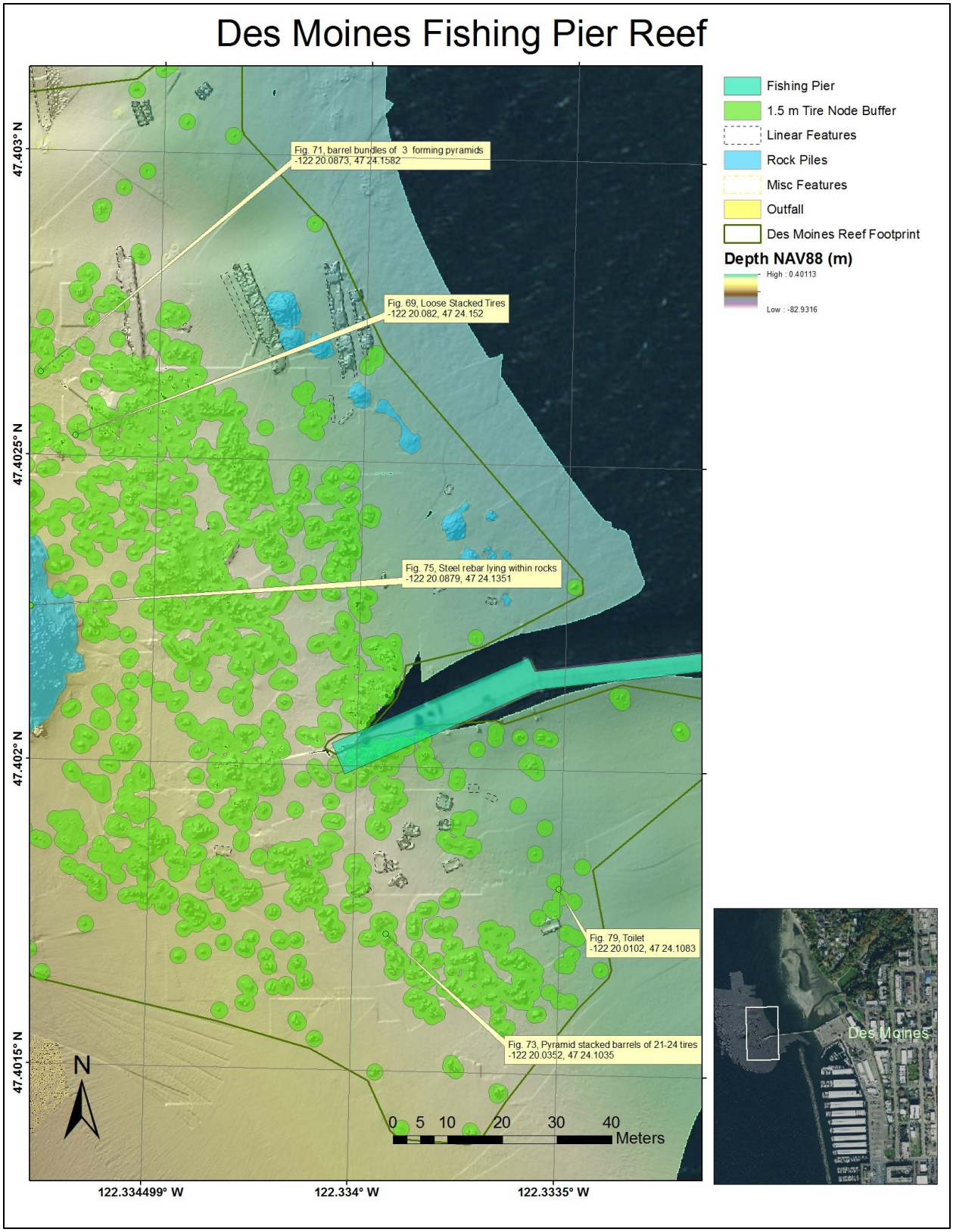

Figure 66. Reference guide for video images.

Figure 67. Habitat and species maps for the area surrounding the Des Moines tire reef.

Figure 68. Barrel stacked bundles of tires that have begun to disband and separate from original placement.

Figure 69. Tires that were likely in a bundle are now separated and lying on the seafloor.

Figure 70. Side view of a pyramid – barrel stacked tire bundle (2 barrel stacked rows at base with one on top). Each row in the bundle appears to have 8 to 10 tires. We estimate the total tire count in this bundle to be 24 to 30 standard automobile tires.

Figure 71. Top view of a barrel stacked bundle pyramid of tires. Pyramids of this nature are the prevailing tire feature at the Des Moines site. Tires at the lower level here appear to be buried 15-20%.

Figure 72. End view of a barrel stacked pyramid of tires.

Figure 73. Two person-sized boulders make up many of the boulder mounds found at the Des Moines artificial reef. This photo is from the boulder mound at the Western edge of the reef.

Figure 74. Steel rebar was identified as interspersed throughout the reef. Here it was found lying on the boulder mound at the Western edge of the reef.

Figure 75. California Sea cucumber were observed clinging to the riprap sections of the Des Moines reef.

Figure 76. California Sea cucumber were observed on many hard structures (here on boulders and large concrete blocks) interspersed throughout the reef. Rockfish and lingcod were also observed around boulder mounds.

Figure 77. The edge of one of five large concrete or metal dock structures found at the northern portion of the artificial reef (refer to figure 1).

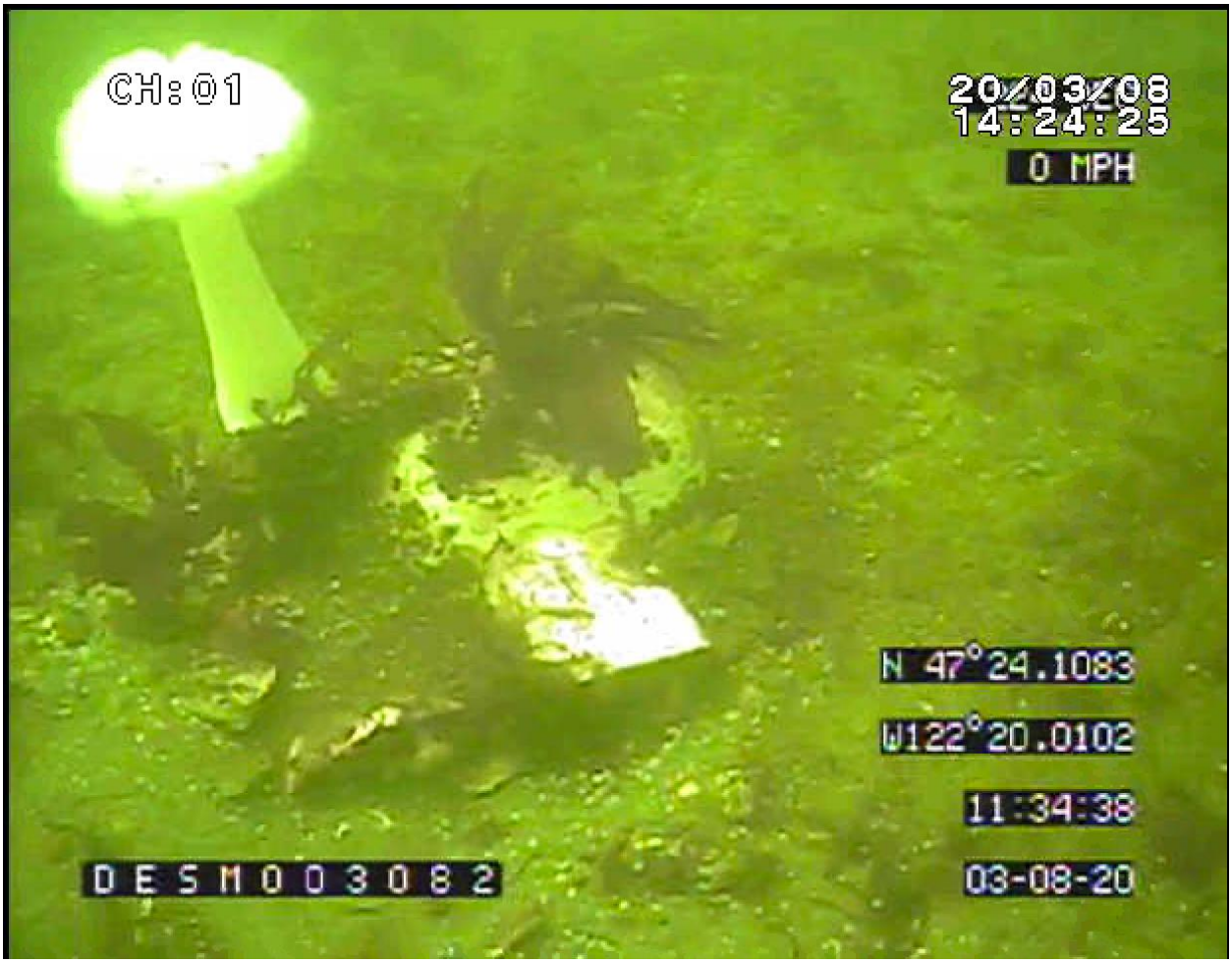

Figure 78. One of two toilets observed during video surveys. A bathtub was also observed in an ROV survey here. There are likely many others like this in the reef area.

4.7 Saltwater State Park

Saltwater State Park

Overview

AAMT staff mapped 77 acres on 6/02/2021 just offshore of Saltwater State Park in Des Moines, Washington. A large tire reef was found spread out over a 4.43-acre footprint, which extended north from Saltwater State Park's well known dive site. Between 1,302 and 4,521 tires are estimated at this site. Upon analysis, three large boulder piles, a large wooden barge, and several horizontally laying concrete pilings, in addition to tires were identified.

Reef Location

General Description of Location

The majority of the Saltwater State Park tire reef is located north of the known diving reef. The center of this reef lies approximately 800 feet offshore and to the northwest of the rock bulkhead at the park (Figure 80). The closest recreational boat launch is the Redondo Beach Boat ramp, 1.7 miles to the south. There is also a boat hoist at the Des Moines marina 2 miles to the north. State parks holds a lease on SOAL (# 20-009648) which covers the entire mapped reef footprint (Figure 83).

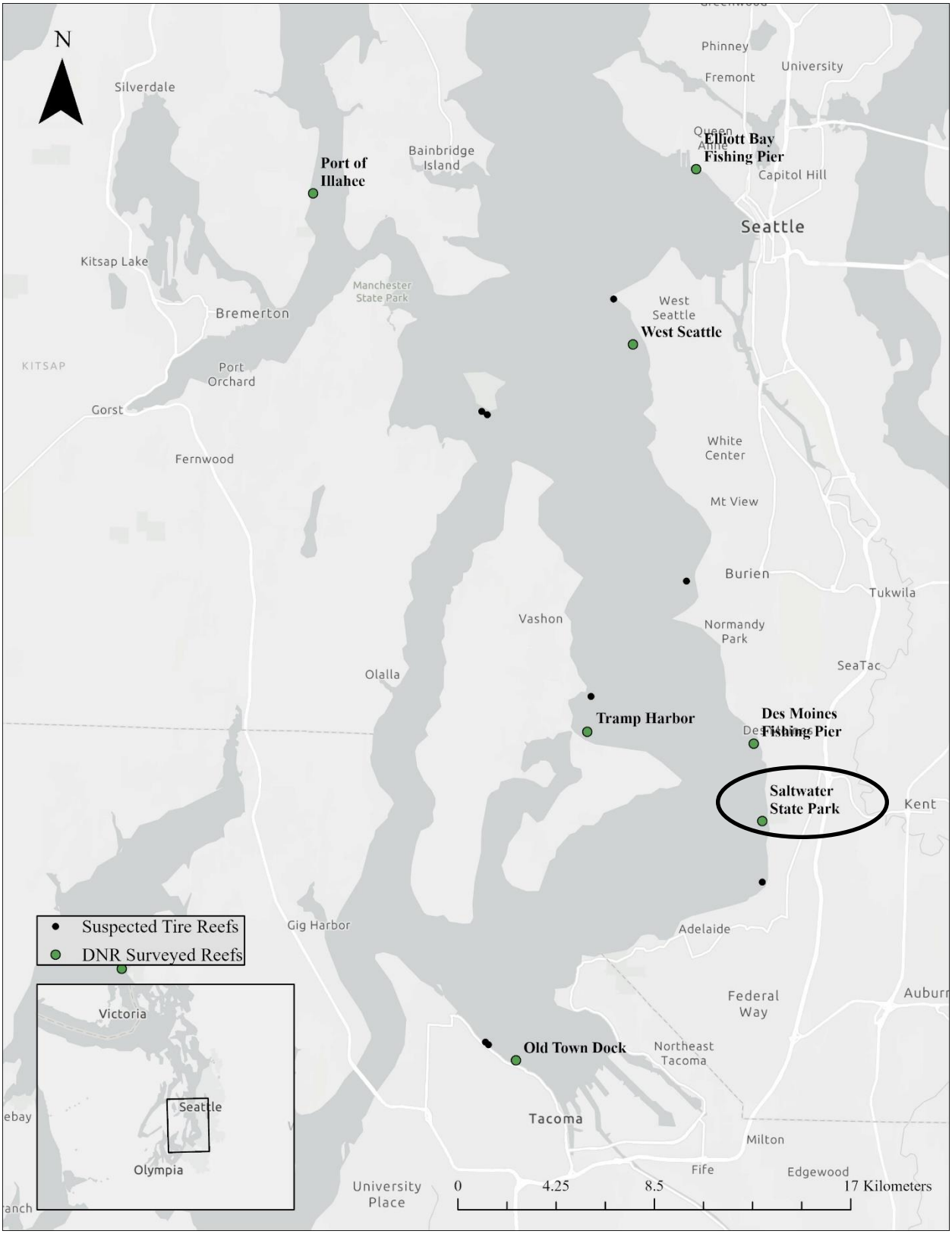

Figure 79. Middle-Sound artificial reef sites. The Saltwater State Park site is circled.

Table 13. Coordinates of the Saltwater Reef Footprint.

	Latitude	Longitude
Center	47.374631 N	-122.327561 W
NW Corner	47.375923 N	-122.328238 W
NE Corner	47.376037 N	-122.326838 W
SW Corner	47.372469 N	-122.329069 W
SE Corner	47.372302 N	-122.327874 W

Reef Attributes

General Description of Reef

The known dive site at Saltwater State Park was commissioned by the Washington State Parks and restoration commission in 2007 and designed by the engineering firm Reid Middleton and associates. To build this dive site, barges brought in boulders and concrete pilings by water (Figure 85 and Figure 87). Automobile tires were not included in this new construction. Any tires that surround the most recently implemented rock piles and concrete pilings (bottom of Figure 82) are holdovers from the original tire reef that was constructed and have been present for far longer than the most recent construction. The sediment at this site appears composed of sand and shell.

Tires

The tire reef at Saltwater State Park appears to be spread out - extending 900 feet to the north from the northernmost rock pile at the more recently constructed dive site (Figure 80). Tires here are joined into barrel formations of eight tires and are banded together with rope that is likely polypropylene. They appear to be standard passenger or truck sized. Many of the bundles appear to have broken apart – as there are many tires laying on their sides individually, or in small-randomly dispersed groups (Figure 91). Tires at the site appear to have been cut open upon placement to allow for air escapement.

Over the time the tires have sat at the Saltwater reef, sediment has accumulated around them leaving many tires buried up to 1/3. Some tires that are on their sides are almost completely buried (Figure 91). In addition to the elongated tire reef footprint to the north, we also identified tire – like features between rock piles at the known dive site. These features were designated as potential tires due to the possibility that they are rocks that strayed from main boulder piles and not tires (Figure 82).

Additional data collected by Coastal Sensing and Survey through a Washington Department of Ecology grant indicates that there are additional tires present deeper than 26 meters. These are located to the west of the rock piles identified in DNR surveys (Figure 80) (Washington Scuba Alliance 2022).

Non – Tire Reef Features

Rock pile features and concrete poles from the Reid Middleton and Associates construction can be seen at the base of the reef footprint in Figure 80– they cover a footprint of approximately 0.20 acres. Figure 85 and Figure 86 show the construction plans for these structures. There are also mounds of cobble, and a wooden barge in the vicinity of this new construction (Figure 82). There is an outfall at the very southern end of the reef; it empties at the very southern end of the reef where there are also probably tire features (Figure 80).

Habitat Characteristics

The Saltwater State Park Artificial Reef is located within NMFS designated critical nearshore rockfish habitat (NMFS 2015). The intertidal shoreline of Saltwater State Park and the surrounding area are also designated as intertidal spawning habitat for surf smelt and sand lance (WDFW 1995) (Figure 83). The terminus of McSorley Creek empties at the southern end of the reef. This creek has been marked for presence and migration of Coho Salmon (WDFW 2005) (Figure 83). The beach at Saltwater State Park is closed to recreational shellfish harvest (DOH 2023).

Rockfish were observed in video around rock piles and concrete pilings at the southern end of the site. Sea cucumber (*Apostichopus californicus*) and anemones (sp. Unidentified) were also abundant on these features in the main site. Tires at the Saltwater site are encrusted in barnacles. Anemones were also observed growing on tires at the site; however, sea cucumber and fish were not as prevalent around tires as they were surrounding rock or concrete structure. A large eelgrass bed lies approximately 200 feet towards shore from the shallow edge of the tire reef. Eelgrass lines the shallow intertidal of the entire footprint at Saltwater. Its deep edge lies at the -4m NAVD88 contour. The Reef is also located on the south end of the Des Moines geoduck tract (tract code 09900) (WDFW 2005).

Figures and Tables

Table 14. Saltwater State Park artificial reef attributes determined from multibeam sonar analysis. Note: more tires than these estimates likely exist. Additional tires to the West of large rock piles were not identified or picked up in DNR sonar data.

Reef Attribute	Minimum	Maximum
Depth at NAVD88 (ft.)	-27.70 ± 3.59	-63.18 ± 4.88
Distance from Shore (ft.)	558	837
Reef Footprint Area (acres)	4.43	
Reef Node 1.5m Buffer Area (acres)	0.62	
Number of Tires	1,302 ± 164	4,521 ± 1,366
Tire Weight (lb.)	26,044	90,411

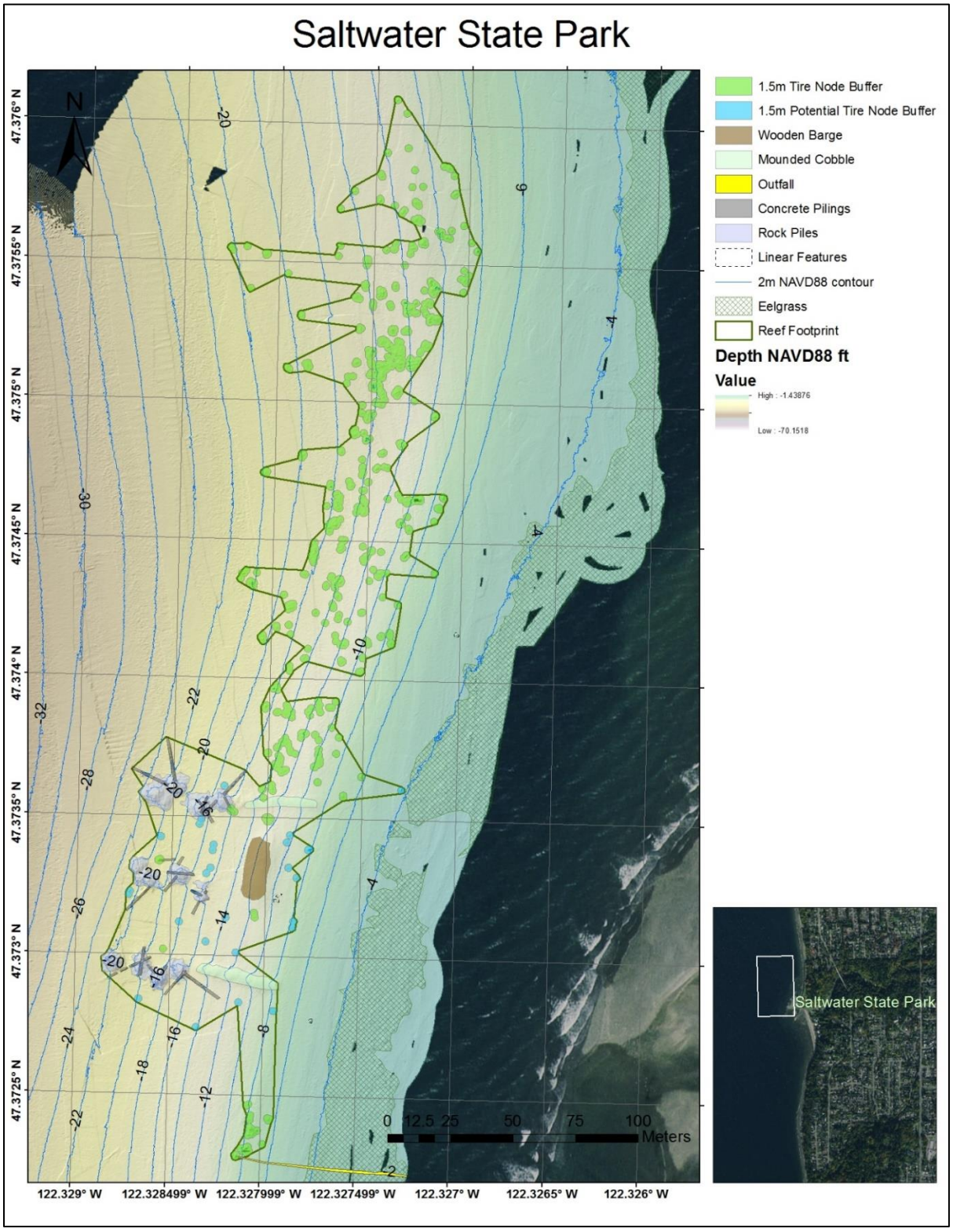

Figure 80. Saltwater State Park dive site and tire reef. The majority of tires were found to the north of the engineered rock piles, however, potential tire features may also exist between and deeper than rock piles in the known reef area.

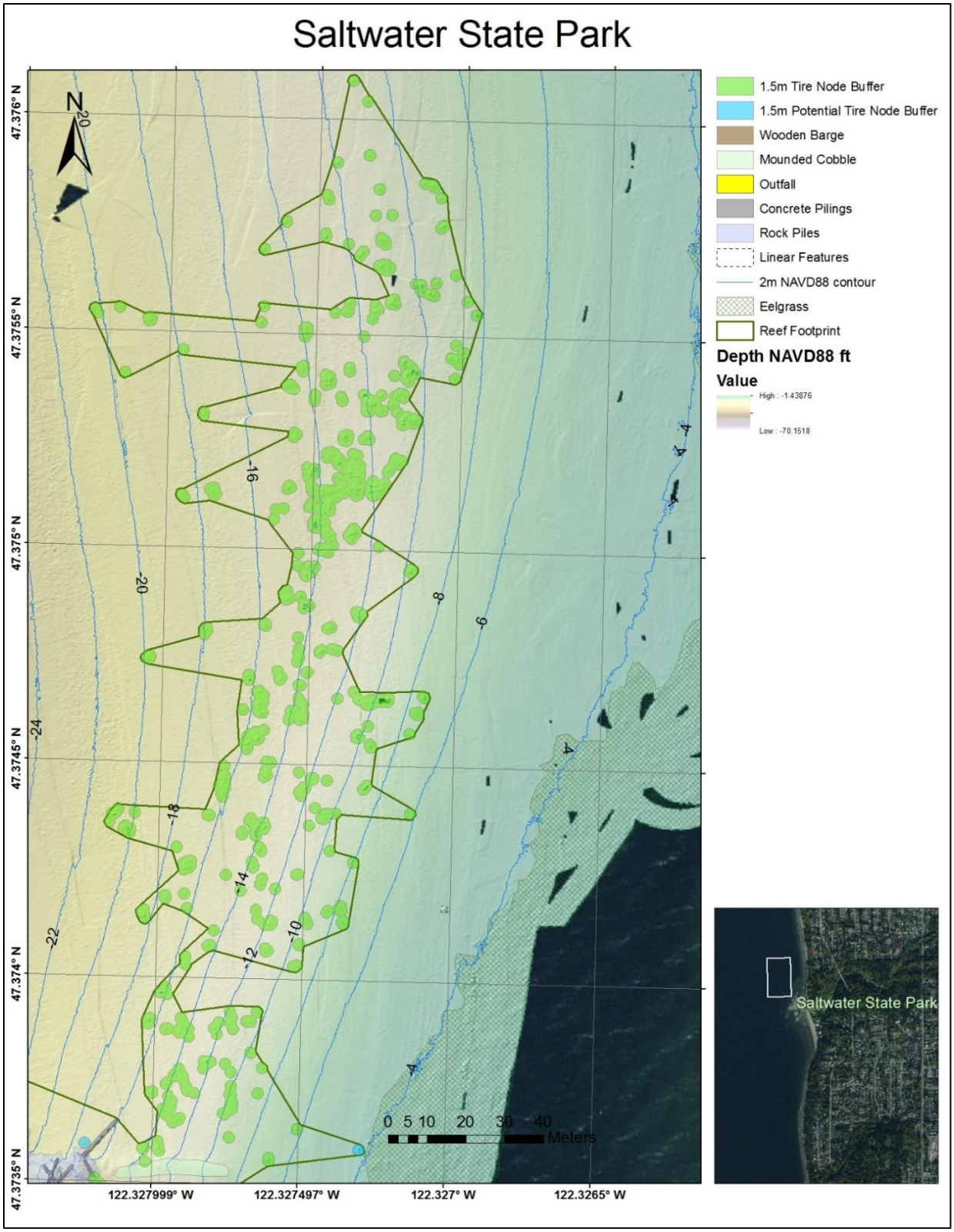

Figure 81. Focused view of tire feature section of Reef

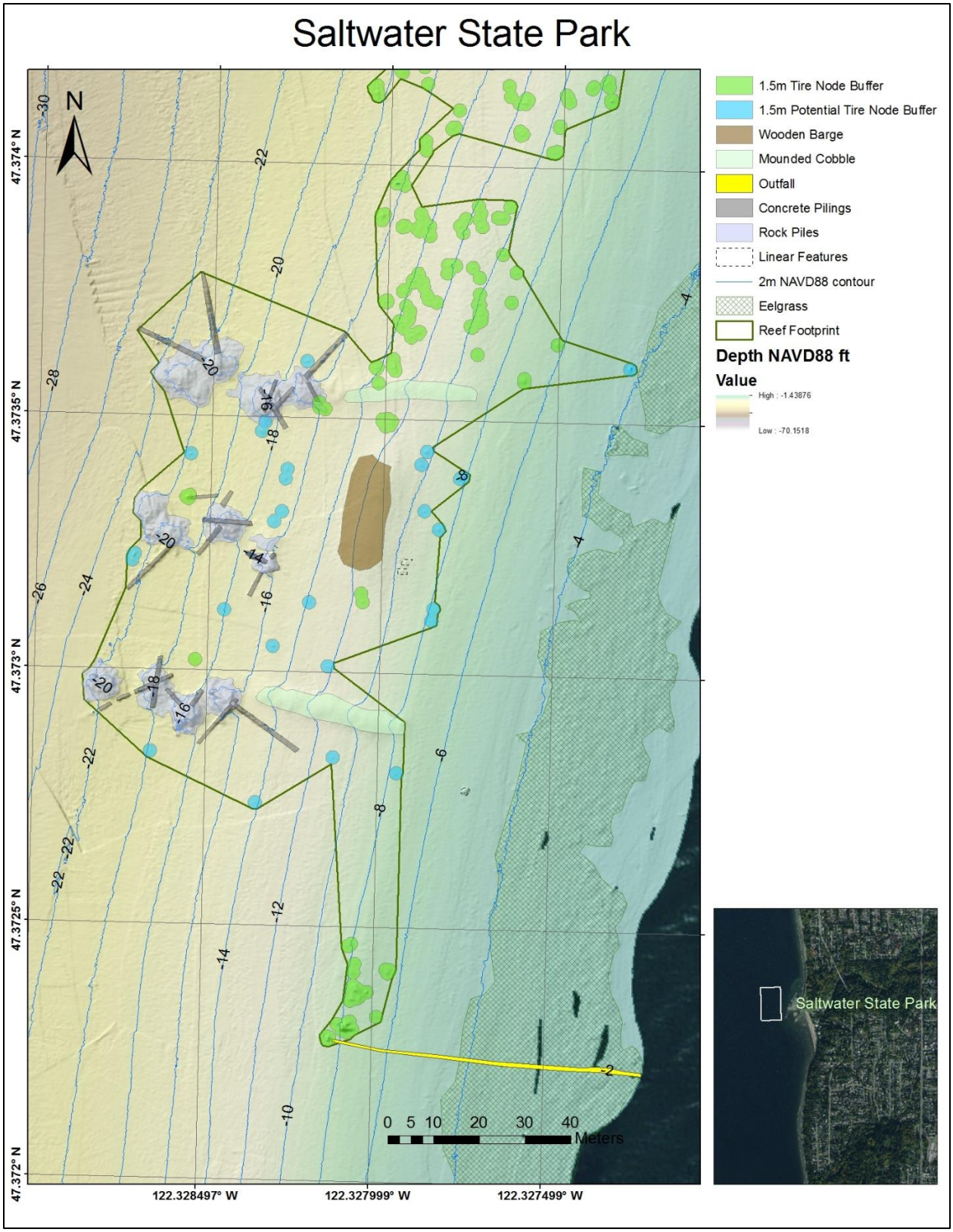

Figure 82. Focused image of Saltwater Park engineered reef section.

Figure 83. Habitat information for the zone surrounding the Saltwater Park reef.

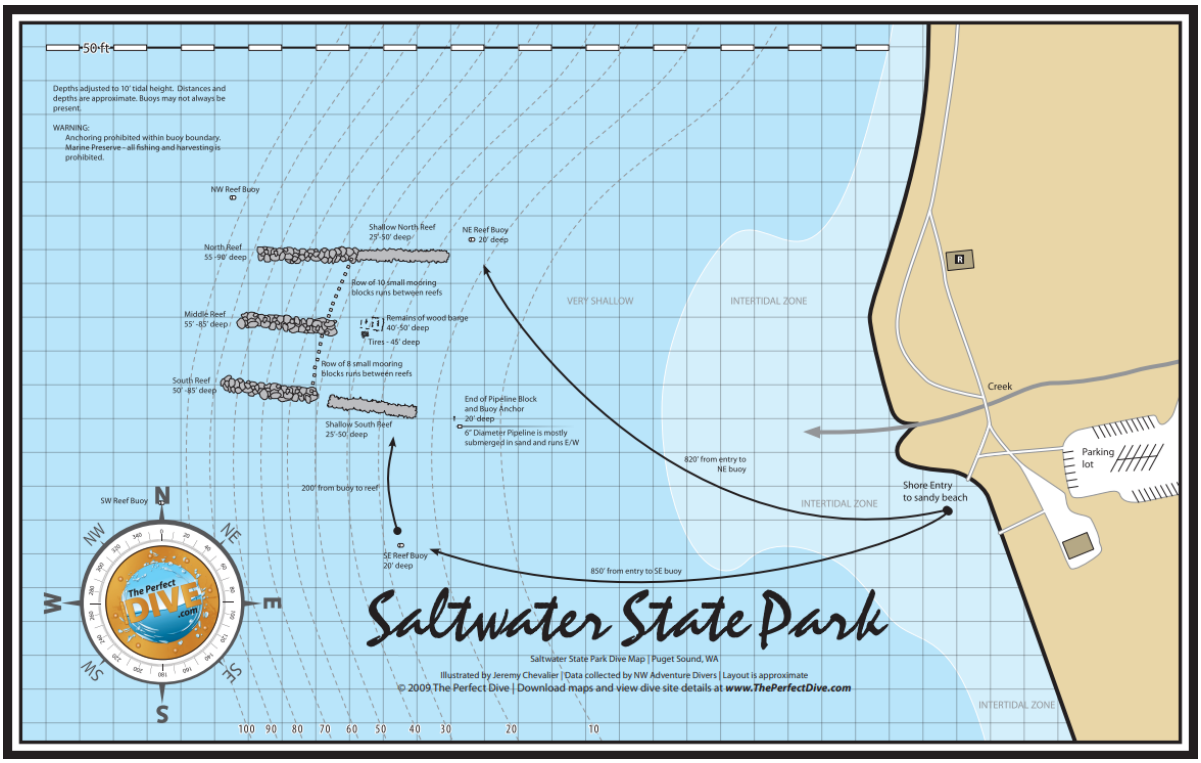

Figure 84. Drawn map of the known diving reef posted on the Saltwater State Park shoreline. Image sourced from theperfectdive.com

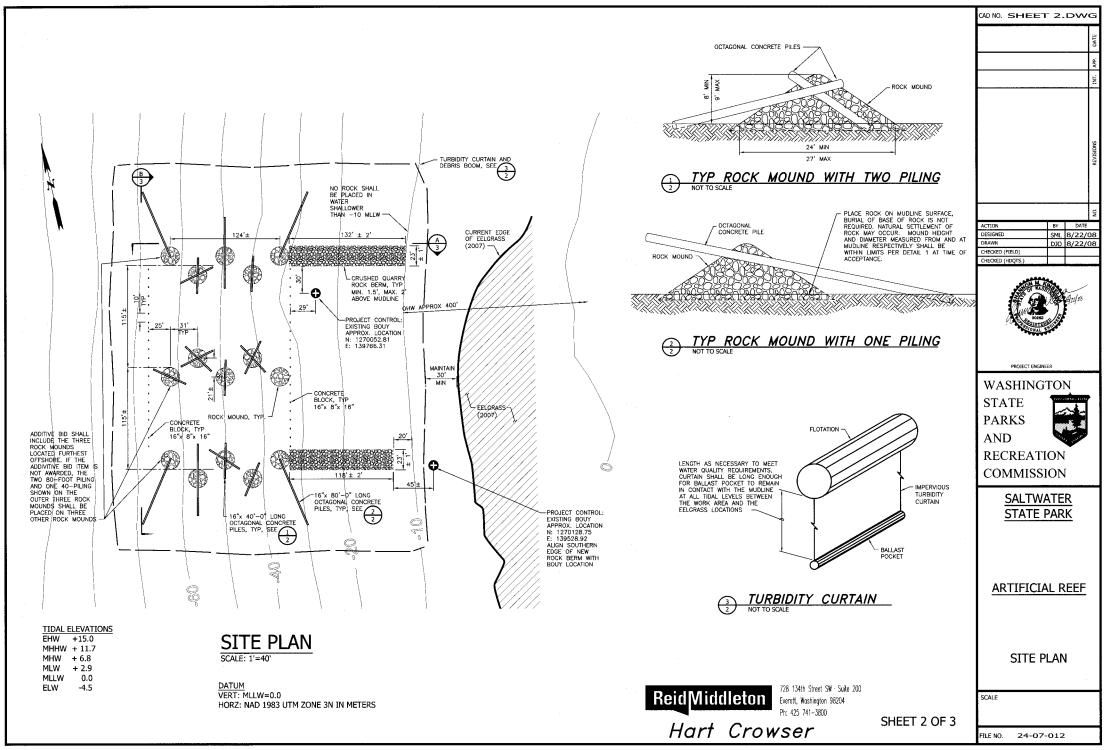

Figure 85. Site plan for 2007 Reid Middleton reef construction

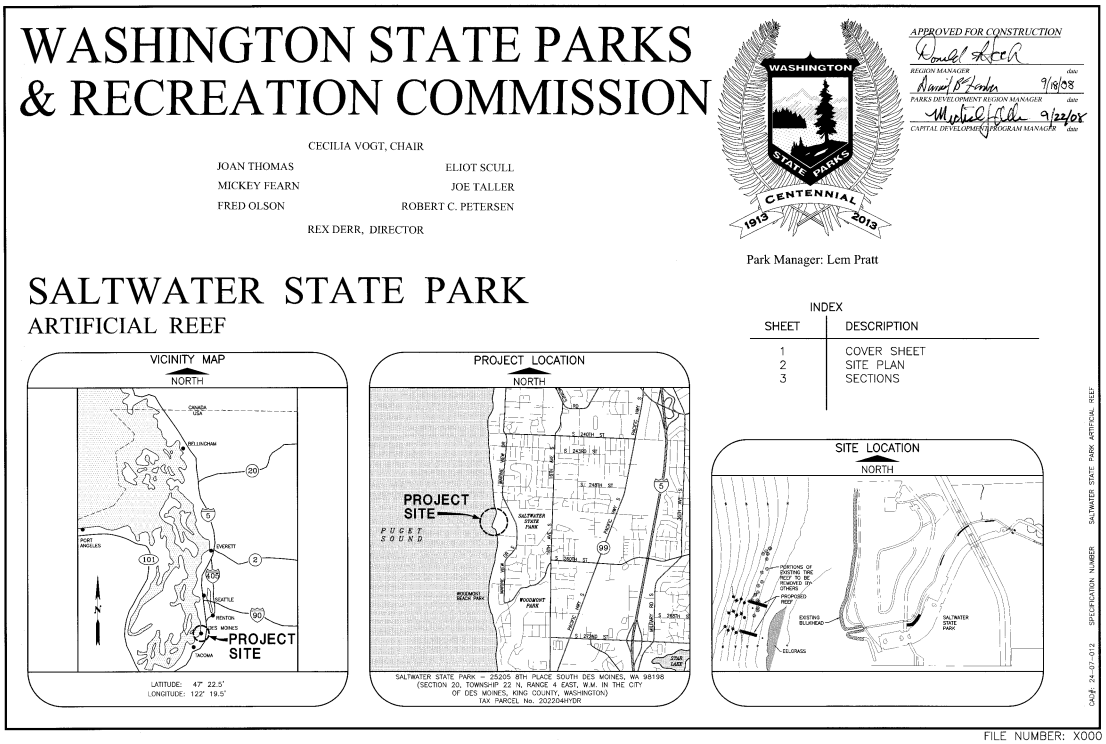

Figure 86. Site plan for 2007 Reid Middleton reef construction

Figure 87. Photo taken from Saltwater State Park in 2006. Boulders and concrete structure were placed in piles to create a well-known diving reef.

Figure 88. Tire laying on its side. This is an example of a tire that is almost completely buried.

Figure 89. Sea cucumber and sea anemone were observed covering concrete structures in the engineered reef.

Figure 90. A barrel joined example of eight tires at the Saltwater State Park reef. Tires at the site are covered by anemones and encrusted with barnacles.

Figure 91. Tires that appear to have broken from their banding, and now lay jumbled and buried up to 1/3 in sediment.

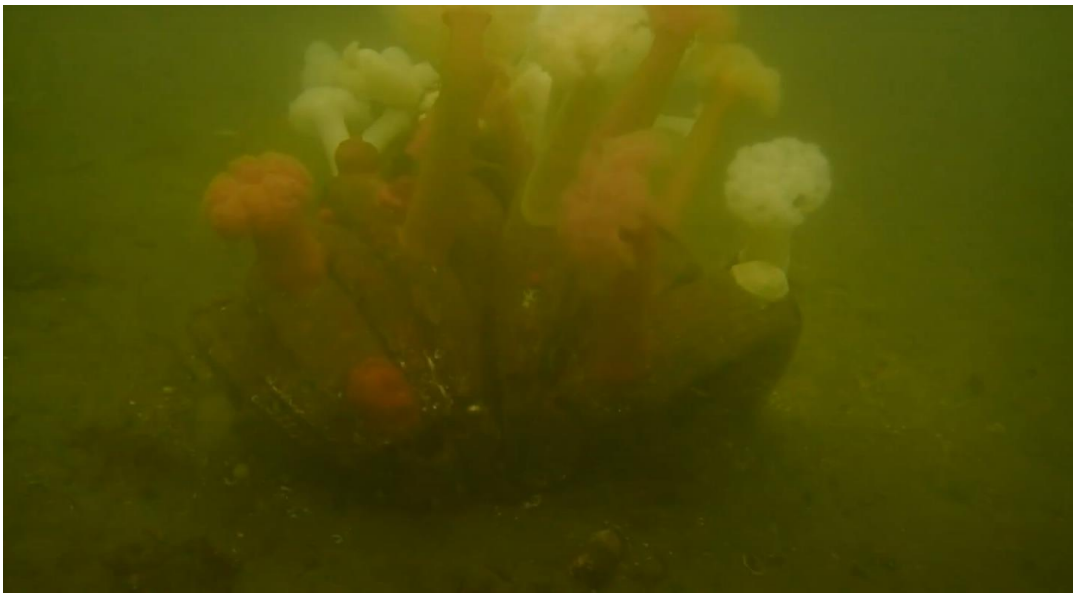

Figure 92. A bundle of seven to eight barrel joined tires.

Figure 93. Tires at the Saltwater Park site are banded together line. This line is likely polypropylene.

Figure 94. Tires barrel joined in bundles of eight. It is evident that these tires were slashed to allow air to escape before placement.

Figure 95. Degraded and/or buried tires. These tires appear to have broken from their barrel formation long ago.

Figure 96. Concrete anchor found in the vicinity of the tire reef. It is unclear whether this was placed to anchor tires, or as part of a buoy system delineating the corners of the engineered reef.

4.8 Old Town Dock Tire Reef

Overview

Twenty-two acres were surveyed on 12/18/2019 around the Old Town Dock off Ruston Way in Tacoma, WA (Pierce County). Various materials were found that make up the reef just offshore of the dock. These materials include tire features, metal chain, electric scooters, metal pipe, concrete pipe, wooden logs, cinderblocks, and other miscellaneous refuse. Eelgrass (Zostera marina) was found at the shallow reaches of the survey inside and around the dock structure.

Reef Location

General Description of Location:

The approximate center of the Old Town Dock tire reef is located 112 m (370 ft.) north of the Ruston Way shoreline, and 30 m (100 ft.) north of the existing dock structure that runs west to east. We found reef structure distributed along both the east and north sides of the Old Town Dock (Figure 98). The reef also runs north- south approximately 9 m (30 ft.) off the west side of the dock structure (Figure 98).

The closest boat launch to the site is at the Point Defiance Ferry Terminal. This boat launch is deep and can be used at all tides. The launch can become busy during the summer months, which should be considered in the eventual reef removal plan. There is a lease agreement between the city of Tacoma and DNR (# 22-002751) which covers part of the tire reef footprint.

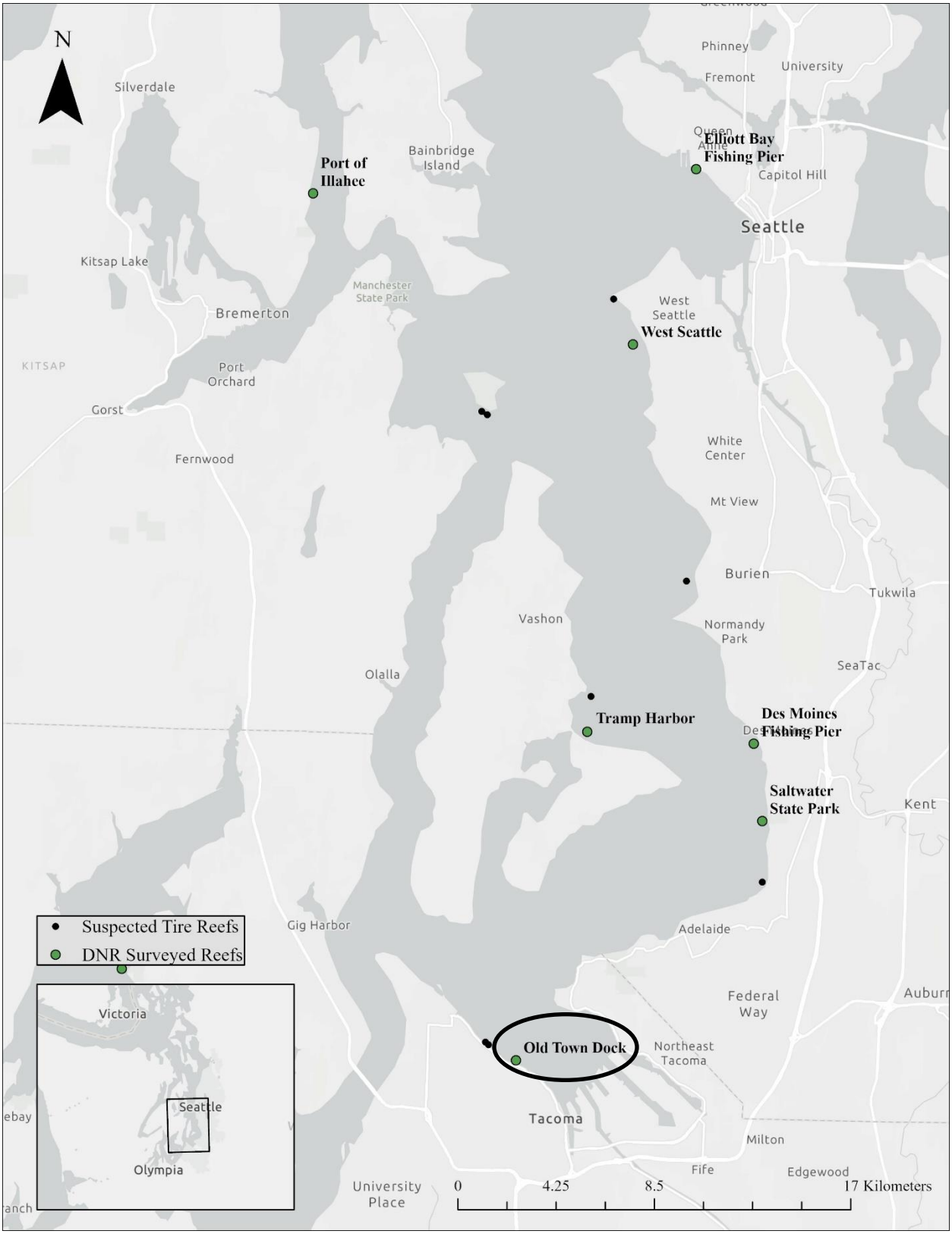

Figure 97. Middle-Sound tire reef locations. Old Town Dock is circled.

Table 15. Coordinates of the Old Town Dock Tire Reef.

	Latitude	Longitude
Center	47.277112 N	-122.465411 W
NW Corner	47.277637 N	-122.466245 W
NE Corner	47.277474 N	-122.464750 W
SW Corner	47.276483 N	-122.465887 W
SE Corner	47.276486 N	-122.465405 W

Reef Attributes

General Description of Reef

The Old Town dock was built in 1873 for Tacoma's shipping industry - it is now a popular public pier and fishing location owned by the city of Tacoma. The dock itself is built of creosote pilings and treated lumber and extends into Commencement Bay in an upside-down L shape. A portion of the site is within a breakwater and moorage slip harbor lease (22-002751) between the City of Tacoma and DNR for 0.95 acres. Other sections of the reef are located on state-owned aquatic lands that are not under lease and on City of Tacoma and other private tidelands (Figure 100). Nearby and to the west, the Les Davis Pier (also owned by the city of Tacoma) is a popular marine park and underwater dive site.

In September 2015, DNR funded the removal of 2,855 tires located within the Les Davis Marine Park lease at a total cost of $29,500. While the majority of the dive park is comprised of artificial concrete habitat obtained from the former Tacoma Narrows Bridge, tires had been placed west of the pier running north and south to form a visual barrier to prevent recreational scuba divers from crossing from the artificial concrete reef into a public fishing pier area. The barrier was made up of 57 bundles of tires consisting of standard passenger and truck tires. Synthetic rope was used to bundle the tires, and some of these bundles were partially buried in the sea floor. Under a new lease (22-A02519) negotiated with DNR, the tires were required to be removed and replaced with inert hazard markers.

DNR hired the Nisqually Indian Tribe Marine Services Division to complete the removal project. Commercial divers utilized surface supplied (hardhat) diving equipment to access and remove tire bundles. The bundles were rigged with lifting straps and slings and pulled to the surface with a barge positioned crane. Waste Recover West, Inc. disposed of tires in Oregon at a cost of $229.50/ton. A Hydraulic Project Approval permit was required prior to tire removal granted from the Washington Department of Fish and Wildlife. The Army Corps of Engineers did not require a Section 10 permit for their work.

Tires

AAMT found the Old Town Dock artificial reef moderately sized (1.04 acres) and complex, with many different types of intentionally placed materials present. Tire bundles here are piled loosely

and typically hold 10 standard passenger car tires, but this varies ± 2 tires. Many bundles lay on the bottom in large mounds. However, some are also arranged into neat rows or "barrels" (Figure 106 and Figure 107). The lower level of tires within bundles at the site are buried at various levels, with the most extensive burial up to 50%. Tires were slashed upon placement to allow air escapement and have large gashes in their sidewalls.

It is difficult to tell which material tire bundles are tied together with, but it is likely some sort of polypropylene line. Chain bisecting the site was also encountered – it is possible that some of the tire bundles are tied together with this anchor chain. Locations where chain features are presumed present is delineated in figure one - the presence of this chain may increase the complexity of removal. A few tire features also appear to be located underneath the dock (Figure 99).

Potential tire features were identified outside the reef footprint (Figure 98). These features were delineated from sonar imagery but could not be identified due to the lack of video in that location. They are less likely to be automobile tires because they are farther from (~50 m) the highest density of confirmed tire features.

Non – Tire Reef Features

In addition to what appear to be standard vehicle tires, the reef includes a variety of other structures including metal anchor chain, electric scooters (Figure 108 and Figure 109), metal pipe, concrete pipe, wooden logs, creosote pilings, cinderblocks, and other miscellaneous refuse such as metal cans.

Habitat Characteristics

The Old Town Dock is located within NMFS designated critical nearshore habitat for rockfish species (NMFC 2015). The beach approximately 80 m to the southeast of Old Town Dock was denoted by WDFW as sand lance intertidal spawning habitat in 2006 (WDFW 2006) (Figure 101).

Eelgrass was observed on the inside of the "L" dock structure, but not around structure in the reef itself, which is deeper.

Figures and Tables

Table 16. Old Town tire reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	Minimum	Maximum
Depth at NAVD88 (ft.)	-13.97 ± 5.24	-43.90 ± 0.48
Distance from Shore (ft.)	80	530
Reef Footprint Area (acres)	1.04	
Reef Node 1.5m Buffer Area (acres)	0.28	
Number of Tires	772 ± 147	6,989 ± 2,872

Tire Weight (lb.)	15,450	139,796

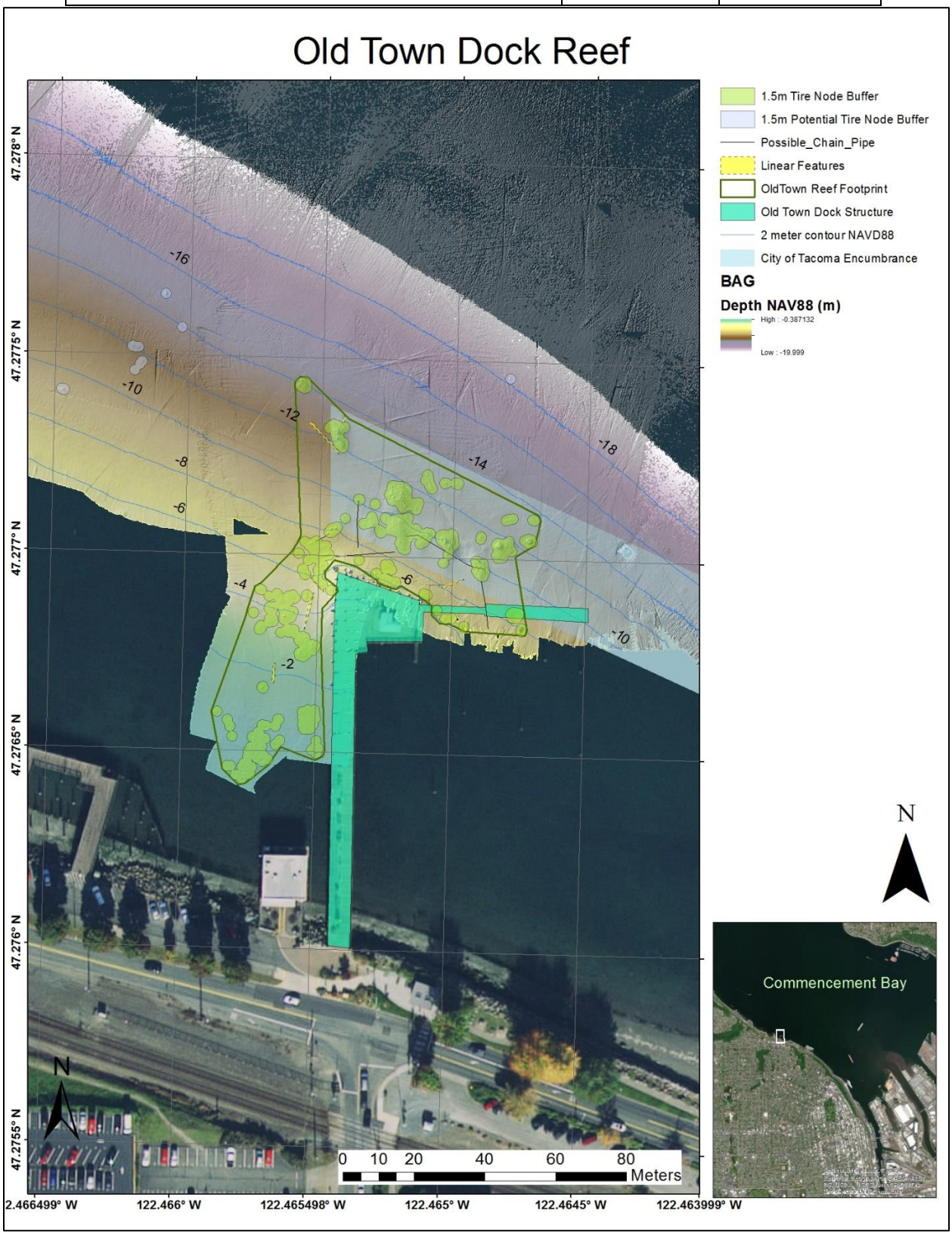

Figure 98. Overview map of Old Town Dock reef including potential tire node buffer.

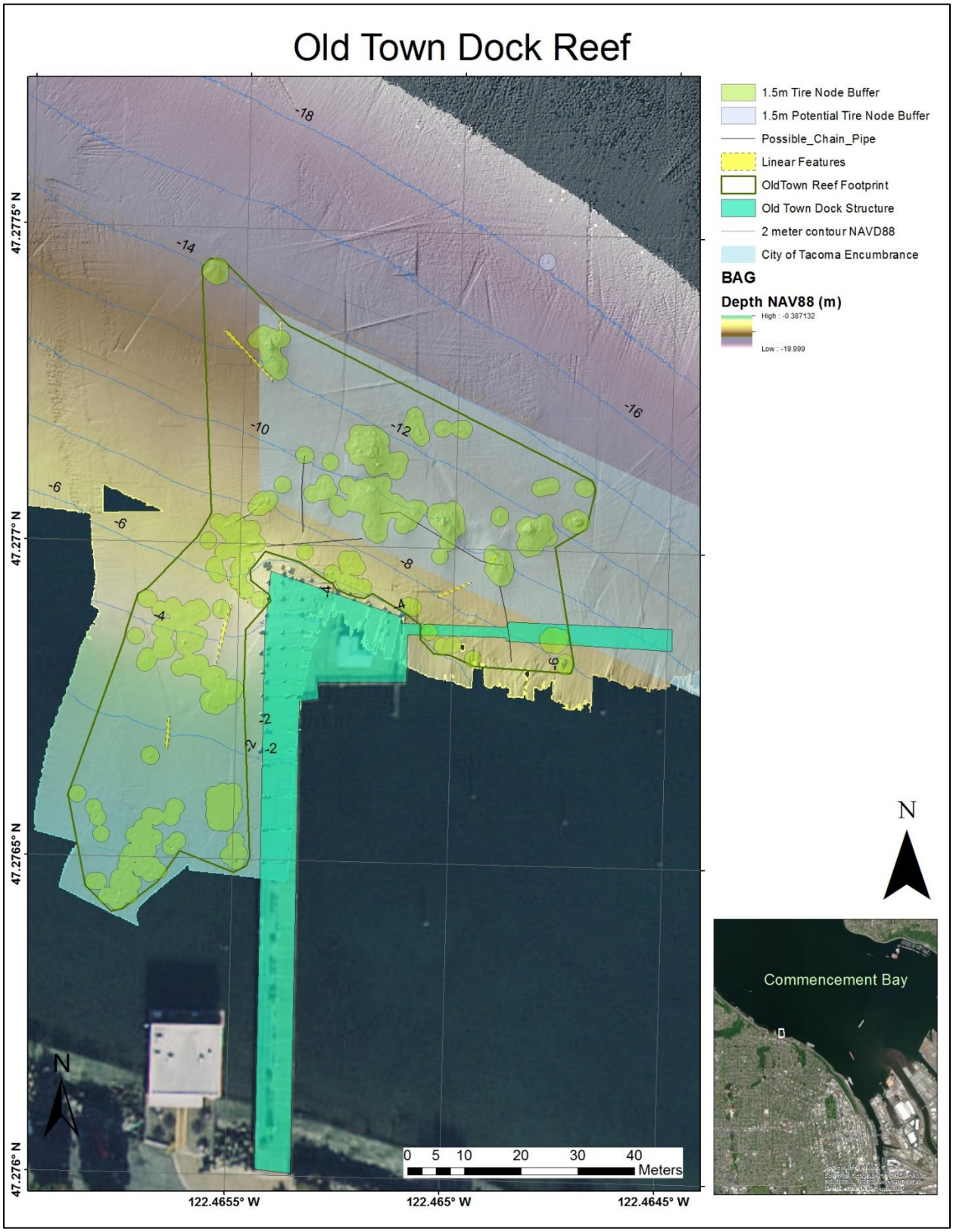

Figure 99. Focused map of Old Town Dock reef in Commencement Bay.

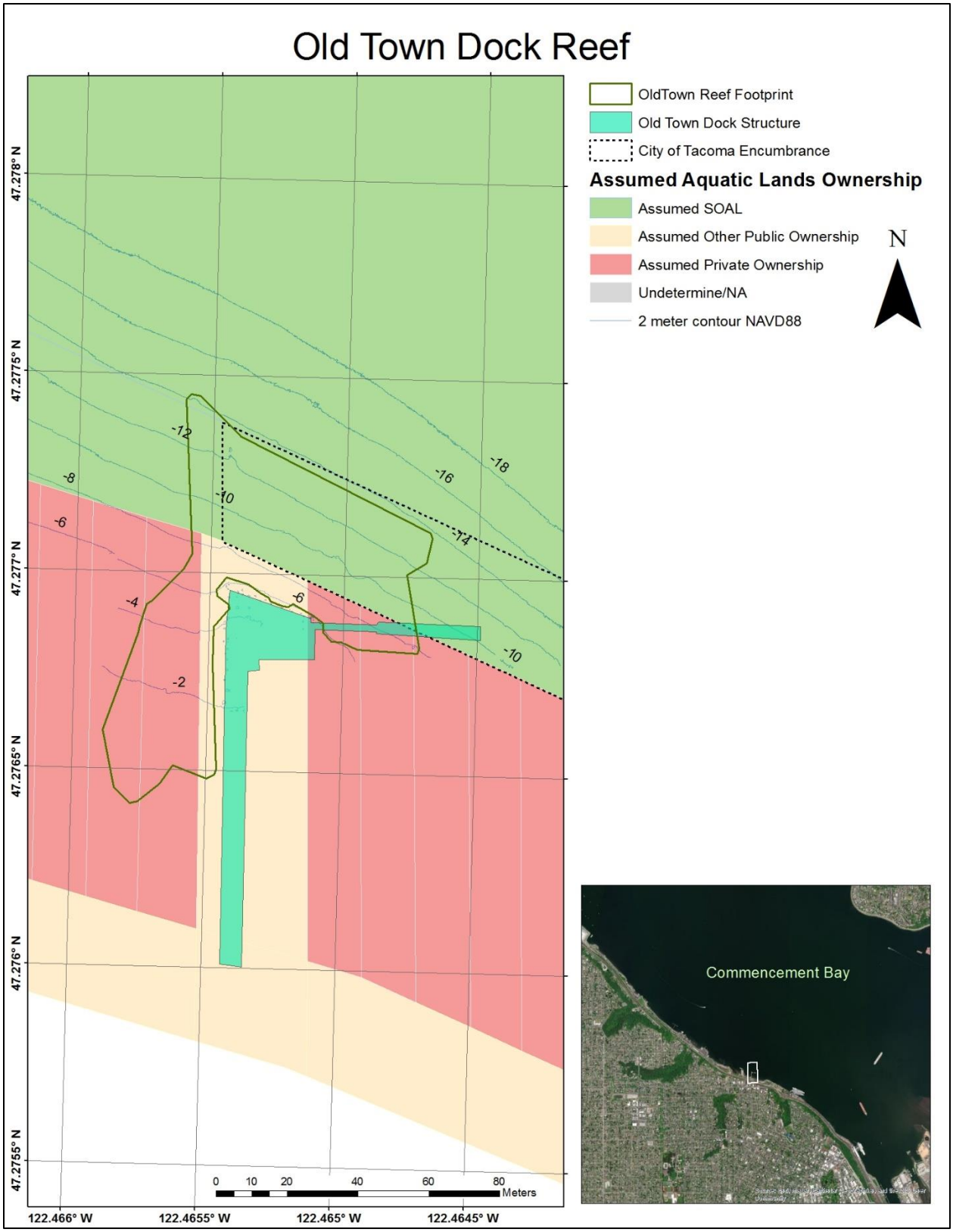

Figure 100. Map showing ownership and encumbrances surrounding the Old Town Dock site.

Figure 101. Habitat and species map for the area surrounding the Old Town Dock reef.

Figure 102. Tires being deployed at the Old Town Dock reef (Date Unknown).

Figure 103. Banded tires being deployed by landing craft at the Old Town Dock reef.

Figure 104. Tires mounded in the Old Town Dock tire reef.

Figure 105. Standard Passenger tires loosely bundled and piled in the Old Town Dock reef.

Figure 106. Standard passenger tires loosely bundled and piled in the Old Town Dock reef.

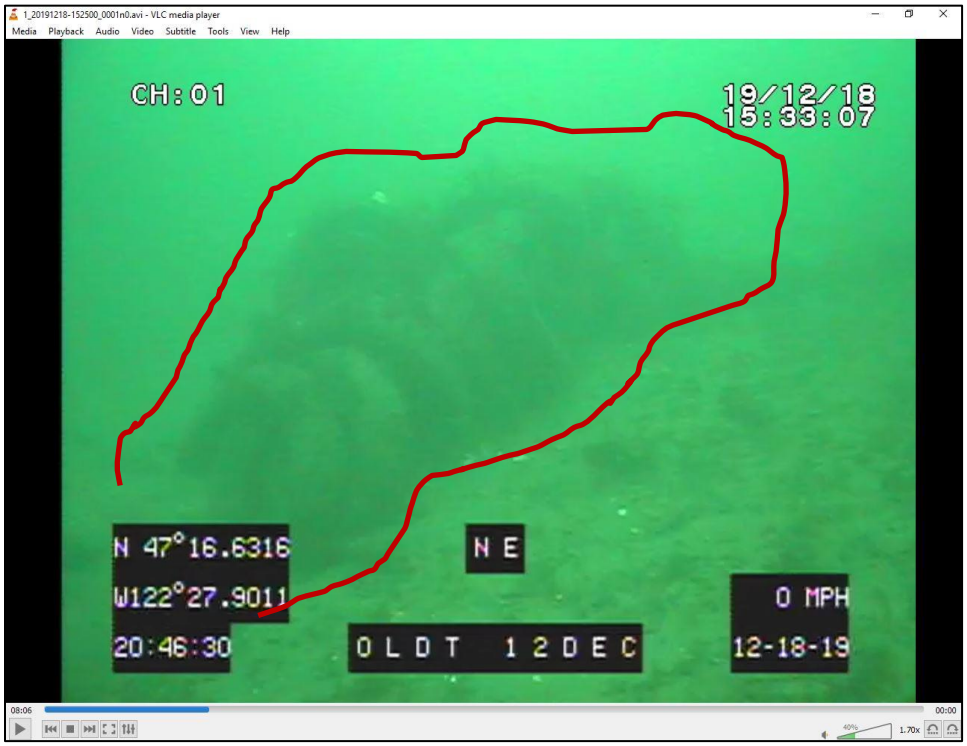

Figure 107. Standard passenger tires barrel stacked in the Old Town Dock reef.

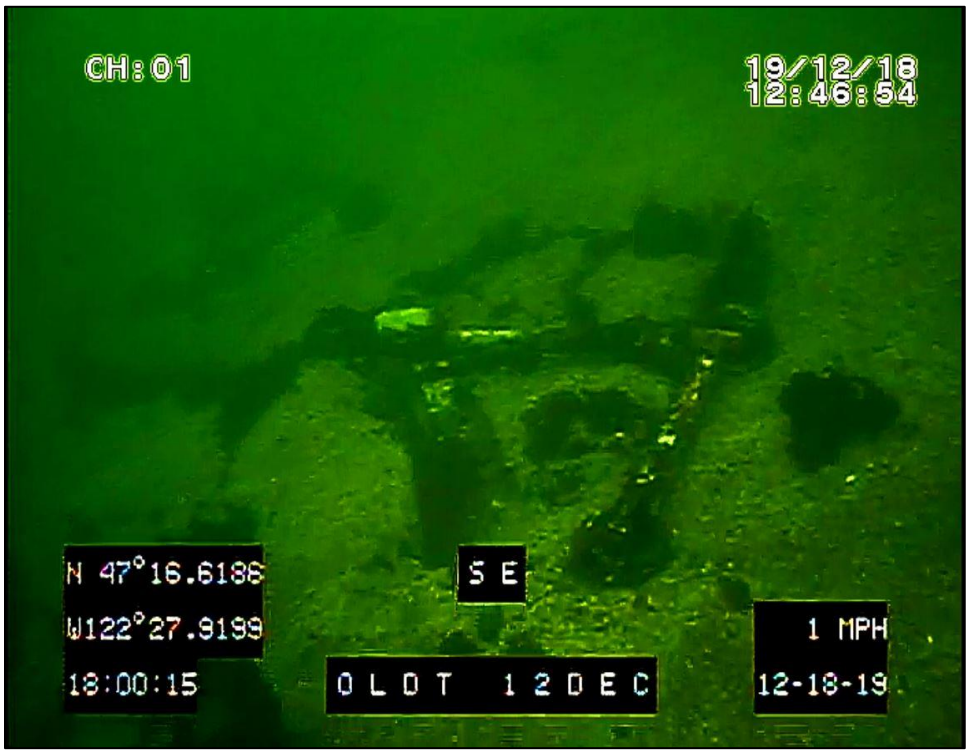

Figure 108. Electric scooters, possibly from the city of Tacoma's Lime scooter program, litter the bottom just north of the west – east oriented dock portion.

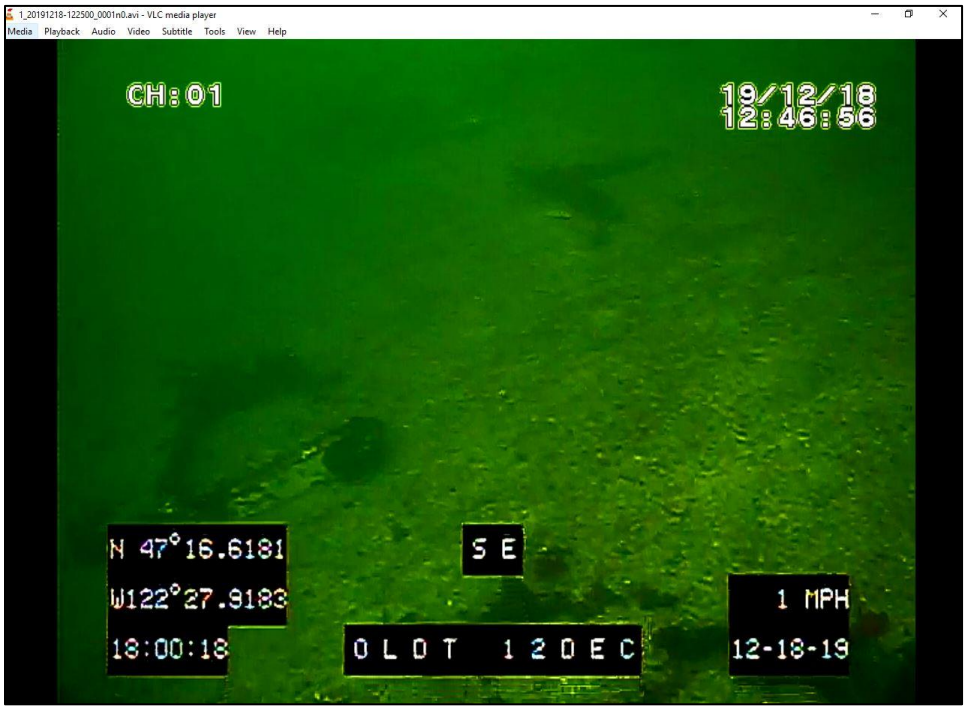

Figure 109. Two electric scooters are present in background of video.

Carr Inlet Tire Reef (Kopachuck State Park)

Overview

The Carr Inlet tire reef was surveyed on 3/06/2020. Roughly 80 acres were covered with a multibeam sonar just offshore of Kopachuck State Park. A small reef was found relatively close to shore (600 to 800 feet offshore). Shallow regions of the survey were characterized by gravel, small cobble, and boulders, but the deeper area around the tire reef is composed of sand and finer sediments. No eelgrass or other vegetation was found in the accompanying video survey. Tire bundles making up the reef are grouped into 8 to 10 tire bundles and are only one row high or are in jumbled piles. The tires in this reef also appear to be skinnier than traditional automobile tires. The shoreline at Kopachuck State Park above the Carr Inlet tire reef site is wooded and undeveloped. No other structures (docks etc.) exist in the immediate area.

Reef Location

General Description of Location:

The center of the Carr Inlet tire reef is located approximately 744 feet offshore of Kopachuck State Park. A portion of the reef is within bed lands that have been withdrawn from leasing since 1972 (DNR agreement # 20-009759 with Washington State Parks) (Figure 112). The closest public boat launch to the site is located on the other side of Carr Inlet in Purdy, WA. This is a small ramp, and the condition and attributes of the ramp are unknown.

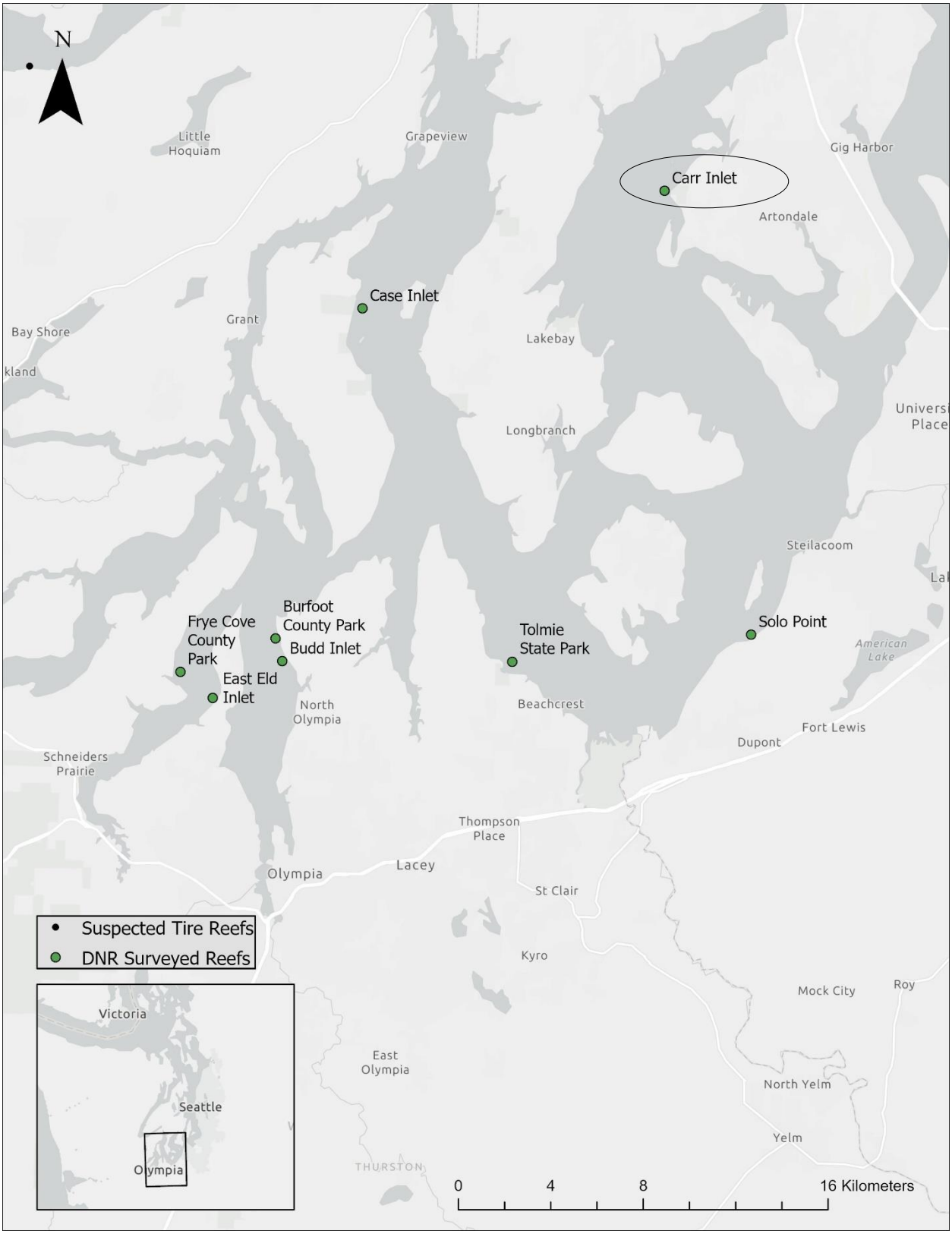

Figure 110. South Sound tire reef sites - the Carr Inlet reef is circled.

Table 17. Coordinates of the Carr Inlet Tire Reef. Note: center reef coordinates indicate the approximate spatial center of all four corners and not the highest density of reef features.

	Latitude	Longitude
Center	47.311417 N	-122.689825 W
NW Corner	47.311136 N	-122.690948 W
NE Corner	47.311802 N	-122.688740 W
SW Corner	47.310927 N	-122.690819 W
SE Corner	47.311198 N	-122.689392 W

Reef Attributes

Tires

The Carr Inlet tire reef is small (1.91 - acre footprint) and partially intact, as some tire features are still bundled with rope. Many of the tire bundles have either broken apart or were originally placed in unorganized and banded piles, as some tires appear to have fallen over on their sides. In addition to these loose bundles of 8 to 10 tires (Figure 113), single tires were also identified in video and sonar data. The tires used throughout the reef are of many different types but are skinnier than traditional automobile tires (Figure 113). Banding for tire bundles appears to be ¾-inch 3-braid rope of which was in good shape at the time of survey. It is likely that this rope is polypropylene based on its appearance. Most tires are buried 25 - 50% into the sediment, which is composed of fines (sand and silt).

Non-Tire Reef Features

There is a large wooden barge (4,137 sq. ft.) in the northeast corner of the reef footprint (Figure 115). This feature is at a depth of 46.9 ft. NAVD88 and is raised 1.64 to 3.28 ft. off the bottom. Another rectangular feature exists approximately 30 ft. to the south of the barge (Figure 111). This object remains unidentified and is 135 sq. ft. in area.

Habitat Characteristics

The Carr Inlet tire reef is within critical nearshore habitat for rockfish species (NMFS 2015). It is also located within subtidal geoduck leases 11450 and 11400 (Figure 112). Surf smelt spawn has been found and documented on the beach at Kopachuck State Park (Figure 112). The beach at Kopachuck State Park is closed to recreational shellfish harvest (DOH 2023).

Tunicates and sea stars (sp. Unidentified) covered many of the tire bundles. Fifteen rockfish were seen swimming among the tire bundles in towed video (Figure 116). Most of these fish were copper rockfish (*Sebastes caurinus*).

Figures and Tables

Table 18. Carr Inlet tire reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	Minimum	Maximum
Depth at NAV88 (ft.)	-50.89 ± 4.12	-55.73 ± 5.85
Distance from Shore (ft.)	744	860
Reef Footprint Area (acres)	1.91	
Reef Node 1.5m Buffer Area (acres)	0.04	
Number of Tires	76 ± 13	455 ± 81
Tire Weight (lb.)	1,539	9,092

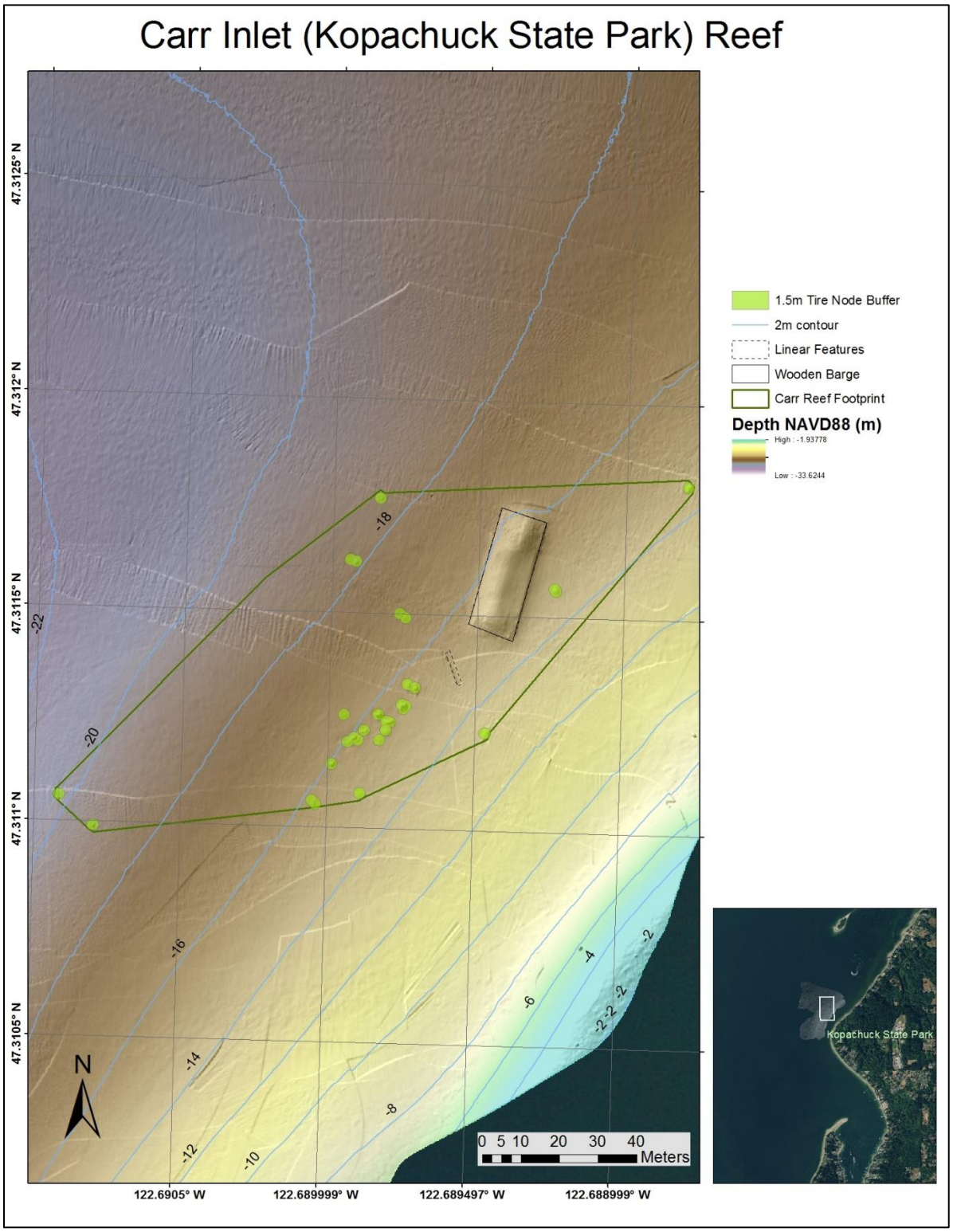
Carr Inlet (Kopachuck State Park) Reef
47.3125° N
47.312° N
47.3115° N
47.311° N
47.3105° N
122.6905° W
122.689999° W
122.689497° W
122.688999° W
-18
-22
-20
-16
-14
-12
-10
-8
-6
-4
-2
N
0 5 10 20 30 40
Meters
1.5m Tire Node Buffer
2m contour
Linear Features
Wooden Barge
Carr Reef Footprint
Depth NAVD88 (m)
High : -1.93778
Low : -33.6244
Kopachuck State Park

Figure 111. Carr Inlet tire reef located off Kopachuck State Park in Carr Inlet. The 1.5 m tire buffer indicates where tire bundles are located. Linear features in the image identify features that are not tire bundles, but are unknown features. These features could be wood, concrete, or metal structure.

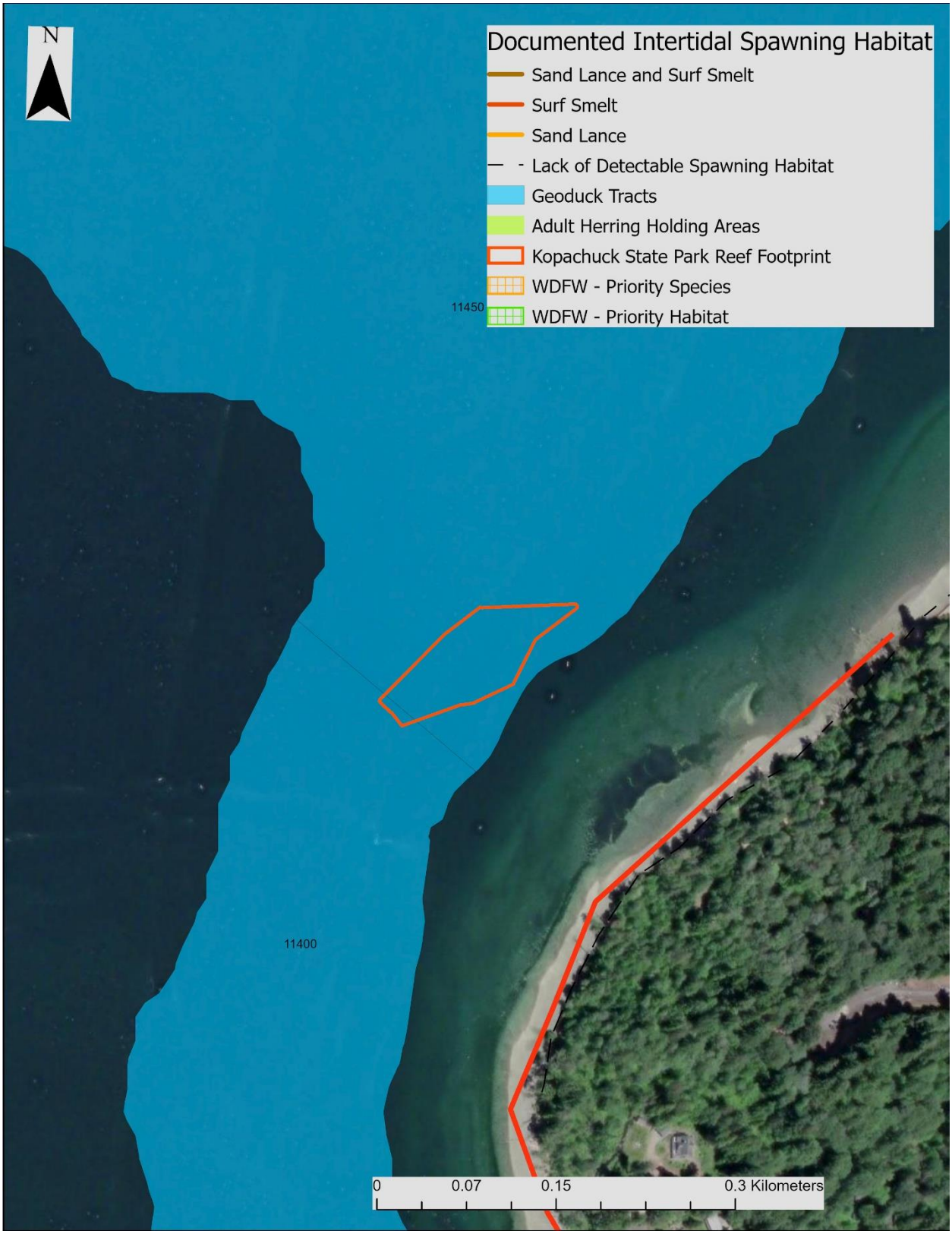

Figure 112. Available habitat and species data in reference to the Carr Inlet reef footprint.

Figure 113. Tires banded by what appears to be three strand line. The tires do not appear to be traditional automobile tires, and could be from jeep or military equipment.

Figure 114. Tire bundles. In this photo, the bundle appears to have broken apart.

Figure 115. Image of the side of the wooden dock or barge located in the northwest portion of the reef.

Figure 116. Copper rockfish were detected in the video survey at the site. They were grouped and present around tire structures. Tunicates covered the surface of many of the tire bundles as well.

Figure 117. Tires buried 20-25% at the site.

Figure 118. Tires buried 20-25% at the site.

Figure 119. Three lone tires banded together.

Figure 120. Piles of tires with sea stars on them.

Figure 121. Anemones on tires found at the Carr Inlet tire reef site.

4.10 Case Inlet (Harstine Island State Park)

Case Inlet Tire Reef (Harstine Island State Park)

Overview

The Case Inlet tire reef was surveyed on 12/19/2019. Eighty acres were surveyed with a multibeam, sonar just North of McMicken Island and offshore of Harstine Island State Park. A small reef was found relatively close to shore (300 to 600 feet offshore), spread out over a comparatively large footprint (3 acres). A few large boulders were found dispersed within the survey area. It appears that these are from upslope bluff erosion. Gravel, small cobbles, boulders, and sand dollars characterized the shallow regions of the survey site. Deeper regions and the area around the present tire reef is characterized by sand and finer sediments. No eelgrass was found in our video survey nor was it evident in multibeam surfaces. Bundles making up the reef appear to be built from eight to ten tires and are only one row high. Many of these bundles are up to 50% buried in fine sediment. Visibility on 12/19/2019 was poor, and it was not possible to determine if bundles were tied together and with what material if so. Single tires that were found were 25 – 50% buried and standing upright. The shoreline above the Case Inlet tire reef site is wooded and undeveloped. No other structures (docks etc.) exist in the immediate area.

Reef Location

General Description of Location:

The center of the Case Inlet tire reef is located approximately 500 feet off shore of Harstine Island State Park. The closest private boat launch to the site is at the Fair Harbor Marina in Grapeview, WA. This boat launch has a concrete pad, and is relatively deep. It can be used at all tides except extreme lows. The launch is owned by the Port of Grapeview and can be used for a fee.

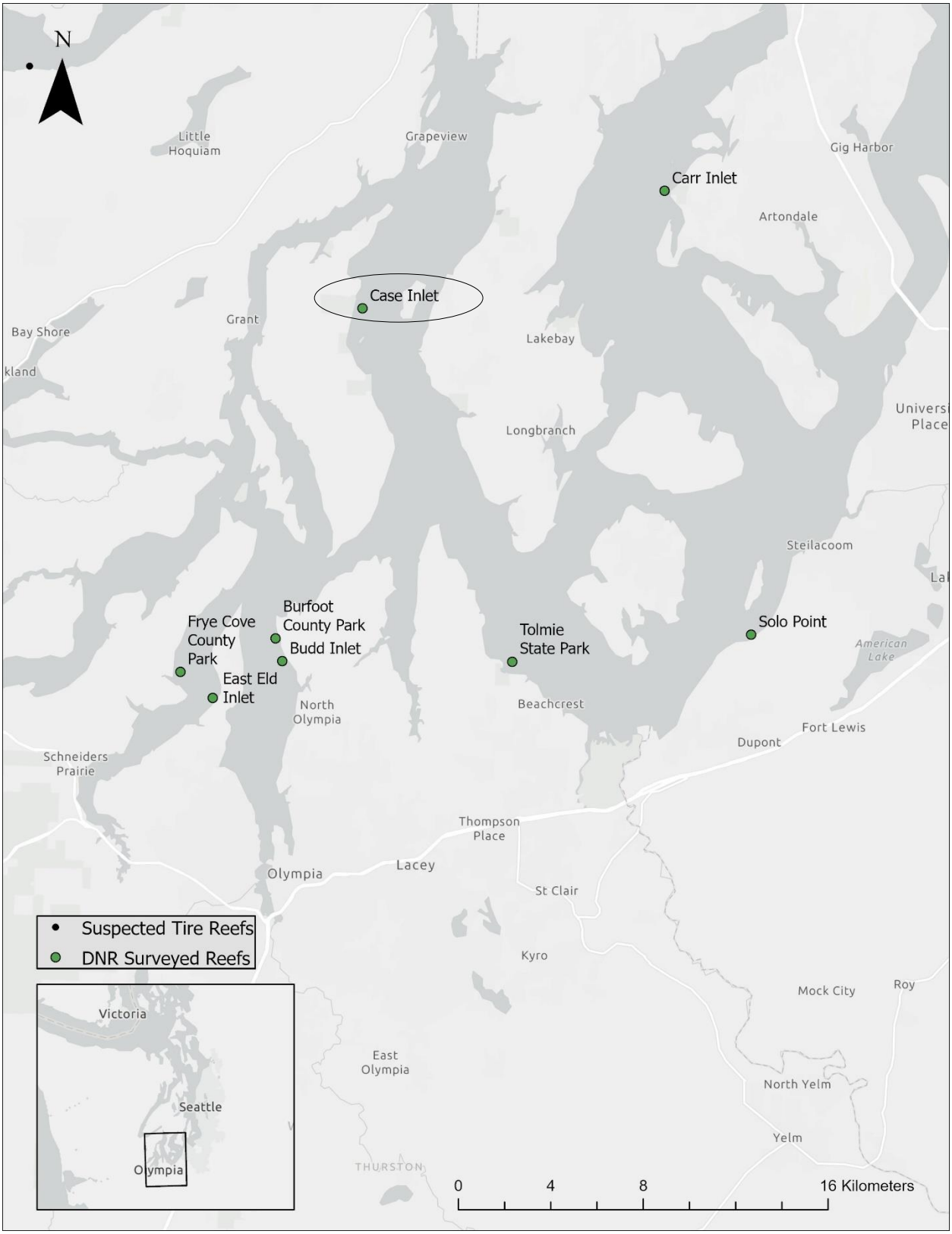

Figure 122. South Sound Tire Reef Sites - the Case Inlet reef is circled.

Table 19. Coordinates of the Case Inlet Tire Reef. Note: center reef coordinates indicate the approximate spatial center of all four corners and not the highest density of reef features.

	Latitude	Longitude
Center	47.261668 N	-122.864879 W
NW Corner	47.262311 N	-122.865803 W
NE Corner	47.262115 N	-122.864171 W
SW Corner	47.261162 N	-122.865143
SE Corner	47.261143 N	-122.864681

Reef Attributes

Tires

This tire reef is relatively small (3 acre footprint) with three main tire groupings of standard automobile tires (Figure 123). A few smaller groupings (~ 8-10 tires) and individual single tires were also found spread out within the 3-acre footprint (Figure 123). Bundles at this site typically hold 8 to 10 tires and are barrel joined in one tire high rows. Most of these rows are 25 to 50% buried in fine sediment.

Non - Tire Features

No other materials (concrete/wood/metal) were found within our survey bounds of the Case Inlet reef.

Habitat Characteristics

The Case Inlet site is located within nearshore critical habitat for rockfish species (NMFS 2015). It is also located within a subtidal geoduck tract (#15750) (Figure 124). The deeper portions of Case Inlet, just offshore from the Harstine Island State Park reef are designated as an adult herring holding area (Figure 124). In addition to these classifications, the beach at Harstine Island State Park (Ballow) just inshore of the tire reef is open for recreational shellfish harvest (DOH 2023). WDFW has not documented sand lance or surf smelt spawn on the beach inshore or on either side (both north and south) of the tire reef (Figure 124).

At the time of survey, there appeared to be tunicates living on the tires (Figure 125), however due to the poor clarity on 12/19/2019 we did not observe other animals living on or around the reef.

Figures and Tables

Table 20. Case Inlet tire reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	Minimum	Maximum

Depth at NAVD88 (ft.)	-14.03 ± 1.19	-28.01 ± 0.77
Distance from Shore (ft.)	272	541
Reef Footprint Area (acres)	3.00	
Reef Node 1.5m Buffer Area (acres)	0.072	
Number of Tires	139 ± 44	481 ± 131
Tire Weight (lb.)	2,783	9,625

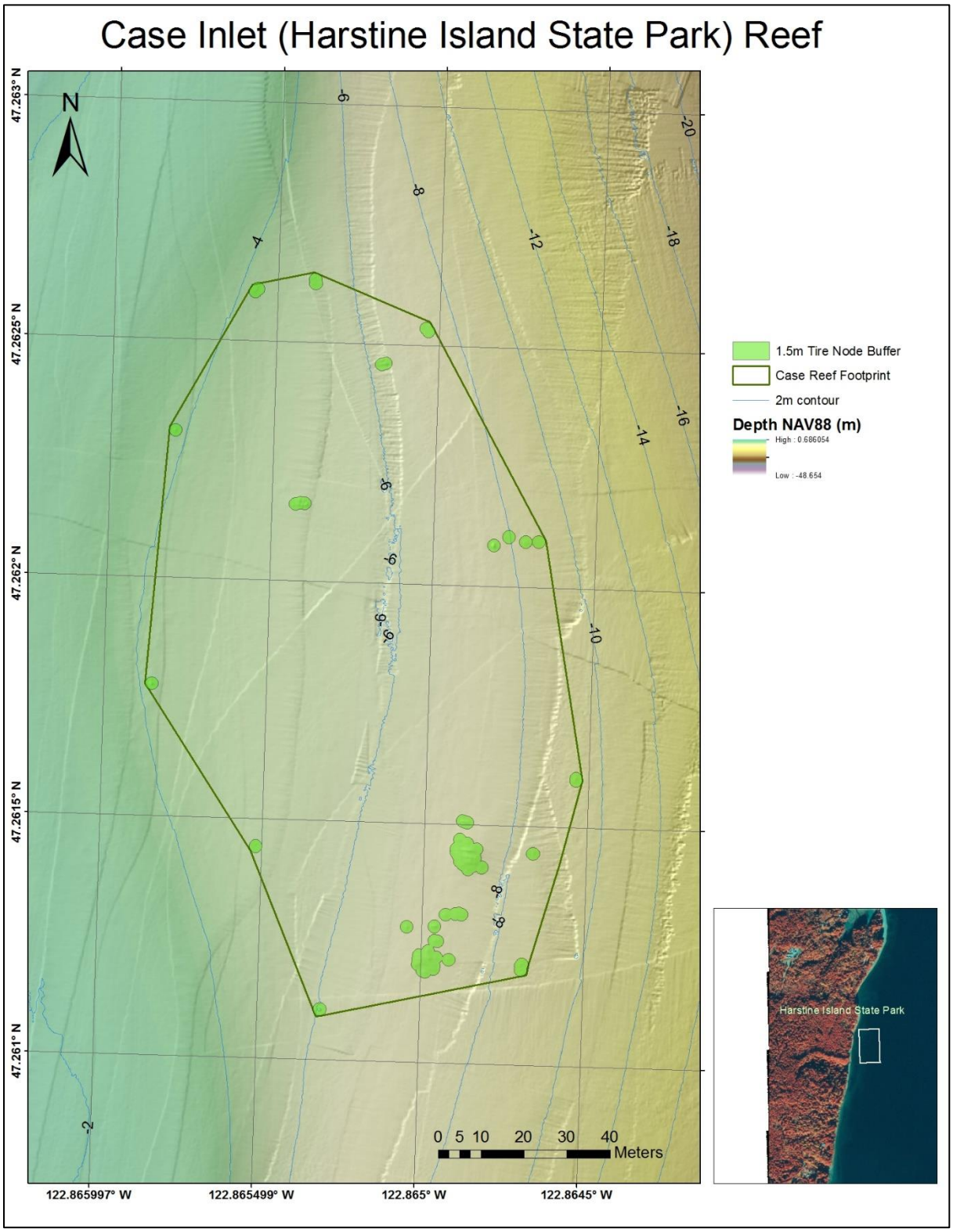

Figure 123. Map of the Case Inlet Tire Reef.

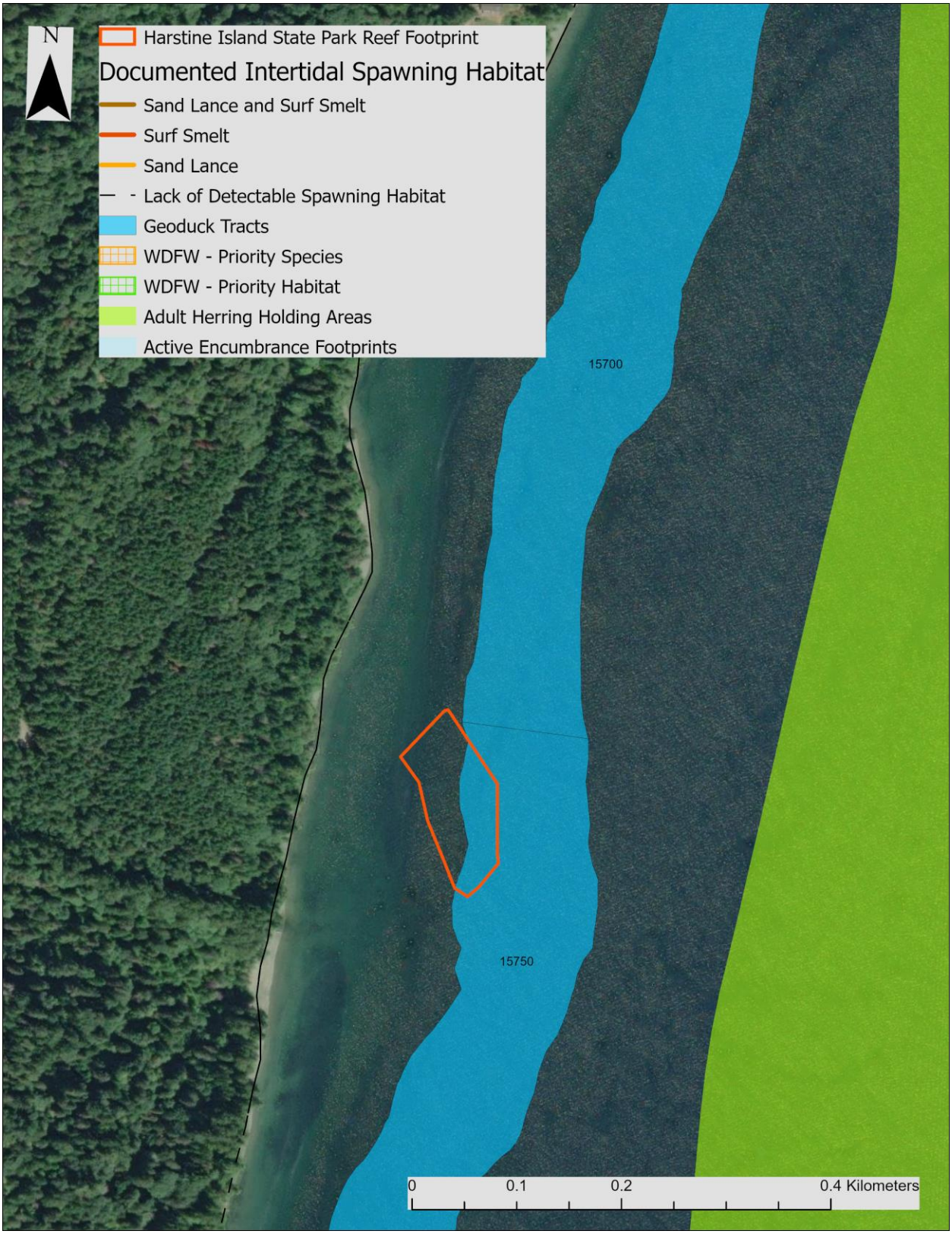

Figure 124. Habitat and species map of the area surrounding the Harstine Island State Park Tire Reef.

Figure 125. 50% buried tires to the left of the frame.

Figure 126. 50% buried tires to the right of the frame.

4.11 Solo Point

Solo Point Tire Reef

Overview

Solo Point is located in a high-current area of southern Puget Sound, directly across from the active sediment feeder bluff of southern Ketron Island. Large tidal currents rush through this narrow gap, driven by the large diurnal tides in southern Puget Sound, and the fast currents generated by the constricted gap of the Tacoma Narrows. Average currents near Solo Point range from 1.8 to 2.1 knots on the flood and ebb tide respectfully. A large reef spread out over nearly seven acres was detected here from our video and multibeam surveys.

Reef Location

General Description of Location and Access:

Solo Point is located in South Puget Sound near Ketron Island between the cities of Steilacoom and Dupont, WA. It is a heavily used recreation site within the Joint Base Lewis-McCord military complex. A railroad riprap seawall protects the narrow rail corridor through this part of the coastline, closely bordered by steep bluffs with high landslide potential (WDNR 2020). The point is used as an active recreation area and has a paved boat launch on its northwest side as well as a wastewater treatment outfall to the south. This sewer outfall is recorded under easement agreement 51-033960. It is just west of the reef and extends approximately 600 feet into the Sound (Figure 129).

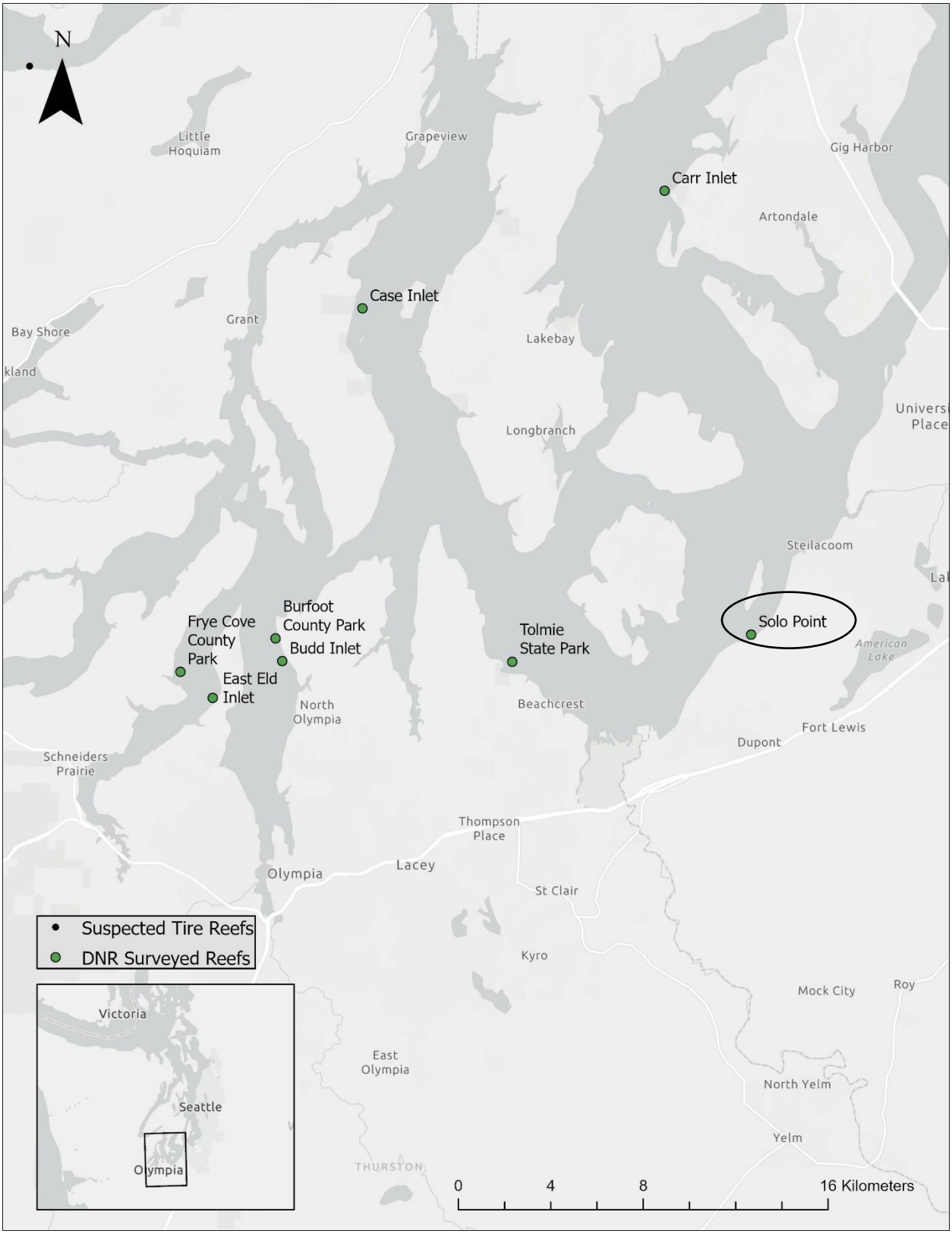

Figure 127. Overview of known and mapped South Sound artificial reefs. Solo Pt. is circled.

Table 21. Approx. coordinates of the Solo Point Tire Reef located just offshore of Solo Pt. (JBLM) in South Puget Sound.

	Latitude	Longitude
Center	47.137 N	-122.63 W
NW Corner	47.1383 N	-122.6352 W
NE Corner	47.1378 N	-122.6342 W
SW Corner	47.1359 N	-122.6371 W

Reef Attributes

General Description of Reef Site

Solo Point was mapped by AAMT staff, and investigated by DNR divers in 2020. A copy of the DNR dive team report is available in supplementary materials. The tire reef at Solo Point may have shifted from its original location as the charted location is to the North approximately 50 meters. Due to high currents at the site, we estimate that the reef is now spread over a larger area than it was originally placed.

According to a Fort Lewis State of the Environment Report, DNR and Fort Lewis worked in partnership to install a tire reef at Solo Point in 1979. The report notes that prior to installation of the tires the site was barren and sandy with a 5% slope and a depth of 45 to 65 feet. Funding from the Sikes Act facilitated the placement of 40,000 donated used tires on the bed lands offshore from Solo Point. Volunteers from the Army National Guard were used to create this reef. SCUBA divers installed the tires and later transplanted kelp to the 2.5-acre reef. The reef was intended for both recreational divers and anglers.

Tires

Tires at this site cover approximately 7 acres of seafloor, with the majority located in a range of depths between -6 and -35 feet relative to Mean Lower-Low Water (MLLW). Very few of the tires appear in pyramid - like formations and are instead spread out in individual barrel rows of six to eight tires (Figure 134). Tire features are banded together with thick three strand polypropylene line. Tires at this site are on average 64 cm in diameter, and 15 cm wide.

Due to heavy sedimentation from the nearby Nisqually River, many of the tire features are almost completely buried, with only the tops visible (Figure 137). Because many of the tire features were 90 – 95% buried at the time of this survey, we assume that more remain under the surface of sediment, undetected by sonar or video analysis. Therefore, it is possible that many more tires are present at Solo Point than our maximum tire estimate, which is based on the total area of identified tire features (Table 22).

Non – Tire Features

In water shallower than approximately - 8m NAVD88, some tire nodes may have been mistakenly placed where riprap boulders exist. These boulders have fallen from the nearby

railway, and are difficult to delineate from tires within shallow portions of the reef. We have been able to delineate some of these uncertain shallow portions, where a DNR dive team was able to provide more detailed information about the reef (1.5 m potential tire buffer, Figure 128). In deeper sections, no other materials were found in video or diver surveys to suggest the reef is anything other than tire formations.

Habitat Characteristics

The Solo Point Reef lies within NMFS designated critical nearshore habitat for rockfish species (NMFS 2015). The beach north of Solo Point is closed to recreational shellfish harvest (DOH 2014) (Figure 130). Surf smelt spawning habitat has been documented along the shoreline to the North of the Solo Point tire reef (Figure 130).

Sea anemones (white and orange) were found throughout the reef attached to tires as well as red algae (DNR Dive Team 2020). Sea cucumber (*Apostichopus californicus*) were also observed roaming the sediment's surface around tire structures. Pacific Geoduck (*Panopea generosa*) necks were abundant and observed by DNR divers surrounding tires in the reef (DNR Dive Team 2022).

Figures and Tables

Table 22. Tire reef estimates determined from spatial data and multibeam sonar analysis. Note: many more buried tires may exist at this site. The values in this table are representative of what was discernable in DNR surveys.

Reef Attributes	**Minimum**	**Maximum**
Depth NAVD88 (ft.)	- 17.05 ± 3.30	-45.91 ± 3.56
Distance from Shore (ft.)	82	524
1.5m Tire Buffer Area (acres)	1.03	
Reef Area (acres)	6.75	
Estimated Number of Tires	2,148 ± 570	8,283 ± 1,723
Tire Weight (lb.)	42,975	165,664

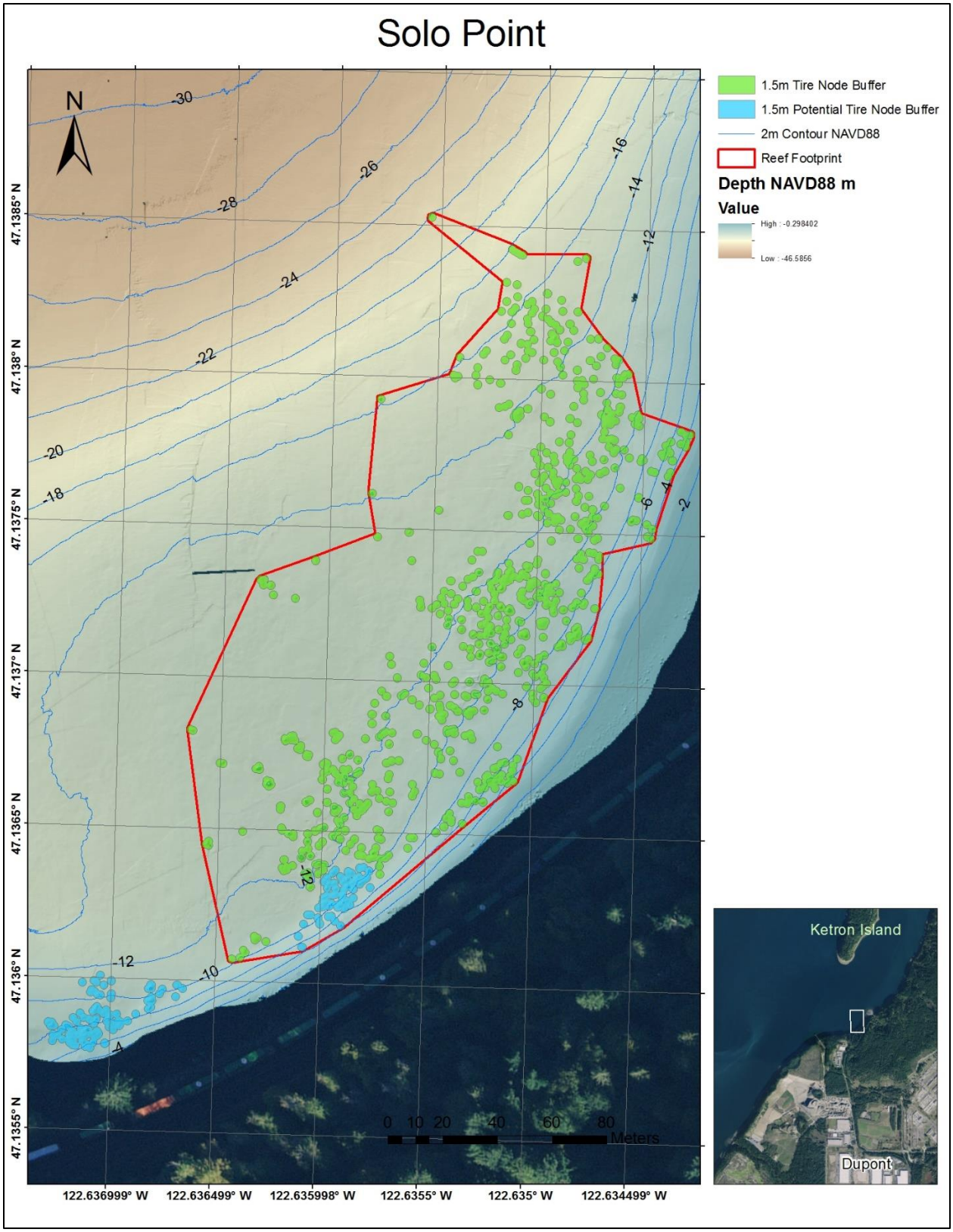

Figure 128. Map of the Solo Point tire reef. Features were delineated with a multibeam sonar and towed video.

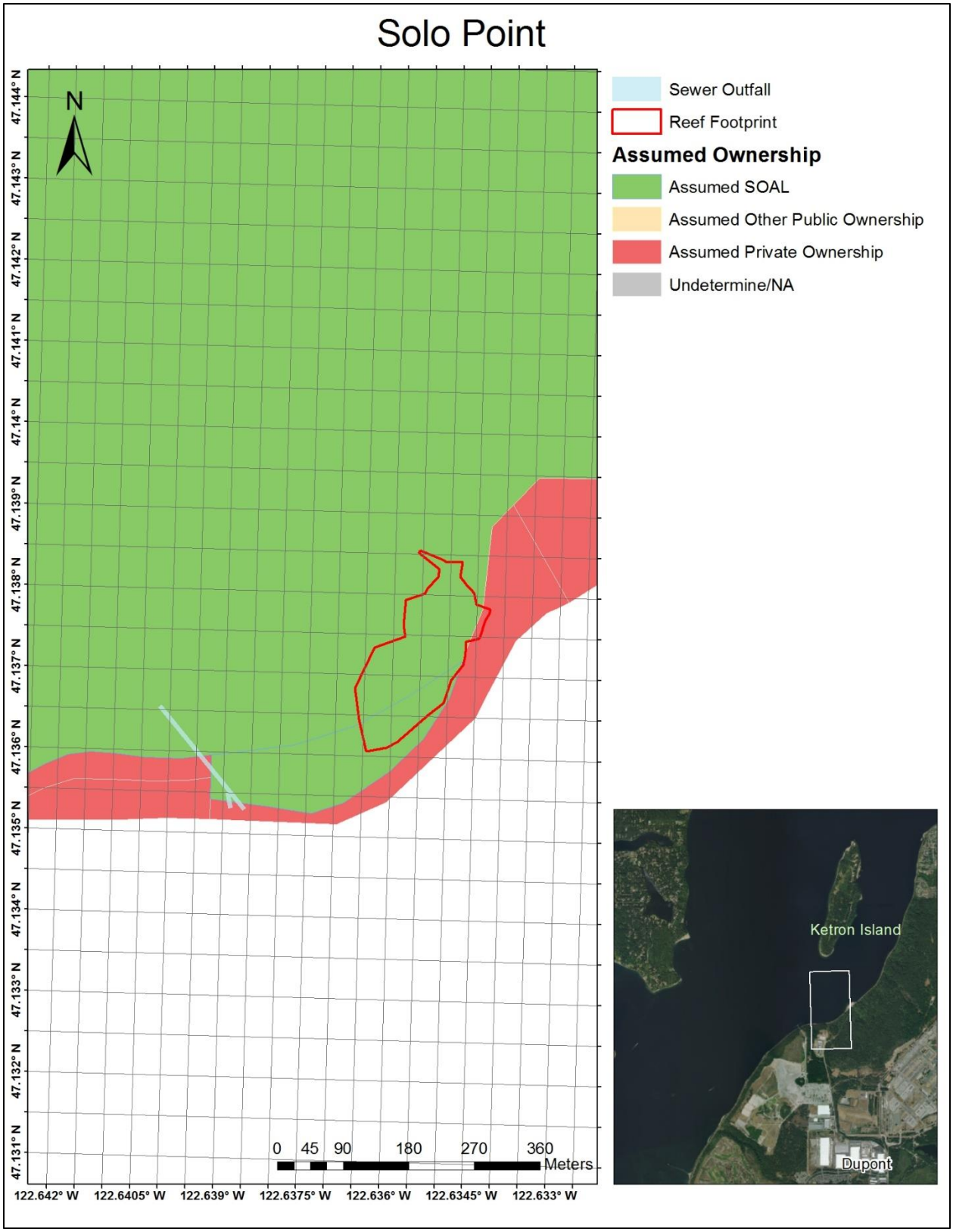

Figure 129. Map showing ownership and encumbrances surrounding Solo Point.

Figure 130. Habitat and species map of Solo Point and the surrounding area.

Figure 131. Tires ready to be deployed into the Solo Point tire reef (date unknown).

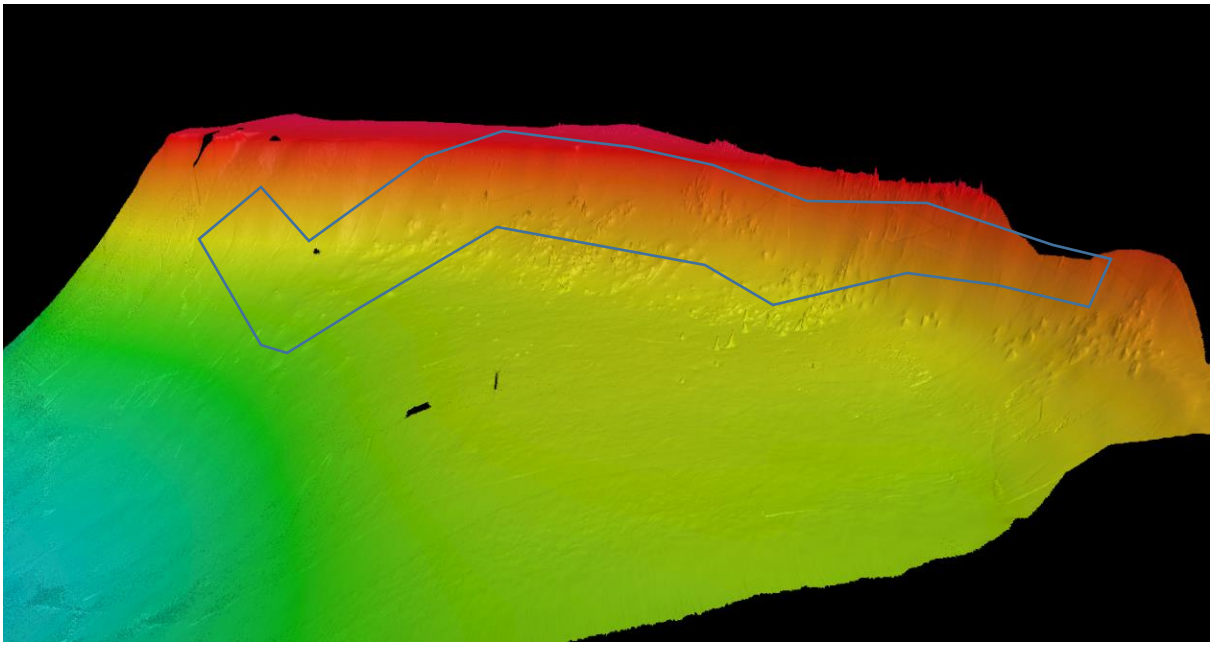

Figure 132. Multibeam sonar data from the Solo Point survey (reef located center of screen). Elevation in this model is vertically exaggerated to highlight differences in relief by five times.

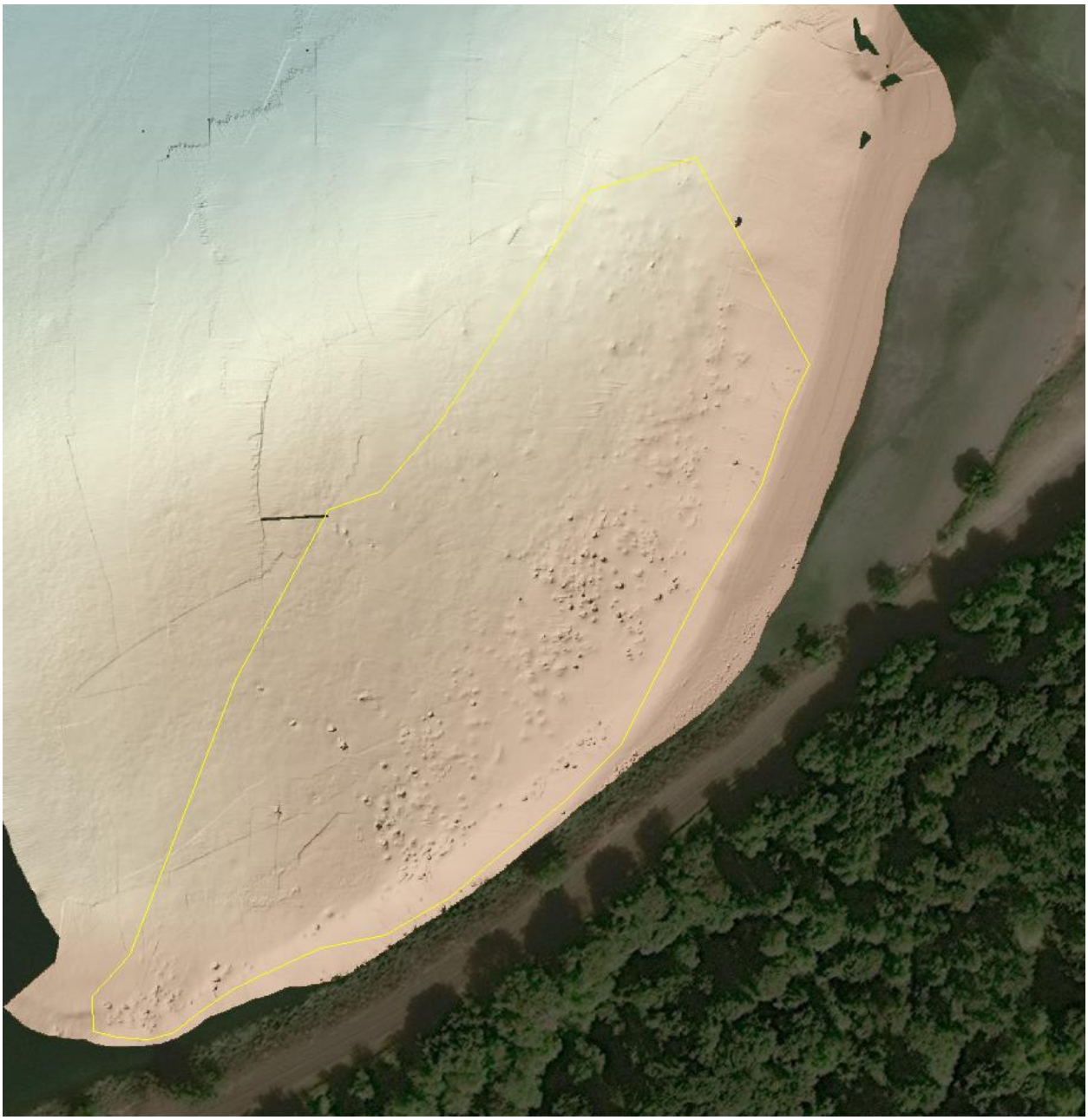

Figure 133. Bathymetry and hill shade showing the Solo Point tire reef and the large boulders from the railroad grade.

Figure 134. DNR diver survey: tires at Solo Point are banded together with three strand polypropylene line.

Figure 135. DNR diver survey: while tires were likely deployed in banded barrels, many groupings have broken from their ordered banding, and are less organized.

Figure 136. DNR diver survey: barrel-grouped tires that are buried up to 50% in sediment

Figure 137. DNR diver survey: barrel-grouped tires that are almost completely buried in sediment.

Figure 138. DNR diver survey: another example of tires that are almost completely buried.

Figure 139 . WDFW ROV footage: an example of one of the few pyramid stacked formations of barrel-grouped tires. It is possible that pyramid groupings were deployed, and over time, the features broke apart into individual barrel rows.

Figure 140. WDFW ROV footage: many tire features at the site are completely buried in sediment.

4.12 Tolmie State Park

Tolmie State Park Tire Reef

A large footprint was surveyed for tires just offshore of Tolmie State Park (Thurston County). A large reef was found that includes many individual tires, tire bundles, and three large wooden barges. The approximate size of the reef covers 2.10 acres. The site has a clear reef with many tire piles that have 6 to 10 tires each. We identified these features from multibeam sonar, drop camera video analysis, and a DNR diver survey carried out on 3/5/2020.

Reef Location

General Description of Location

The center of the Tolmie State Park tire reef is located approximately 500 meters off the Tolmie State Park shoreline in Olympia, WA (Figure 141). The closest boat launch to the site is at

Zittle's Marina located off Johnson Point road. This boat launch is private and should only be used at medium to high tides, as it becomes difficult to access at low tides. There is an agreement between the state parks and DNR (#20-009760) for the mooring buoy zone within the reef footprint.

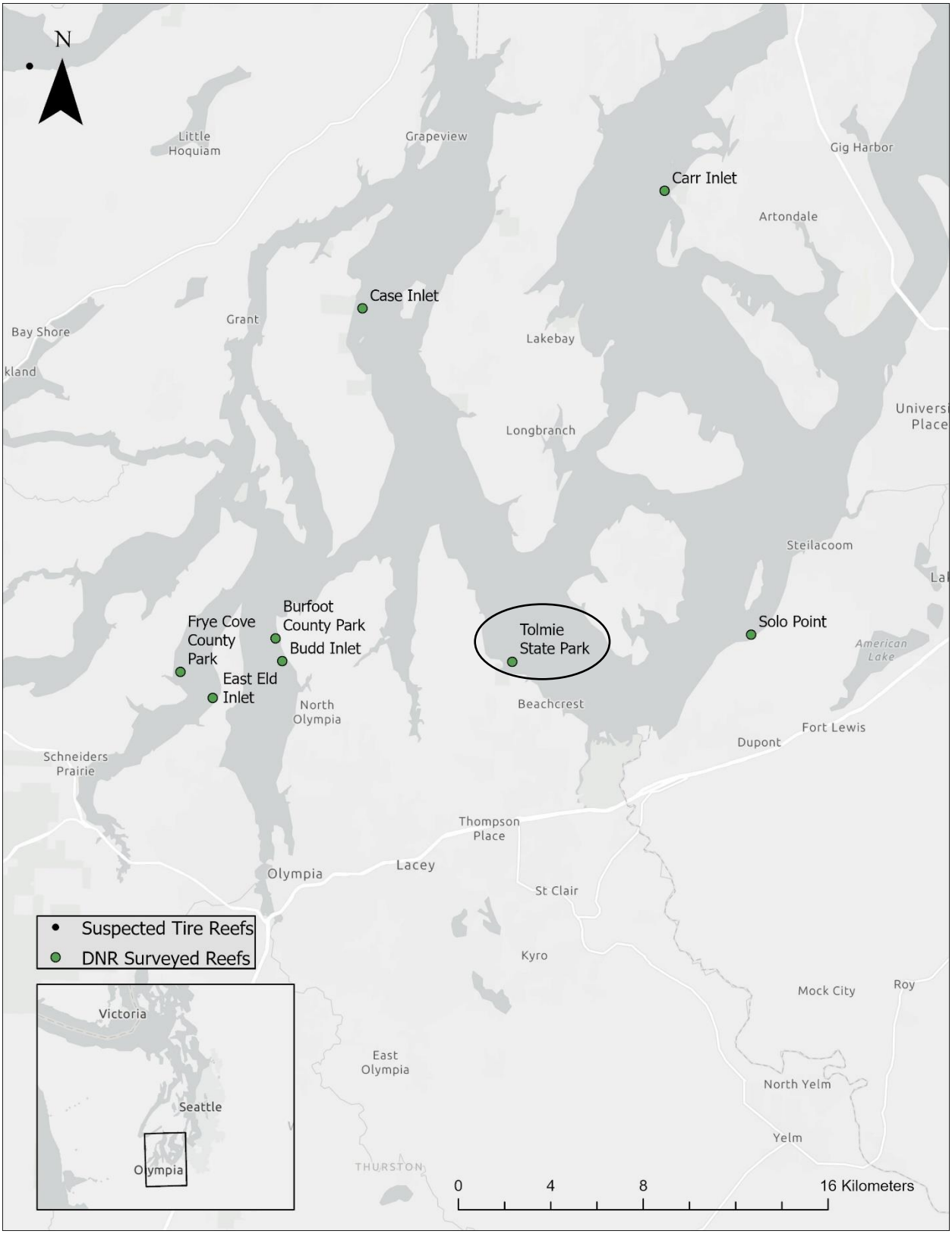

Figure 141. South Sound artificial reef sites - the Tolmie reef is circled.

Table 23. Approximate coordinates of the Tolmie State Park tire reef.

	Latitude	Longitude
Center	47.123946 N	-122.770139 W
NW Corner	47.124589 N	-122.770637 W
NE Corner	47.124083 N	-122.769454 W
SW Corner	47.123572 N	-122.770880 W
SE Corner	47.123475 N	-122.770004 W

Reef Attributes

General Description of Reef

The Tolmie State Park artificial reef is located offshore of Tolmie State Park. It was built in cooperation with and for use by recreational divers (Washington State Parks 2020). The reef is located nearby a State Park-owned mooring buoy field where recreational boaters regularly moor boats. The closest mooring buoys to the reef are located only 20 m from the western edge of the reef footprint.

Tires

The Tolmie State Park tire reef is moderately sized (2.10 acres) and "semi - intact," meaning many tires are still bundled with three strand polypropylene line. Tire bundles at this reef typically hold eight standard passenger or truck tires, but this can vary ± 2 tires. Tires at this site are on average 74 cm in diameter, and 20 cm wide. Most bundles lay horizontal, but in some places tire bundles sit vertically stacked. Most of the Tolmie State Park reef is dispersed (tire bundles and individual tires) between three intentionally sunk wooden barges at the site. Some tires (especially those around the Northeast barge) are mixed in with wooden barge debris (Figure 142 and Figure 146).

Evidence of banding failure was found where some bundles' polypropylene line had worn through, allowing tires to be separated. Regardless of whether bundles had broken into singular groupings, or remained together, the majority tires that were in contact with the sediment were buried up to 25% into sandy substrate. This included the bottom row of tire bundles as well as singular tires that lay on their sides.

Non - Tire Reef Features

Other debris found among tires and wooden barge debris included plastic geoduck tubes from nearby intertidal geoduck farming operations.

Habitat Characteristics

The Tolmie State Park reef lies within NMFS designated critical nearshore habitat for rockfish species (NMFS 2015). It is also just south of an adult herring holding areas along Johnson Pt. and Anderson Island (WDFW 2022). The beaches at Tolmie State Park provide intertidal spawning habitat for sand lance and surf smelt (WDFW 2004). There is WDFW designated lagoon priority habitat inshore of the reef at the park as well (Figure 143).

In DNR dive surveys of the Tolmie reef, Geoduck (*Panopea generosa*) were observed living in the sediment surrounding the site and tunicates (sp. Unidentified) were observed growing on many of the tires in the reef. Rockfish (sp. unknown) were observed in video surveys living among the wooden barge debris. No fish were observed swimming among tire bundles in the diving survey. For a more detailed record of the diving survey, see supplementary Tolmie Dive Report.

Figures and Tables

Table 24. Tolmie State Park tire reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	**Minimum**	**Maximum**
Depth NAVD88 (ft.)	-35.18 ± 5.94	-49.53 ± .0.49
Distance from Shore (ft.)	1,240	1,604
1.5m Node Buffer (acres)	0.37	
Reef Footprint (acres)	2.10	
Number of Tires	NA	2,188 ± 543
Tire Weight (lb.)	NA	43,778

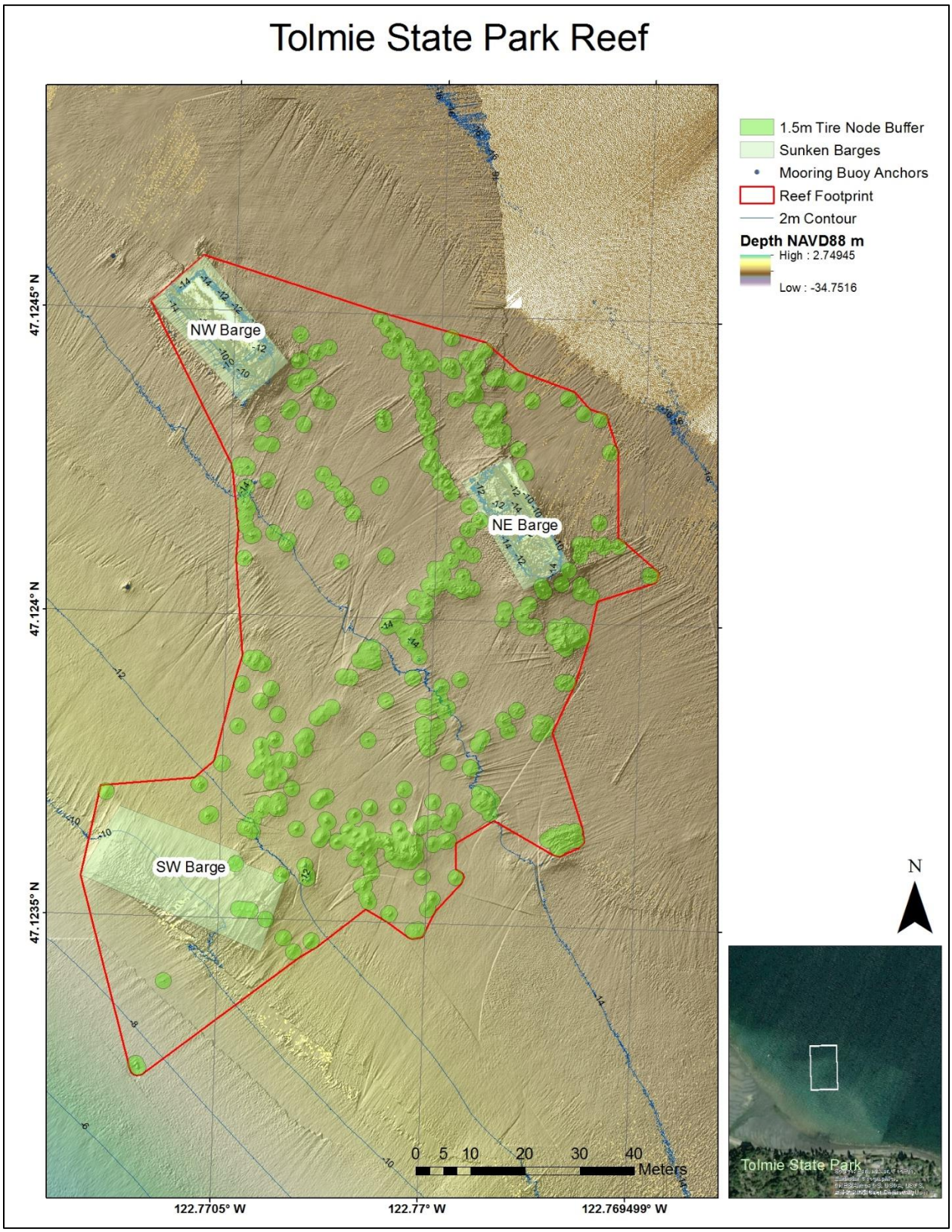

Figure 142. Reef overview of Tolmie site from multibeam and video analysis.

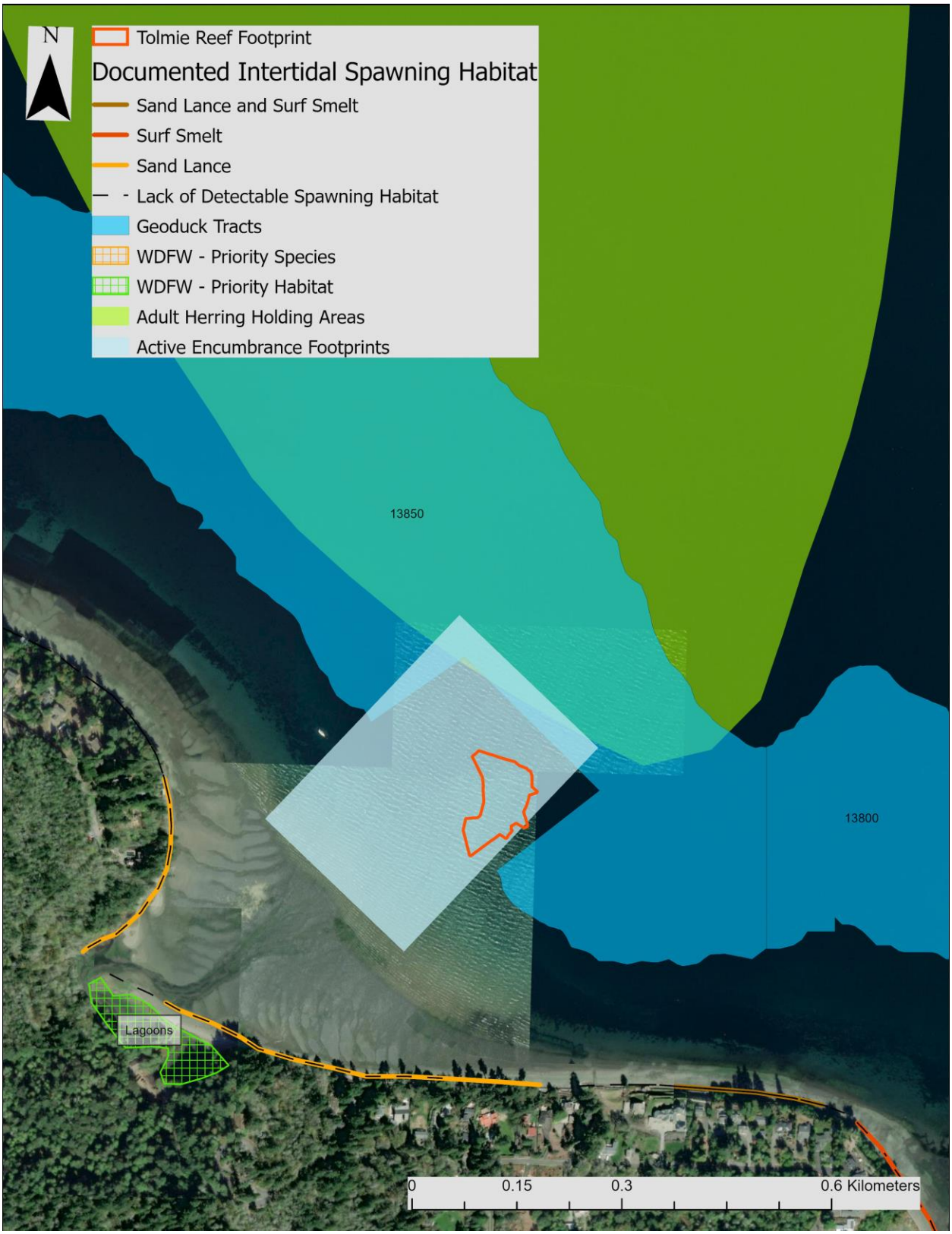

Figure 143. Tolmie State Park habitat and encumbrance map.

Figure 144. Horizontal bundle of eight tires. Tires appear to have been intentionally slashed on placement. Photo taken by DNR divers.

Figure 145. Tolmie Reef tire bundles buried 50%. Bundle in photo is banded with three-strand polypropylene. Photo taken by DNR divers.

Figure 146. Tolmie Reef tire bundles that are mixed with Northeast barge debris. Photo taken by DNR divers

Figure 147. Vertical tire mound identified with towed video survey.

4.13 Burfoot County Park

Burfoot County Park Tire Reef

Overview

*Two areas of interest were surveyed for tires near the north end of Budd Inlet. A reef with many aggregated tire piles (more than 5 tires) was found at the northern area located just offshore of Burfoot County Park. Bundled and individual tires were the only reef materials observed in towed video, with no other large structures (metal/ concrete/ wood) posing an obstacle to tire removal. Additionally, smaller piles with less than five tires and individual tires that appear to have separated from their initial bundle were found. A second site was surveyed approximately 0.50 - 0.75 miles south of Burfoot County Park which was named the Budd Inlet site (*Figure 148*). No evidence of reef structure was found in this location.*

In March 2023, a second survey was completed by DNR staff. This survey revealed many more tires in a reef starting 1,000 ft. from the southern edge of the Burfoot reef to 2,300 down the beach to the south. This data will be amended to this report at a later date.

Reef Location

General Description of Location and Access:

The Burfoot County Park tire reef is located approximately 80 – 180 meters off the Burfoot County Park shoreline in Budd Inlet, seven miles north of Olympia, WA (Figure 148). The most reliable public boat launch nearby is at Swantown Marina near downtown Olympia, and is accessible at most tides.

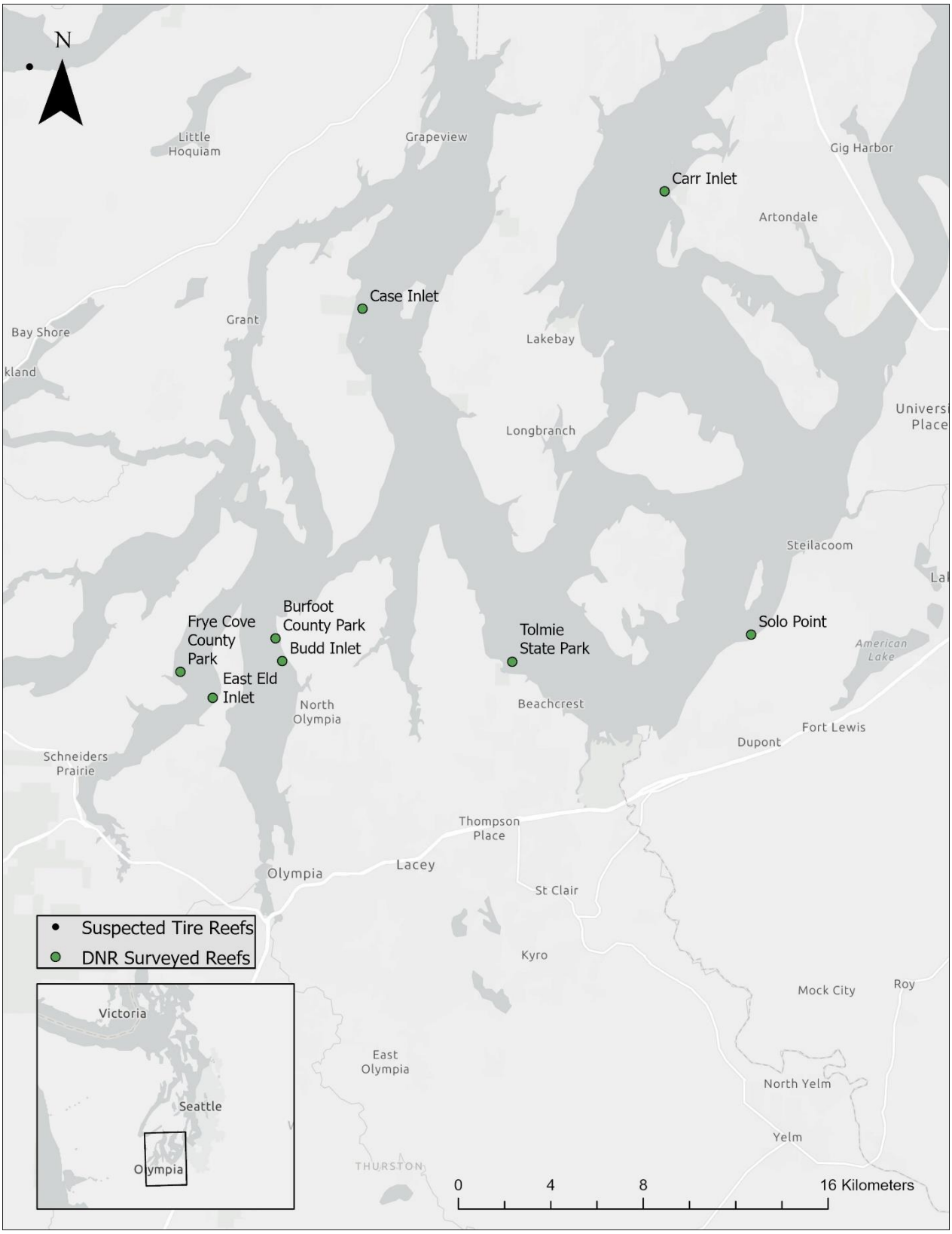

Figure 148. South Sound tire reef sites

	Latitude	Longitude
Center	47.1325 N	122.9073 W
NW Corner	47.1335 N	122.9079 W
NE Corner	47.1335 N	122.9068 W
SW Corner	47.1315 N	122.9080 W
SE Corner	47.1315 N	122.9069 W

Table 25. Approximate coordinates of the Burfoot County Park tire reef.

Reef Attributes

Tires

The Burfoot County Park tire reef is large and dispersed (3.21 acres), with many individual tire nodes falling well outside two main areas of aggregated bundles (Figure 149). Tires within the reef appear to have been initially deployed as single barrel rows of five to eight tires bundled yellow ½-inch polypropylene line. Over the last 40 – 50 years, some of these rows have broken apart into fractional groupings. Evidence for this is supported by multiple individual tires found in the vicinity of larger banded mounds, as well as tires found washed ashore just upland of the tire reef site (Figure 152). Many of these tires are moderately degraded and slashed open (Figure 153). The line bundling tires together at this site is in poor condition and is much thinner than what has been observed at other sites nearby (ex. compared to thicker line found at nearby Solo Pt.). A majority of tires are buried in sediment (up to 10-20% of the tire is buried), however many barrel-joined rows were observed buried up to 95% (Figure 156). Due to the extensive burial of some tires observed here it is possible that the actual number of tires is much larger than our largest estimate. One zone of mostly buried single tires was observed in video, but not detectable within sonar data. This field was located at approximately the -4 m NAVD88 contour, with coordinates 47.133394°N, -122.90706°W. Tires at this site are on average 77 cm in diameter, and 10 cm wide.

Habitat Characteristics

Burfoot County Park and the surrounding shoreline is critical nearshore habitat for rockfish species (NMFS). WDFW has also designated the beach as habitat for spawning surf smelt, and the park is along the migration routes for Coho, fall Chinook, and fall Chum salmon. The beach just inshore from the tire reef is conditionally open for recreational shellfish harvest (DOH 2014) There are platted geoduck beds on SOAL just offshore of the tire reef at Burfoot – the closest in proximity being #16750 (Figure 151).

Video footage of the tire reef at Burfoot County Park revealed that orange (*Ptiloscarus gurneyi*) and slender sea pens (*Stylatula elongata*) are abundant in the soft sediment around the deeper regions of the reef, as are many white and orange Giant Plumose anemones (*Mertridium farcimen*), which were attached to the outer surface of automobile tires (Figure 153 and Figure 158). DNR divers identified Pacific Geoduck (*Panopea generosa*) in the sediment surrounding tires during a diving survey in May of 2022. Marine vegetation such as eelgrass or kelp was not detected within the surveyed area surrounding tires at Burfoot County Park.

Additional Information

The bathymetry surrounding the Burfoot County Park tire reef is steep and there appears to be evidence of an underwater landslide of indeterminate age that occurred at the deep edge of the reef (along the -18m contour mid reef (Figure 150). It is unclear whether this landslide occurred before or after reef construction. If the slump occurred after tires had been placed there, it is possible that some tires could be buried at the bottom of this slump. Sediment at the Burfoot site is composed of fines and sand.

Figure and Tables

Table 26. Burfoot tire reef attributes determined from spatial data and multibeam sonar analysis.

Reef Attribute	**Minimum**	**Maximum**
Depth NAV88 (ft.)	-11.78 ± 4.56	-57.05 ± 5.97
Distance from Shore (ft.)	278	554
Reef Footprint Area (acres)	3.21	
Reef Node 1.5m Buffer Area (acres)	0.94	
Number of Tires	858 ± 142	6,175 ± 1,929
Number of Potential Tires	NA	219 ± 64
Tire Weight (lb.)	17,160	123,500

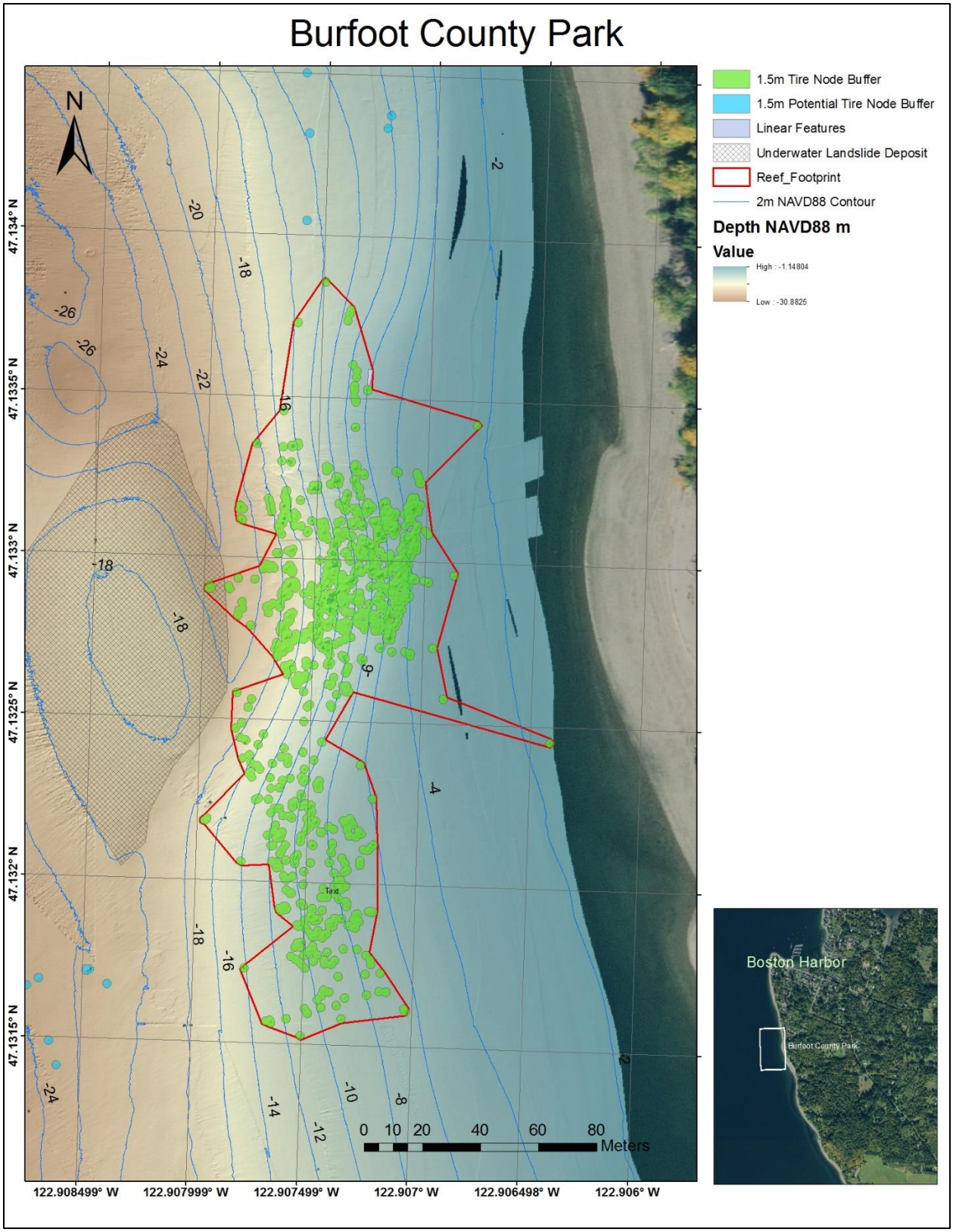

Figure 149. Overview of the Burfoot County Park site

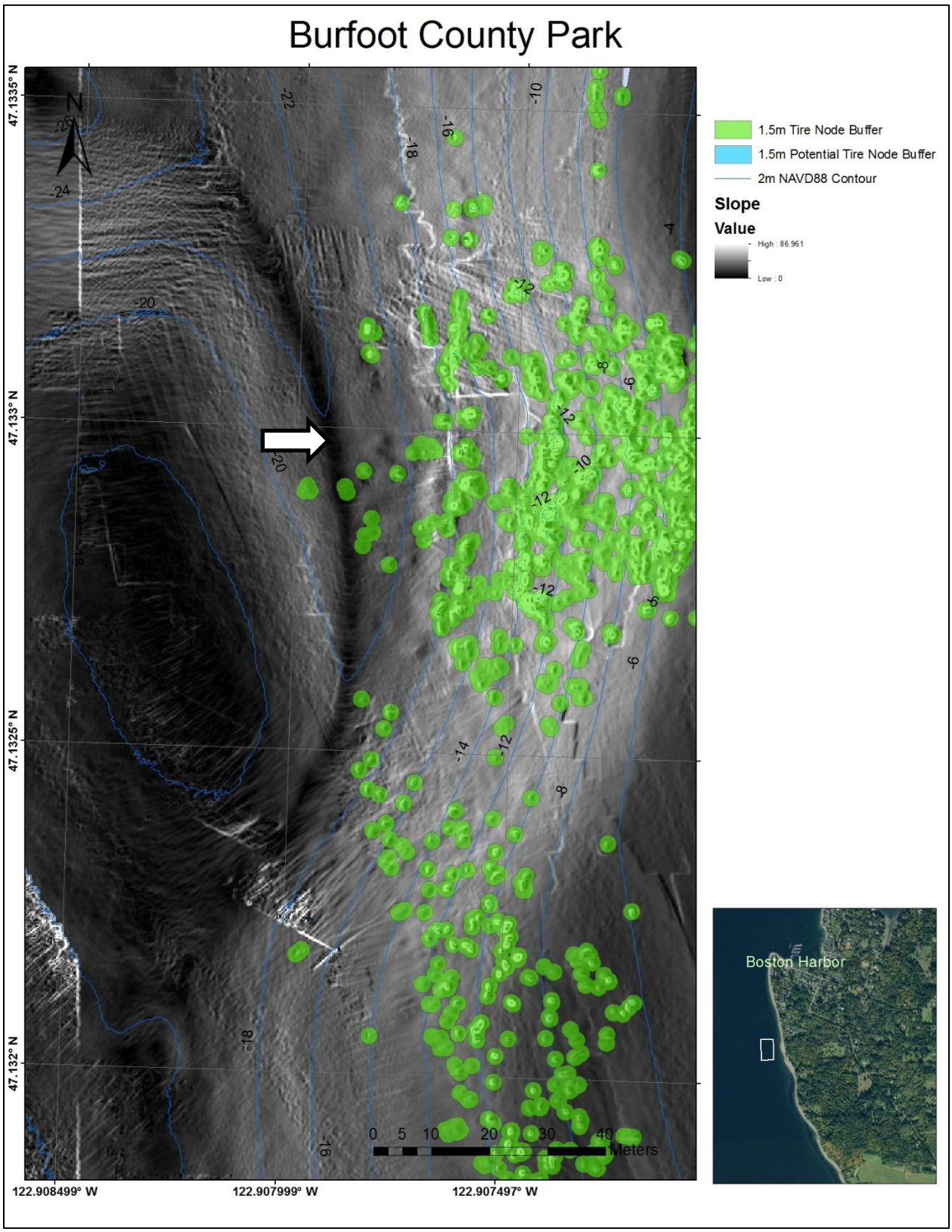
Burfoot County Park
47.1335° N
47.133° N
47.1325° N
47.132° N
122.908499° W
122.907999° W
122.907497° W
N
0 5 10 20 30 40
Meters
1.5m Tire Node Buffer
1.5m Potential Tire Node Buffer
2m NAVD88 Contour
Slope
Value
High : 86.961
Low : 0
Boston Harbor

Figure 150. Image highlighting the "slump" observed in multibeam data that appears to be an underwater landslide. The white arrow highlights the edge of this slump. It is unclear whether this slump occurred before or after reef creation.

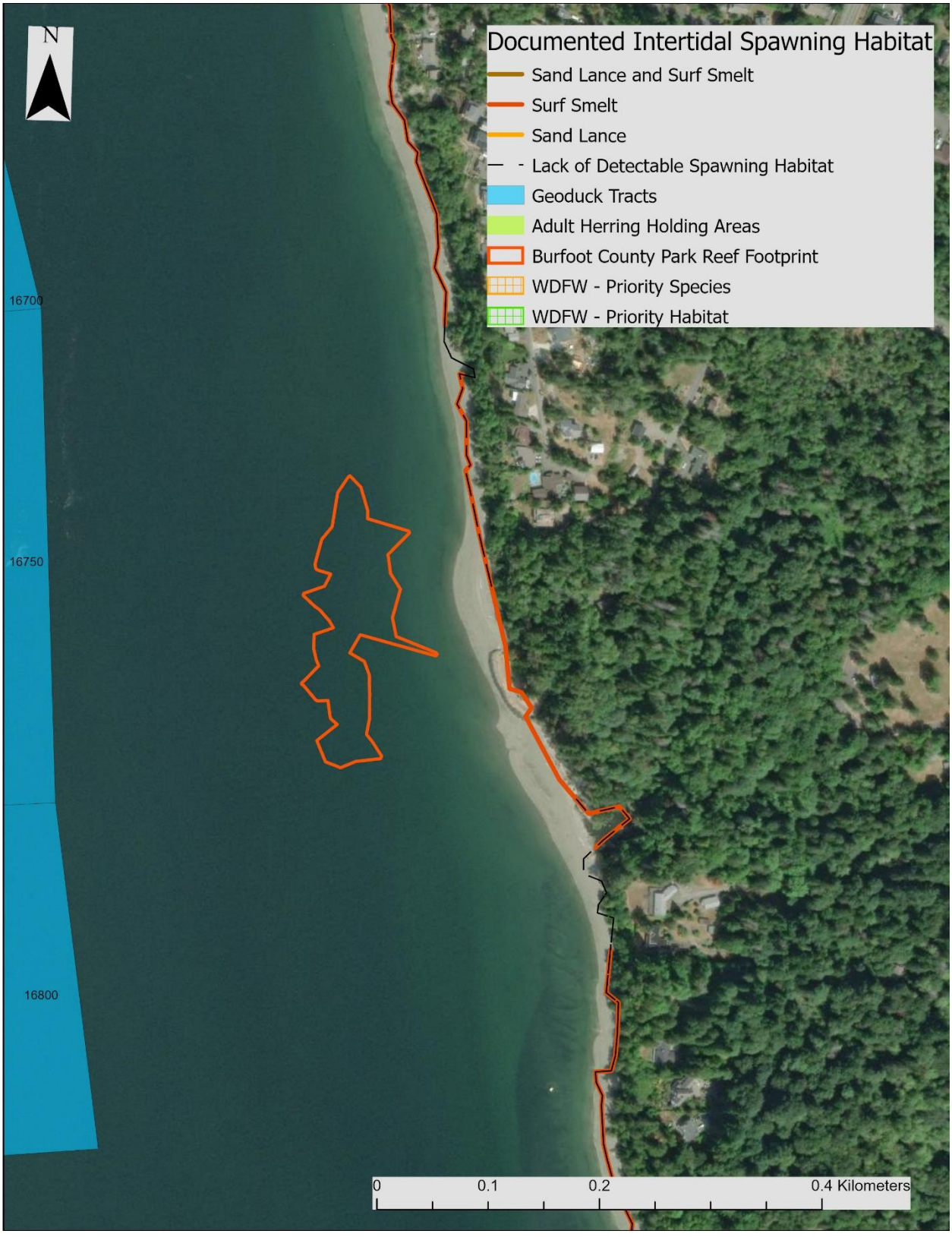

Figure 151. Habitat and species map for the area surrounding the tire reef at Burfoot County Park.

Figure 152. Tires washed ashore upland of the Burfoot County Park reef. (Photo by Chris Robertson, DNR)

Figure 153. An example of tires with air escapement slits.

Figure 154. A group of three tires buried up to 25%.

Figure 155. Tires that have broken apart from their bundles.

Figure 156. Tires that are buried up to 95% at the Burfoot County Park tire reef

Figure 157. Another example of tires almost completely buried at the Burfoot County Park Tire Reef.

Figure 158. Tires at the Burfoot Park reef appear to be a mixture of standard and skinnier off road tires.

Figure 159. A barrel row of five tires buried up to 25% in fine sediment.

Figure 160. Tire condition was moderate to poor at Burfoot County Park. This is an example of a tire that appears to have split in half widthwise at the site.

Figure 161. Tires buried up to 25%. Tires at the site appear to have air escapement slits like these.

Figure 162. Barrel joined rows of 5 to 8 tires were connected together with thin polypropylene line.

Figure 163. One of many groupings of tires where rope banding has broken, allowing tires to fall apart.

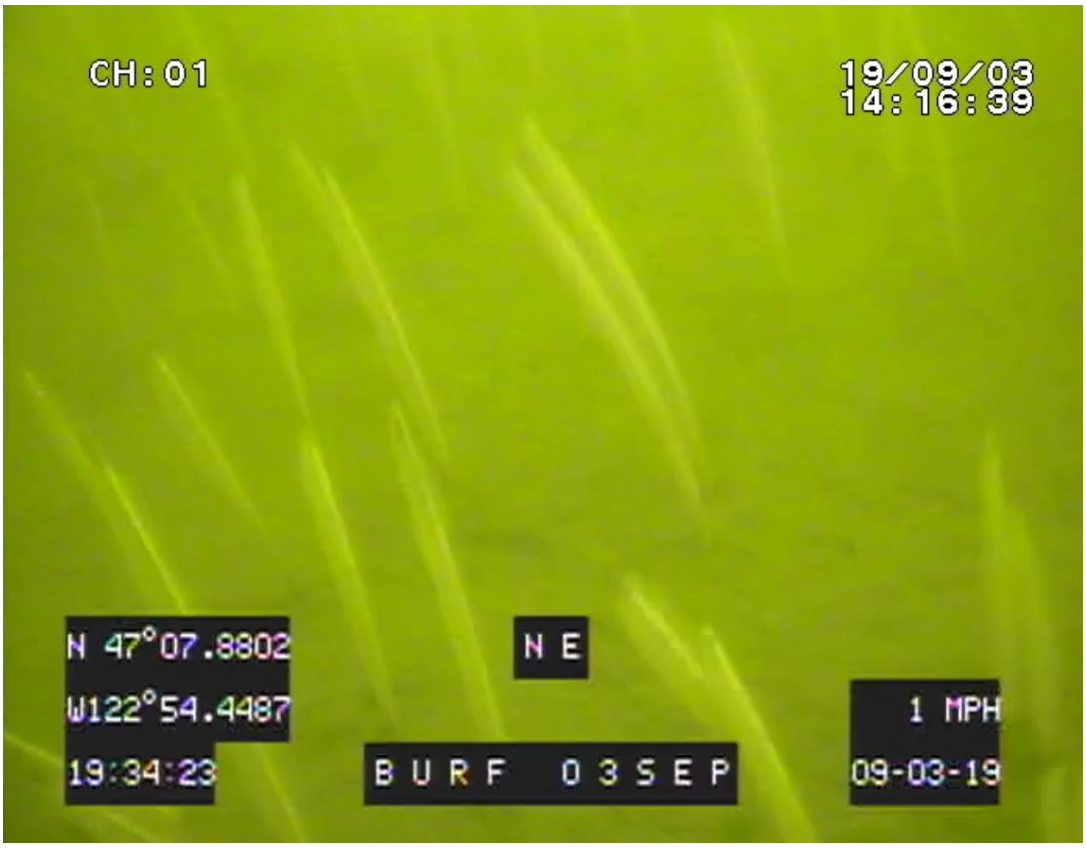

Figure 164. Slender sea pens (*Stylatula elongata*) were observed in the deeper regions of the reef.

Figure 165. Orange sea pens (*Ptiloscarus gurneyi*) were found living within the deeper regions of the Burfoot reef.

4.14 Eld Inlet (Frye Cove County Park)

Eld Inlet (Frye Cove County Park)

Two areas (Frye Cove and Countryside Beach) were surveyed for tires within Eld Inlet on 2/20/2020. An obvious reef with many tire piles (piles with more than 5 tires) and scattered individual tires were found within the survey area located off Frye Cove County Park. The second location across the inlet near Countryside Beach did not reveal any tires. Moving forward, any discussion of the Eld Inlet Tire Reef is referring to the reef off Frye Cove County Park. Only after AAMT processed the Frye Cove sonar data was it realized that a portion of the reef was not mapped. There is likely additional reef at Frye Cove County Park which extends south of where DNR collected data.

Reef Location

General Description of Location:

The Eld Inlet tire reef is located approximately 182 m (596 ft.) off the Frye Cove County Park shoreline near Gravelly Beach, WA (Figure 166). This site is the farthest known inland tire reef in Puget Sound, and tidal current speeds here are low. The closest boat launch to the site is the Arcadia Public Boat Launch in Mason County. This boat launch is used heavily by commercial shellfish operations in the vicinity (Taylor/Seattle Shellfish/Squaxin) and should only be used at medium to high tides. The concrete pad is wide and in good condition, however the launch does not have a dock. The closest public boat launch with a dock ramp is at Swantown Marina near downtown Olympia WA, which is accessible at all tides.

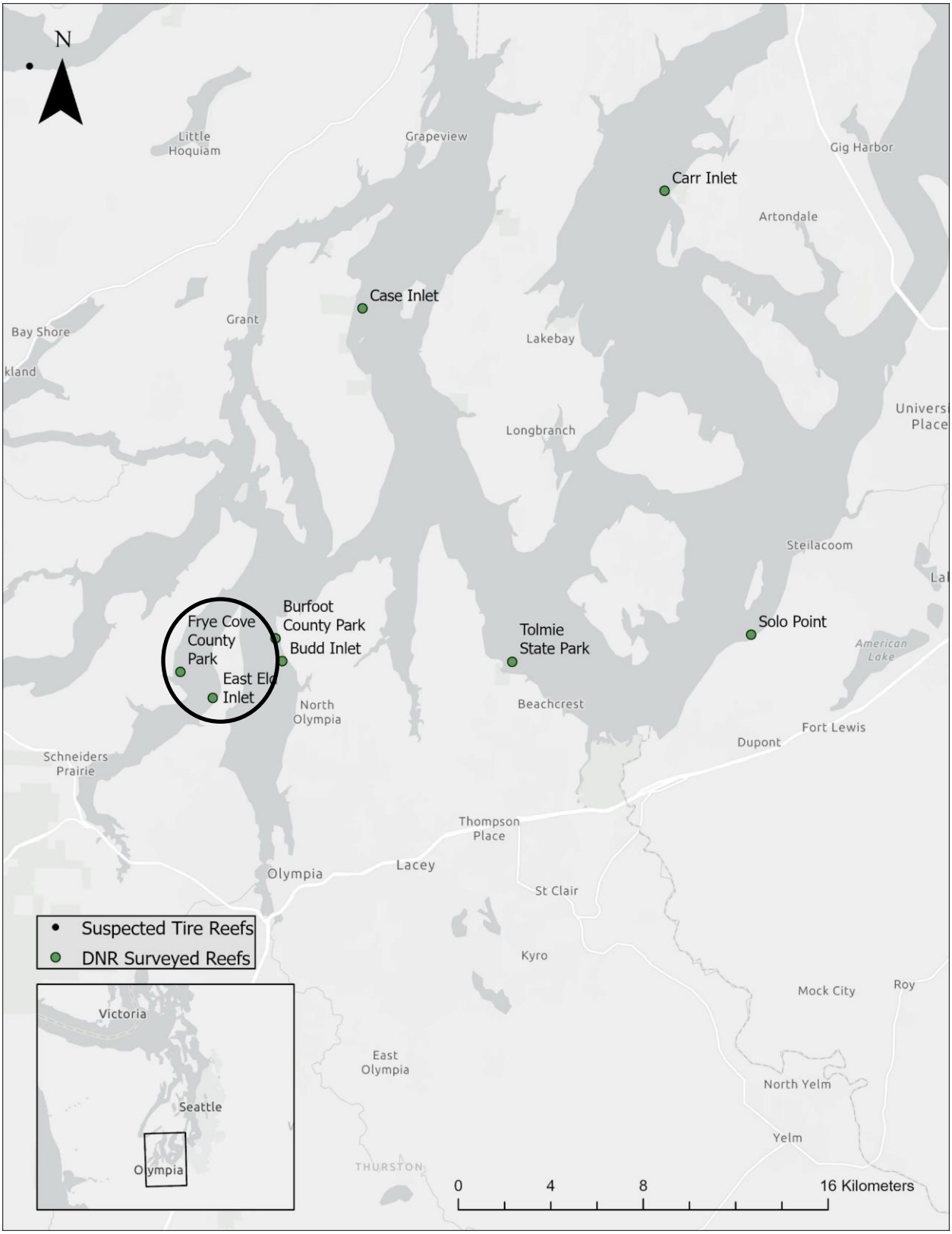

Figure 166. Locations of Eld Inlet surveys. Note: evidence of reef structure was only found at the Eld Inlet site at Frye Cove, and not at Eld Inlet East.

Table 27. Coordinates of the Eld Inlet tire reef located off Frye Cove County Park.

	Latitude	Longitude
Center	47.11675 N	122.9614 W
NW Corner	47.11722 N	122.96179 W
NE Corner	47.11722 N	122.96114 W
SW Corner	47.11624 N	122.96179 W
SE Corner	47.11624 N	122.96114 W

Reef Attributes

Tires

The Frye Cove County Park tire reef is relatively small (1.31 acres) and "intact," meaning the tires are still mostly bundled. The site is characterized by soft, silty sediment with large piles of passenger and small truck tires bundled together with thick polypropylene rope. Many tires in the reef are grouped into barrel rows of 5 to 8 tires (Figure 170); however, there are also disorganized piles of more than 20 tires within the reef footprint. In addition to groupings and bundles of tires, individual tires were also found separate from the main reef. The reef is spread out over 1.31 acres, and more reef features are likely to exist in the identified unmapped portion south of the known reef (Figure 167). Through video analysis, tires at this reef have been determined to be degraded with many identified as slit-open. A few of the tire features here may be significantly buried (> 50%), though most are 20-50% buried (Figure 170). Tires at this site are on average 75 cm in diameter, and 16 cm wide.

Non –Tire Reef Features

Non-tire reef features were not observed in video analysis, nor detected in the multibeam surface at the Eld Inlet site.

Habitat Characteristics

The Frye Cove County Park tire reef lies within critical nearshore habitat for rockfish species (NMFS 2015). There is a salmon bearing stream at the terminus of Frye Cove where Coho Salmon have been documented to spawn (WDFW 2004). The intertidal beach to the south of Flapjack Point (south of Frye Cove) is documented sand lance and surf smelt spawning habitat (WDFW 2004). The site is also along the migration route for Coho, Fall Chinook, and Winter Steelhead who make their way to the Mclane Creek spawning grounds (WDFW 2004). The beach at Frye cove County Park is open for recreational shellfish collection (DOH 2023).

Sea pens (*Stylatula elongata*) were abundant within the soft sediment around the Frye Cove Reef. Orange and white sea anemones were also attached to and covering tire structures (Figure

171). No vegetation (kelps or other macro algae) was found growing on tires at this site. Additionally, our analysis did not pick up eelgrass within the vicinity of the reef.

Figures and Tables

Table 28. Eld Inlet tire reef attributes determined from spatial data and multibeam sonar analysis. It is important to note that these values only represent the portion of reef that was mapped.

Reef Attribute	Minimum	Maximum
Depth at NAVD88 (ft.)	-18.24 ± 2.92	-30.11 ± 0.96
Distance from Shore (ft.)	590	688
Reef Footprint Area (acres)	1.31	
1.5m Tire Node Area (acres)	0.23	
Number of Tires	153 ± 17	1,310 ± 312
Tire Weight (lb.)	3,067	26,212

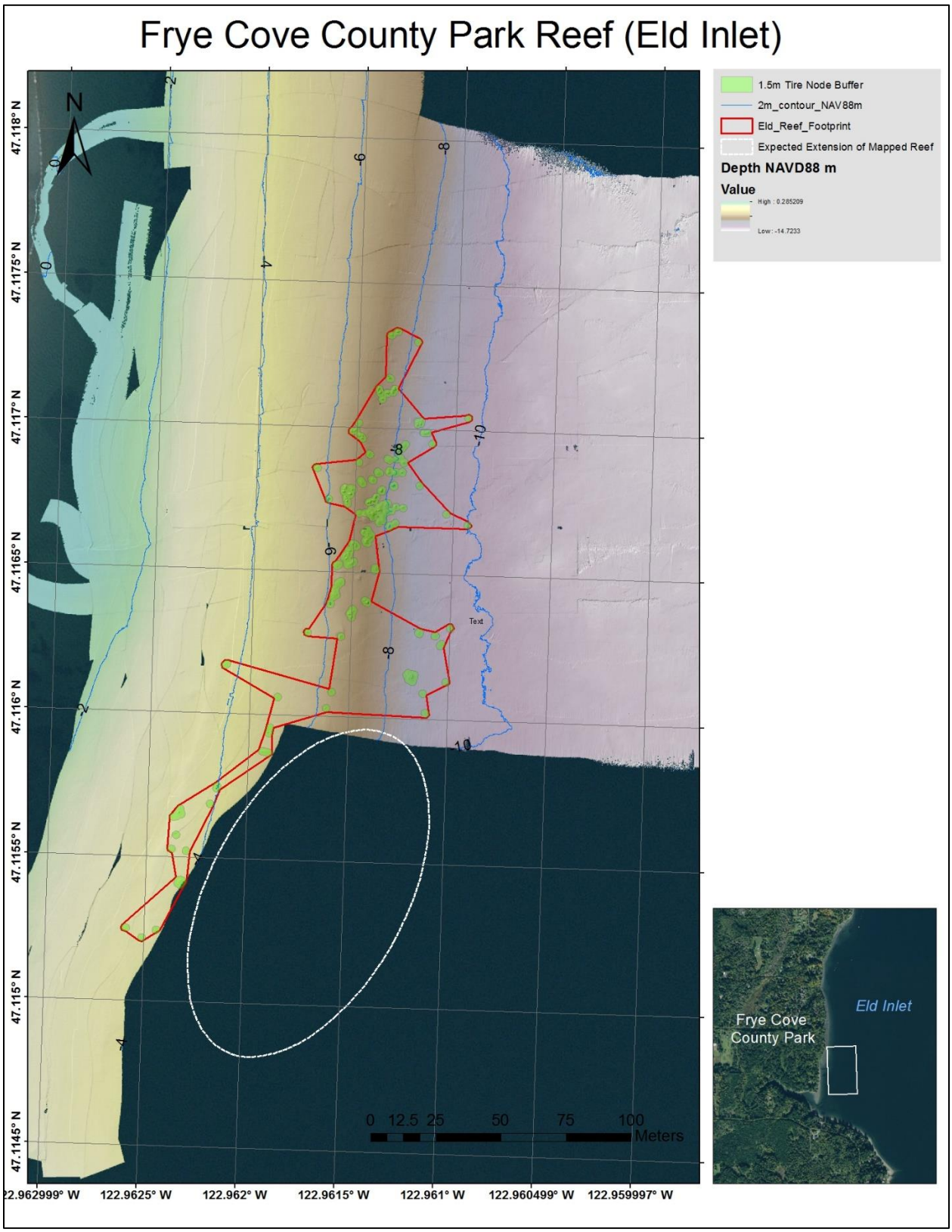

Figure 167. Eld inlet reef at Frye Cove. White circle demarcates where we expect the Frye Cove reef to extend.

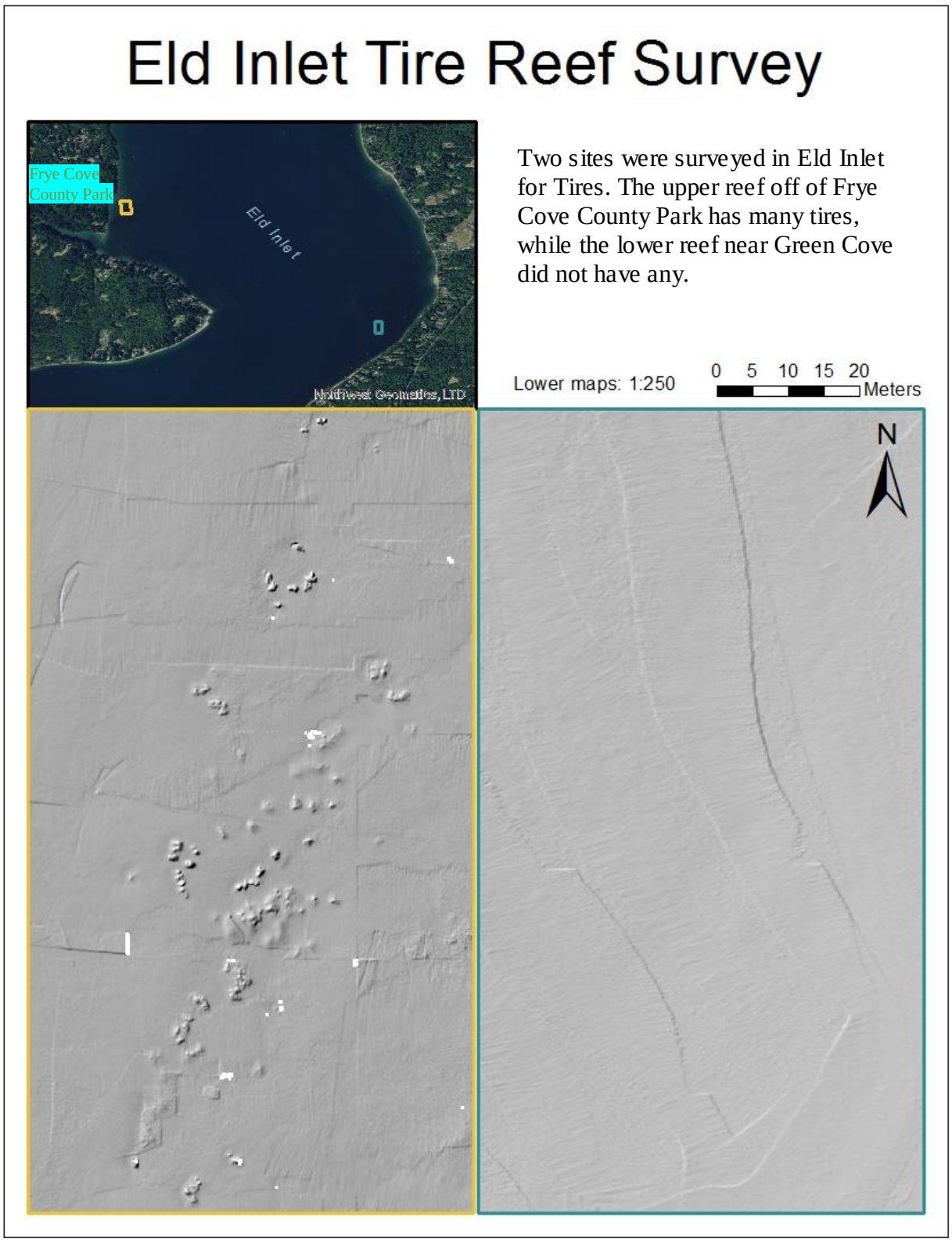

Figure 168. Both sites surveyed for tire reefs within Eld Inlet, south Puget Sound. The upper reef located off Frye Cove County Park demonstrated obvious tires during multibeam sonar analysis as demonstrated by the

left frame. The Eld Inlet East site, located near Green Cove, did not demonstrate any evidence of structure during multibeam sonar analysis, as demonstrated by the right frame.

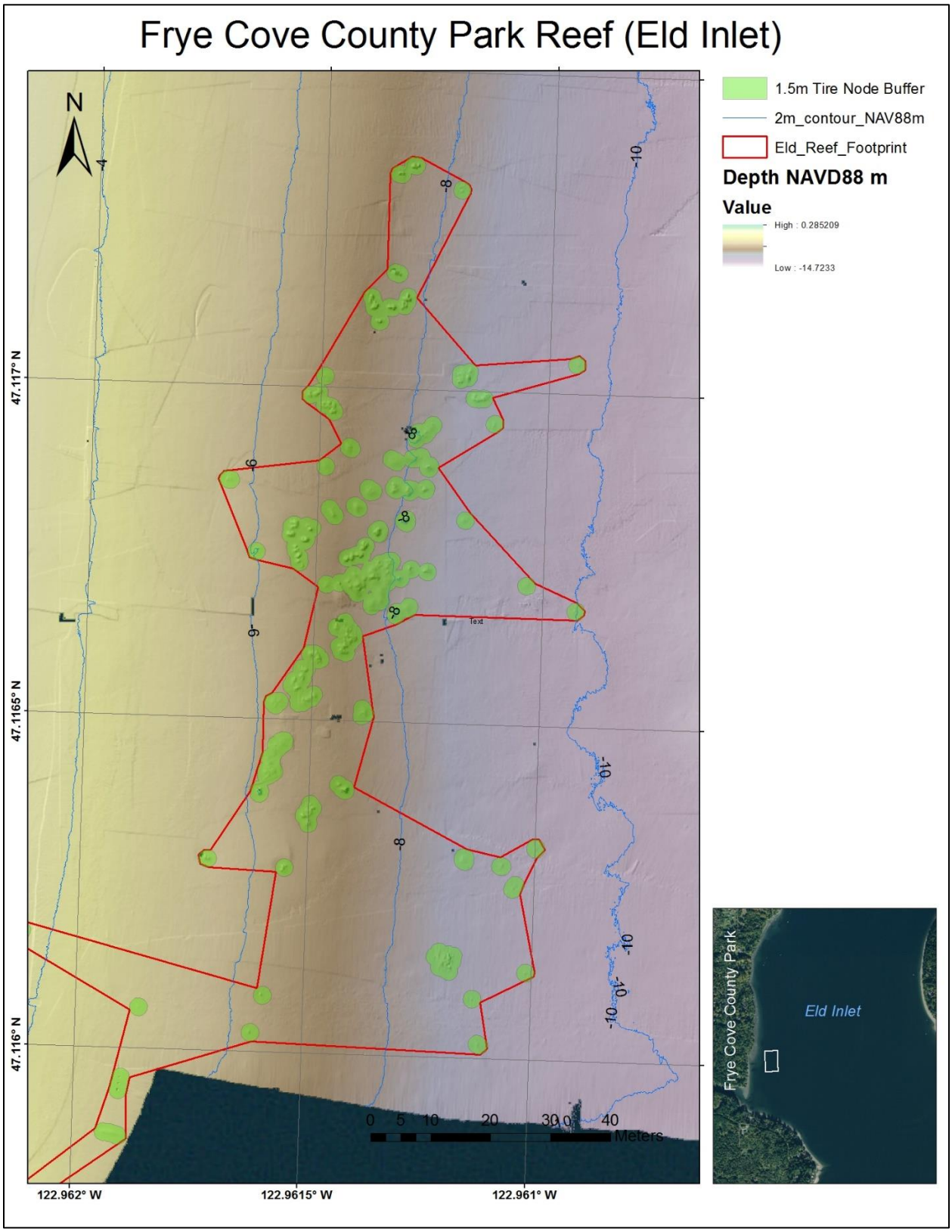

Figure 169. Focused image of Eld Inlet tire reef located off Frye Cove County Park.

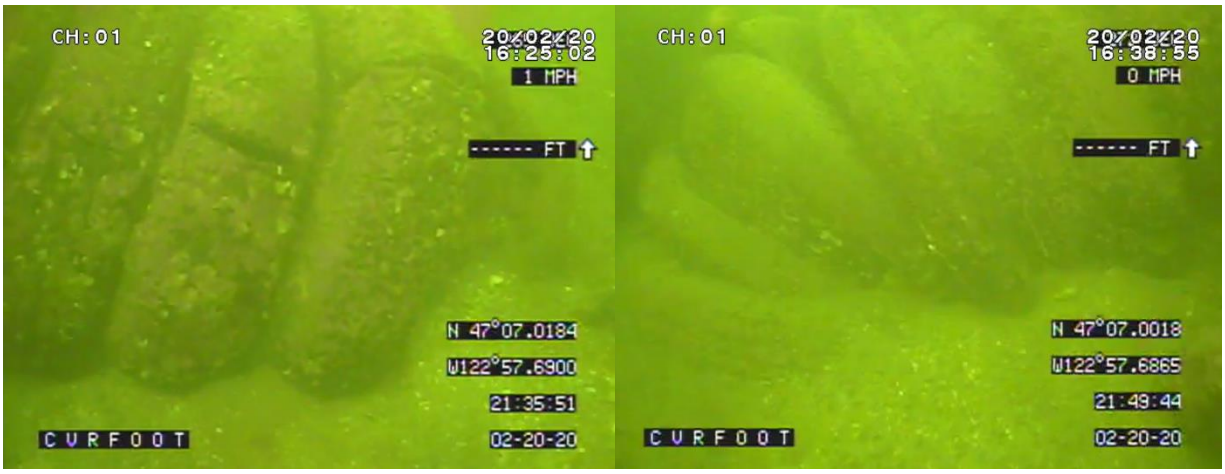

Figure 170. Eld Inlet tire bundles that represent tire bundling, burial levels, and tire degradation typical of the nodes/piles found in the reef.

Figure 171. Singular tire identified with video 25 meters to the east of the main tire reef. Tire exhibits degradation typical of the site but is buried deeper than the average bundle. Orange and white sea anemones cover this tire.

Figure 172. Thick line found to be connecting groupings and bundles of tire.

Figure 173. Tires at the Frye Cove reef site are generally in poor condition. This is an example of a tire that is buried ~ 30% in sediment, with slash for air escapement.

5 Appendix

Barrel Stacked: A common technique of banding multiple tires together. Tires are banded with strapping (usually polypropylene line) into a cylinder shape. Figure 8B shows barrel stacking for tires stacked upright without banding. Barrel stacked formations within tire reefs are usually laying parallel to the sediment surface and are often in groups of three "barrels" which form a pyramid.

Pyramid Formation: A stack of three barrel stacked groupings. Figure 3 is a demonstration of this tire feature. Many tire reefs within Puget Sound use pyramid formations.

Loose Stacked: A pile form found in tire reefs. In these formations, tires are loosely piled on top of one another in an unorganized mound. The tires within the mound are usually bound with polypropylene line.

Tire Nodes: Spatial point features that are placed manually over a bathymetrically calculated hill shade or slope layer within ArcGIS to demarcate where confirmed tire features exist within a reef.

Potential Tire Nodes: Point features that are placed manually over a bathymetrically calculated hill shade or slope layer within ArcGIS to demarcate where potential tires may be. These are placed on mounded features that are too far from the bulk of a tire reef to likely be placed tires, but have not been confirmed otherwise by video.

Linear Features: Reef Features that are not mound shaped in multibeam data (not rock or tire). These can include concrete pilings, sunken barges, concrete blocks, wooden logs, chain, metal sheets, and other materials that were placed within reefs to attract fish.

1.5 meter Tire Node Buffer Area: An area created from the Tire Node data. This polygon feature class is created by a 1.5 meter (m) buffer with dissolve function of the tire node feature class. It represents the approximate area of tire reef features.

1.5m Potential Feature Buffer Area:
This polygon feature class is created by a 1.5 meter (m) buffer with dissolve function of the potential node feature class. This area may include potential features such as boulders or other mound like features are too far from the main portion of the reef to likely be tires, but cannot be confirmed otherwise.

Reef Footprint: A hand delineated area inclusive of all reef features (both confirmed and potential in the immediate vicinity of the main reef). This is likely an overestimate; however, it provides a general reef shape for comparison and is used for the volume estimate tool.

Bathymetry Attributed Grid (BAG): A two-band raster dataset generated from cleaned and processed multibeam data. The file includes and elevation layer and an uncertainty, both measured in m. A hill shade and slope layer are created from this layer.

Reef Feature: Any reef feature that was intentionally placed and not naturally present.

Tire Feature/ Module: Any grouping or banding of more than one tire. The terms feature/module are used interchangeably

Tire Condition: A scale from "good" to "poor" based on the visual integrity of tires at the reef site. Good tires are not distorted or torn and are relatively clear of barnacles/ other fouling organisms. A detailed tire condition description is within each site report.

NAVD88: The North American Vertical Datum of 1988. A vertical survey datum that serves as the vertical control datum for North America. It is in m above the fixed-height of the primary tidal benchmark at Father Point/Rimouski Quebec, Canada.

MLLW: Mean Lower Low Water (tidal datum). Measurements in feet. This datum is based on observations that are calculated and referenced to an 18-year tidal cycle. It is the average height of the lower of the two diurnal low tides each day.

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