

# Submerged Rock Shoal Mapping of Lake Huron Wetlands

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## Final Report

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**GEORGIAN BAY  
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## SCOPE

### Objective

The purpose of this contract is to collect side-scan sonar data at select coastal wetland sites within Lake Huron and Georgian Bay to delineate the extent of submerged rock shoals and rocky outcrops and to improve the understanding of the potential for wetland migration under different environmental conditions. This brief report summarizes survey notes and provides a visualization of the data and imagery files separately provided to the ECCC research team with site specific examples of observations.

### Background

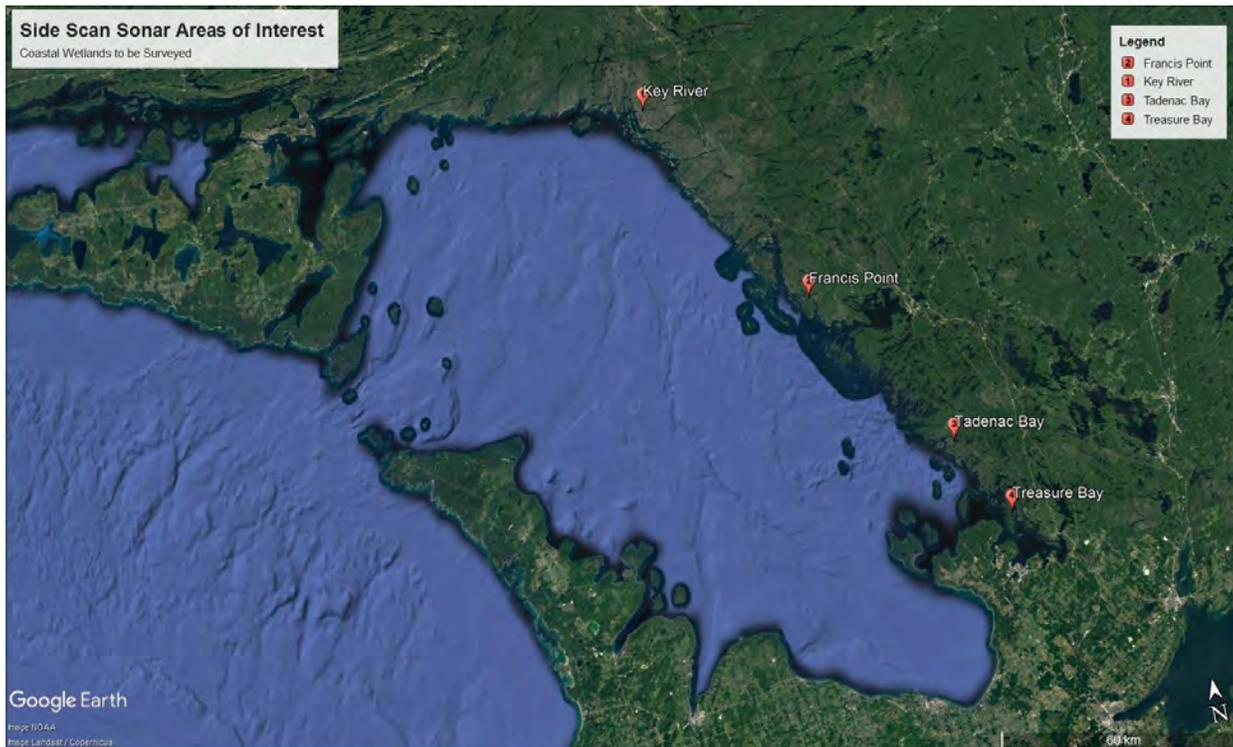
Environment and Climate Change Canada is the primary Canadian federal body with responsibilities under the 2012 Canada-United States Great Lakes Water Quality Agreement (GLWQA). The Government of Canada is taking action to address the most significant environmental challenges affecting Great Lakes water quality and ecosystem health by delivering on Canada’s commitments under the GLWQA through the Great Lakes Protection Initiative. As part of this initiative, ECCC is implementing a five-year program to “assess and enhance the resilience of coastal wetlands” along the Canadian shorelines of the Great Lakes. This program addresses the commitments of the GLWQA to ensure that the Great Lakes ecosystem supports healthy and productive wetlands and other habitats to sustain resilient populations of native species, as well as the commitment to increase awareness of Great Lakes coastal wetlands and conservation methods.

Coastal wetlands in Lake Huron and Georgian Bay are unique in the Great Lakes basin due to the complexity of their underlying bedrock geology that is characterized by thin soils and exposed granitic bedrock. This bedrock forms extensive shoals, islands and outcrops throughout this region. Identifying the extent and distribution of submerged rock shoals within the context of our study wetland sites is required to determine where wetland plant communities are able to evolve, transition to, and establish plant communities. This information will improve the modelling of wetland response to projected climate change conditions, including projected sustained low and high-water levels.

### Requirements

Environment and Climate Change Canada requires a contractor with knowledge and experience in collecting shallow water hydrographic data in Lake Huron including wetlands and river mouths for the one-time collection and processing of side scan sonar data at four (4) coastal wetland sites in Georgian Bay (Figure 1):

Region	Wetland Site	Longitude	Latitude	Land Ownership
Lake Huron	Key River Wetland	-80.719858	45.887083	Private
	Francis Point	-80.334214	45.417535	Crown Land
	Tadenac Bay	-79.987663	45.047933	Private
	Treasure Bay	-79.857690	44.866860	Parks Canada



**Figure 1:** Map illustrating the locations of the 4 coastal wetlands to be surveyed in Lake Huron. Rock Shoal Delineation Methodology

### Requirements

Survey routes will be dictated by the morphology of the wetland basin, but the supplier must survey shallow water habitats ( $\leq 1.2\text{m}$  in depth) and open water habitats ( $> 1.2\text{m}$  and as deep as  $3\text{m}$ ) identified within the predetermined polygons. The supplier will collect groundtruthing information to assist ECCC in classifying and delineating rock features from the side scan data. Groundtruthing data could include georeferenced locations of known rock shoals, paper map-based delineations, or georeferenced underwater photos. This will allow ECCC to develop derived products and further process and incorporate the data into physical datasets.

#### Wikipedia

In [oceanography](#), [geomorphology](#), and [earth sciences](#), a **shoal** is a natural submerged ridge, bank, or bar that consists of, or is covered by, sand or other unconsolidated material, and rises from the bed of a body of water to near the surface. Often it refers to those submerged ridges, banks, or bars that rise near enough to the surface of a body of water as to constitute a danger to navigation. Shoals are also known as **sandbanks**, **sandbars**, or **gravelbars**. Two or more shoals that are either separated by shared troughs or interconnected by past or present sedimentary and hydrographic processes are referred to as a **shoal complex**.

### Field Observations

Environment Canada is specifically interested in the rock shoals substrate type. Bottom features such as isolated boulders were occasionally detected but did not qualify as shoals. Exposed granite bedrock outcrops extending perpendicularly from shores were also occasionally identified and mapped, however, field observations suggest that not all such locations would impact wetland resilience since the footprint of existing

wetlands bracketing such protrusions are not differentially affected by the shoal at various water levels. The protruding rock outcropping hosts no growth at present so dropping water levels will not result in any declining biomass due to these features. The types of plants marginal to these features would vary related to the water depth under different regimes but the area of habitable substrate would be constant. In protracted high water level conditions sediment migration might occur, but at the time of observation no suitable substrates covered the rock outcroppings noted. Surface area of the water in the wetland would be the only parameter impacted as water levels decline in those cases.

The sites studied had no rock shoals that would impede wetland migrations resulting from extreme water surface levels changes. One site (Treasure Bay) has a choke point at which connectivity could be reduced or impaired between the inner embayment and the outer water bay.

Sonar and side scan sonar provide a means of imaging the acoustic signature of the wave reflection from the surface encountered by the ping. Sonar reflectance can also be used to indicate surface roughness and surface hardness. The strength and dispersion can be processed to indicate a range of surfaces from the potential presence of hard reflective granite or sand features to soft absorbent humus and smooth or rough surface features. These techniques are well referenced in the literature and outlined in Appendix A.<sup>1,2</sup>

The measurements are stored in the .SL2 files and the calculations were processed by the ReefMaster™ software post data collection. These files store geo-referenced sonar and side scan imagery data containing a large amount of information that might be useful in future studies.

Measurements were taken at the end of the growing season with many plants quiescing. Significant enough biomass existed in a few sections of Treasure Bay to impair bottom depth detection. Those sites were not situated at rock shoals and show in the raw data files as unmeasured segments of the tracks.

### General Site Conditions

All lakebeds are granite bedrock in the selected study areas. There are depositions of various substratum, soils and humus, compost and detritus on top of this bedrock that vary based upon basin morphology, landcover, previous surface activities like logging and hydrology. The granite shorelines were historically covered in topsoil that experienced erosion during the previous century due to clear-cutting forests. These eroded soils settled into pockets in the surface of the underwater bedrock.

Some of the sediments are located in appropriate proximity to the photic zone allowing for macrophyte growth – from submergent to emergent plant communities. These zones may be interrupted with protrusions of the bedrock layer and these subsurface hard bottoms do not support growth zones independent of water level changes. These features have no impact on the surrounding wetland inventories and those localized inventories are independent of the historic water level regime. The biota composition of those inventories however will be dependant on the water level regime. Based on the water level regime the substrate may be closer or further from the photic zone and thereby create conditions more or less conducive to each species growth thereby resulting in plant community transitions at each location that are dependant on the water level regime. This dynamic variability is why protecting the biodiversity of these zones is important. These

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<sup>1</sup> Fauziyah et al 2020 IOP Conf. Ser.: Earth Environ. Sci. 404 012004

<sup>2</sup> Buscombe, Daniel “Shallow water benthic imaging and substrate characterization using recreational-grade sidescan-sonar”: Environmental Modelling & Software Volume 89, March 2017, Pages 1-18

globally unique wetlands support thousands of species including threatened and endangered terrestrial species.

## Methodology

The general methodology was to survey the area using a vessel mounted GPS imaging system using two separate sensors feeding into one head unit. Equipment used and set-up are outlined in Appendix B. Water levels were at or above extreme high levels during the past two summers (2019, 2020) allowing the vessel to transit over areas that would be considered inaccessible during normal or low water level periods. This facilitated a collected data record that will be more useful for DEM development and truthing that a similar data record created at low water levels.

The Lowrance sonar and side scanning systems collect and log collocated data in an “.SL2” file format that can be read back using software such as the ReefMaster™ software used in this project to reveal the structure using reflectance processing. This software can also redisplay the survey tracks with all of the associated vertical and side scan sonar imagery.

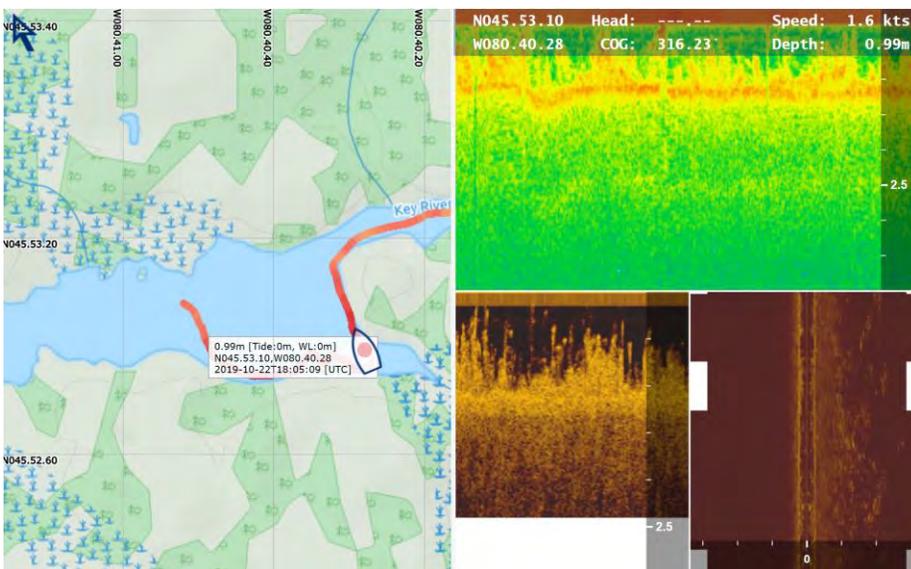


Figure 1-Example of .SL2 file contents including track, side scan and downward sonar. Plant growth, substrate hardness and smoothness data is available in the data file for future study.

Outcroppings were mapped in less than 3m of water using the live sonar systems and visual and surface or underwater photographic confirmation. This collected information was then examined along with existing charts and historic imagery and local observations and knowledge of the waters. Post collection data processing was created using the embedded reflectance data by the multi-wave processing software allowing bathymetric isobaths and bottom hardness determinations to be charted. As previously referenced, there are numerous publications describing the capabilities of sonar systems to provide indications of lake bed topology, roughness (E1) and hardness(E2) correlations. The ReefMaster™ software used in the course of this project has internal algorithms to process these sonar waves and render visualizations of these features as outlined in Appendix A.

Automated software processing was completed post field data collection to determine bottom hardness values using ReefMaster™ Pro. The hardness values associated with observed outcrops at each site were then used as boundary values for the site. Specific numeric ranges vary slightly with site due to the localized nature

of the processing algorithms. However, in general the ranges across all sites are consistent as shown in the table below.

<b>Table 1 – Rock Shoal Polygon Hardness Values</b>	
<b>Treasure Bay</b>	
22686.82 - 24209.38	
21164.25 - 22686.82	
19641.68 - 21164.25	
<b>KeyRiver</b>	
23369.01 - 24446.99	
23119.04 - 24472.84	
22291.04 - 23369.01	
21213.06 - 22291.04	
20412.99 - 21766.28	
20135.09 - 21213.06	
19057.11 - 20135.09	
<b>Tadenac</b>	
21300.58 - 22436.22	
20164.95 - 21300.58	
19029.32 - 20164.95	
17893.68 - 19029.32 (3 polygons)	
<b>Franklin</b>	
21431.99 - 22482.41	
20381.57 - 21431.99	
19331.16 - 20381.57	
18280.74 - 19331.16	

Polygons with in-boundary hardness values were then mapped and compared with local site knowledge, concurrent ground-truthing photographs, historic low water images available and the other ground-truthing observations collected coincident with the sonar scans. These harness values were then displayed in the Google Earth products delivered to ECCC.

A small number of specific sites where profuse aquatic plant grow had obscured the sonar signal were checked to ensure they were not included in the Rock Shoals products provided to ECCC.

Hardness determinations for the purpose of this project were only included for rock shoals, however the “.SL2” data files contain information that will allow future determinations of other substrata types and extent.

Rock shorelines are everywhere on all study areas and were not considered as relevant to the project area unless there was a shoal extending from the shore that would cause wetland stranding as water levels change from the extreme limits. Visual confirmation of the rock shoals was possible in most instances and where necessary real-time sonar

imaging was examined to confirm the siting. Surface and subsurface georeferenced photographs were taken for several reference points at each site. GIS located imagery and GPS readings on separate systems were periodically compared to ensure locations were being accurately recorded by all systems. Side scan data imagery was continuously monitored for it’s rendering of the structural features being visually observed in real time and on sperate occasions to ensure accurate sonar siting was occurring.

The remaining continuum of hardness values and roughness reside within the .SL2 files provided to ECCC for possible future processing if desired. Further hardness processing is outside of the scope of this project.



*Figure 2-Example of additional outputs available from processing the .SL2 files such as these detailed shaded isobaths at Treasure Bay.*

Post data processing imagery was then examined on a polygon by polygon basis to eliminate reflectance due to dense surface plant growth that were observed in a small number of sites by the operator. Non-rock shoal derived reflections were manually removed from the processed data set. Historic background satellite images are available and several examples of rock shoal delineations have been overlaid on images of low-water and high-water levels as shown below to corroborate the rock shoal observations made.

Numerous observation photographs are included in the data files provided separately to ECCC for this project. These images were taken both at surface and subsurface of

identified rock shoals as well as the general surrounding conditions to show wetland plant growth, shore conditions and bottom substrate. Examples of these included images are displayed in the sections below. The images are GPS labelled.

## Site Specific Observations

### Key River

This site is predominantly an east-west oriented river used as a small vessel navigational channel with two widely separated riparian embayments on the southern shoreline grooved out of the granite bedrock substrata. The channel was slow moving at the time of the survey (October 2019) and at a high-water level. This allows for light sediment, compost and humus transport into bowl-like sections of the riverbed.

Forrest fire damage was observed from the extensive fire in this area in 2018. North and south river banks were denuded of vegetation and limited emerging succession communities were seen on the shorelines.



45.88893, -80.65725 – Facing South (blue arrow) from marker



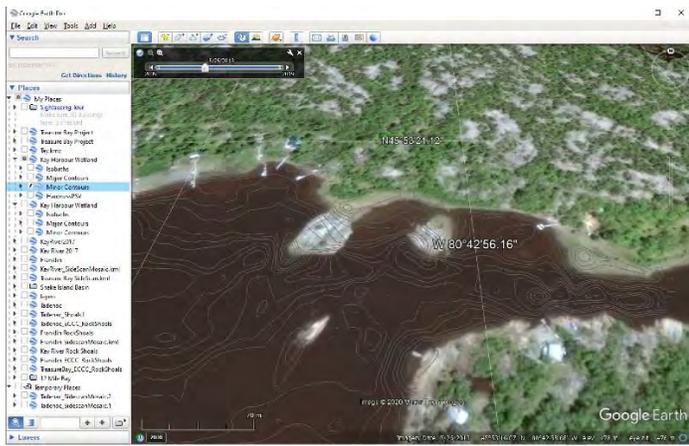
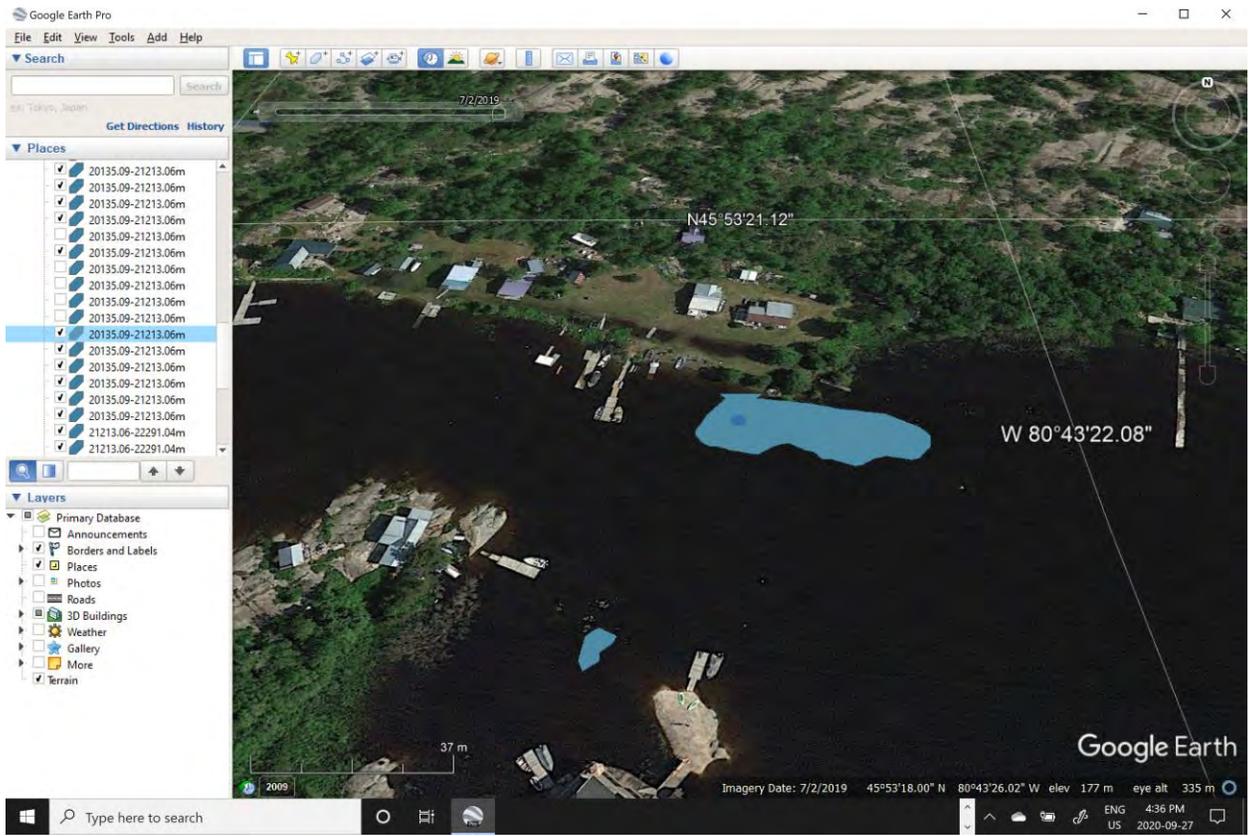


Figure 3- Key River Isobaths with 2013 Historic Image

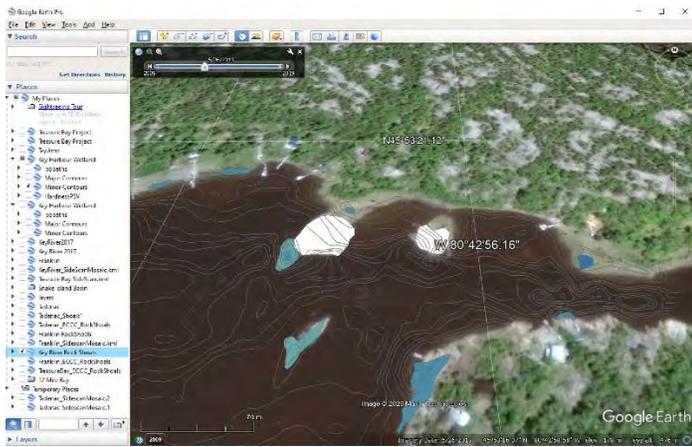


Figure 4- Key River Isobaths with Rock Shoals over 2013 Historic Image

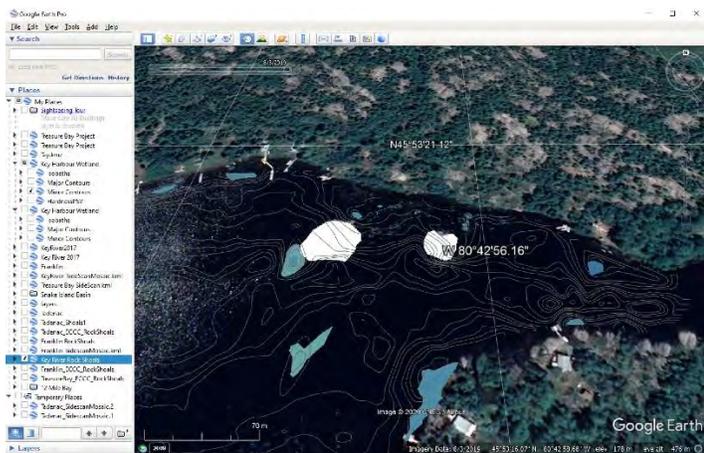


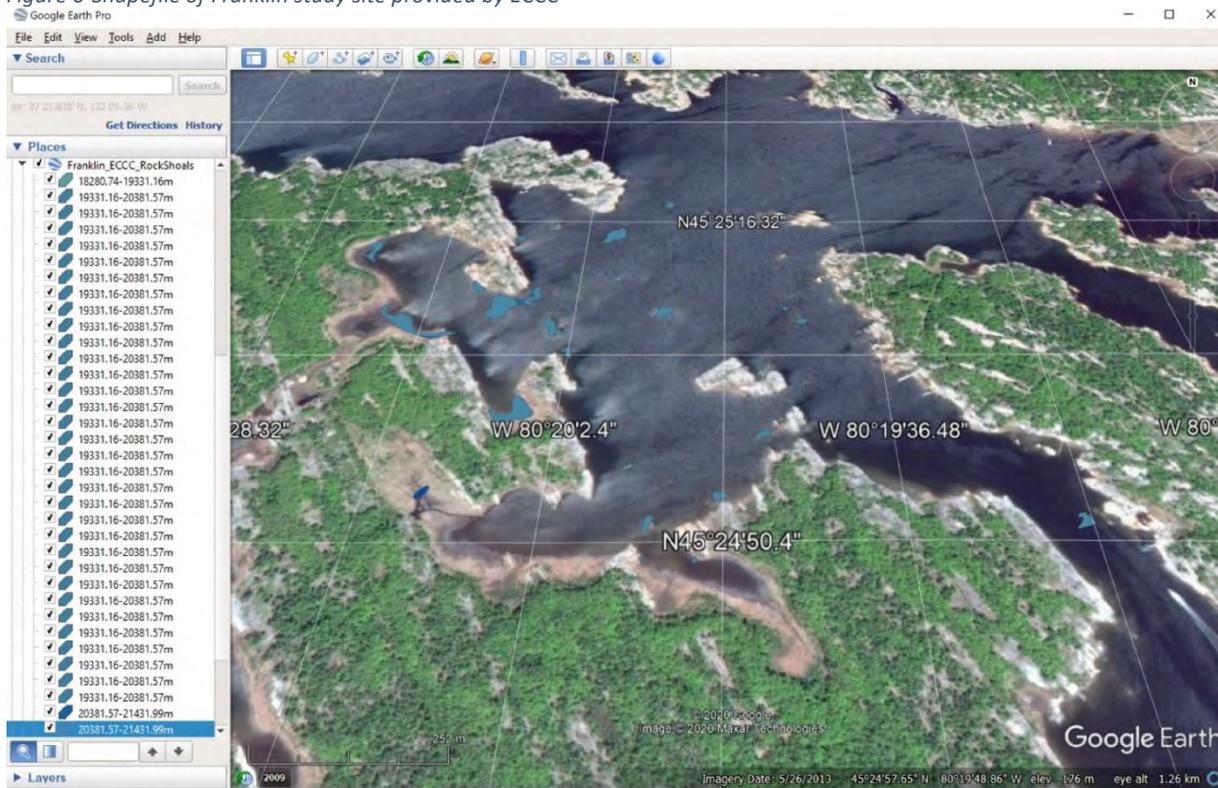
Figure 5- Key River Isobaths with Rock Shoals over 2019 Historic Image

## Franklin Island

The Franklin Island site is at the north east (leeward) extent of the island adjacent to and incorporating the small vessel navigational channel on the east and northern boundaries. This site includes shallow sloping granite bedrock substrates, a number of isolated discrete rock shoals, several granite bedrock islands and a number of wetlands forming a large wetlands complex. Small vessel traffic is regular and frequent at this location throughout the summer months. There is a small marina/resort and a public boat launch on the mainland one kilometer to the north-east providing ready access to this site.



Figure 6-Shapefile of Franklin study site provided by ECCC



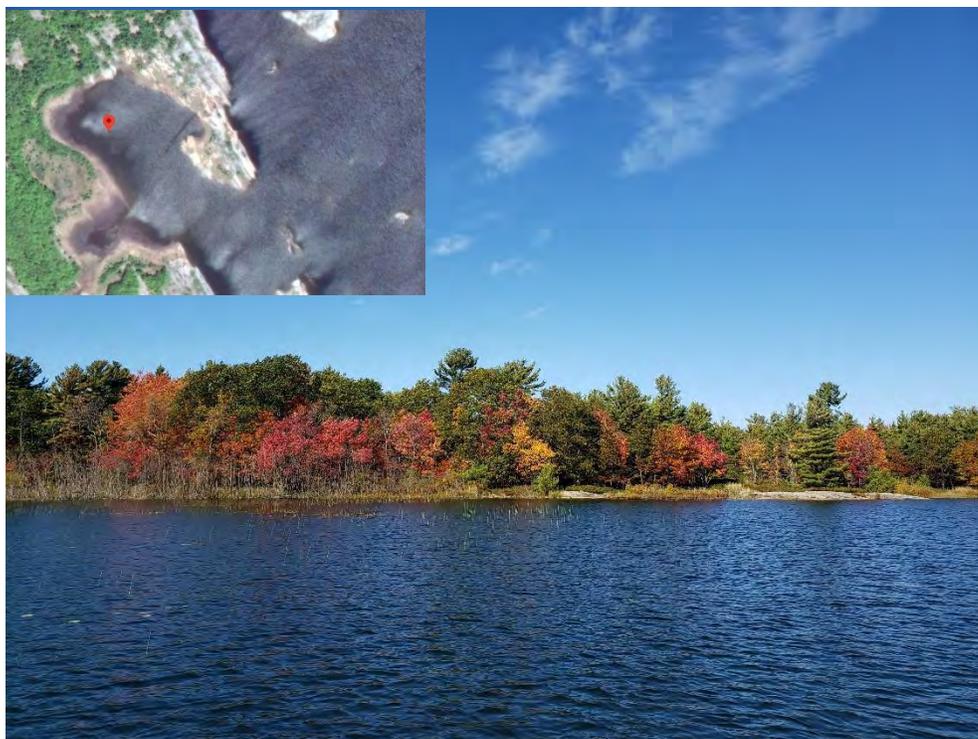
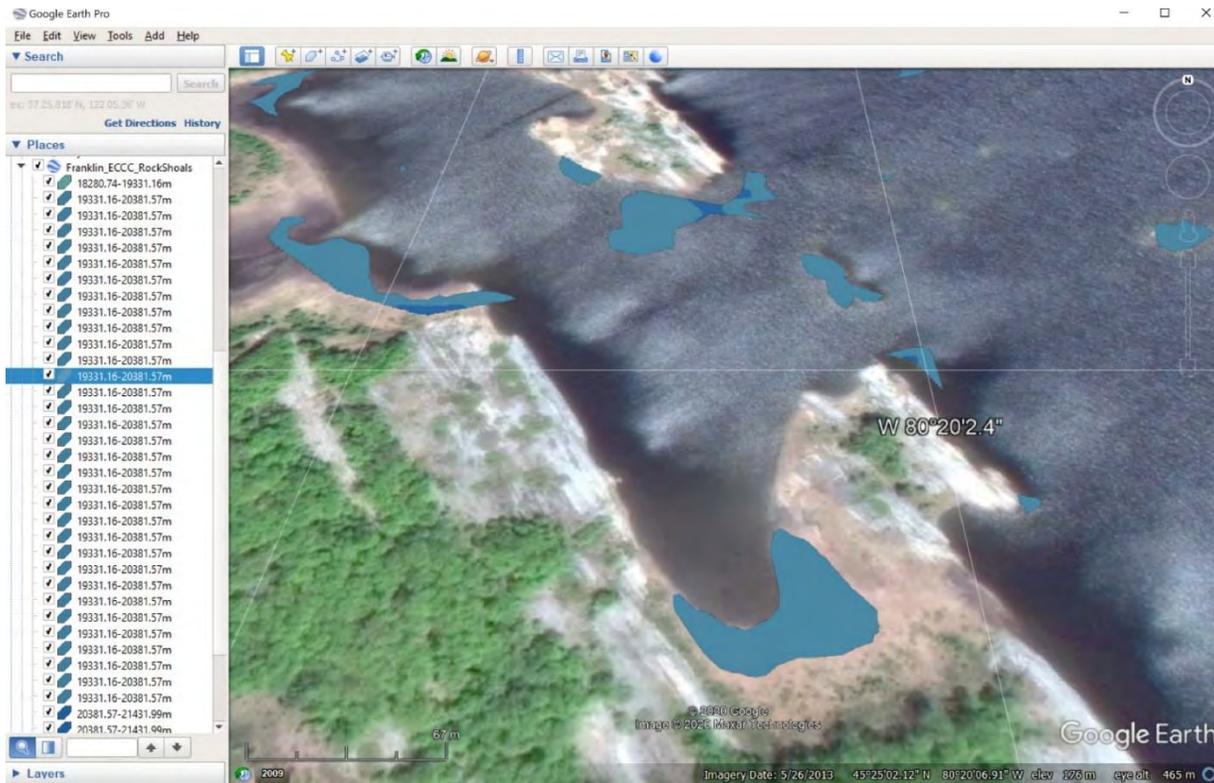


Figure 7- 45.420027,-80.338672 (Inset is the georeferenced location shown on the background image)

## Tadenac

Tadenac is a pristine site and is owned by the private Tadenac Club. The club is unique in that it owns the water rights to this bay thereby allowing it to restrict the use of the entire property to members only and making it a perfect control site for numerous scientific studies. GBF and ECCC were granted access to the property for this project by the club. This site is a water access only location in proximity to King Bay Marina.

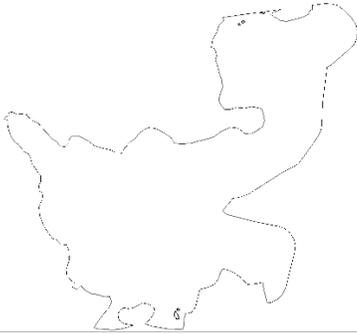


Figure 8-Shape file of Tadenac study site provided by ECCC

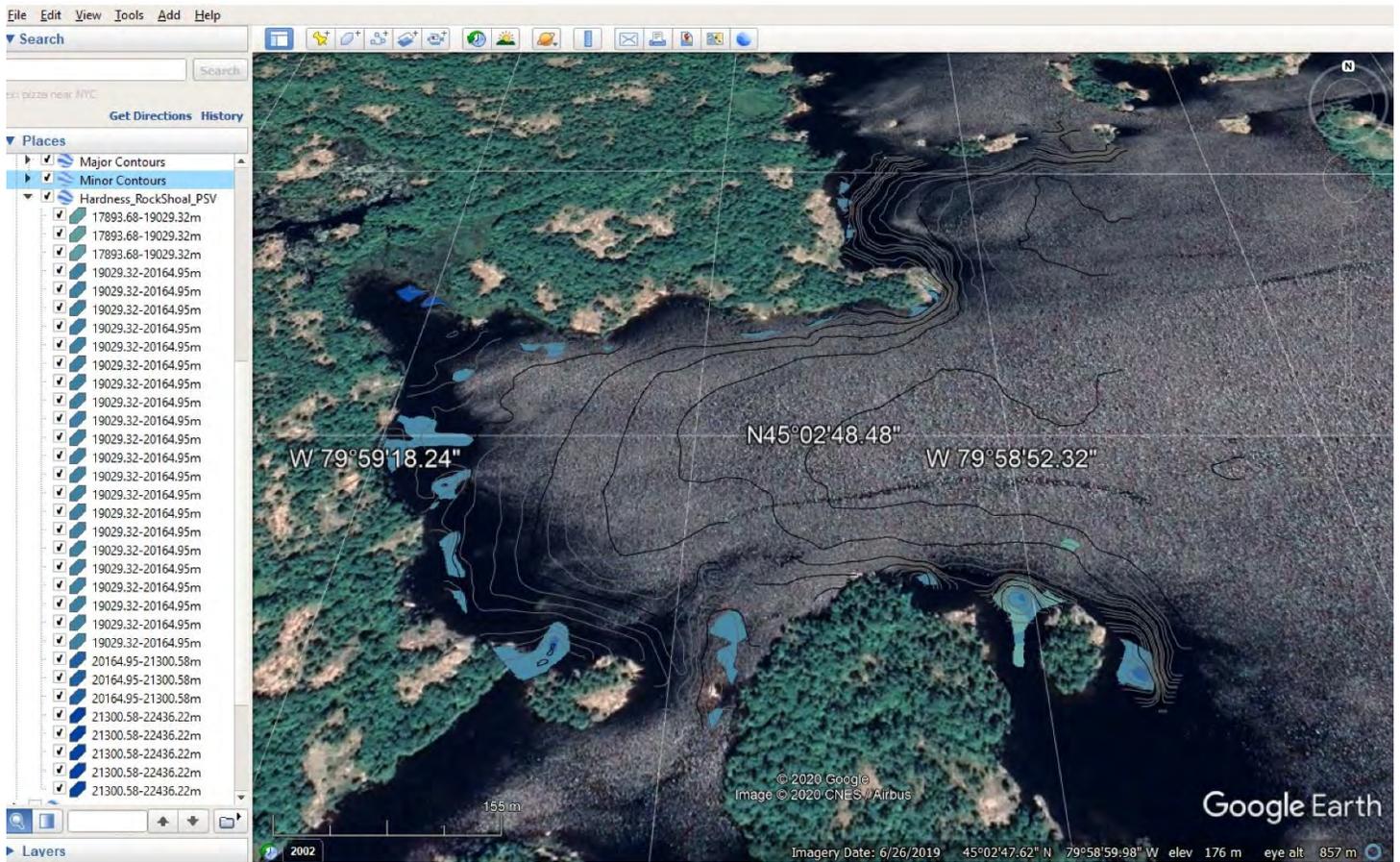


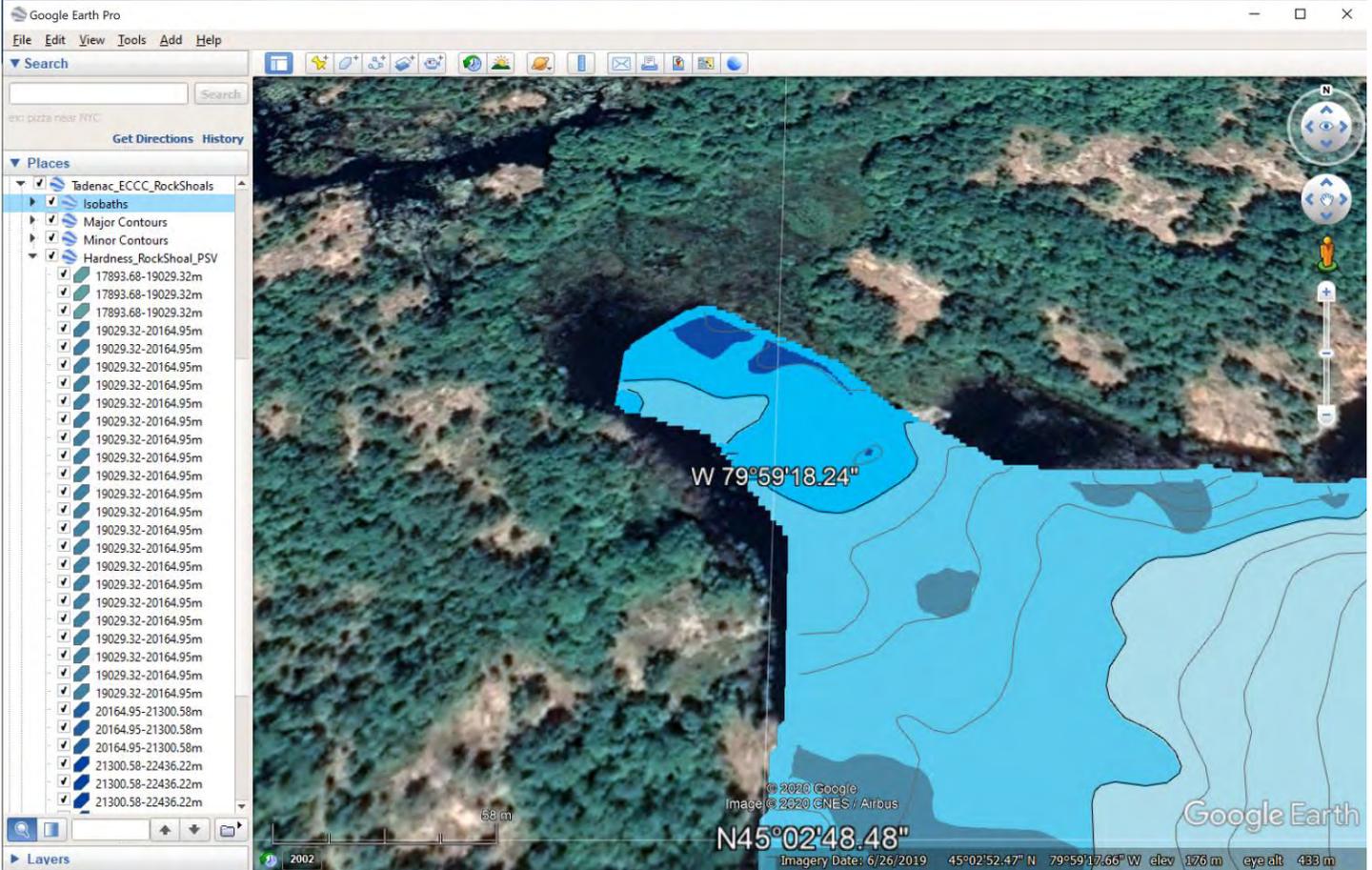
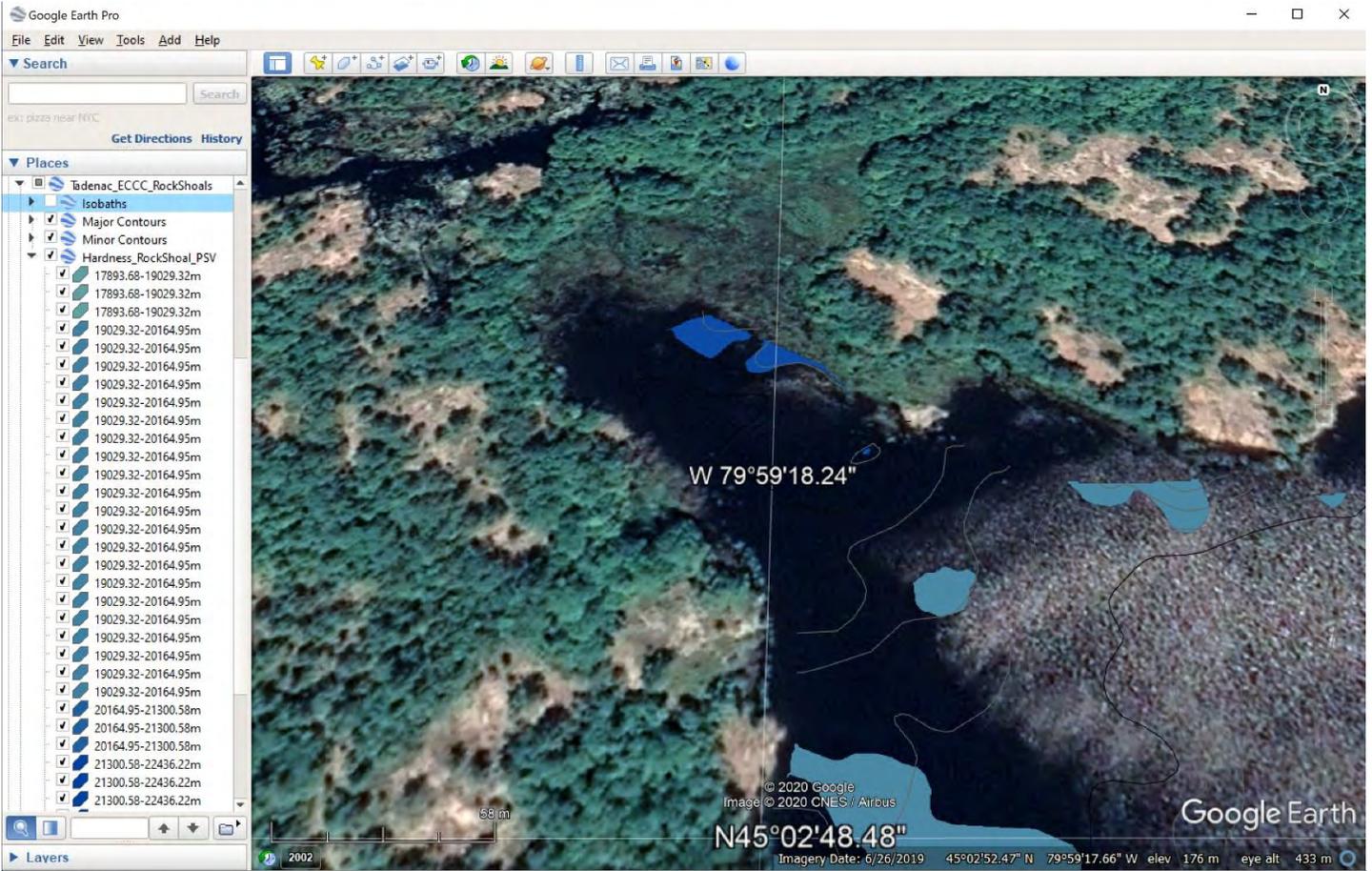
Figure 9-Delineated rock shoals in area of study



Figure 10-20200920\_132853.jpg - 45.045306, -79.981188 (Inset is the georeferenced location shown on the background image)

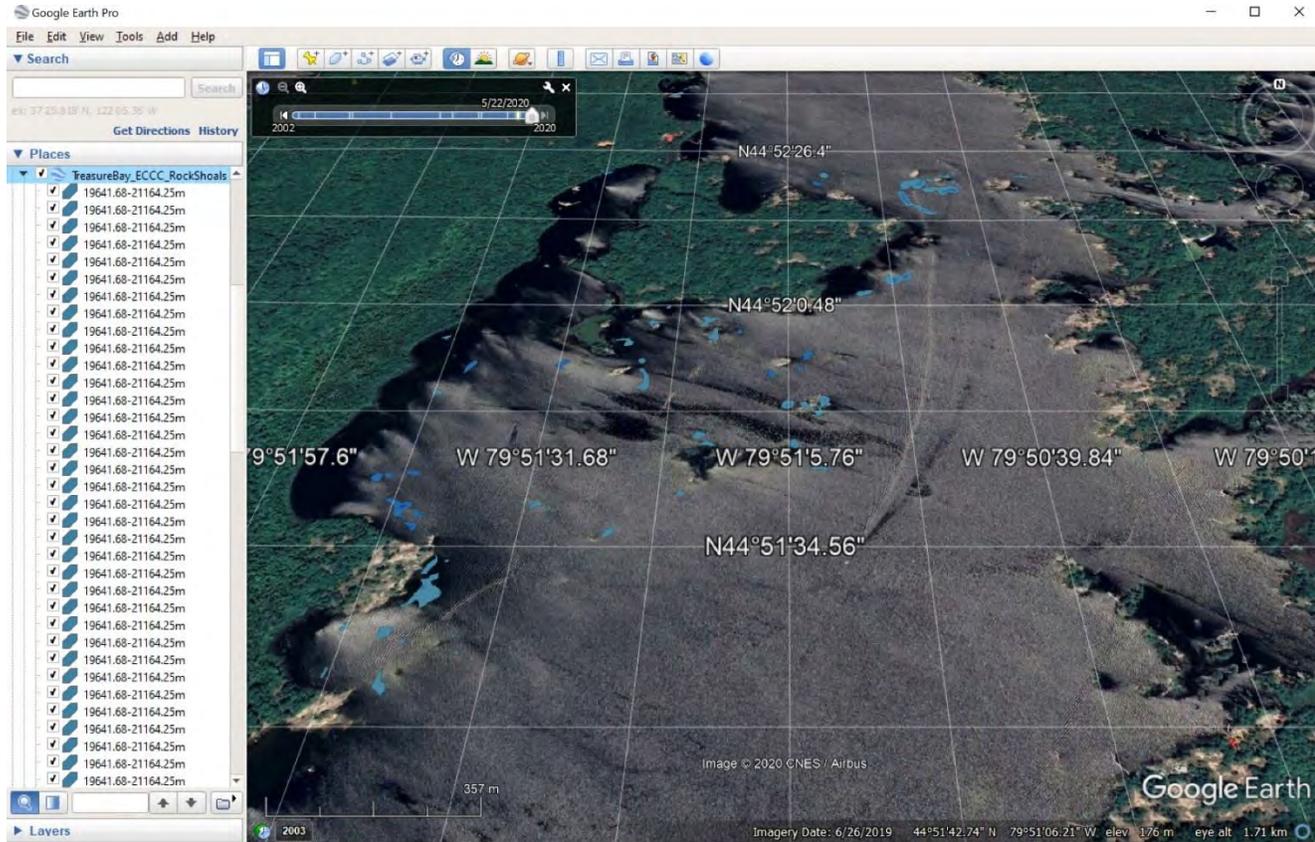


Figure 11- 20200920\_132801.jpg - 45.045375, -79.981307 (Inset is the georeferenced location shown on the background image)



## Treasure Bay

This was the largest site requiring three days of on the water survey work. The site is adjacent to Georgian Bay Islands National Park in the protected waters between Roberts and Beausoleil Islands. There is a small vessel navigational channel here and frequent and high occurrence of motor yachts transiting the space and utilizing a number of park docks and proximal anchorages. The site is susceptible to wave action arising from south to south easterly winds. The study site is entirely populated along the coasts and embayments with aquatic macrophytes and natural shorelines except for the summer camp located in the north-western section.



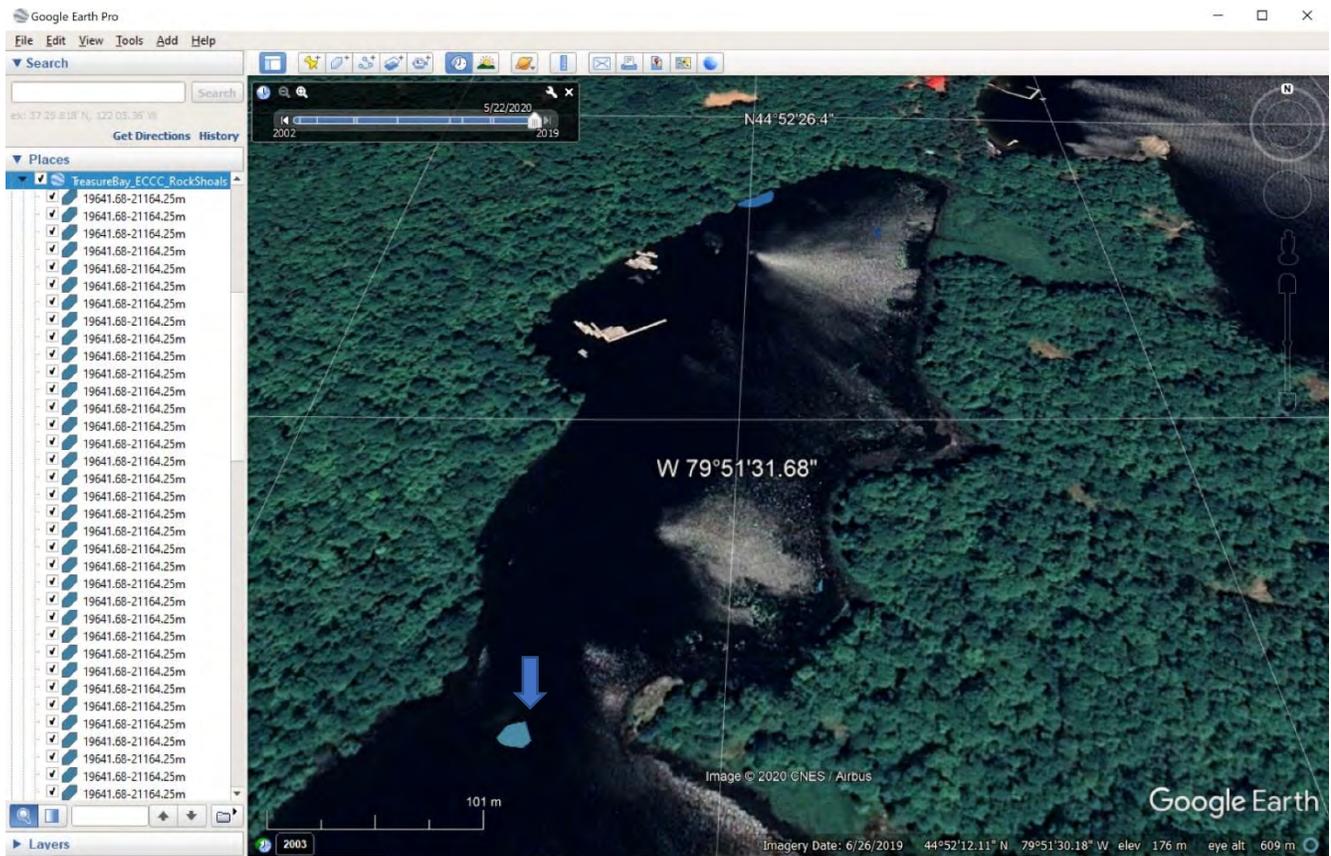


Figure 12-Subsurface photograph of rock shoal at arrow from previous figure

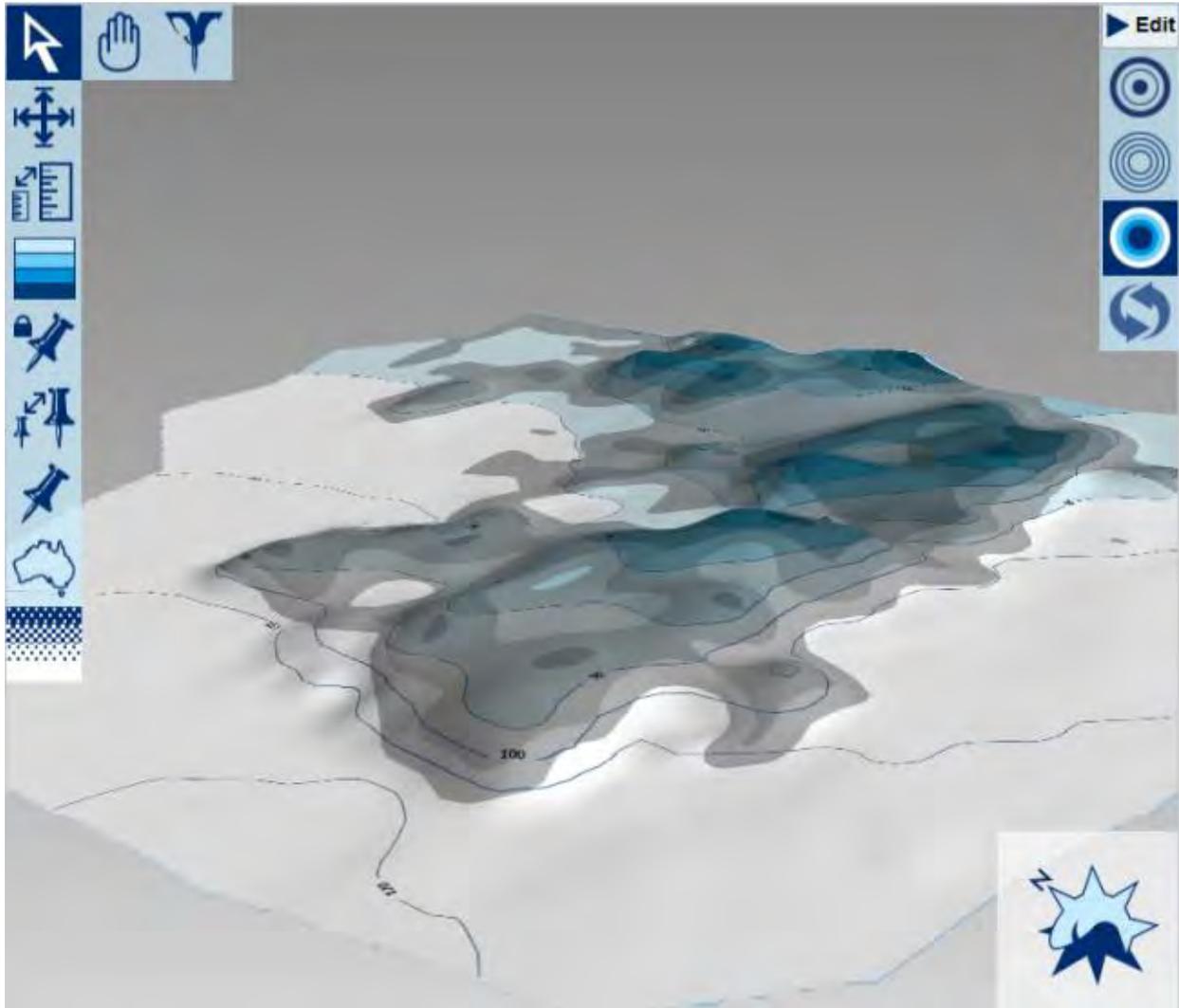


*Figure 13-Surface photograph at same location as previous figure*

## Bottom Composition

The bottom composition module provides a way to visualise changes in the nature of the sea, lake or river bed. The relative hardness and roughness of the bottom can be determined from sonar log files in Humminbird or Lowrance formats, and processed to produce overlays on map projects. Bottom composition overlays can then be exported in a range of formats suitable for viewing on GPS devices or use in other GIS applications.

The *Bottom Composition* module is an additional module to the ReefMaster PRO edition. See [ReefMaster license activation](#) for information on how to upgrade to, and install, the bottom composition module.



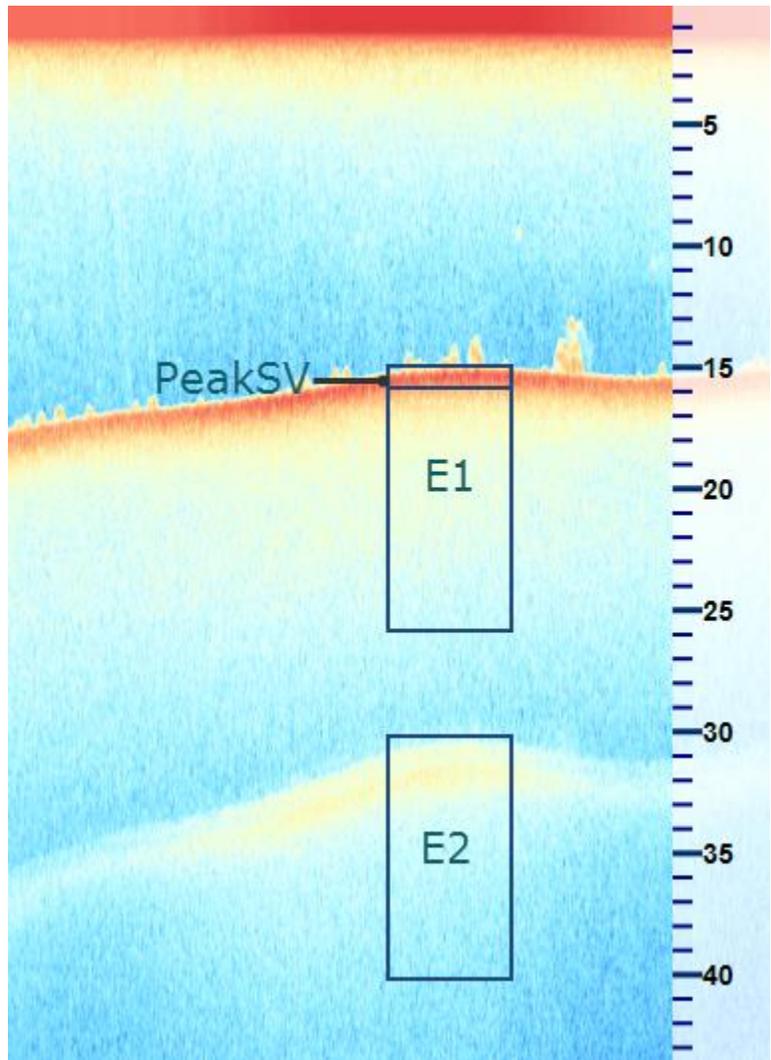
*3D map image with an overlay showing harder sea bed areas*

### Overview

Bottom composition is determined by analysing the data within sonar log files and looking at signal returns at various positions within the returned "ping". By calculating and averaging a range of values, ReefMaster is able to determine to *relative* hardness and roughness of areas within the map project. It is important to note that the values that ReefMaster calculates for bottom hardness are unit-less and provide only an indication of relative changes in bottom type across the mapped area.

### Hardness Layers

Information about the bottom type is extracted from several places in each sonar return, each of which provides a different value and each of which can be shown separately as different layers within the bottom composition module.



The image above shows a typical sonar return. Information that is useful for determining the relative bottom type is extracted from three distinct areas, labelled in the image above as *PeakSV*, *E1* (first return) and *E2* (second return). Each layer can tell us something slightly different about the nature of the bottom.

### Peak SV

Peak SV simply measures the strength of the sonar return as it is reflected off the bottom, and is highly correlated to the hardness of the bottom. For various reasons, simply measuring the peak signal return at the bottom is not always as reliable as using the second echo return (*E2*, see below) but in many cases the results can be very useful. Peak SV is included as a layer in ReefMaster because many sonar logs are not recorded with a sufficient depth-range to include a usable *E2* layer.

### E1

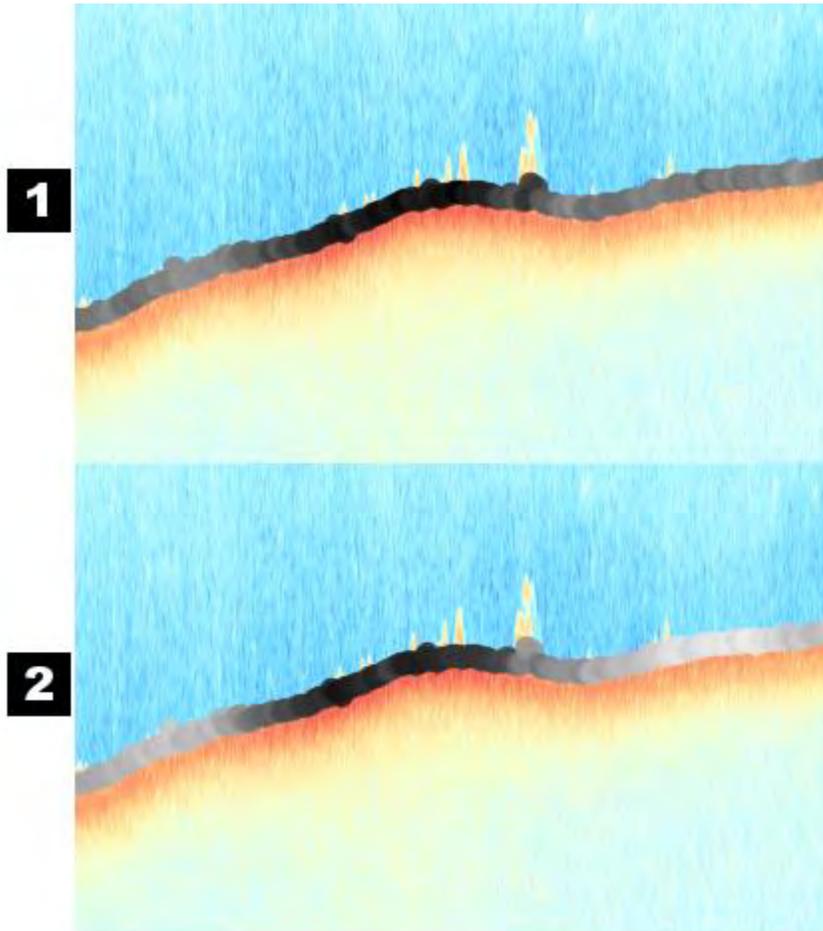
The *E1* layer is derived from the sonar returns that immediately follow the peak return of the first echo return. This value is commonly referred to as *roughness* or *rugosity* and is a measure of the roughness of the bottom. Although this value is not a direct measurement of hardness, the two are often closely correlated.

### E2

The *E2* layer is derived from the full second echo return of the bottom and is commonly referred to as *hardness*. The second echo return is generated when the sonar echos once again off the bottom, after having returned once to the surface and bounced off the underside of the boat. This second echo return is particularly useful for determining the relative hardness of the bottom. For example, in the image above, the second return shows a hard area in the middle much more clearly than the first.

### **Collecting data for use by the bottom composition module**

- The process of calculating bottom composition values can be very sensitive to noise. Run slowly over areas of interest to minimise the amount of noise in the sonar recording.



*"hardness" values extracted from the PeakSV and E2 layers*

- The E2 layer is the most reliable source of relative hardness information. The image above shows track-points coloured according to hardness values extracted from the PeakSV (**1**) and E2 (**2**) layers (darker colours indicate a higher return). Notice how much more clearly the harder area in the centre of the image is defined by the E2 layer. Where possible, always collect data with the sonar depth-range configured so that it is large enough range to include the full E2 return. In practice, this should be a good 10m more than *double the current depth*. Auto-range on many devices often truncates the E2 layer, or even omits it entirely, which means that a large amount of usable information is lost.

### **Importing bottom composition data**

Sonar log files from Lowrance and Humminbird may be used to provide data for the bottom composition module. Any sonar file which is able to be displayed in the [sonar viewer](#) is capable of providing the required information. If the file cannot be seen in the sonar viewer (this applies to some early Lowrance slg files), then hardness data cannot be extracted.

When the bottom composition module is installed, hardness data will automatically be calculated whenever a compatible sonar log file is imported. Bottom composition values are assigned to each track-point within the imported track, for each of the three layers.

*Note that sonar log files must be imported again after activation of the bottom composition module.*

The image shows a software interface with two main sections highlighted by red boxes and numbered 1 and 2. Section 1, titled "Sonar log file import options", contains two checkboxes: "Use slg2txt.exe" and "Using Lowrance Elite 7". Below these are three tabs: "Water", "Salt", and "Fresh", with "Salt" selected. To the right is a "Temperature" field set to "15" with a "°C" unit. Section 2, titled "Bottom composition import options", features a "Scale" slider set to "1.0" and an "Offset" slider set to "0".

## Importing Humminbird sonar log files

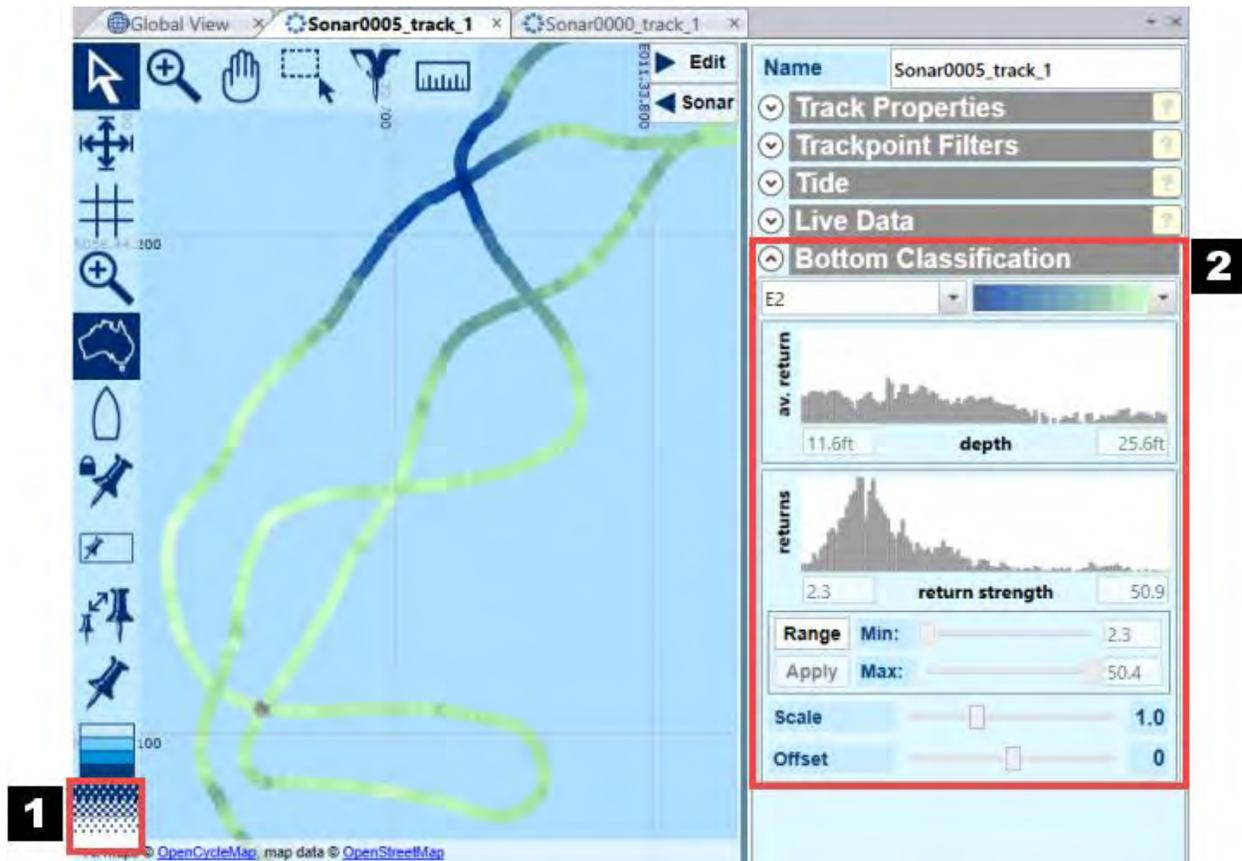
It is very important to set the water type and temperature parameters in the active [GPS Equipment Profile \(1\)](#). Temperature should be accurate to within 5 degrees C.

## Scale and Offset

Scale and offset are provided as import parameters, and can also be edited in the individual track properties. Scale and offset simply scale and shift the calculated hardness values by the specified amounts; scale is applied first, followed by the offset. Raw values for hardness are in the range 0 - 255; values that become less than zero after scale and offset are applied are ignored in all bottom composition calculations.

The scale and offset parameters are provided to assist in calibrating files recorded using different units or transducers and should be left to their default values unless combining data from different sources.

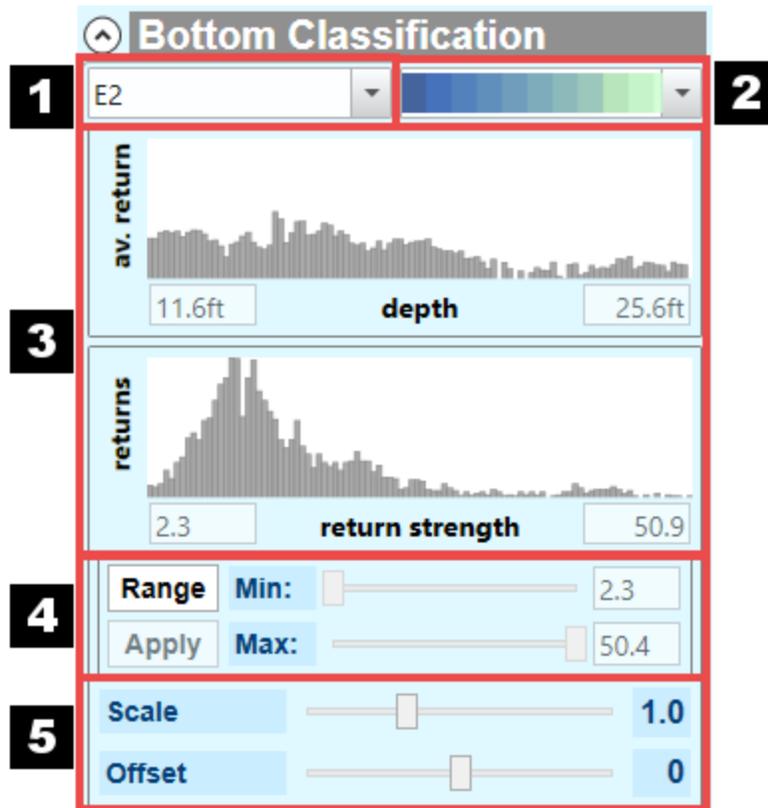
## Viewing Bottom Composition in Tracks



The *show hardness values* button (1) is enabled on tracks that have associated bottom composition values. Click this button to change the colouring of the track-points to reflect their relative bottom composition values, instead of depth.

Track-points overlaid in the [sonar viewer](#) are also shown with their hardness values when the *show hardness values* button is selected.

The *bottom classification* edit section (2) in the track properties panel will also be enabled when bottom composition values are present.



### (1) Layer Selector

Choose the active layer using the drop-down layer selector. The track-point colours displayed in the graphical edit area will update to reflect the new layer values, along with the rest of the values in the bottom classification edit area.

### (2) Palette Selector

The palette used for the track-point bottom composition colours can be selected using the drop-down palette selector.

### (3) Signal Histograms

Two charts are shown, displaying information about the signal returns in the selected layer. The top chart displays the *average return* across the depth range of the track. The second histogram shows the distribution of signal returns across the range of return strengths. This chart in particular can be useful when adjusting range, scale and offset parameters.

### (4) Range

Use a defined range to truncate values to specified lower and/or upper values. When a range is applied, any values falling above or below the maximum or minimum values specified are set to be equal to the upper or lower value; *the range values do not act as a filter*.

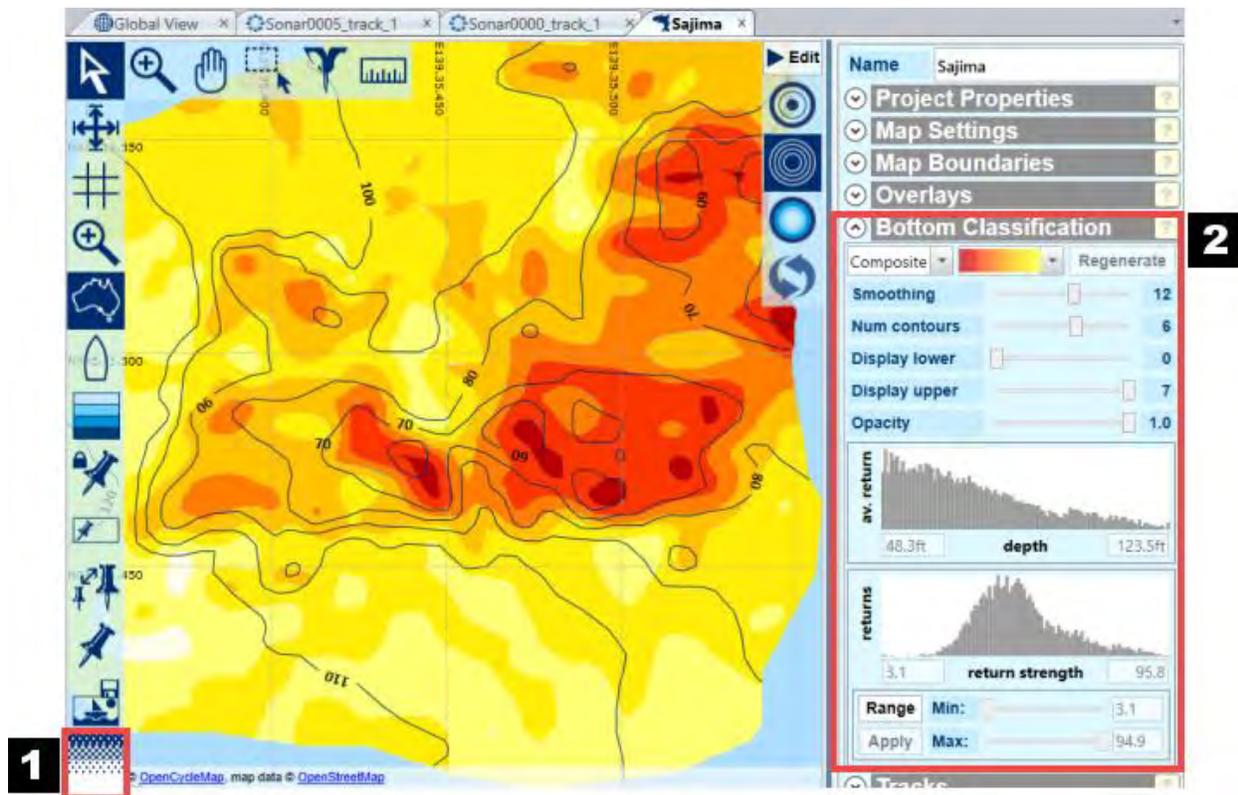
To apply a range, select the *Range* button and adjust the upper and lower range values using the sliders. Click *Apply* to apply the chosen values. Setting a range is not a destructive operation; the range can be set back to the full limits of the track, or the *Range* button can be de-selected so that the range is no longer applied.

### (5) Scale and Offset

Scale and offset parameters, as described above. These should be left to their default values unless required to calibrate tracks from different devices.

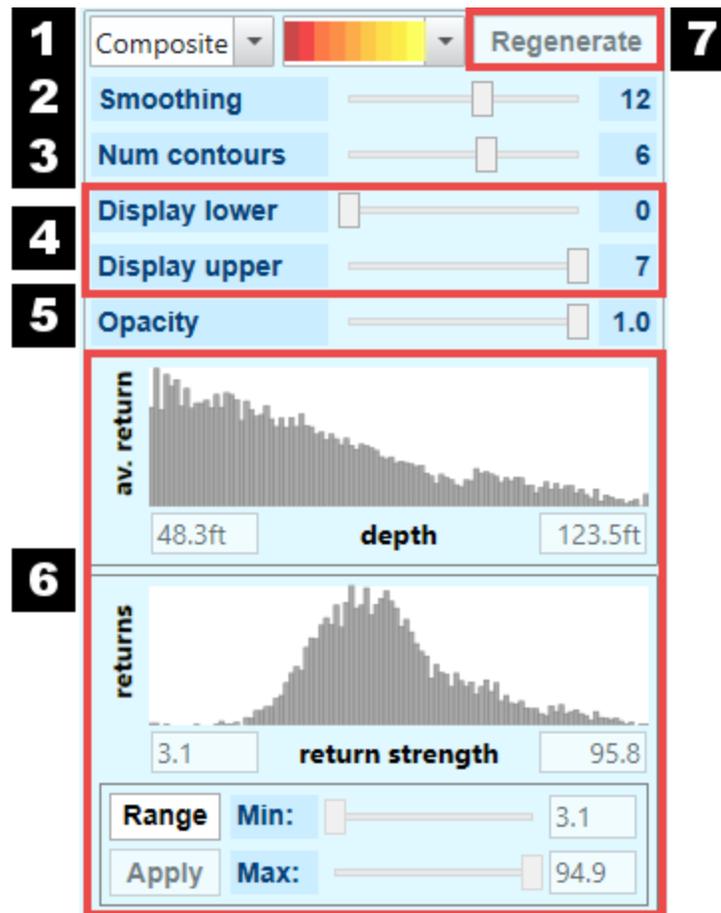
## Bottom Composition in Map Projects

Bottom composition is shown as a vector layer on top of the depth map, and is available in both the 2D and 3D views.



If bottom composition information is present in at least one of the map project's *component tracks* then the *Show Bottom Type* button (1) is enabled. Clicking this button will cause the bottom composition vector overlay to be generated, using the currently selected layer. Once the bottom composition layer has been generated, this button can be used to toggle the visibility of the layer without having to regenerate it.

The *Bottom Classification* section (2) of the [project properties](#) window contains further options for generating and displaying the bottom composition layers.



**(1) Layer and palette selectors**

Select the active layer using the layer selector.

Projects have an additional layer, *Composite*, which is an average of the normalised values of all of the layers present.

**(2) Smoothing**

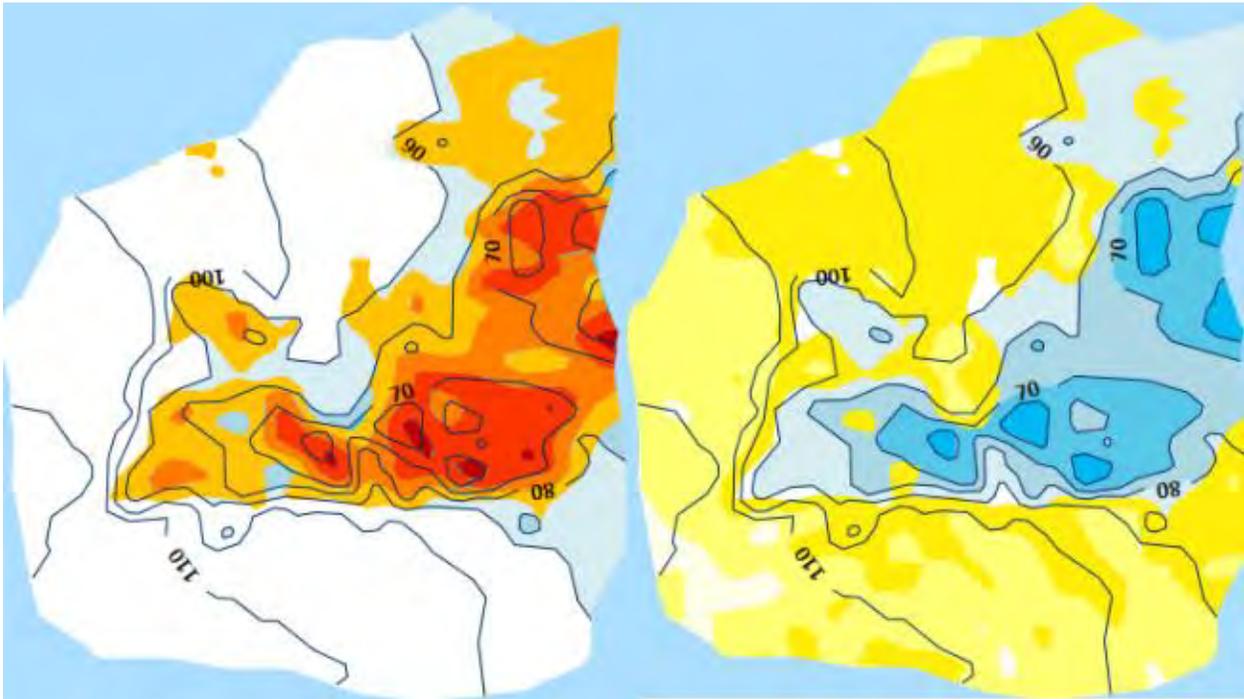
The smoothing parameter relates to the amount of smoothing carried on the grid of calculated bottom composition values, before the contouring process is carried out. Higher values give smoother looking contours, at the loss of some detail.

**(3) Number of contours**

The number of contour levels to generate. Higher values equate to a smaller contour interval and will give a larger number of hardness areas in the finished map.

**(4) Hardness area display range**

Once the hardness areas have been generated, the displayed area ranges can be adjusted using the *Display lower* and *Display upper* sliders.



*Higher value hardness areas shown on left, with lower values on the right*

Adjust the sliders so that just the required areas are shown; this could be higher areas, as shown on the left in the image above, or lower areas, or any contiguous subset of areas within the range. Showing just the areas on interest is very useful when exporting maps; for example, it may be that only harder or rougher areas are of interest, so the resulting map will be much less cluttered if only those areas are exported.

**(5) Opacity**

Adjust the opacity slider to vary the transparency of the bottom composition layer.

**(6) Range**

Range can be adjusted and applied using the *Range* controls, as described above. Adjusting range in map projects can be very useful to increase the level of discrimination within a smaller range of bottom composition values.

**(7) Regenerate**

The bottom composition must be regenerated when parameters are changed. The *Regenerate* button will become enabled when changes have been made to parameters which affect the finished layer.

<http://reefmaster.com.au/reference/index.htm?context=450>

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Appendix B - Equipment

LOWRANCE–LSS-2 StructureScan HD Transducer





83/200 kHz Transom Mount Skimmer with Temp



Similar installation of Structure Scan and skimmer transducers.



Lowrance HDS 9 – Gen3