A Video, Sidescan and Echosounder Survey of Nearshore Halifax Harbour

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2016

Canadian Technical Report of Fisheries and Aquatic Sciences 3162

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This is the three hundred and nineteenth Technical Report
of the St. Andrews Biological Station.

Cat. No. Fs 97-6/3162E-PDF ISBN 978-0-660-04852-9 ISSN 1488-5379

Correct citation for this publication:

Vandermeulen, H. 2016. A video, sidescan and echosounder survey of nearshore Halifax Harbour. Can. Tech. Rep. Fish. Aquat. Sci. 3162: xiii + 170 p.

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ABSTRACT

Vandermeulen, H. 2016. A video, sidescan and echosounder survey of nearshore Halifax Harbour. Can. Tech. Rep. Fish. Aquat. Sci. 3162: xiii + 170 p.

A novel towfish incorporating sidescan and video hardware was used to ground truth echosounder data for the nearshore of Halifax Harbour. The resulting sampling grid extended from the shoreline to a depth of 10 m, including Bedford Basin through the Inner Harbour to the Outer Harbour. Each of these three zones could be distinguished from the others based upon combinations of substrate type, benthic invertebrates, and macrophyte canopy. Bedford Basin had a relative lack of macrophytes and evidence of intense herbivory. The Inner Harbour was characterized by shoreline hardening due to anthropogenic activities. The Outer Harbour was the most “natural” nearshore area with a mix of bottom types and a relatively abundant and diverse macrophyte canopy. All survey data were placed into a GIS, which could be used to answer management questions such as the placement and character of habitat compensation projects in the harbour. Future surveys utilizing similar techniques could be used to determine long term changes in the nearshore of the harbour.

RÉSUMÉ

Vandermeulen, H. 2016. Une relevé par vidéo, sonar à balayage latéral et de sondeur de la zone sublittorale du port d'Halifax. Can. Tech. Rep. Fish. Aquat. Sci. 3162: xiii + 170 p.

On a utilisé un nouveau poisson muni d'équipement vidéo et de balayage latéral afin de vérifier sur le terrain les données d'échosondeur pour la zone sublittorale du port d'Halifax. La grille d'échantillonnage en résultant s'étendait de la rive jusqu'à une profondeur de 10 m, y compris le bassin de Bedford de l'arrière-port à l'avant-port. Chacune de ces trois zones pourrait se distinguer des autres en fonction des combinaisons de type de substrat, d'invertébrés benthiques et de couverture de macrophytes. Le bassin de Bedford présentait un manque relatif de macrophytes et de preuves de broutage intense. L'arrière-port se caractérisait par l'artificialisation des rives due aux activités anthropiques. L'avant-port était la zone sublittorale la plus « naturelle » et présentait un mélange de types de fonds et une couverture de macrophytes relativement abondante et diverse. Toutes les données de relevés ont été placées dans un système d'information géographique qui pourrait être utilisé pour répondre à des questions de gestion telles que la mise en place et la nature des projets de compensation de l'habitat dans le port. De futurs relevés à l'aide de techniques semblables pourraient être utilisés afin de déterminer les changements à long terme dans la zone sublittorale du port.

INTRODUCTION

The author has been developing nearshore survey methods for marine and estuarine environments for over a decade. The earliest attempts were with a hull mounted sidescan ground-truthed via drop camera or direct observations, plus a transponder positioned towed camera system (Vandermeulen 2007, 2014a). Video and sidescan hardware were then fused into one towfish (Vandermeulen 2011a). The new towfish was used to map nearshore habitats in Bras d'Or Lake (Vandermeulen 2011a) as well as a number of estuaries in northern New Brunswick (Vandermeulen 2013, 2014b).

The next step was to use the towfish to ground-truth a newly acquired echosounder system, a BioSonics Inc. DT-X with dual transducers (Vandermeulen 2011b). This report covers the application of that mapping method to Halifax Harbour.

2.0 MATERIALS AND METHODS

2.1 Study Site

Halifax harbour is one of eastern Canada's largest deep water harbours, located in the middle of the Atlantic shore of the province of Nova Scotia. The harbour was divided into three areas (Fig. 1). The areas were chosen to reflect differences in depth, exposure and anthropogenic impacts:

1. Bedford Basin – the northernmost extension of Halifax harbour, used as an anchoring basin for large vessels (60 m maximum depth). The basin is moderately industrialized with a container terminal, rail yards, a number of marinas, a naval facility, the Bedford Institute of Oceanography and a gypsum loading terminal. The basin is moderately exposed, with larger waves generally associated with strong northern winds.
2. Inner Harbour – a relatively narrow channel extending south from Bedford Basin to the outer harbour. The channel is at most 20 m deep and heavily industrialized, with numerous commercial jetties, rail yards, a naval yard, large floating dry docks, vessel repair facilities, an oil refinery and a container terminal. The Northwest Arm is included as an inner harbour feature located on the western edge of Halifax's downtown core. It is a residential and parkland area with two main marinas. The inner harbour is relatively protected and large waves rarely occur.
3. Outer Harbour - a transition area extending south from the inner harbour to the open Atlantic. This area is primarily residential, with some industry and an active fishing port. There are some relatively pristine sites such as McNabs and Lawlor Islands. Wave expose is moderate, although strong southerly winds can create large waves throughout this area.

2.2 Towfish Survey

A novel towfish was deployed as described in Vandermeulen (2011a, 2013, 2014b). Briefly, the towfish consisted of a video camera with 10cm laser scale and a 330 kHz sidescan sonar set to a 30 m swath width. The video feed was used to ground truth the sidescan imagery in real time. The towfish was positioned to sub-meter precision via a transponder / transceiver system coupled to a high end dGPS with Canadian Coast Guard beacon correction. During the survey, the towfish was hauled behind the vessel from depth to the shallows on transects perpendicular to shore. Some transects were run from shore to an opposite shore. Additionally, perpendicular cross runs were made over the transects at 5 and 10 m depth contours for future ground truthing of echosounder data. The vessel speed over ground during transect runs was approximately 1.5 knots.

Post processing of towfish data was accomplished via the use of specialized software (Vandermeulen 2011a). A MapInfo GIS project was created with a hydrographic chart background layer in which sidescan GeoTIFF images, towfish track positions (which were updated every 1.3 seconds) and AVI video clips were embedded. Each video clip was 10 min long or less and embedded into its starting point on the associated GeoTIFF image. Each transect was assigned a number based upon its location (e.g. BB01 is transect #1 in Bedford Basin) and cross point towfish runs on the transect were given sub-names by depth (e.g. the cross run a 5 m depth on BB01 was coded as BB01-5). By examining the sidescan imagery in a particular section of the transect or its cross points and comparing it to the video clip for that section, it was possible to classify bottom types associated with each towfish track position. Via an analysis of the video alone, larger benthic invertebrates and macrophytes were also identified. The resulting towfish based classification was used to ground truth the echosounder survey that followed.

2.3 Echosounder Survey

An echosounder system was deployed as described in Vandermeulen (2011b). The BioSonics Inc. (Seattle, WA 98107) system consisted of a DT-X digital echosounder surface unit, a 210 kHz single beam digital transducer with 6° cone angle, and a 430 kHz single beam digital transducer with 6° cone angle and built in heading / pitch / roll (HPR) sensor. The transducers were chosen for their ability to detect bottom type and macrophyte cover, respectively. The echosounder track was recorded to sub-meter precision via the same dGPS unit used for the towfish. During the survey, hydrographic chart contour lines were followed to get relatively uniform sized ping foot prints for better precision in later data analyses (Vandermeulen 2011b). The vessel speed over ground was approximately 4 knots. In order to observe a variety of habitat types, 5 and 10 m contours were chosen for this survey.

Data processing was accomplished via specialized software from BioSonics, Inc. (Vandermeulen 2011b). Visual Bottom Typer™ (VBT2) was applied to the 210 kHz dataset and EcoSAV™ to the 430 kHz dataset.

3.0 RESULTS

3.1 Towfish survey

Towfish survey runs were performed on July 8, 10, 13, 16, 17, 20, 21, 23, 24, and 27, 2009. Over those 10 days, 109 transects and associated cross runs were covered – a total transect distance of approximately 24 km. Transect positions and numbers are shown in Figures 2, 3 & 4.

The sidescan proved to be very useful for discerning soft versus hard bottoms, and three dimensional bottom features. The GeoTIFF images were produced so that soft bottoms with low acoustic reflectivity were indicated as dark brown, while acoustically reflective hard surfaces (e.g. rocks, pilings, debris) were light brown to yellow. The hardness contrast is illustrated in Fig. 5 for BB07.

Figure 6 shows the same transect but now with the towfish data based bottom classification at the two cross points. Similar towfish based classifications were created for macrophytes and benthic invertebrates.

3.2 Echosounder Survey

Echosounder survey runs were performed on July 30 & 31 and August 5 & 6, 2009, covering the 5 and 10 m depth contours for all three areas of Halifax Harbour. After some trial and error, it was determined that a VBT2 analysis searching for four classes of acoustic bottom signatures from the 210 kHz transducer data provided the most satisfactory results. These results provided the best match to the towfish bottom classifications at transect cross runs. Figure 7 illustrates this point at the BB07 cross runs. At the 10 m cross run, which was classified as boulders on sand / mud in the towfish classification, the VBT2 acoustic classification determined that the bottom was a mix of boulders (or boulders on sand / mud) and sand / mud. In other words, there was a very good match between what was seen in the video and sidescan imagery versus the BioSonics echosounder data at the same location. The same was true at the 5 m cross run, where the towfish bottom classification indicated a mud bottom and the VBT2 analysis indicated a sand / mud bottom. Note that the VBT2 bottom classification of sand / mud covers a slightly wider range of bottom hardness than the more selective ‘mud’ classification of the towfish analysis. This was due to the wider number of bottom types that could be discerned in the towfish analysis.

Table 1 is a comparison of towfish observations to the VBT2 analysis at transect cross runs. ‘Cross type’ refers to the alignment of the echosounder ping track versus the towfish cross track. While on survey, the intention was to align the ping track as parallel as possible to the cross track. A parallel alignment provided the best possible scenario for comparing the two survey methods along the same patch of bottom. The next best alignment for comparison purposes was a ping track at an ‘angle’ to the cross track. In some cases, it was not possible to keep the vessel on a straight course relative to the original cross track, and a tangential ‘arc’ ping track was the result. With all three cross types, parallel, angle and arc, it was possible to compare the towfish

classification to the VBT2 classification. Rarely, the echosounder survey ping track did not adequately cross the sidescan imagery of the towfish cross track and no comparison was possible. Also, in some cases it was not possible to run a towfish cross run.

Due to the relatively limited number of bottom types discerned in the VBT2 analysis, if the towfish and VBT2 classifications both indicated a similar bottom at the same location it was considered a positive correspondence ('yes' in the table). In other words, the VBT2 analysis was primarily about discerning hard versus soft bottoms rather than providing more detail like boulders versus cobble or mud versus a soft silty sand mixture.

Of the 161 locations where it was possible to compare towfish bottom type observations to the VBT2 analysis, only 16 mismatches were found, plus one inconclusive match. Table 1, therefore, demonstrates a good rate of correspondence between the towfish bottom classification and the more general VBT2 bottom classification.

A similar comparison of towfish versus echosounder data was performed for macrophyte cover in the harbour. The EcoSAV™ program was able to bin detected macrophyte heights into three classes, 0 to 0.25 m (the detection limit for the analysis, essentially no macrophytes detected so 'bare bottom'), >0.25 to 1 m (macrophytes present) and >1 m tall macrophytes. The EcoSAV™ height bins were compared to the towfish macrophyte classification at cross runs. The results are shown in Table 2.

Bedford Basin was unusual in its lack of canopy producing macrophytes in the nearshore (Table 2). The towfish video at the 5 and 10 m cross runs, and even in the shallows at the end of towfish transects, indicated a very high abundance of sea urchins and snails on any available rock surface in Bedford Basin. The very high rates of herbivory suggested by this observation precludes the establishment of an algal canopy. The main algal material seen in the basin was coralline crusts (specialized species of the Rhodophyta) on rocks, which also indicate intense grazing pressure.

Unfortunately, the EcoSAV™ analysis in Bedford Basin proved unsatisfactory. There were many 'false positives' where the EcoSAV™ analysis indicated an algal canopy while the towfish video on the same patch of bottom clearly did not show any canopy.

The Inner Harbour EcoSAV™ analysis was also not satisfactory, matching the towfish ground truth information only about half of the time – with a continuing preponderance of false positive canopy detection (Table 2). Less than half of the cross points actually had a macrophyte canopy – indicating that the Inner Harbour was also not particularly conducive to algal growth. 'Urchin barrens' of coralline algae on rock were common. 'Reds' in the towfish classification column of Table 2 refer to a collection of smaller folious and filamentous algal members of the Rhodophyta.

The Outer Harbour EcoSAV™ analysis was slightly better, more able to detect a macrophyte canopy when one was actually present (Table 2).

3.3 GIS Results

3.3.1 Towfish Data

Towfish classification information has been provided here for general reference for each transect in the GIS. Since this is a digital publication, the reader can zoom in and out to get an appreciation of the level of detail possible in the sidescan imagery. A far greater level of manipulation and calculations are possible in the actual GIS.

Our transect 'atlas' begins with Figure 8, the towfish classification results for transect BB01. Note how each color coded classification follows the midline of the cross run sidescan imagery at 5 and 10 m. This of course was the position of the towfish during each run, with the sidescan imagery to the port and starboard of the towfish to a distance of 15 m on either side. There is some scatter of the classification dots in this particular example due to poor quality satellite GPS signals near this bridge. Note the abundance of sea urchins at both depths at this particular transect and the subsequent absence of a macrophyte canopy. Even though the video clip for the main transect (red arrow in red circle) was not used for classification purposes, it can still be viewed in the GIS if desired.

In some cases it was not possible to produce towfish classifications for a particular transect. In one instance, IH01 (Figure 41), the cross run data was too poor to produce a classification. In other cases, cross runs were not made for a particular transect due to field conditions or a lack of time (IH02, IH03, IH09, OH03, OH08, OH17, OH18, OH22).

Some transect locations had neither large benthic invertebrates nor a macrophyte canopy (e.g. BB06, Figure 13). This was most likely due to the physical characteristics of the site but water quality issues are also possible causes.

The towfish classifications presented here were biased towards identifying the most prevalent organisms seen in the video. As a result, cryptic invertebrates residing under a dense algal canopy would not be recorded. This created a situation where either benthic invertebrates or a macrophyte canopy was recorded at a particular point along the cross run, but not both.

The towfish classification legends in each figure are simplistic and intended for a general audience. The bottom type classification relies upon simple combinations of boulders, cobble, sand and mud. The "animals" classification uses common names for a variety of large benthic invertebrates. In the macrophytes classification, the kelps predominate (*Agarum*, *Desmarestia*, and *Saccharina*) while the detailed taxonomy of the Rhodophyta is relegated to the term "Reds" – "eelgrass" refers to the seagrass *Zostera marina*.

The reader will note the relative absence of any macrophyte cover in Bedford Basin (Figures 8 – 40). The Inner Harbour area (Figures 41 – 87) had a relatively greater abundance of macrophytes, particularly in some of the more 'pristine' locations such as Georges Island (IH10 & 11, Figures 50 & 51), Point Pleasant Park (IH13 & 14, Figures 53 & 54), portions of the Northwest Arm (e.g. IH17, Figure 57), and McNabs Island (e.g. the eelgrass patches at IH33-5, Figure 73). The Dartmouth side of the

Inner Harbour also had scattered macrophyte cover (e.g. IH38-10, Figure 78).The Outer Harbour (Figures 88 – 116), the most ‘pristine’ or ‘natural’ area, also had the most consistent and diverse macrophyte cover on suitable hard substrates and depths.

3.3.2 Echosounder Data

As mentioned above, the VBT2 echosounder based bottom classification appeared to be robust and corresponded quite well to the towfish based bottom classification at cross runs. Figures 117 – 123 show the VBT2 bottom classification results for Bedford Basin.

The classification results are best interpreted as strings of colored dots along specific stretches of shore. If there is a preponderance of red, blue, or yellow dots in a particular string, then that bottom is relatively hard (boulders present, or solid hard bottoms). A preponderance of green dots in a string refers to softer bottoms like sand or mud combinations. Individual dots examined in isolation from others in a string may provide misleading results (i.e. a single blue dot in a long string of green dots does not necessarily mean there is a hard bottom right at the blue dot position).

As would be expected, strings of dots representing hard bottoms occur right near steep jetty areas like those at the Bedford Institute of Oceanography and the National Gypsum Jetty (Fig. 117), or the Fairview Container Terminal (Fig. 122). Strings of green dots (sand / mud) occur in more sheltered depositional areas like the north end of Bedford Bay (Fig. 119).

The legends in these figures provide a count of the total number of dots in each color category. For example, in Bedford Basin at 5 m, there are 14051 dots classified as sand / mud (green) by VBT2, and 7724 dots classified as harder surfaces. So softer bottoms are about twice as common as hard ones at 5 m in the Basin. Interestingly, this ratio is about 1.7: 1 at 10 m.

Figures 124 – 132 show the VBT2 bottom classification results for the Inner Harbour. There was a preponderance of harder substrates at both 5 and 10 m in this area with an overall soft to hard bottom ratio of about 1.2: 1. This is in part due to the infill and other shore hardening construction in this busy port area, but more natural sites such as Pleasant Shoal also had a quite rocky bottom (Figs. 128 & 129). Some of the bays in the Inner Harbour, Tufts Cove (Fig. 124), Dartmouth Cove (Fig. 126), head of Northwest Arm (Fig. 131), and Eisner Cove (Fig. 132) had softer bottoms.

Figures 133 – 141 show the VBT2 bottom classification results for the Outer Harbour. In this classification, it was possible to discern well sorted relatively hard packed sand a separate category at 5 m (bottom type 4 in each legend). This type of substrate is included in the sand / mud category for our total tallies of bottom type by dot count. The ratio is 1:1 for soft to hard bottoms at 5 m in that case. At 10 m, the ratio is approximately 2.8:1 – the softest bottoms for our entire survey area. Note how Eastern Passage has uniformly soft sediments along its 10 m contour (Figs. 134, 135, 141).

Figures 142 – 150 show the EcoSAV macrophyte canopy height classification results for the Outer Harbour. In general, the presence of a macrophyte canopy is usually associated with harder bottom types that support algal attachment. For example, the harder bottoms at both 5 and 10 m around Thrumcap Shoal were associated with a consistent macrophyte cover (Figs. 146 & 147). Conversely, the softer bottoms at 10 m in Eastern Passage were rarely linked to a macrophyte canopy (Figs. 143, 144, 150). Unfortunately, as mentioned above, the EcoSAV results for Bedford Basin and the Inner Harbour were not usable. As a result it was not possible to discuss ratios of bare bottom to macrophyte cover for the Outer Harbour.

DISCUSSION

Our survey method, utilizing sidescan and video data to ground truth echosounder survey results, appears to work. There was a logical consistency in the VBT2 bottom classification results, where hard and soft bottoms were indicated at locations where one would expect them. There was also a very good correspondence between the towfish bottom classification results and the VBT2 results at transect cross runs. It took a total of 14 days to complete our survey of Halifax Harbour with one boat and a crew of three. That is a relatively small field effort considering the very large area covered.

The EcoSAV results however, were disappointing. The software had a tendency to produce false positive macrophyte canopy classifications. As a result, only the Outer Harbour survey area produced interpretable results.

Some general observations can be made for each of the three harbour areas surveyed:

1. Bedford Basin – a general lack of macrophytes, most likely due to herbivory and a preponderance of softer bottoms.
2. Inner Harbour – macrophytes more abundant and hard substrates common due to infill and jetty construction.
3. Outer Harbour – the most consistent and diverse macrophyte cover with hard bottoms at 5 m and softer substrates common at 10 m.

The data embedded into the GIS (bottom type, benthic invertebrates and macrophyte cover) can be used to answer a variety of management based questions at different scales. The GIS should be particularly useful for determining the nature and location of compensation projects due to habitat loss from construction activities. Future surveys of similar design could be used to detect long-term changes in the nearshore of the harbour.

ACKNOWLEDGMENTS

The field assistance of Brian Jones, Bob Semple and Megan Wilson is appreciated. Philip Longue spent three days at the helm. Megan Wilson assisted with the development of the towfish classification. Brian Jones processed the towfish classification and entered data for the GIS.

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Table 1: A comparison of towfish versus VBT2 bottom classifications at towfish cross points.

Transect #	Cross Type	Towfish Classification	VBT2 matches towfish?
BB01-5	arc	mud	yes
BB01-10	parallel	boulders on sand / mud	no
BB02-5	parallel	boulders and boulders on sand / mud	yes
BB02-10	angle	boulders on sand / mud	yes
BB03-5	parallel	sand and boulders on sand / mud	yes
BB03-10	parallel	sand and boulders on sand / mud	yes
BB04-10	parallel	boulders and cobble on sand / mud	yes
BB05-5	parallel	sand and cobble on sand / mud	yes
BB05-10	parallel	sand	yes
BB06-5	parallel	boulders on sand / mud	yes
BB06-10	parallel	mud	yes
BB07-5	parallel	mud	yes
BB07-10	parallel	boulders on sand / mud	yes
BB08-5	angle	sand and boulders on sand / mud	yes
BB09-5	parallel	sand and boulders on sand / mud	yes
BB09-10	parallel	sand and boulders on sand / mud	yes
BB10-5	arc	mud	yes
BB10-10	parallel	sand, boulders and boulders on sand / mud	yes
BB11-5	parallel	mud and boulders on sand / mud	yes
BB11-10	angle	mud	yes
BB12-5	parallel	sand and boulders on sand / mud	yes
BB12-10	angle	boulders and boulders on sand / mud	yes
BB13-5	parallel	boulders	yes
BB13-10	arc	mud	yes
BB14-10	parallel	mud	yes

BB15-5	parallel	mud and boulders on sand / mud	yes
BB15-10	angle	mud	yes
BB16-5	parallel	mud	yes
BB16-10	parallel	mud	yes
BB17-5	parallel	mud	yes
BB17-10	parallel	mud	yes
BB18-5	parallel	mud	yes
BB19-10	arc	boulders and boulders on sand / mud	yes
BB20-5	parallel	riprap	yes
BB20-10	angle	mud	yes
BB21-5	arc	boulders on sand / mud	yes
BB21-10	angle	boulders on sand / mud	yes
BB22-5	angle	sand and boulders on sand / mud	yes
BB22-10	parallel	boulders on sand / mud	yes
BB23-5	parallel	sand and boulders on sand / mud	yes
BB23-10	parallel	sand and boulders on sand / mud	yes
BB24-5	parallel	sand, boulders and boulders on sand / mud	yes
BB24-10	parallel	sand and boulders	yes
BB25-10	parallel	sand	yes
BB26-5	parallel	rip rap	yes
BB26-10	parallel	mud	no
BB27-5	parallel	sand and boulders on sand / mud	yes
BB28-5	parallel	cobble on sand / mud	yes
BB28-10	angle	sand and boulders on sand / mud	yes
BB29-10	parallel	sand and boulders on sand / mud	yes
BB30-5	parallel	sand	yes
BB30-10	angle	sand and boulders	yes
BB31-5	parallel	mud and boulders on sand / mud	yes
BB31-10	parallel	mud and boulders on sand / mud	yes
BB32-10	parallel	sand and cobble on sand / mud	no
BB33-5	parallel	boulders on sand / mud	yes

BB33-10	parallel	boulders and boulders on sand / mud	yes
IH06-10	parallel	boulders on sand / mud	yes
IH07-10	parallel	cobble on sand / mud	no
IH08-10	angle	sand and boulders on sand / mud	yes
IH10-5	angle	sand	no
IH10-10	parallel	sand	yes
IH11-5	angle	cobble	yes
IH11-10	angle	cobble	yes
IH12-10	parallel	boulders on sand / mud	yes
IH13-5	parallel	boulder on sand / mud	yes
IH13-10	arc	mud and boulders on sand / mud	yes
IH14-5	parallel	boulders	yes
IH14-10	parallel	boulders	yes
IH15-5	parallel	sand and boulders on sand / mud	yes
IH15-10	parallel	sand	yes
IH16-5	parallel	cobble	no
IH16-10	parallel	cobble on sand / mud	yes
IH17-5	parallel	mud and cobble on sand / mud	yes
IH17-10	parallel	sand and boulders on sand / mud	yes
IH18-5	parallel	boulders and cobble	yes
IH18-10	parallel	sand and mud	yes
IH19-5	angle	cobble on sand / mud	no
IH19-10	parallel	sand and cobble on sand / mud	yes
IH20-5	parallel	boulders on sand / mud	yes
IH20-10	parallel	sand and boulders on sand / mud	no
IH21-10	parallel	sand	yes
IH22-5	parallel	cobble on sand / mud	yes
IH22-10	parallel	mud	yes
IH23-5	parallel	mud	yes
IH23-10	parallel	mud	yes
IH24-5	parallel	cobble on sand / mud	yes
IH24-10	parallel	mud	yes

IH25-5	parallel	boulders / cobble on sand / mud	yes
IH25-10	parallel	boulders on sand / mud	yes
IH26-5	parallel	boulders / cobble on sand / mud	yes
IH27-5	parallel	cobble on sand / mud	yes
IH27-10	parallel	mud	yes
IH28-5	parallel	cobble on sand / mud	yes
IH28-10	parallel	mud	yes
IH29-5	parallel	boulders	yes
IH30-5	arc	mud and cobble on sand / mud	yes
IH30-10	parallel	mud and cobble on sand / mud	yes
IH31-5	parallel	sand	yes
IH31-10	arc	cobble on sand / mud	yes
IH32-5	angle	sand	yes
IH33-5	parallel	sand	yes
IH33-10	parallel	mud	yes
IH34-10	parallel	mud	yes
IH35-5	parallel	cobble on sand / mud	no
IH35-10	parallel	mud	no
IH36-5	parallel	cobble on sand / mud	yes
IH36-10	parallel	sand	no
IH37-10	parallel	cobble	yes
IH38-5	parallel	cobble on sand / mud	yes
IH38-10	parallel	sand	yes
IH39-5	parallel	cobble on sand / mud	yes
IH39-10	parallel	sand	?
IH40-10	parallel	sand	yes
IH41-5	parallel	boulders on sand / mud	yes
IH41-10	parallel	mud and boulders on sand / mud	no
IH42-5	parallel	sand	yes
IH42-10	parallel	mud	yes
IH43-5	parallel	sand	yes
IH43-10	parallel	mud	yes

IH44-5	arc	boulders and boulders on sand / mud	yes
IH44-10	parallel	boulders and mud	yes
IH45-5	angle	boulders and boulders on sand / mud	yes
IH45-10	angle	boulders and boulders on sand / mud	yes
IH46-5	parallel	sand and boulders on sand / mud	yes
IH46-10	parallel	boulders on sand / mud	yes
IH47-5	arc	boulders	yes
OH01-5	parallel	mud	no
OH01-10	angle	mud and boulders on sand / mud	yes
OH02-5	parallel	gravel	yes
OH02-10	parallel	boulders on sand / mud	yes
OH04-5	parallel	boulders and boulders on sand / mud	yes
OH04-10	parallel	sand	yes
OH05-5	parallel	cobble on sand / mud	yes
OH05-10	angle	cobble on sand / mud	no
OH06-10	parallel	cobble on sand / mud	yes
OH07-5	arc	boulders on sand / mud	yes
OH09-5	parallel	boulders on sand / mud	yes
OH09-10	parallel	boulders on sand / mud	yes
OH10-10	parallel	sand	yes
OH11-5	parallel	sand	yes
OH11-10	angle	sand	yes
OH12-5	angle	sand	yes
OH12-10	parallel	sand	no
OH13-10	angle	boulders on sand / mud	yes
OH14-5	parallel	boulders on sand / mud	yes
OH14-10	parallel	boulders on sand / mud	yes
OH15-5	parallel	boulders on sand / mud	yes
OH19-5-W	parallel	sand	yes
OH19-5-E	parallel	mud	no
OH20-5	parallel	sand	yes
OH20-10	parallel	mud	yes

OH21-10	parallel	mud	yes
OH23-10	parallel	mud	yes
OH24-5	arc	mud	yes
OH24-10	parallel	mud	yes
OH25-10	angle	mud	yes
OH26-5	parallel	sand and boulders on sand / mud	yes
OH27-5	arc	sand	yes
OH28-5-N	angle	sand	yes
OH29-5	angle	sand and cobble on sand / mud	yes

Table 2: A comparison of towfish macrophyte classifications versus EcoSAV™ canopy height estimates at towfish cross points.

Transect #	Cross Type	Towfish Classification	EcoSAV™ bin height matches towfish?
BB01-5	arc	no macrophytes	yes
BB01-10	parallel	no macrophytes	no
BB02-5	parallel	no macrophytes	no
BB02-10	angle	no macrophytes	no
BB03-5	parallel	no macrophytes	no
BB03-10	parallel	no macrophytes	no
BB04-10	parallel	no macrophytes	no
BB05-5	parallel	no macrophytes	yes
BB05-10	parallel	no macrophytes	no
BB06-5	parallel	no macrophytes	yes
BB06-10	parallel	no macrophytes	yes
BB07-5	parallel	no macrophytes	yes
BB07-10	parallel	no macrophytes	no
BB08-5	angle	no macrophytes	yes
BB09-5	parallel	no macrophytes	yes
BB09-10	parallel	no macrophytes	no
BB10-5	arc	no macrophytes	yes
BB10-10	parallel	no macrophytes	no
BB11-5	parallel	no macrophytes	yes
BB11-10	angle	no macrophytes	yes
BB12-5	parallel	no macrophytes	no
BB12-10	angle	no macrophytes	no
BB13-5	parallel	no macrophytes	no
BB13-10	arc	no macrophytes	no
BB14-10	parallel	no macrophytes	yes
BB15-5	parallel	no macrophytes	no
BB15-10	angle	no macrophytes	yes

BB16-5	parallel	no macrophytes	yes
BB16-10	parallel	no macrophytes	yes
BB17-5	parallel	no macrophytes	yes
BB17-10	parallel	no macrophytes	yes
BB18-5	parallel	no macrophytes	yes
BB19-10	arc	no macrophytes	no
BB20-5	parallel	no macrophytes	no
BB20-10	angle	no macrophytes	yes
BB21-5	arc	no macrophytes	no
BB21-10	angle	no macrophytes	no
BB22-5	angle	no macrophytes	no
BB22-10	parallel	no macrophytes	no
BB23-5	parallel	no macrophytes	no
BB23-10	parallel	no macrophytes	no
BB24-5	parallel	no macrophytes	no
BB24-10	parallel	no macrophytes	no
BB25-10	parallel	no macrophytes	no
BB26-5	parallel	no macrophytes	no
BB26-10	parallel	no macrophytes	no
BB27-5	parallel	no macrophytes	no
BB28-5	parallel	no macrophytes	yes
BB28-10	angle	no macrophytes	no
BB29-10	parallel	no macrophytes	no
BB30-5	parallel	no macrophytes	yes
BB30-10	angle	no macrophytes	no
BB31-5	parallel	no macrophytes	yes
BB31-10	parallel	no macrophytes	no
BB32-10	parallel	no macrophytes	yes
BB33-5	parallel	no macrophytes	no
BB33-10	parallel	no macrophytes	no
IH06-10	parallel	no macrophytes	no
IH07-10	parallel	no macrophytes	no

IH08-10	angle	no macrophytes	no
IH10-5	angle	*Saccharina*	no
IH10-10	parallel	no macrophytes	yes
IH11-5	angle	*Agarum*	yes
IH11-10	angle	*Agarum*	yes
IH12-10	parallel	no macrophytes	no
IH13-5	parallel	*Saccharina*	yes
IH13-10	arc	*Agarum* & reds	yes
IH14-5	parallel	*Agarum* & reds	yes
IH14-10	parallel	*Agarum*	yes
IH15-5	parallel	*Saccharina* and reds	yes
IH15-10	parallel	no macrophytes	no
IH16-5	parallel	*Saccharina*	no
IH16-10	parallel	*Saccharina* and *Agarum* & reds	yes
IH17-5	parallel	*Saccharina*	yes
IH17-10	parallel	*Saccharina*	yes
IH18-5	parallel	no macrophytes	no
IH18-10	parallel	no macrophytes	no
IH19-5	angle	no macrophytes	no
IH19-10	parallel	no macrophytes	no
IH20-5	parallel	*Saccharina*	yes
IH20-10	parallel	*Saccharina*	yes
IH21-10	parallel	no macrophytes	yes
IH22-5	parallel	*Saccharina*	no
IH22-10	parallel	no macrophytes	yes
IH23-5	parallel	no macrophytes	yes
IH23-10	parallel	small patch of *Saccharina*	yes
IH24-5	parallel	*Saccharina*	yes
IH24-10	parallel	no macrophytes	yes
IH25-5	parallel	*Saccharina*	yes
IH25-10	parallel	*Saccharina*	yes
IH26-5	parallel	*Saccharina*	yes

IH27-5	parallel	*Saccharina*	yes
IH27-10	parallel	no macrophytes	yes
IH28-5	parallel	*Saccharina*	yes
IH28-10	parallel	no macrophytes	yes
IH29-5	parallel	*Saccharina*	yes
IH30-5	arc	no macrophytes	no
IH30-10	parallel	small patch of *Saccharina*	yes
IH31-5	parallel	patches of *Agarum*, *Saccharina* and *Desmarestia*	yes
IH31-10	arc	*Agarum*	yes
IH32-5	angle	no macrophytes	no
IH33-5	parallel	patches of eelgrass and *Saccharina*	yes
IH33-10	parallel	no macrophytes	yes
IH34-10	parallel	patches of *Saccharina*	yes
IH35-5	parallel	*Saccharina*	yes
IH35-10	parallel	*Agarum*	no
IH36-5	parallel	no macrophytes	yes
IH36-10	parallel	no macrophytes	no
IH37-10	parallel	no macrophytes	no
IH38-5	parallel	no macrophytes	yes
IH38-10	parallel	*Agarum*	no
IH39-5	parallel	patch of *Saccharina*	yes
IH39-10	parallel	*Agarum* & *Desmarestia*	yes
IH40-5	parallel	*Saccharina*	no
IH40-10	parallel	no macrophytes	yes
IH41-5	parallel	*Saccharina*	yes
IH41-10	parallel	*Saccharina* and *Agarum*	no
IH42-5	parallel	no macrophytes	no
IH42-10	parallel	no macrophytes	yes
IH43-5	parallel	no macrophytes	yes
IH43-10	parallel	no macrophytes	yes
IH44-5	arc	no macrophytes	yes
IH44-10	parallel	no macrophytes	no

IH45-5	angle	no macrophytes	no
IH45-10	angle	no macrophytes	no
IH46-5	parallel	no macrophytes	yes
IH46-10	parallel	no macrophytes	no
IH47-5	arc	no macrophytes	no
OH01-5	parallel	no macrophytes	yes
OH01-10	angle	*Saccharina*	yes
OH02-5	parallel	*Saccharina* & reds	yes
OH02-10	parallel	*Saccharina*	yes
OH04-5	parallel	*Agarum*, eelgrass, *Saccharina*, *Desmarestia*, and reds	yes
OH04-10	parallel	*Agarum*	no
OH05-5	parallel	*Saccharina*, *Desmarestia*, and reds	yes
OH05-10	angle	no macrophytes	no
OH06-10	parallel	*Saccharina*	yes
OH07-5	arc	*Saccharina*	yes
OH09-5	parallel	*Saccharina*	yes
OH09-10	parallel	*Saccharina*	yes
OH10-10	parallel	no macrophytes	no
OH11-5	parallel	no macrophytes	yes
OH11-10	angle	no macrophytes	no
OH12-5	angle	*Agarum*, *Desmarestia*, and reds	no
OH12-10	parallel	no macrophytes	no
OH13-10	angle	*Agarum*, *Saccharina*, and reds	yes
OH14-5	parallel	*Saccharina*	yes
OH14-10	parallel	*Saccharina*	yes
OH15-5	parallel	*Saccharina* & reds	yes
OH19-5-W	parallel	no macrophytes	yes
OH19-5-E	parallel	no macrophytes	yes
OH20-5	parallel	patches of *Saccharina*	yes
OH20-10	parallel	no macrophytes	yes
OH21-10	parallel	no macrophytes	yes

OH23-10	parallel	no macrophytes	yes
OH24-5	arc	patches of *Saccharina* and *Agarum*	yes
OH24-10	parallel	no macrophytes	yes
OH25-10	angle	no macrophytes	yes
OH26-5	parallel	small patches of *Saccharina*	yes
OH27-5	arc	no macrophytes	yes
OH28-5-N	angle	small patch of *Saccharina*	yes
OH29-5	angle	*Saccharina* & reds	no

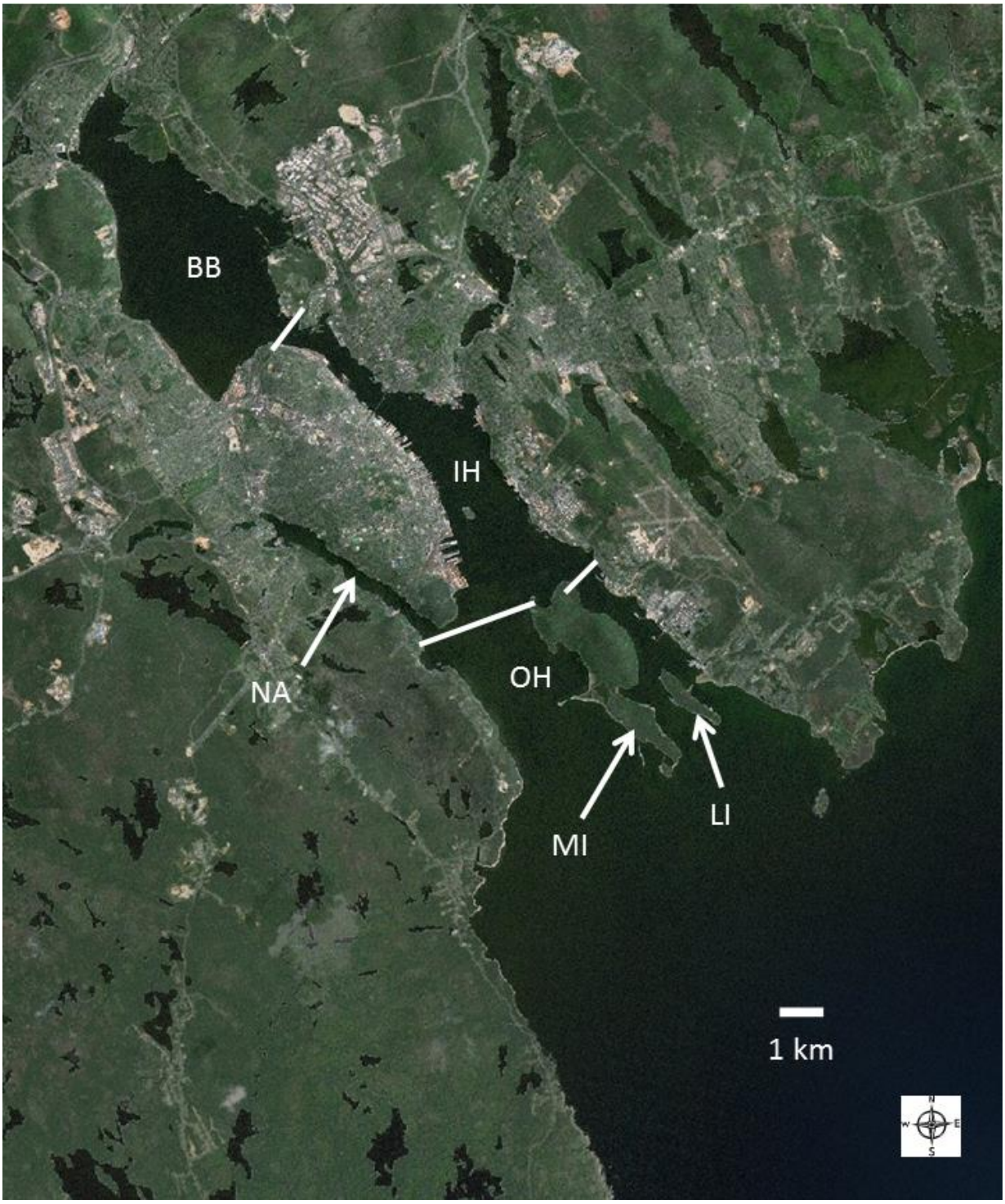


Figure 1: Halifax harbour. **BB** – Bedford Basin, **IH** – Inner harbour, **OH** – outer harbour, **NA** – Northwest Arm, **MI** – McNabs Island, **LI** – Lawlor Island. Satellite image from http://www.mapquest.com/.

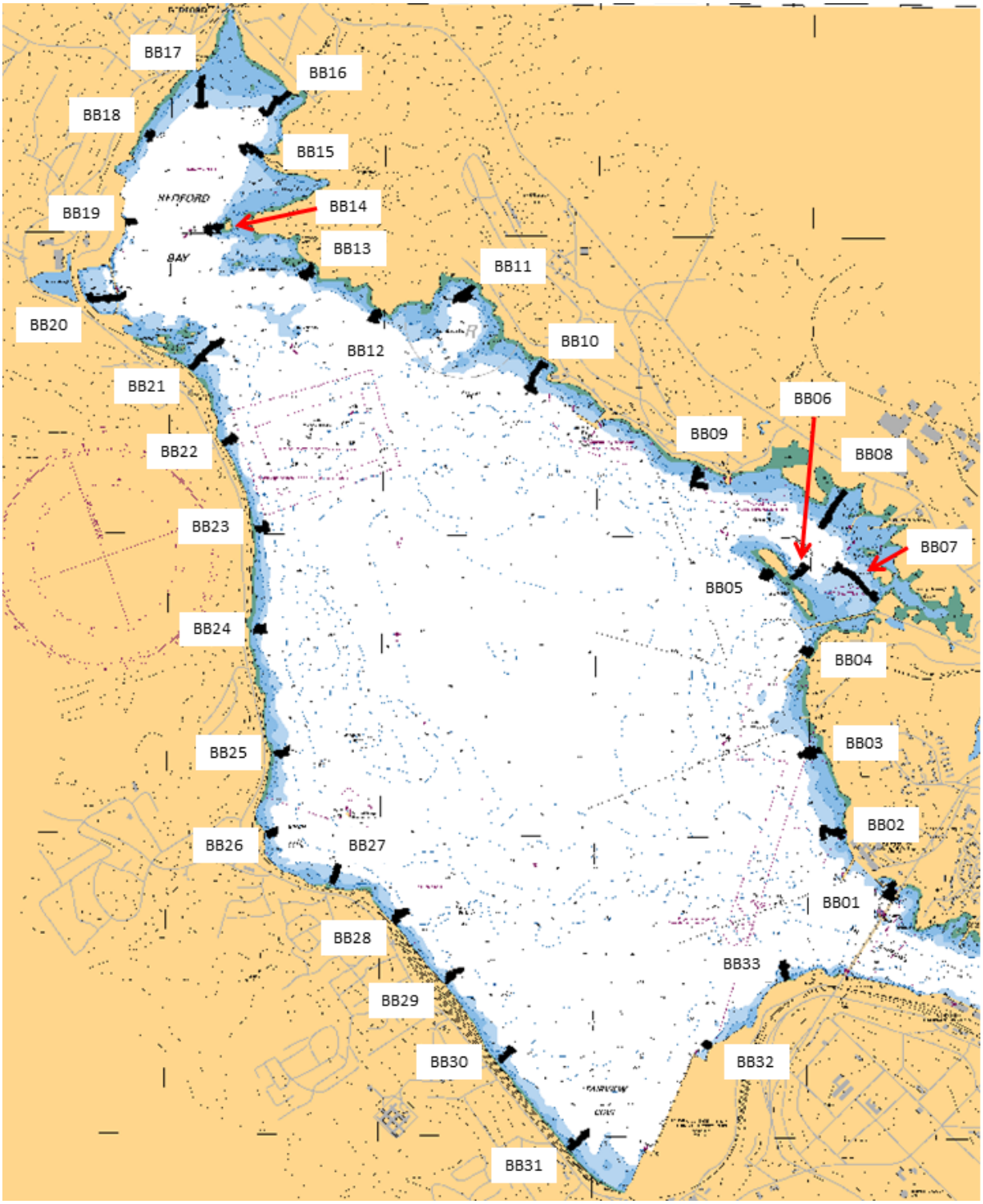


Figure 2: Bedford Basin towfish transect positions (black squiggles) and code numbers.

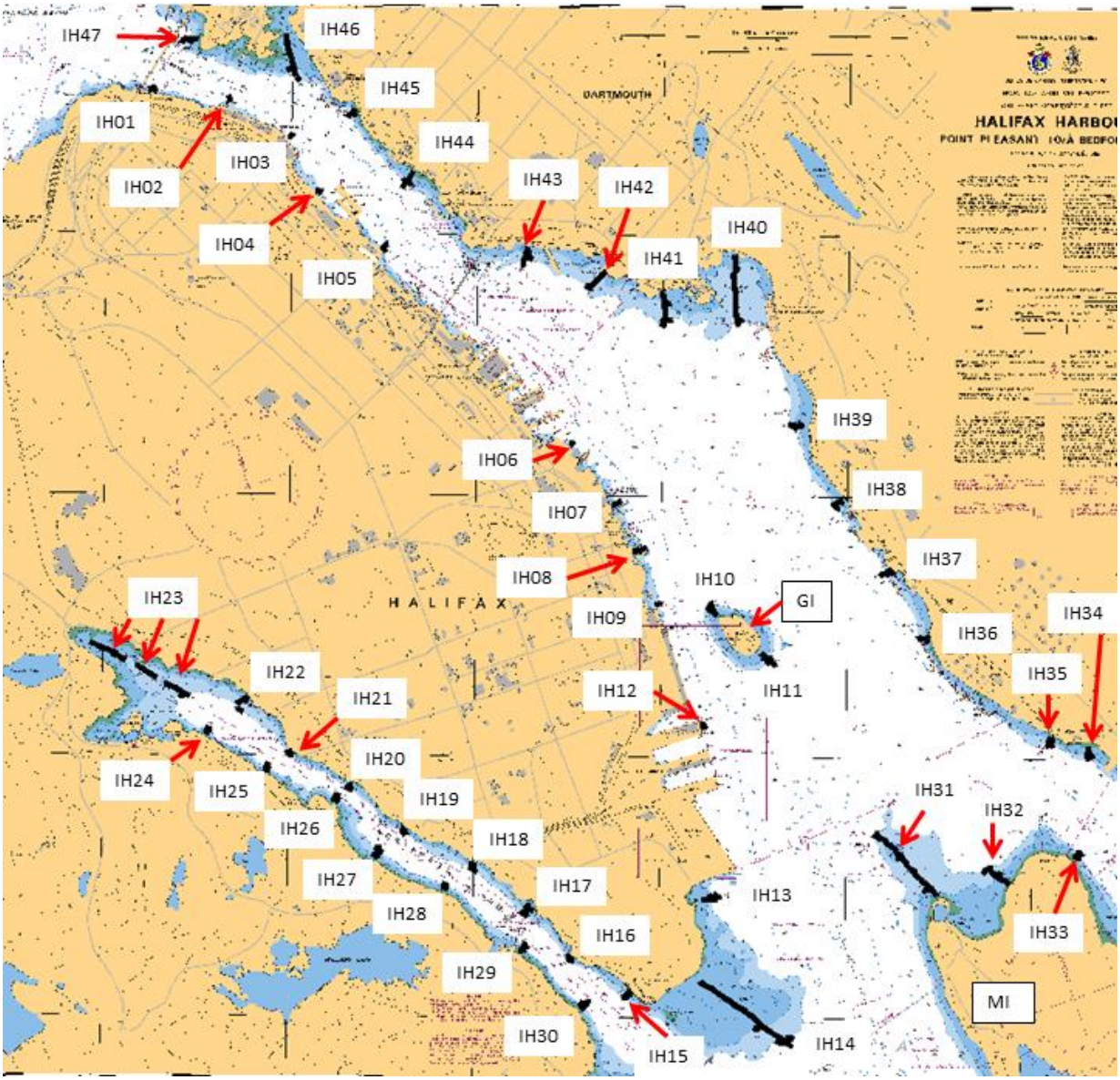


Figure 3: Inner Harbour towfish transect positions and code numbers. **GI** – Georges Island, **MI** – McNabs Island.

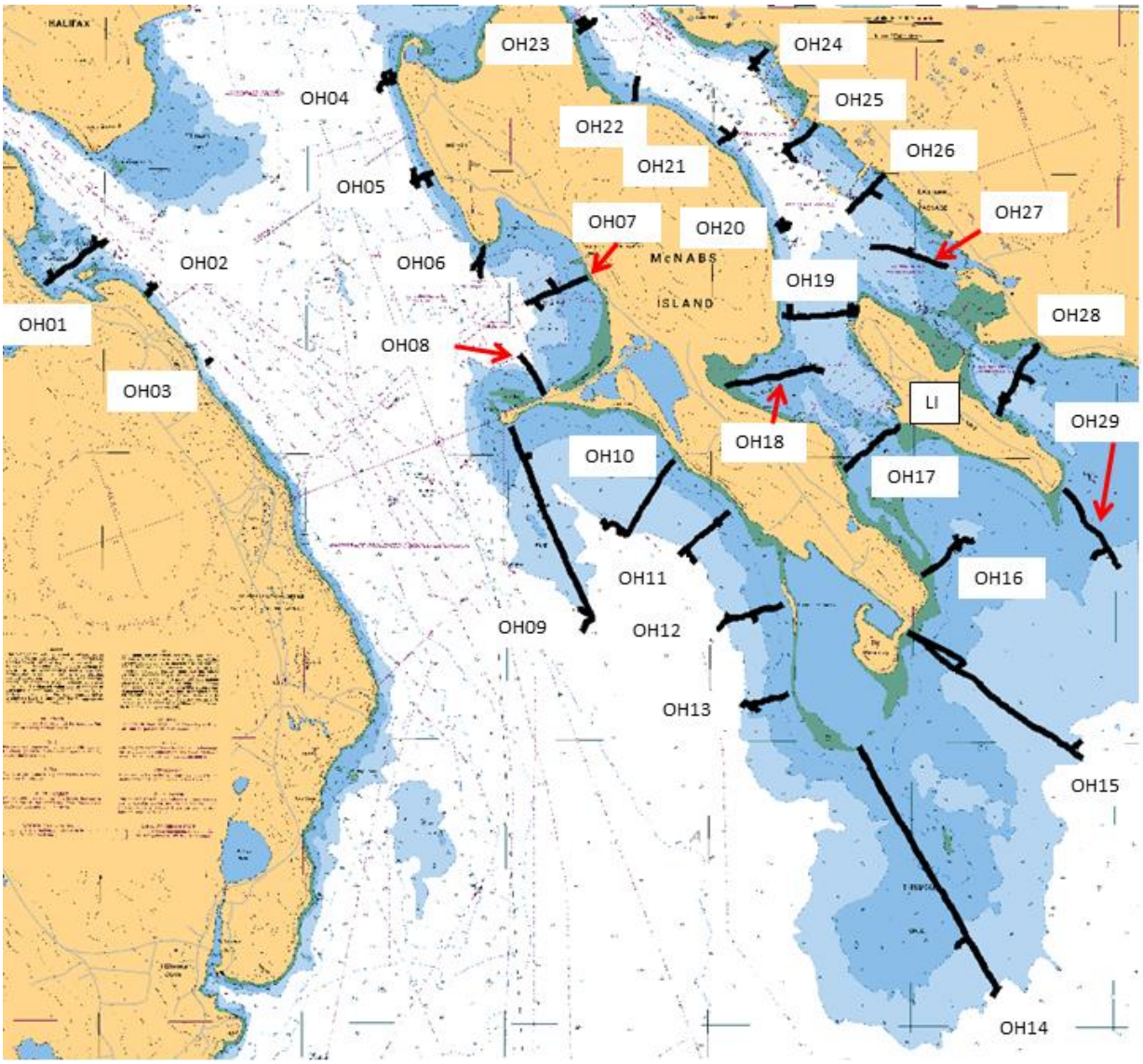


Figure 4: Outer Harbour towfish transect positions and code numbers. **LI** – Lawlor Island.

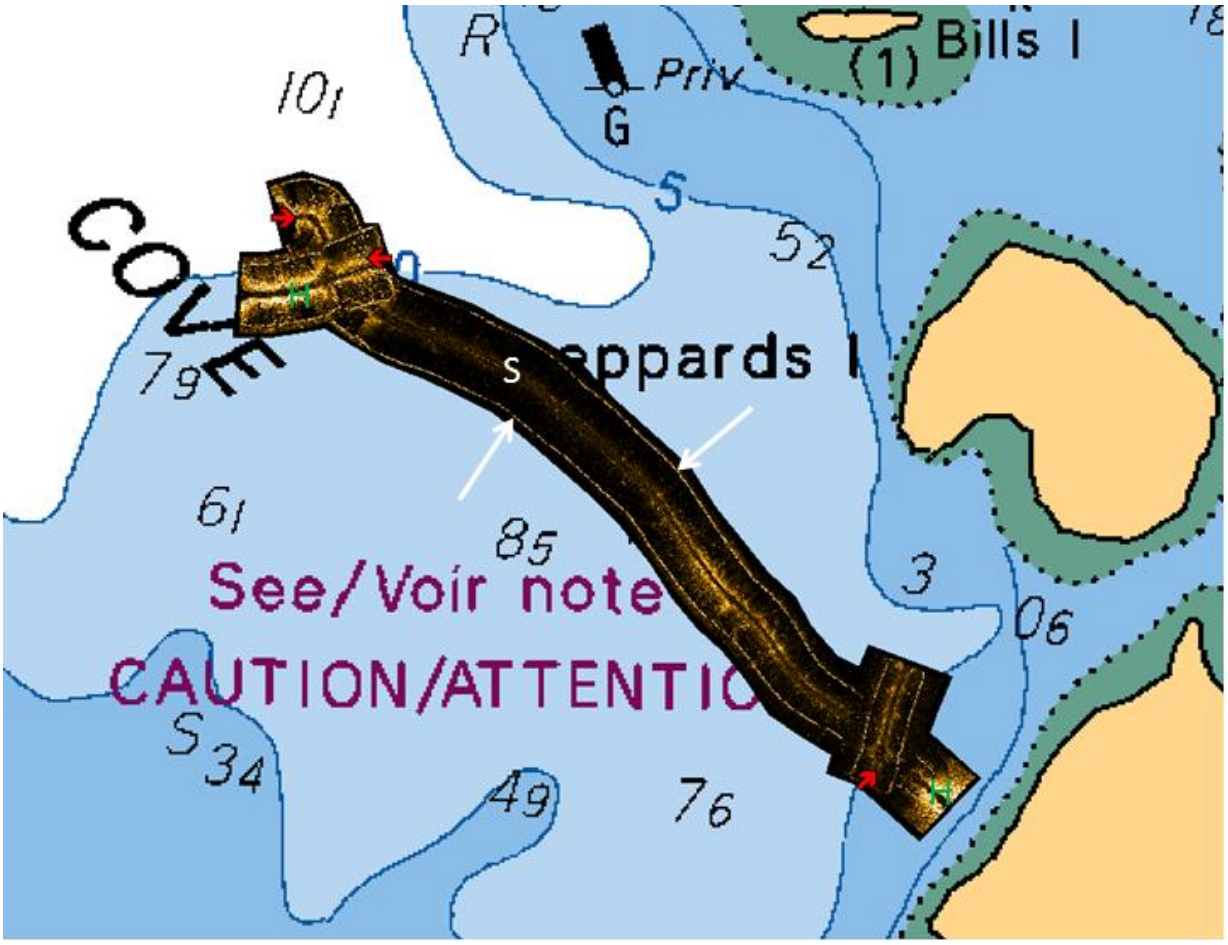


Figure 5: Transect BB07 with cross points at 5 and 10 m depth contours. Screen shot from GIS with GeoTIFF sidescan imagery (30 m total swath width) against chart background. Red arrows indicate direction of tow for main transect run and the two cross points. White arrows indicate bright lines in sidescan imagery which are artifacts. **H** – hard bottom (high acoustic reflectivity, bright yellow in image at 10 m and in shallows), **S** – soft bottom (low acoustic reflectivity, dark brown).

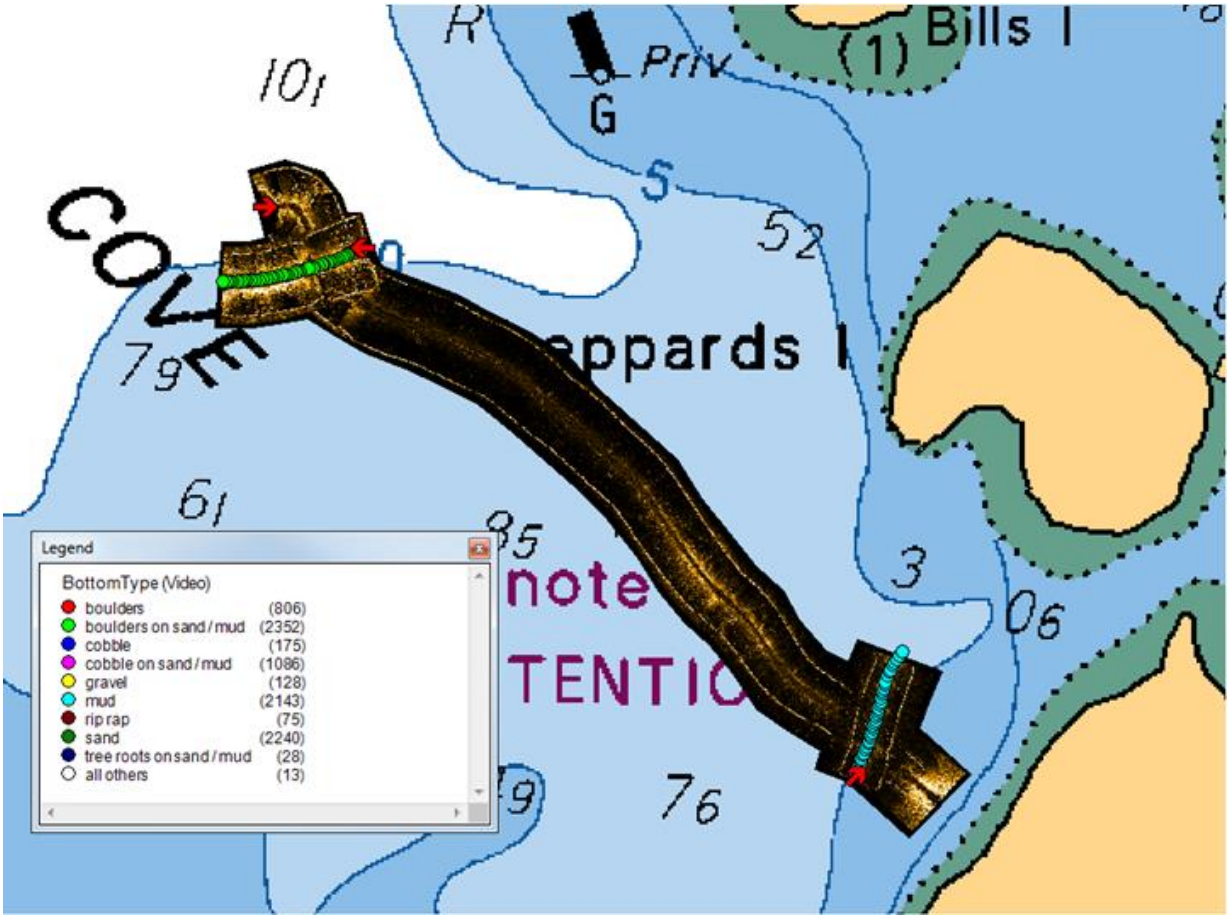


Figure 6: Transect BB07 showing the towfish based (video and sidescan) bottom classification determined for the 5 and 10 m cross runs. The harder bottom at 10 m was boulders on sand / mud (light green dots) and the soft bottom at 5 m was mud (light blue dots).

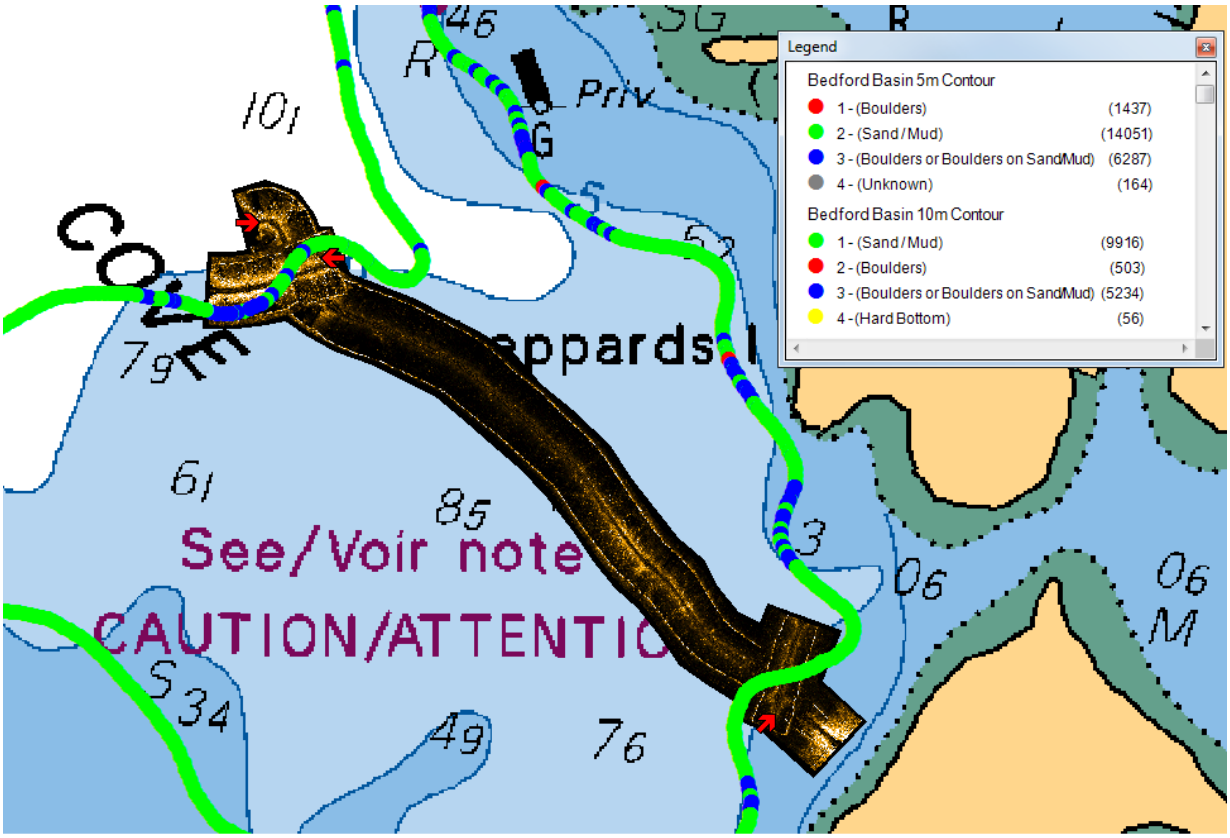


Figure 7: Transect BB07 showing the BioSonics run at 5 and 10 m with the VBT2 bottom classification results based upon four clusters. Note how this classification matches the towfish bottom classification seen in Fig. 6.

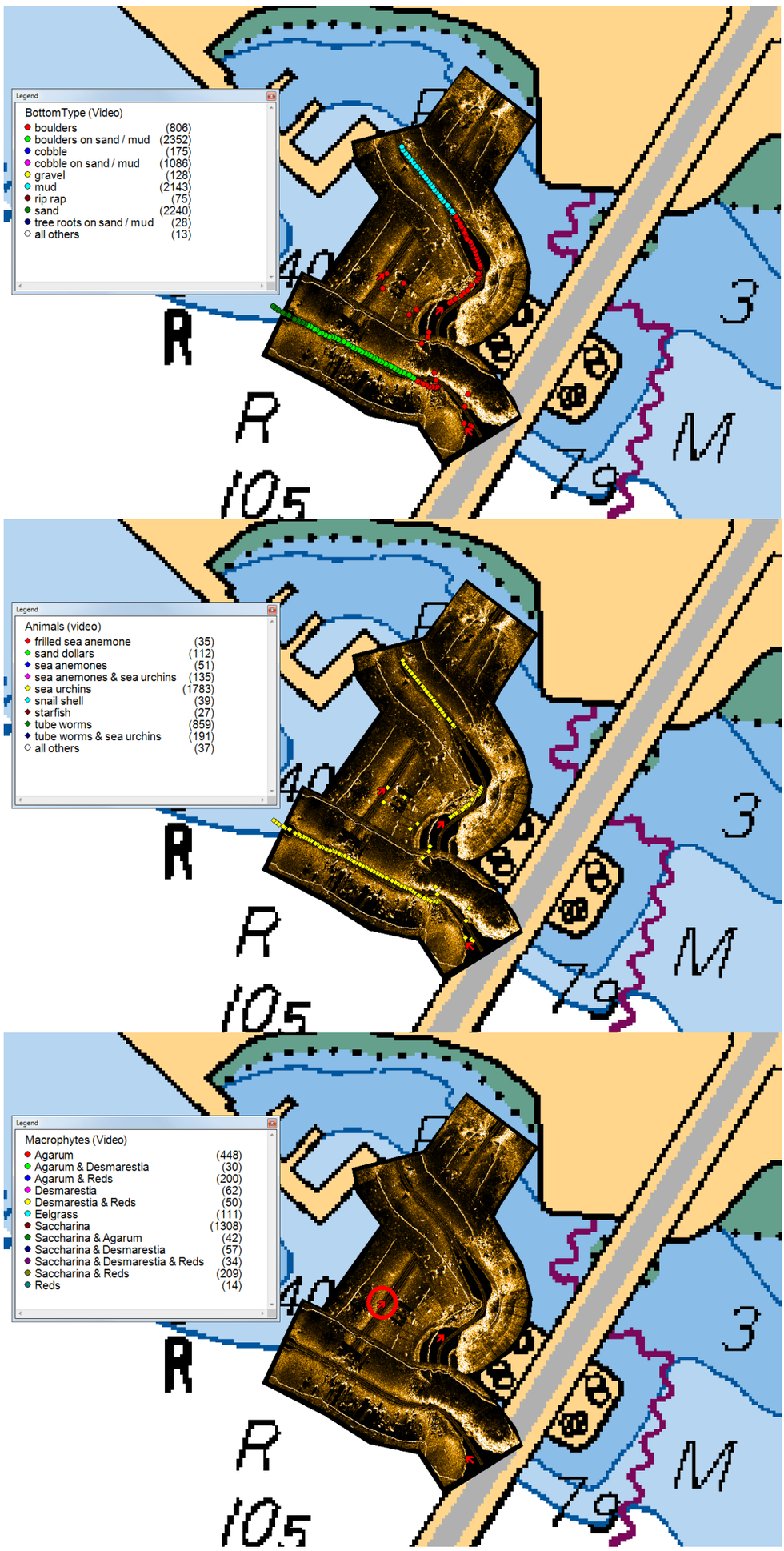


Figure 8: Transect BB01 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.680398N 63.610531W.

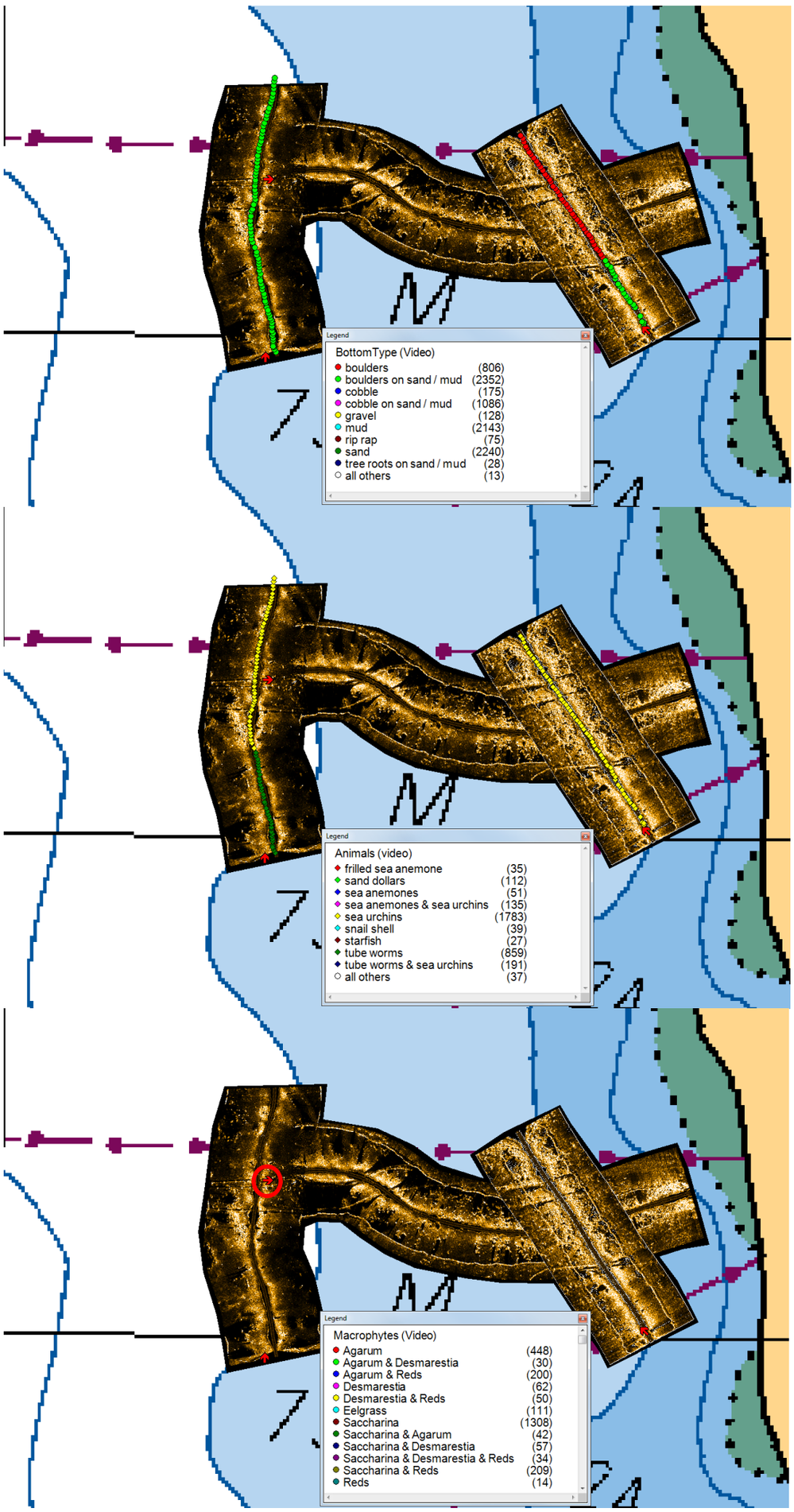


Figure 9: Transect BB02 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.683775N 63.615603W.

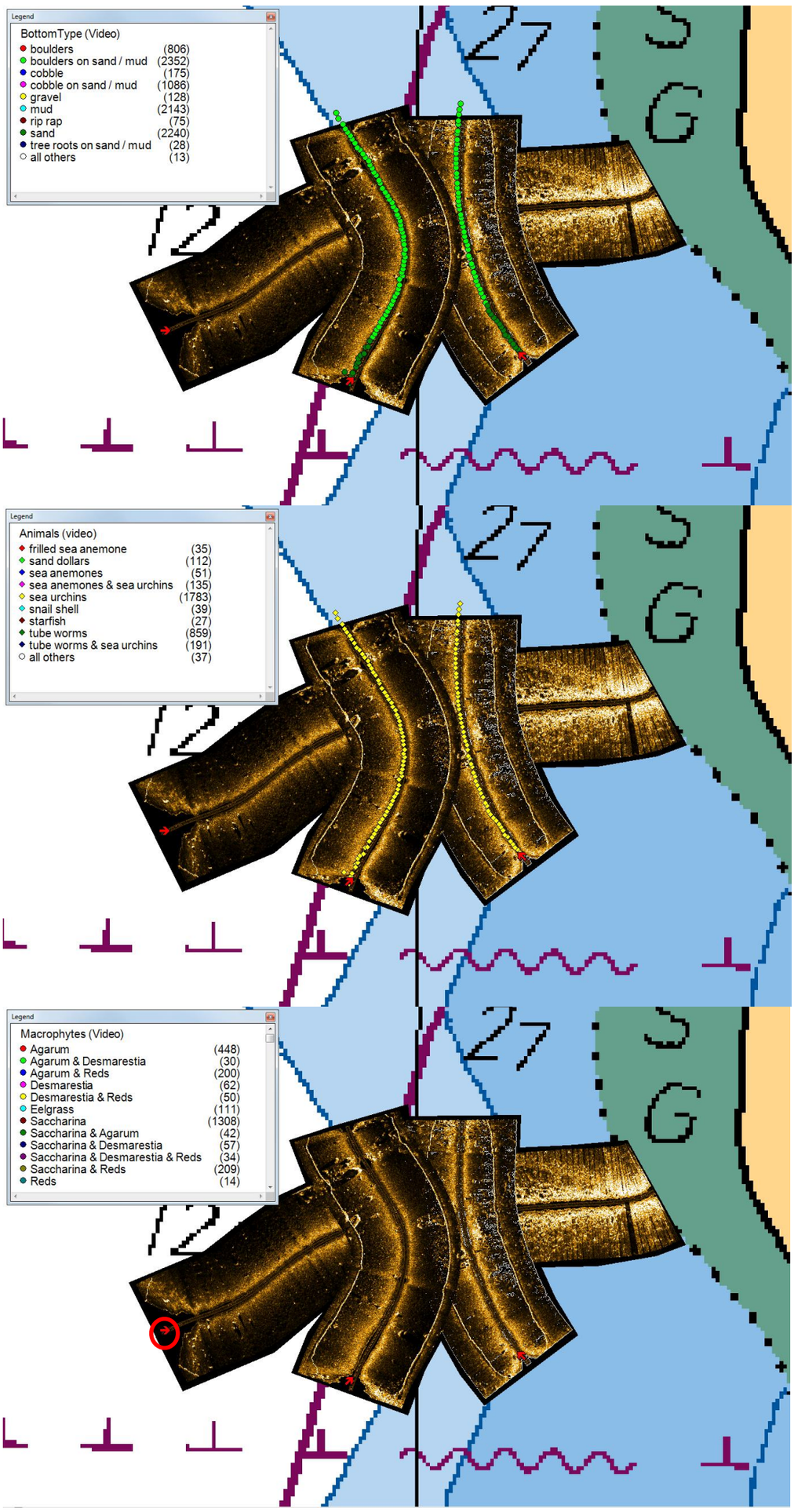


Figure 10: Transect BB03 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.687892N 63.617487W.

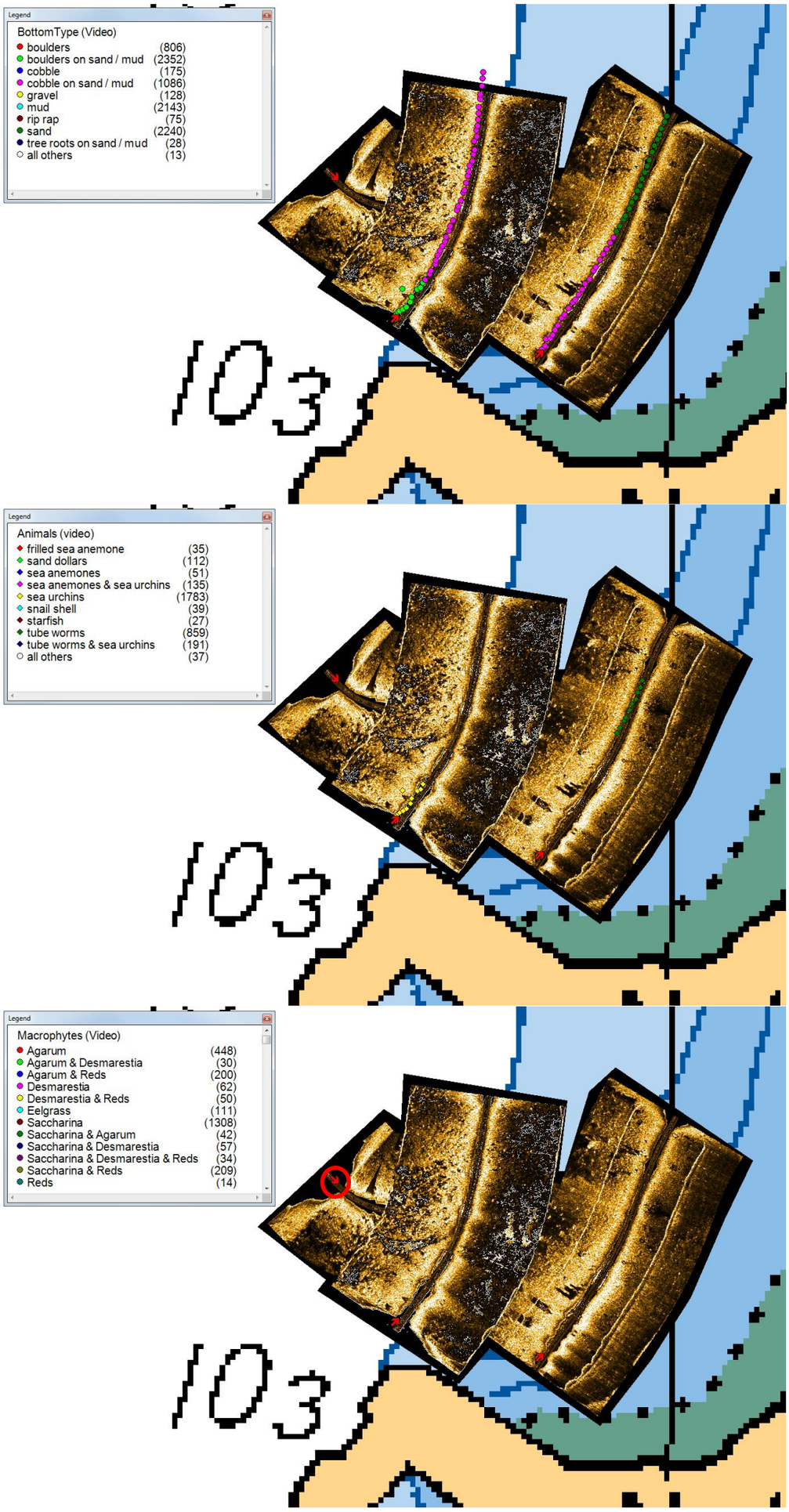


Figure 11: Transect BB04 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.693822N 63.617447W.

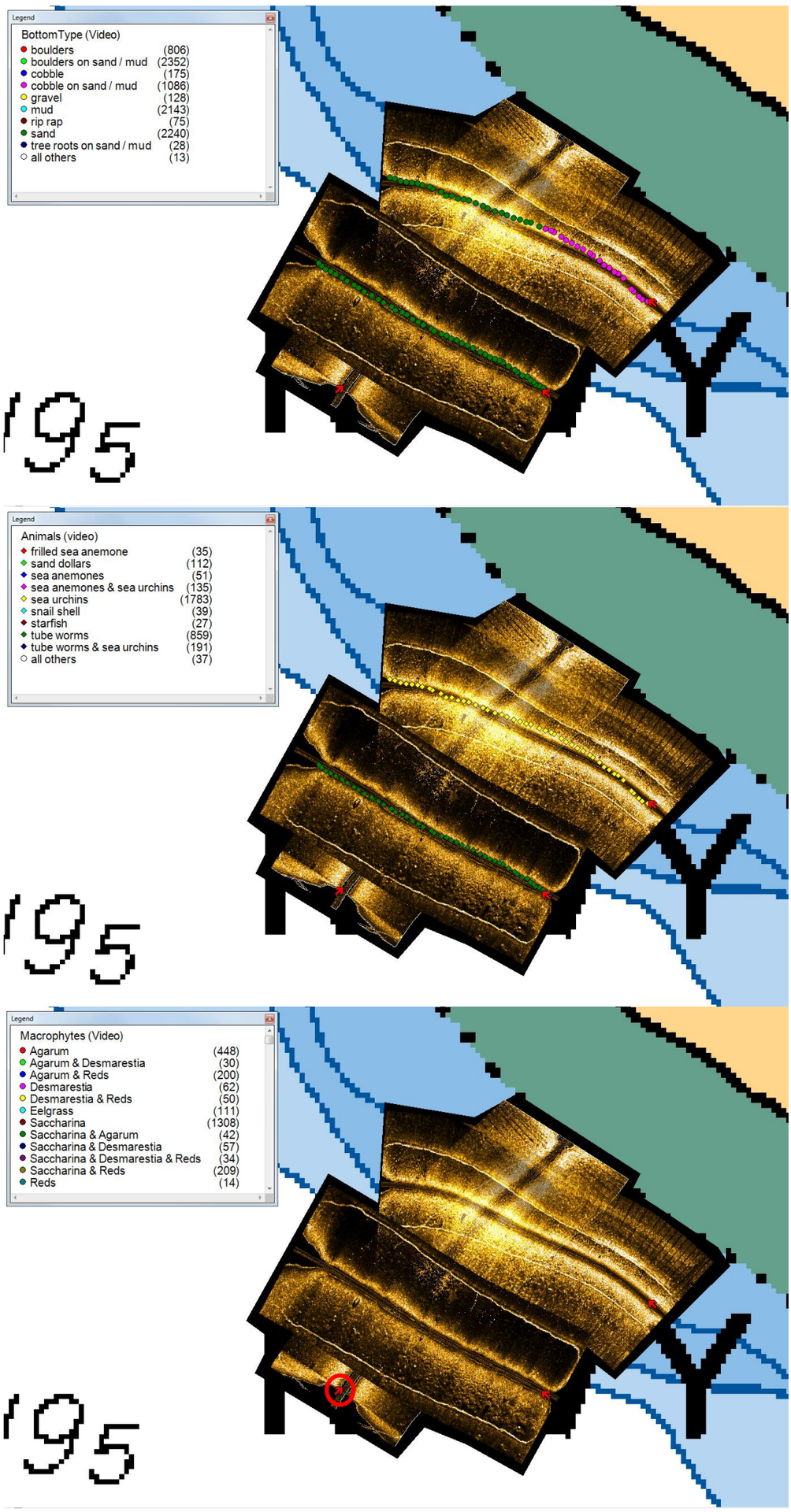


Figure 12: Transect BB05 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.697762N 63.620518W.

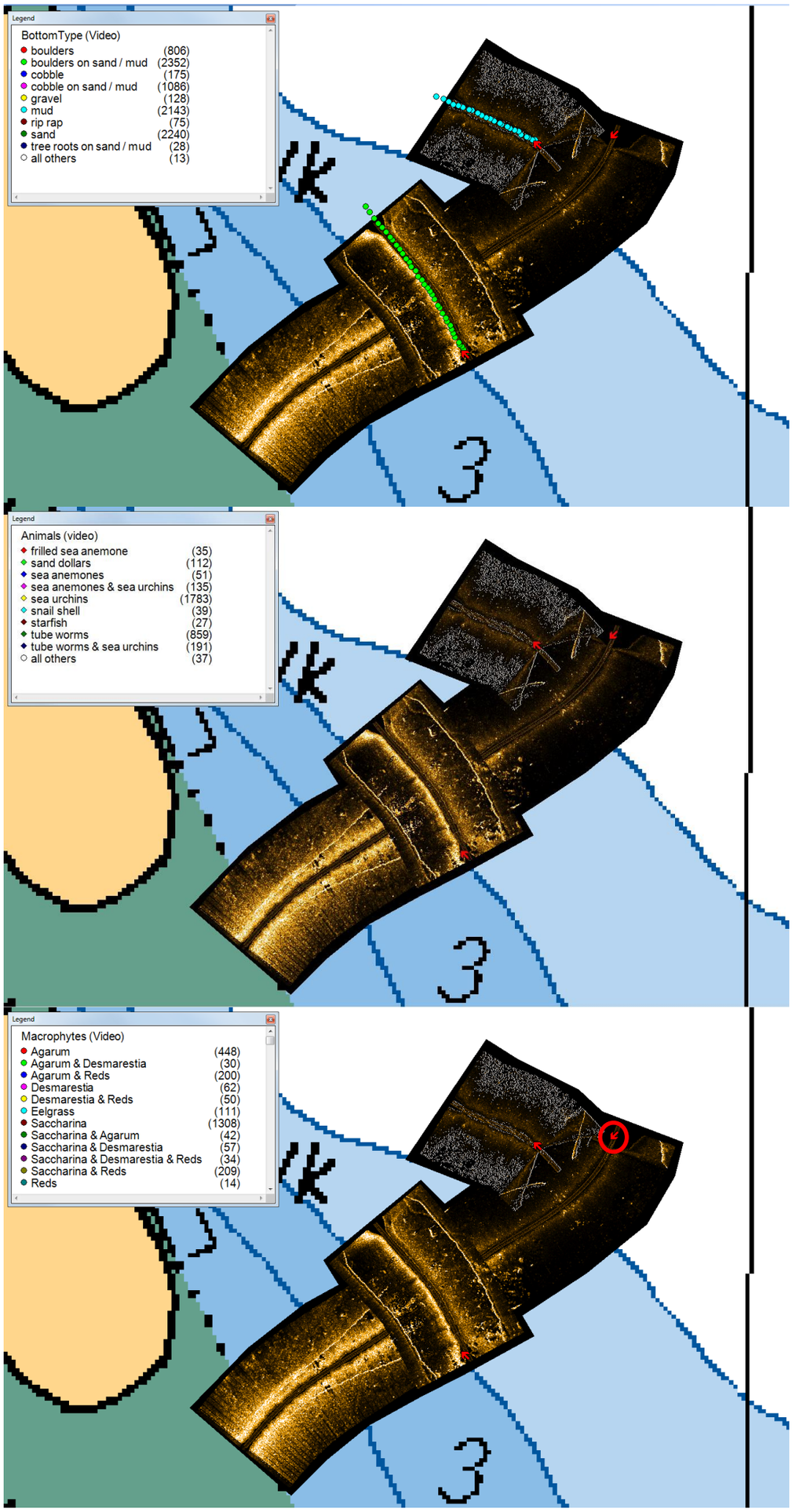


Figure 13: Transect BB06 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.698430N 63.617062W.

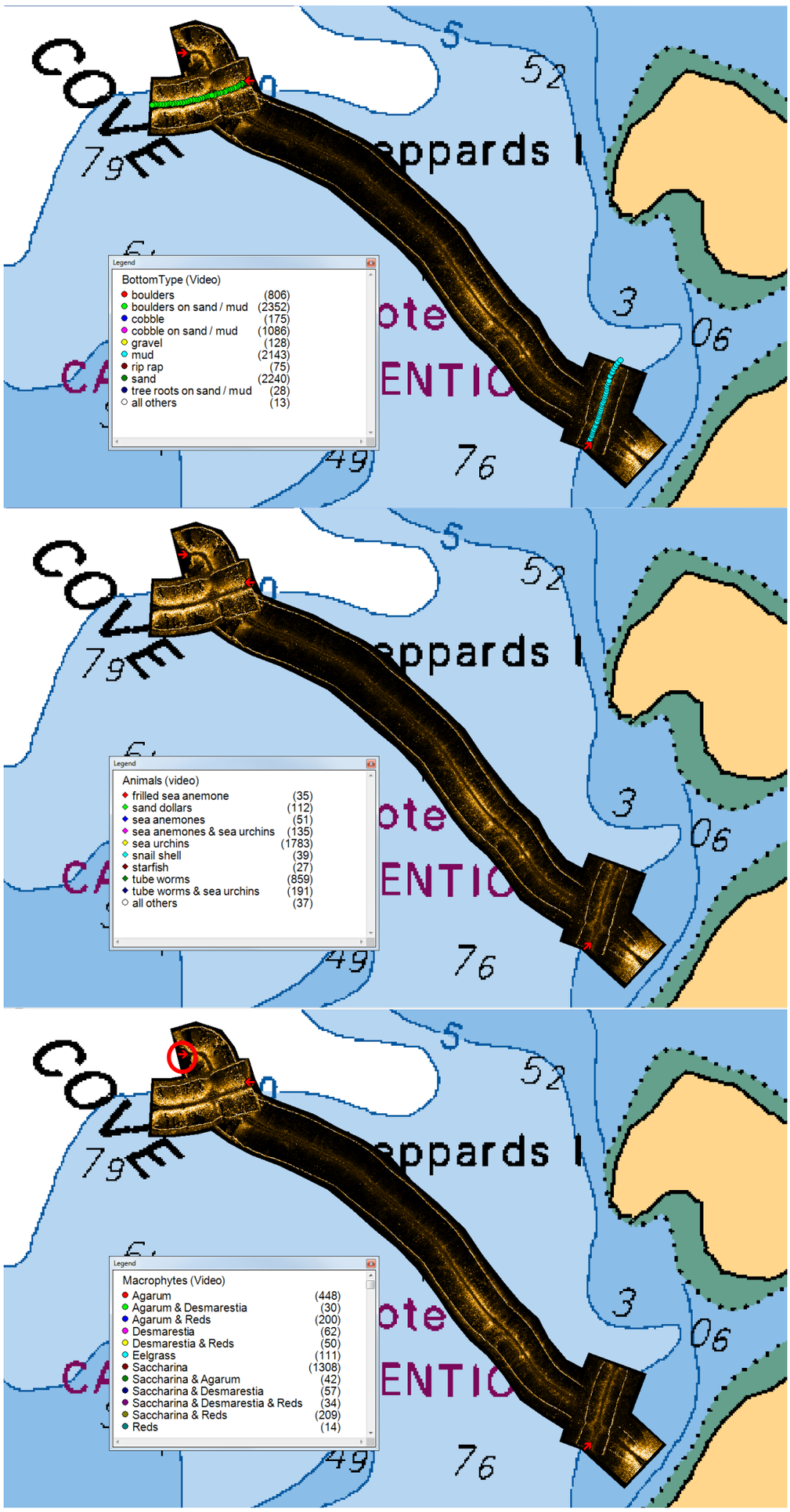


Figure 14: Transect BB07 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.698548N 63.614738W.

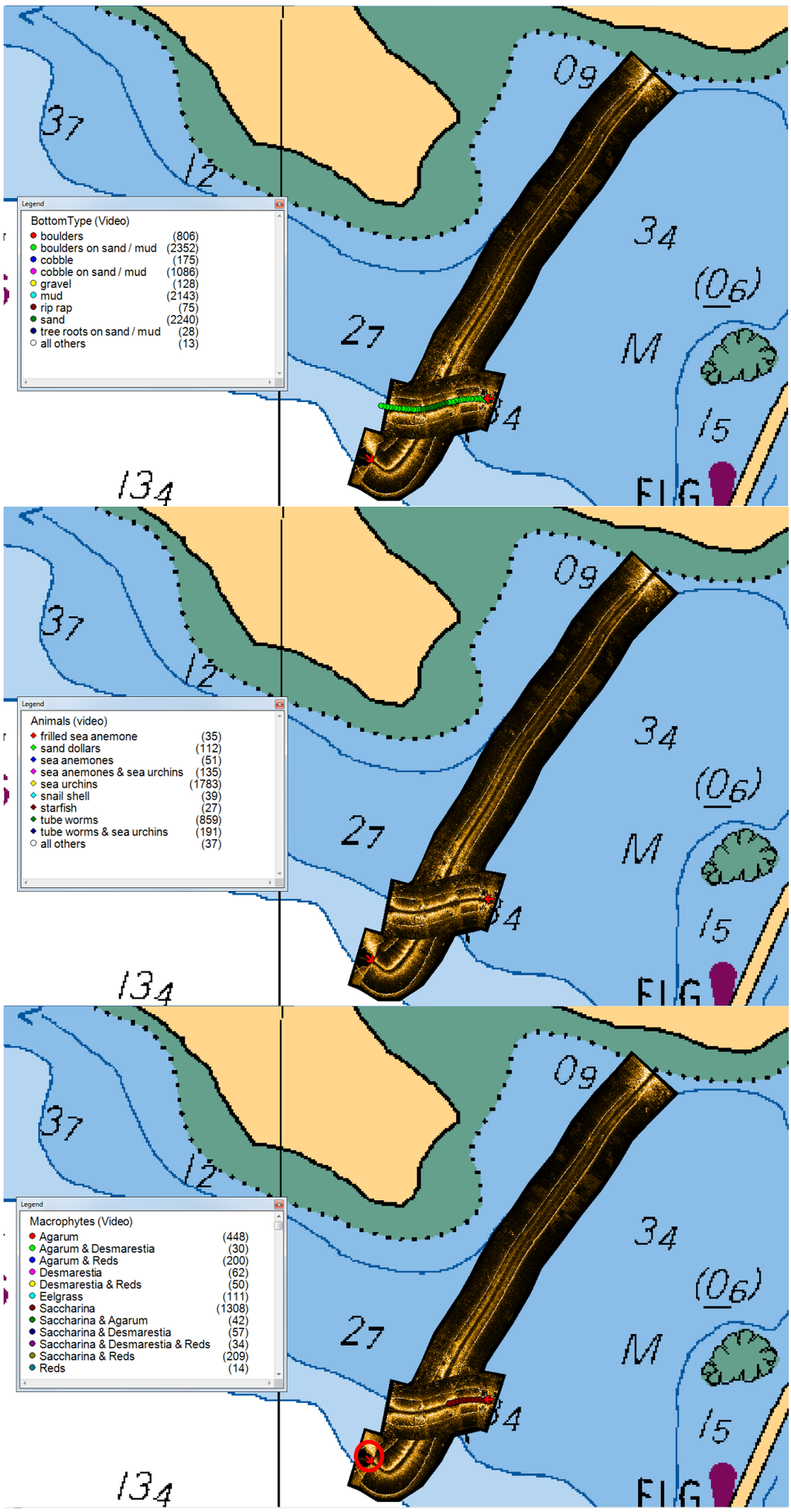


Figure 15: Transect BB08 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.700760N 63.616023W.

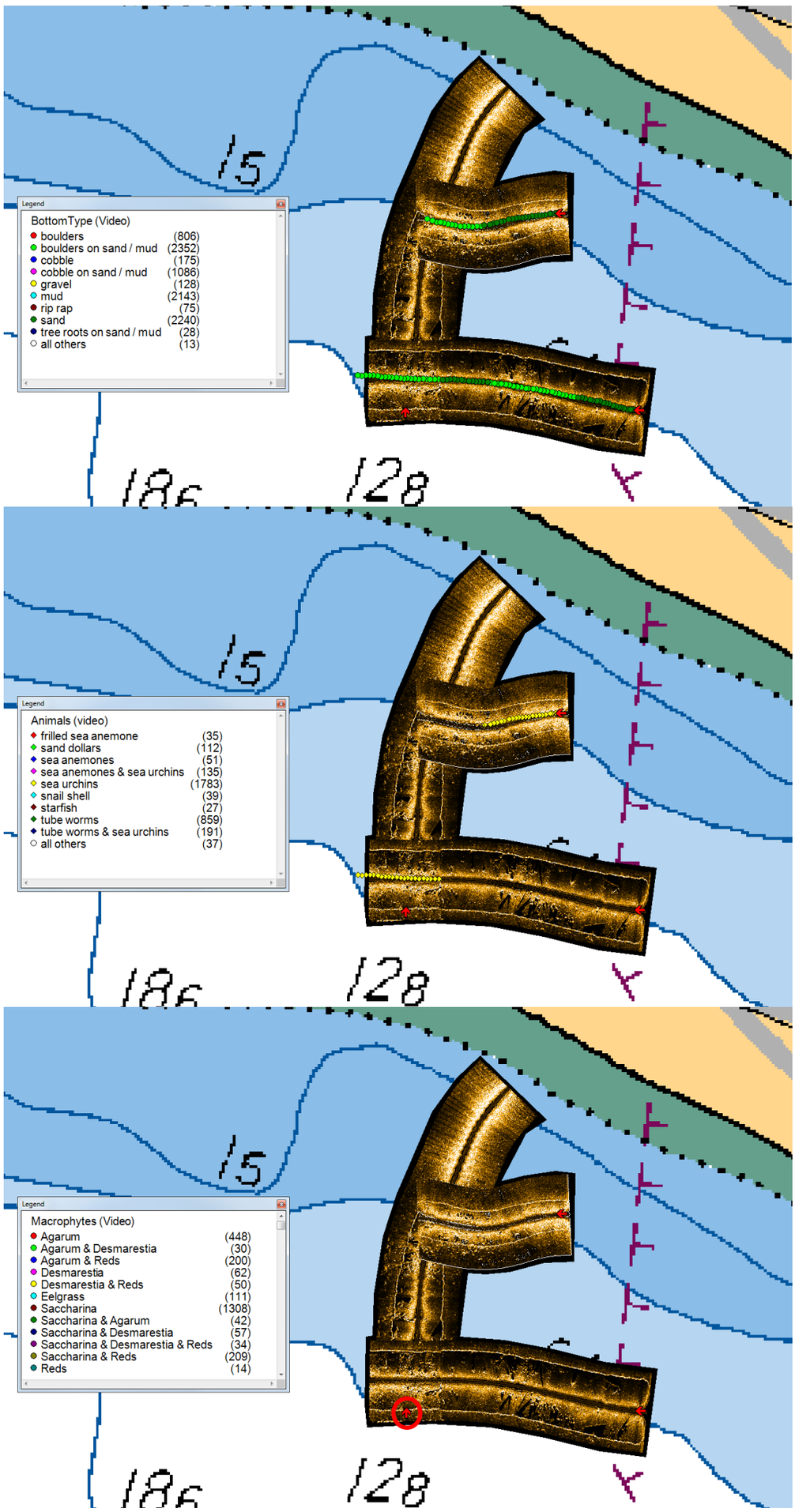


Figure 16: Transect BB09 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.702830N 63.625927W.

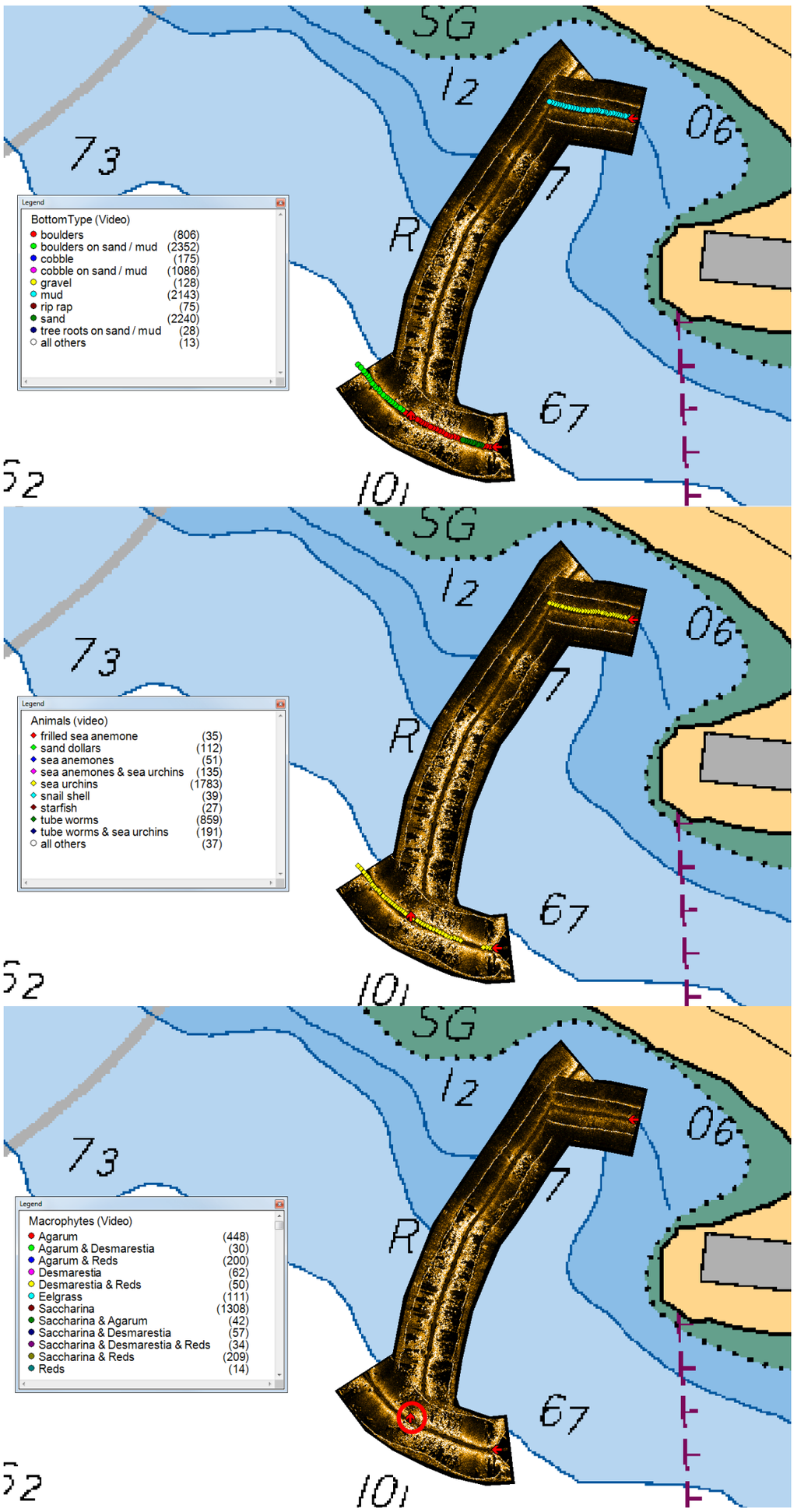


Figure 17: Transect BB10 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.708200N 63.638725W.

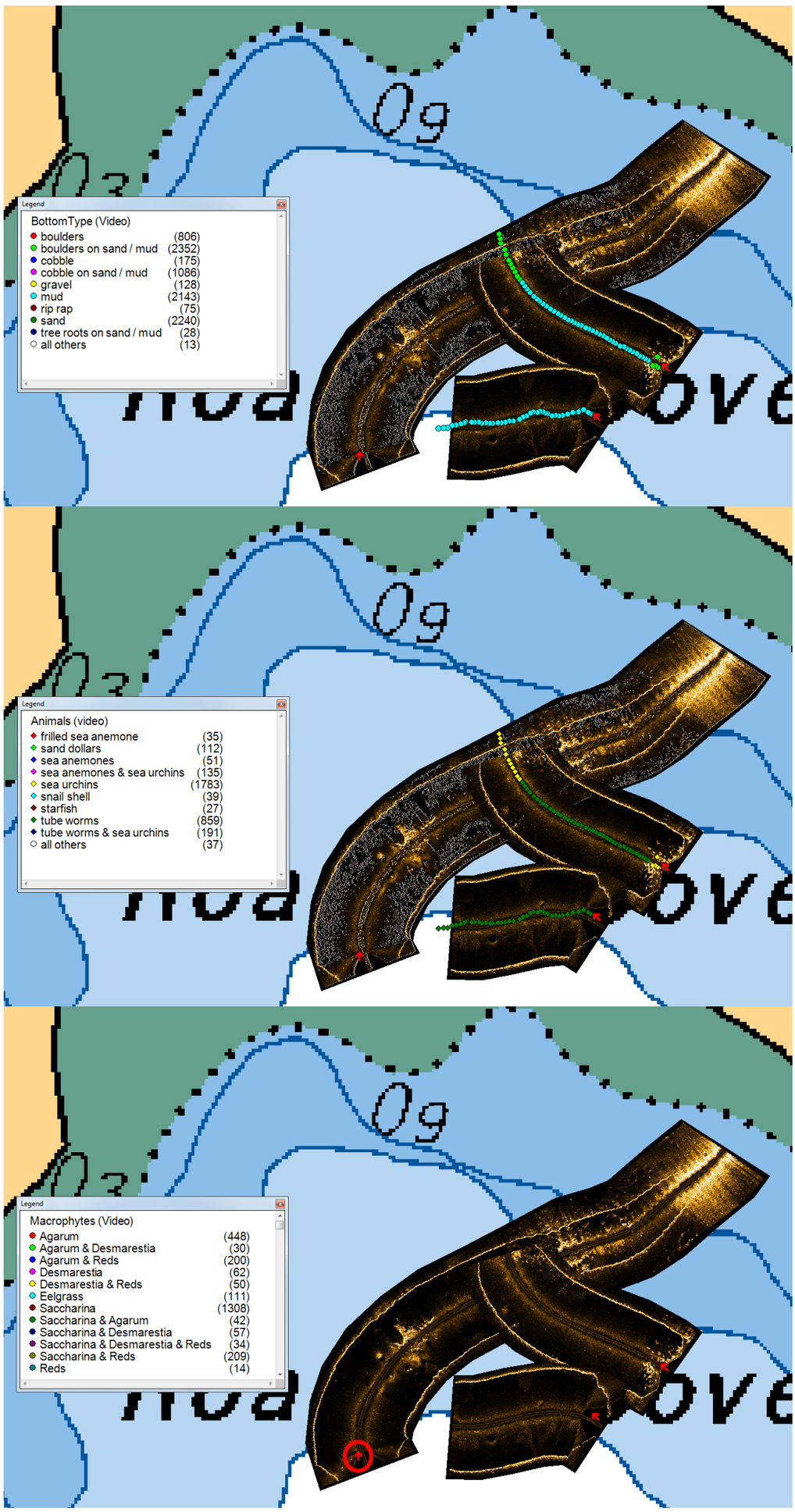


Figure 18: Transect BB11 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.713005N 63.644535W.

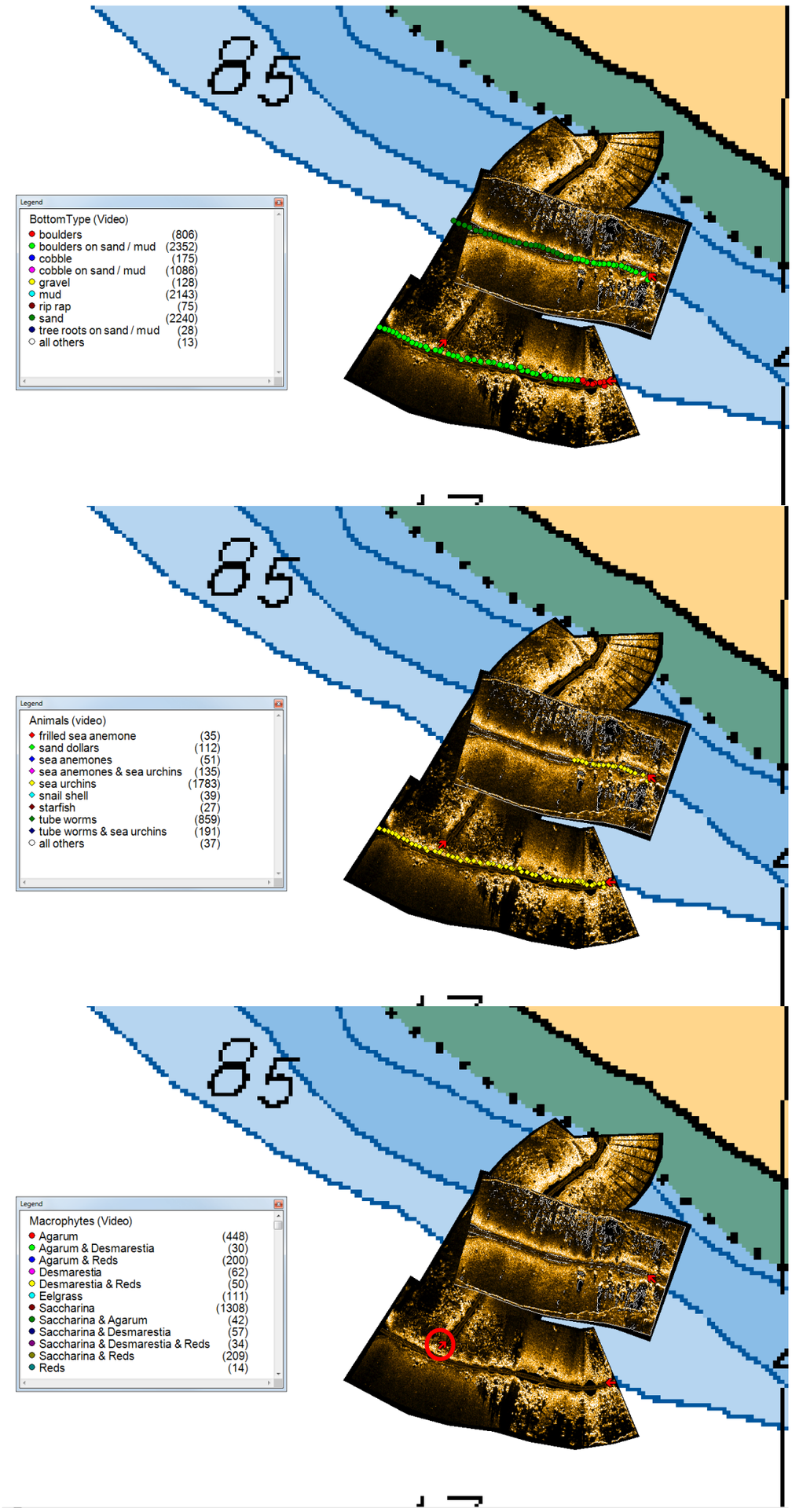


Figure 19: Transect BB12 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.711998N 63.651080W.

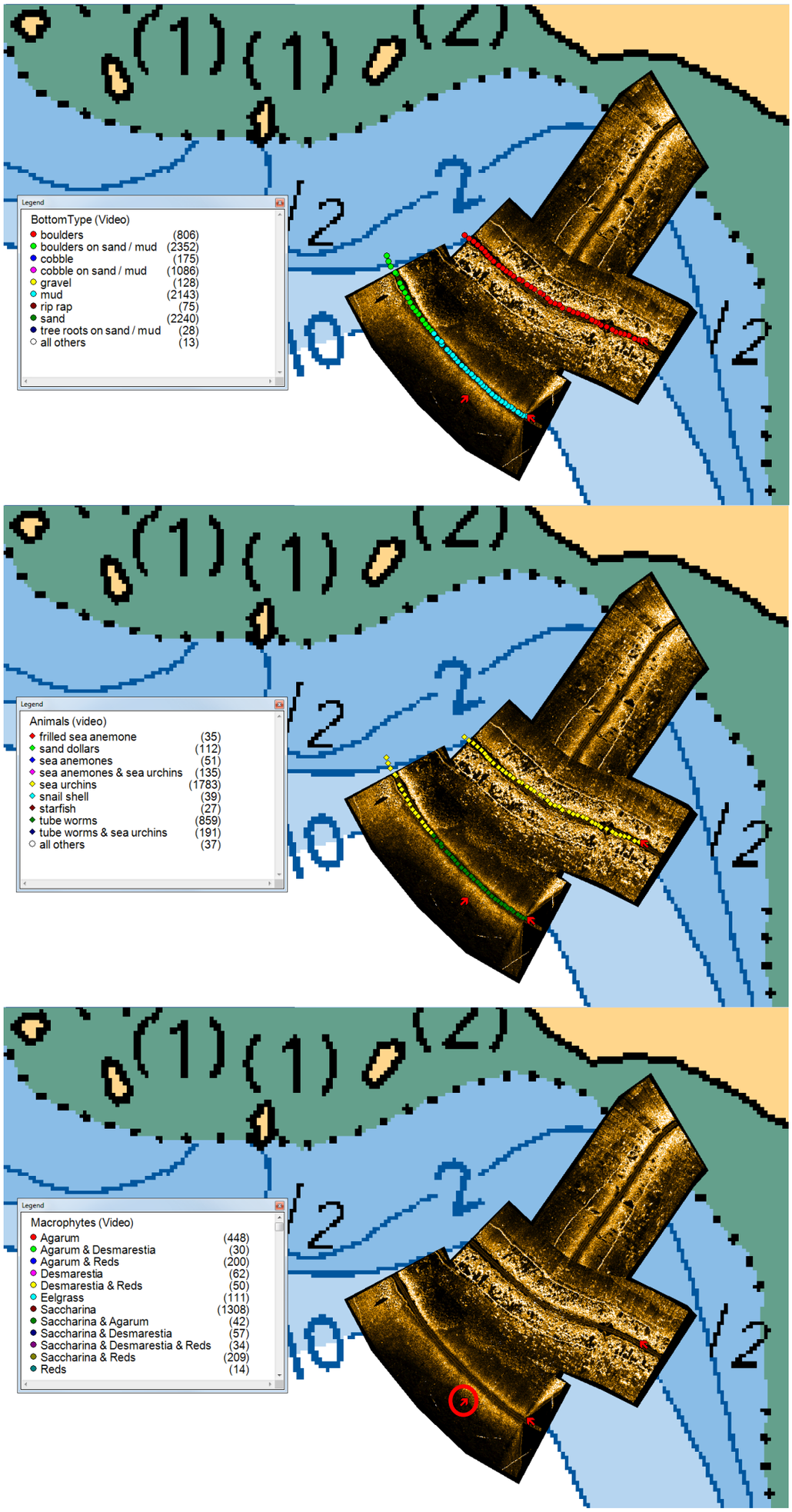


Figure 20: Transect BB13 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.714252N 63.656352W.

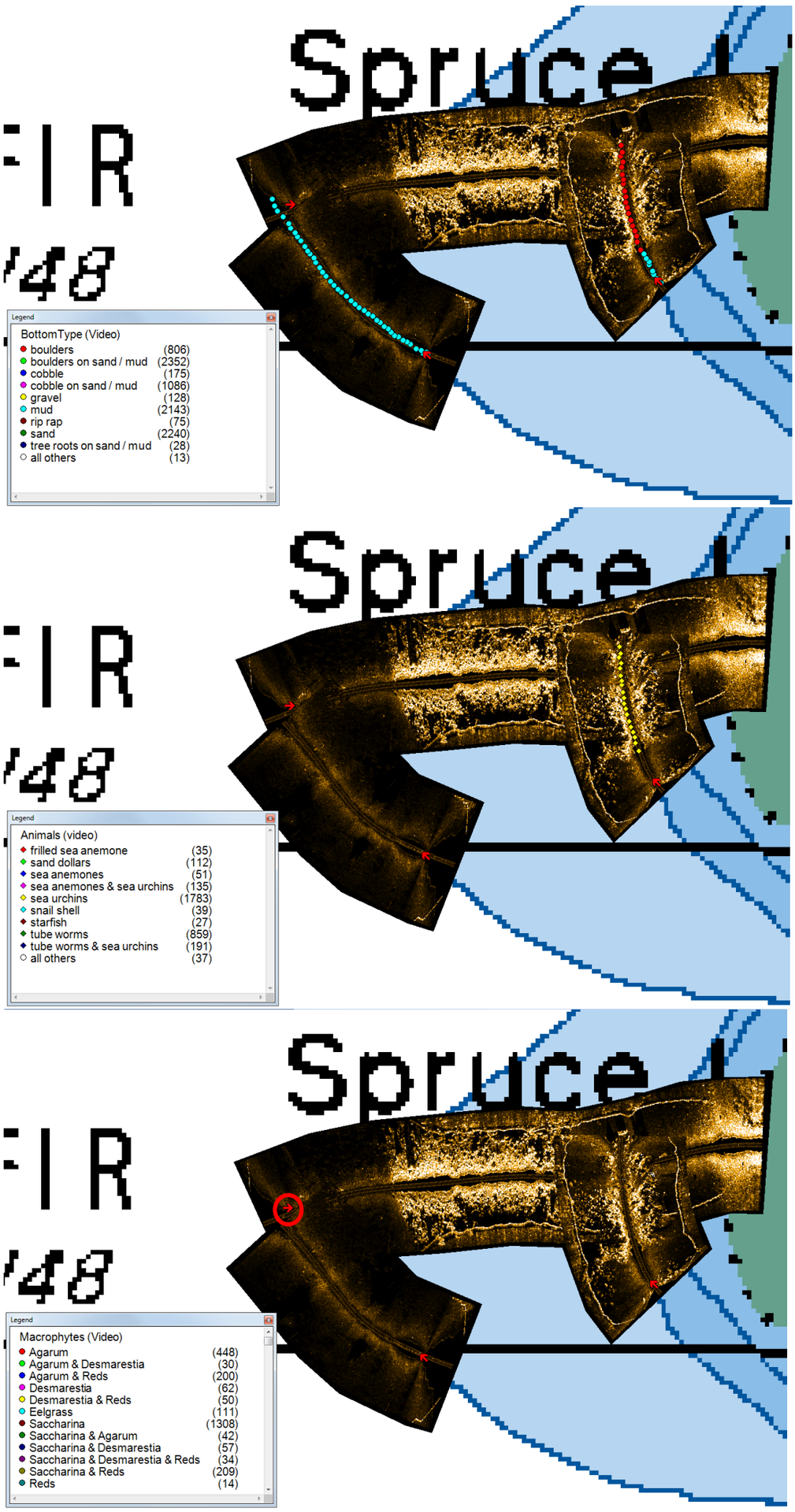


Figure 21: Transect BB14 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.716950N 63.663997W.

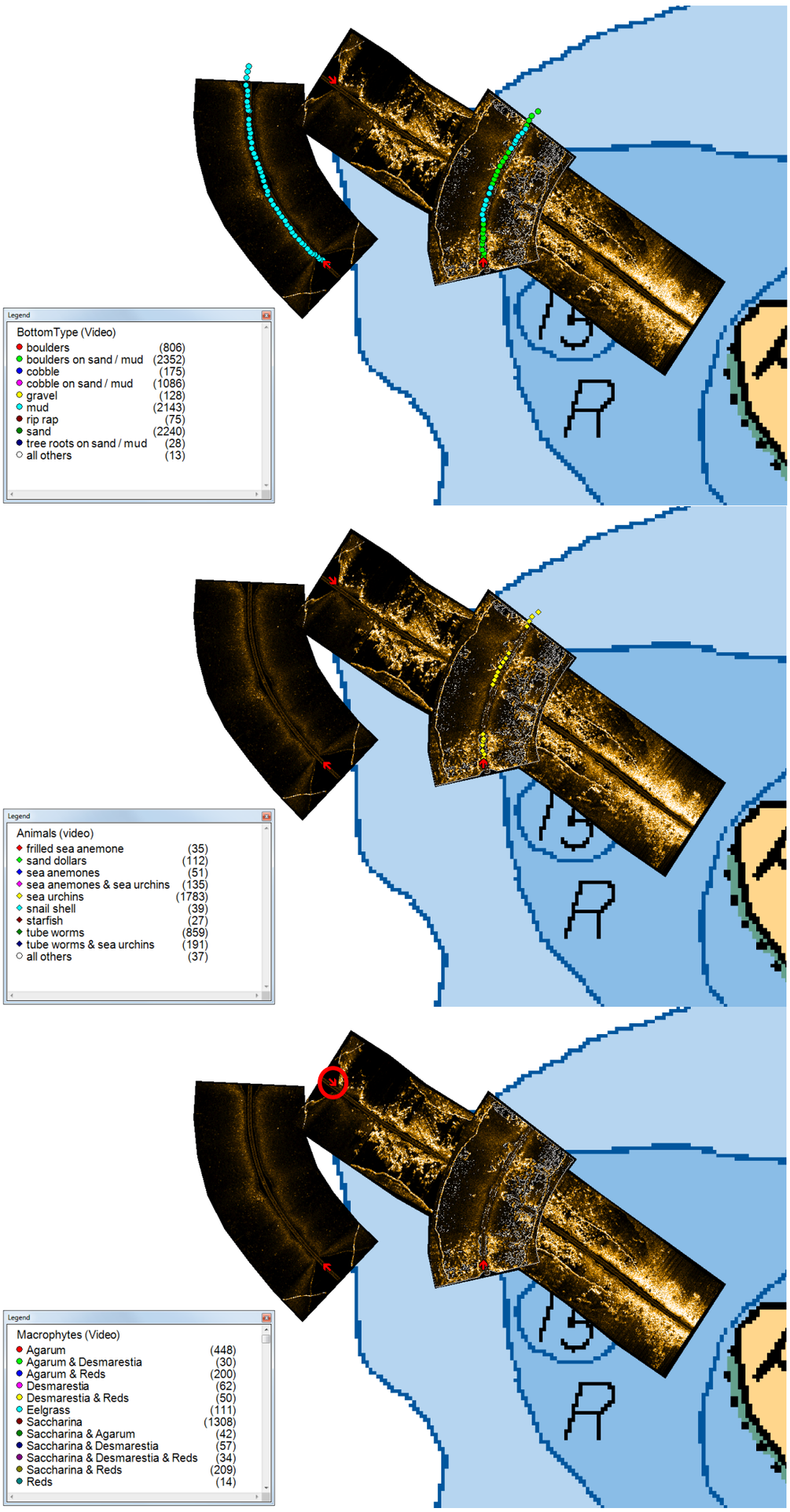


Figure 22: Transect BB15 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.721625N 63.660945W.

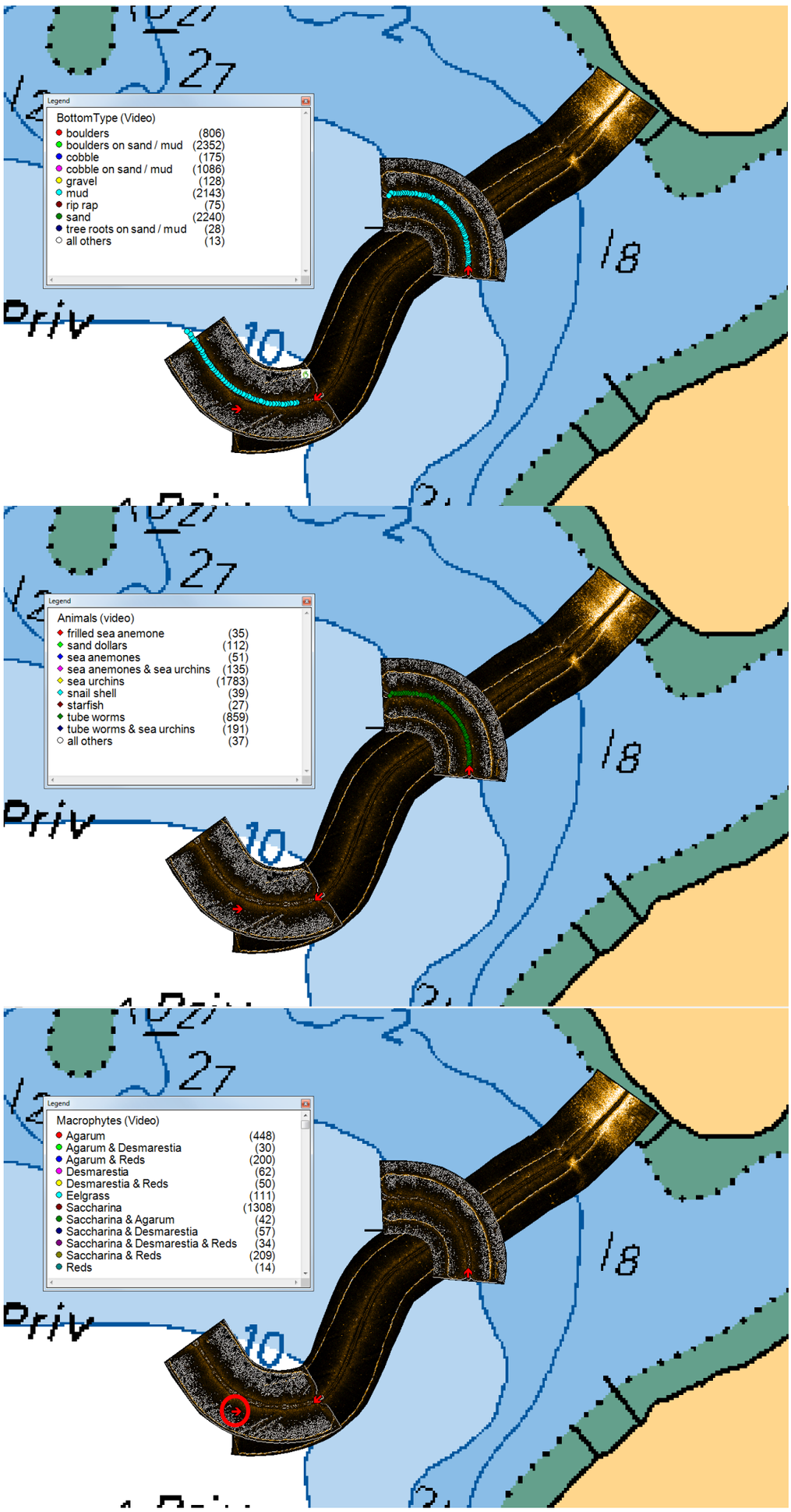


Figure 23: Transect BB16 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.723375N 63.659592W.

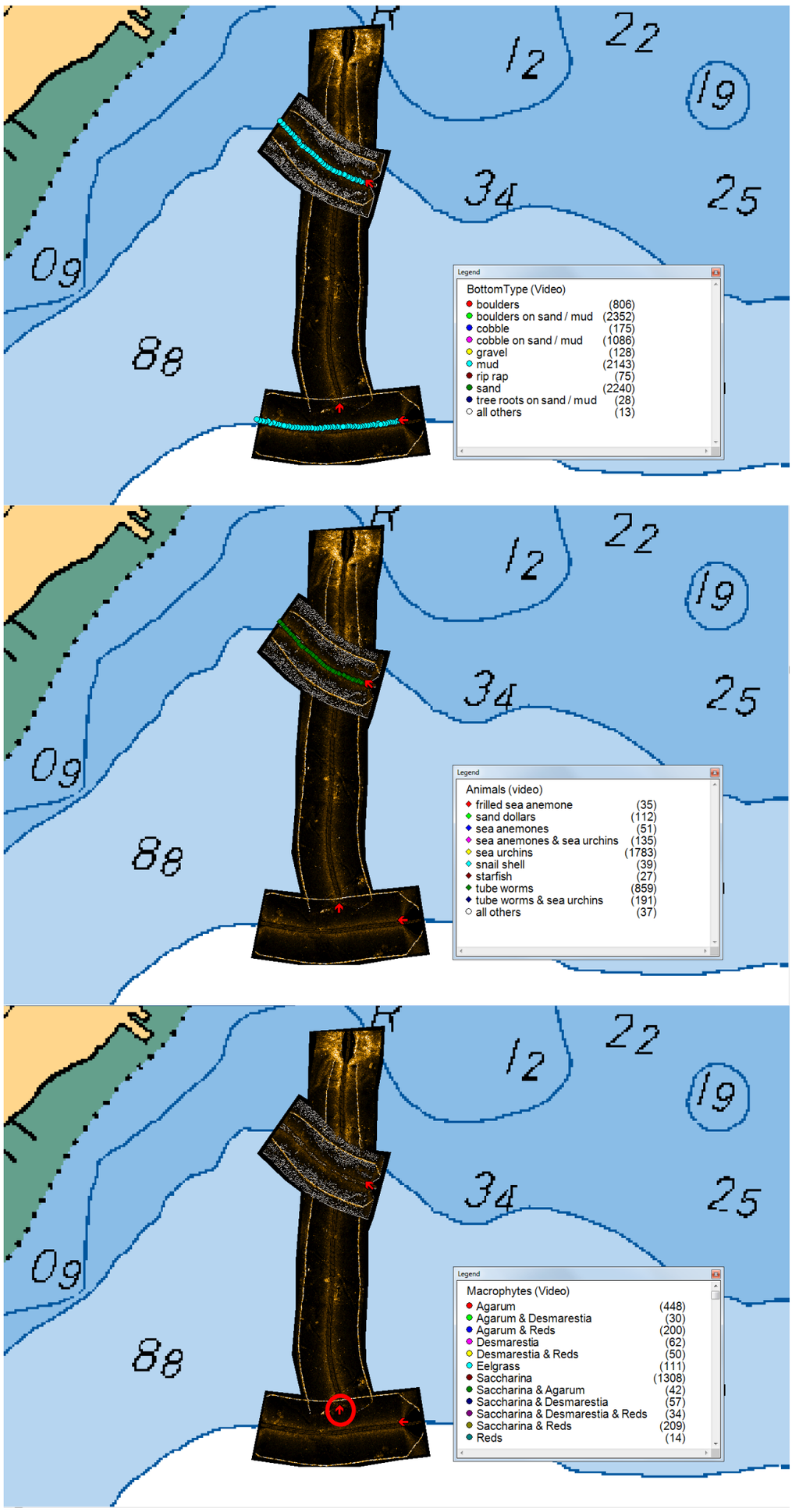


Figure 24: Transect BB17 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.723867N 63.664432W.

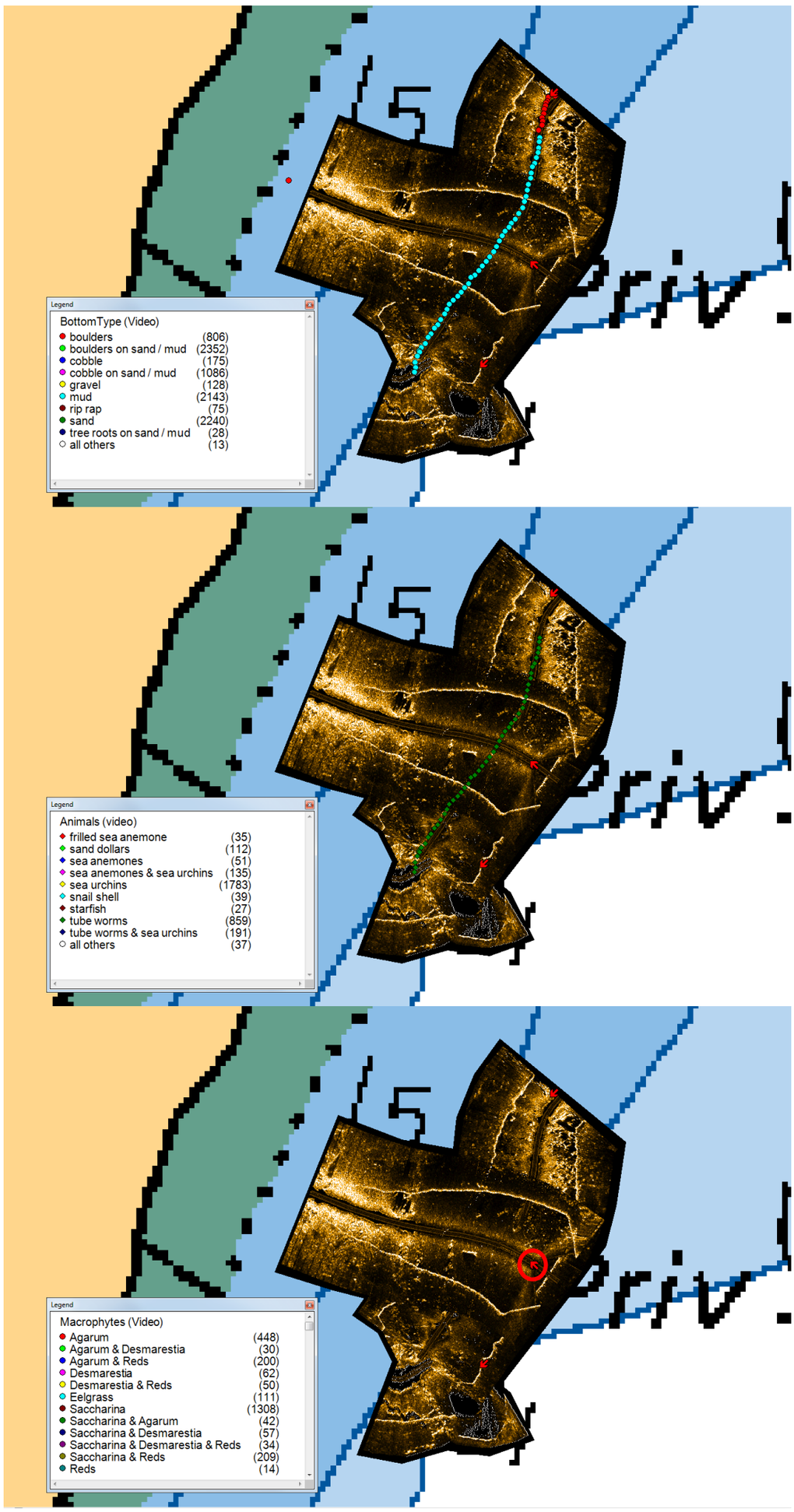


Figure 25: Transect BB18 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.722062N 63.668225W.

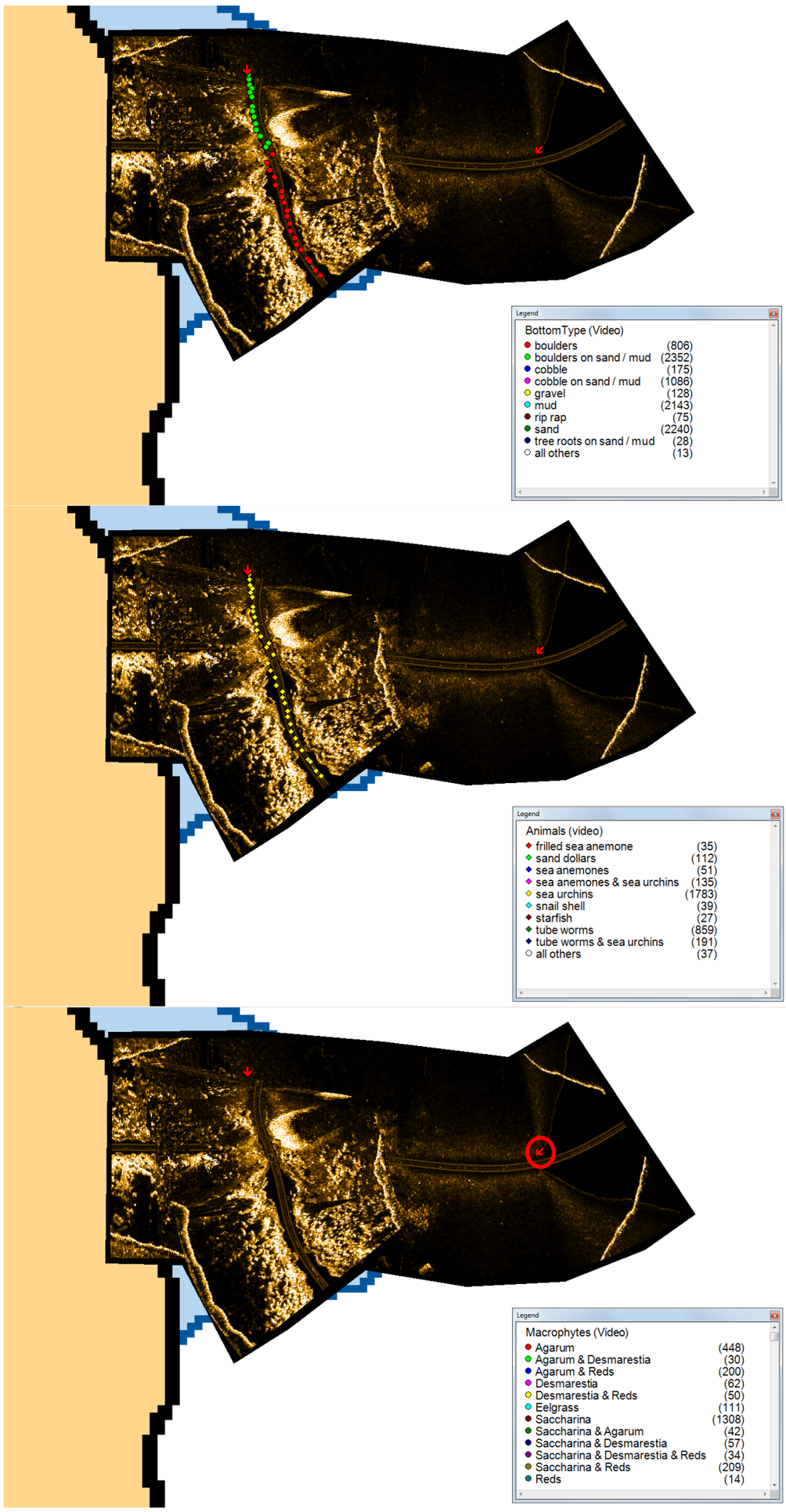


Figure 26: Transect BB19 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.717317N 63.669543W.

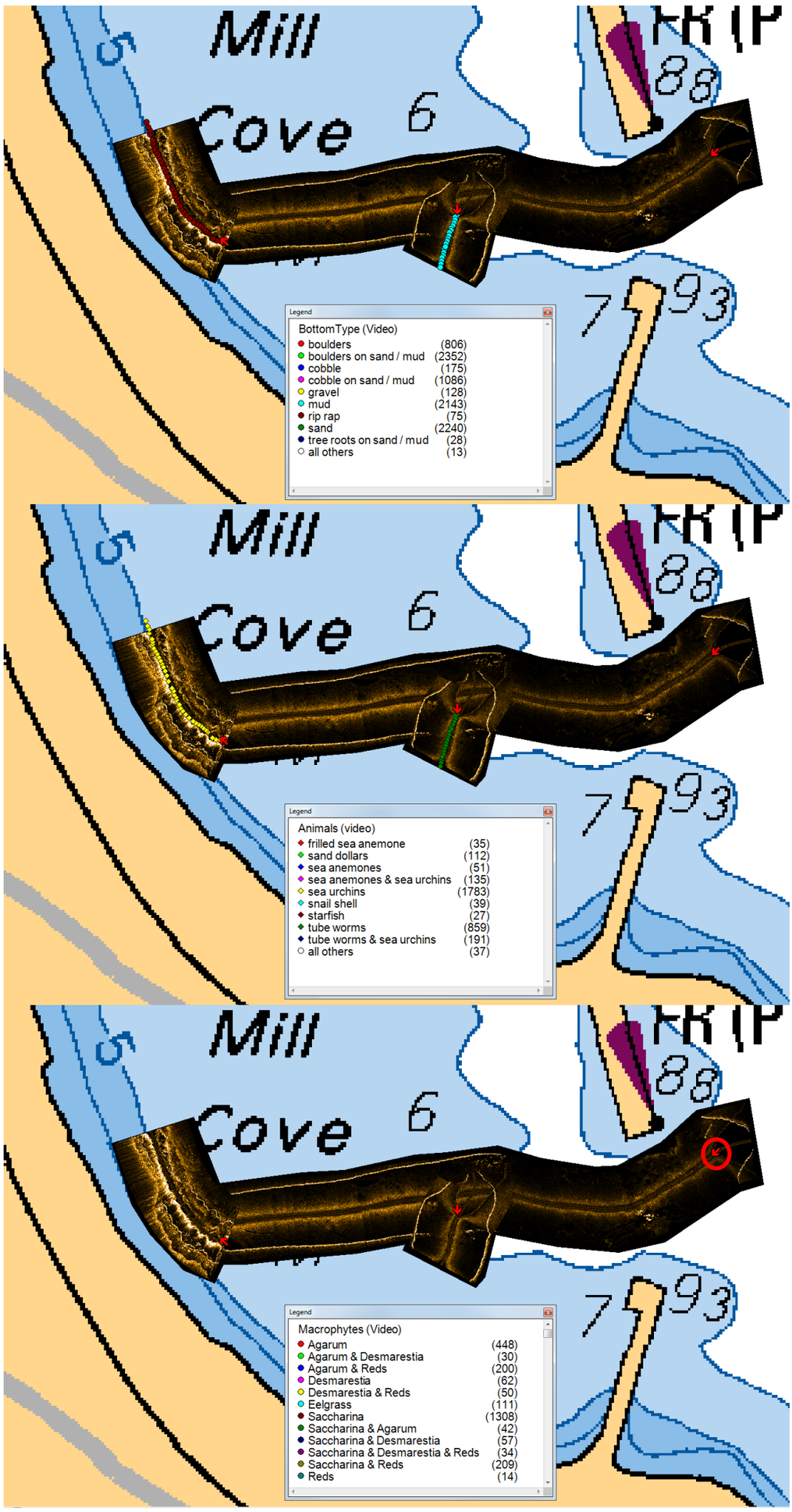


Figure 27: Transect BB20 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.713213N 63.670383W.

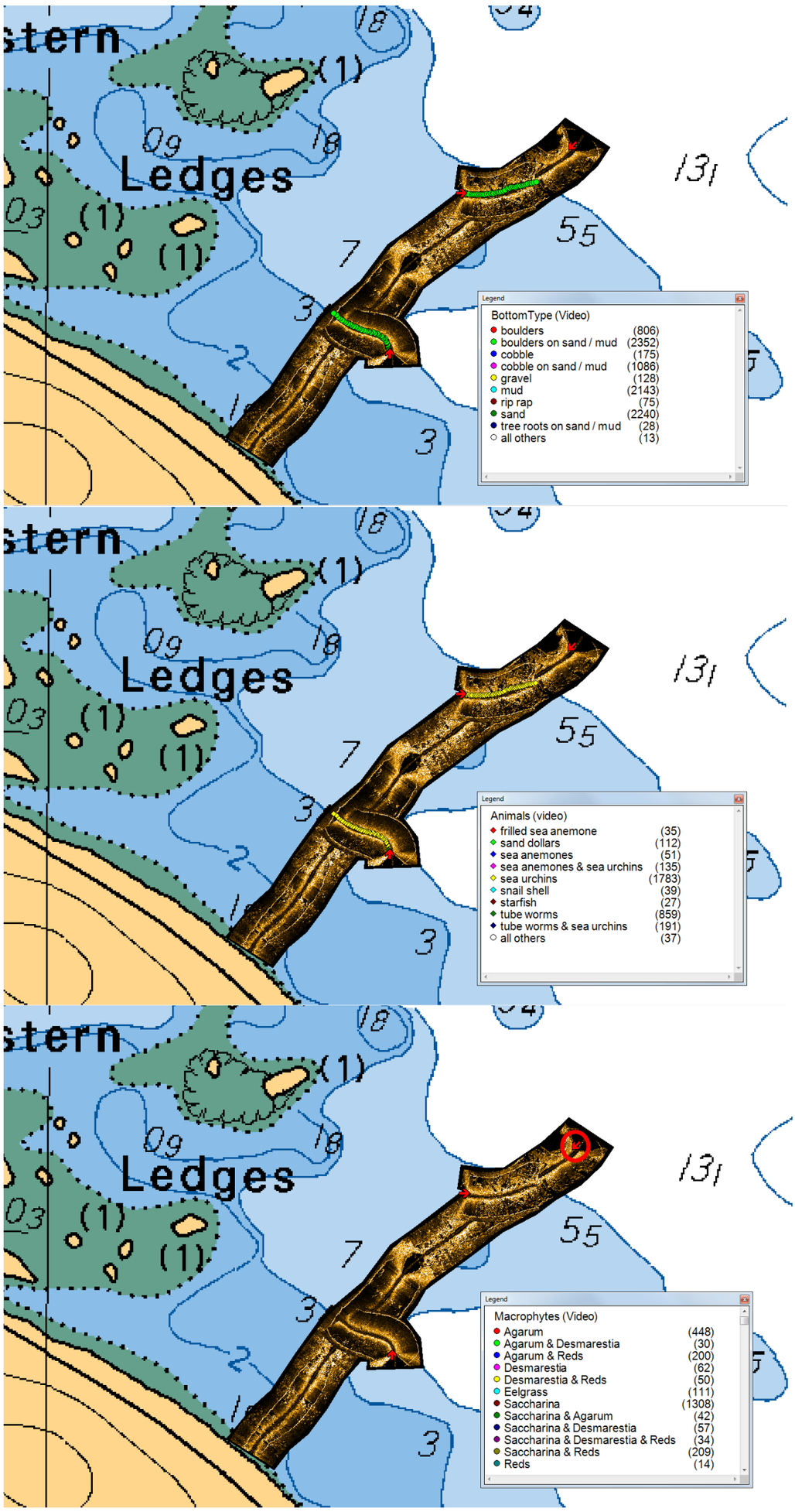


Figure 28: Transect BB21 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.710762N 63.662712W.

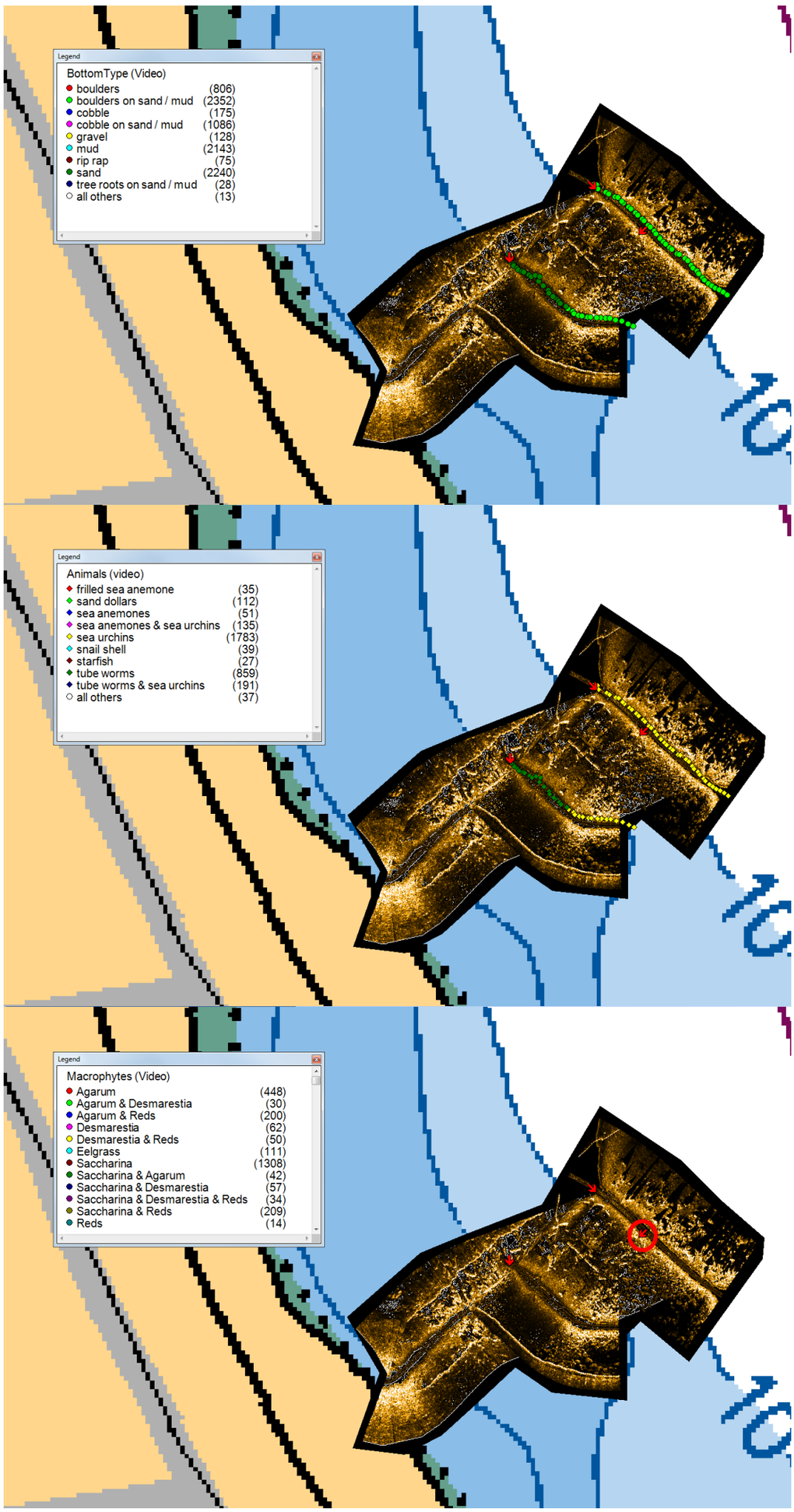


Figure 29: Transect BB22 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.705330N 63.661732W.

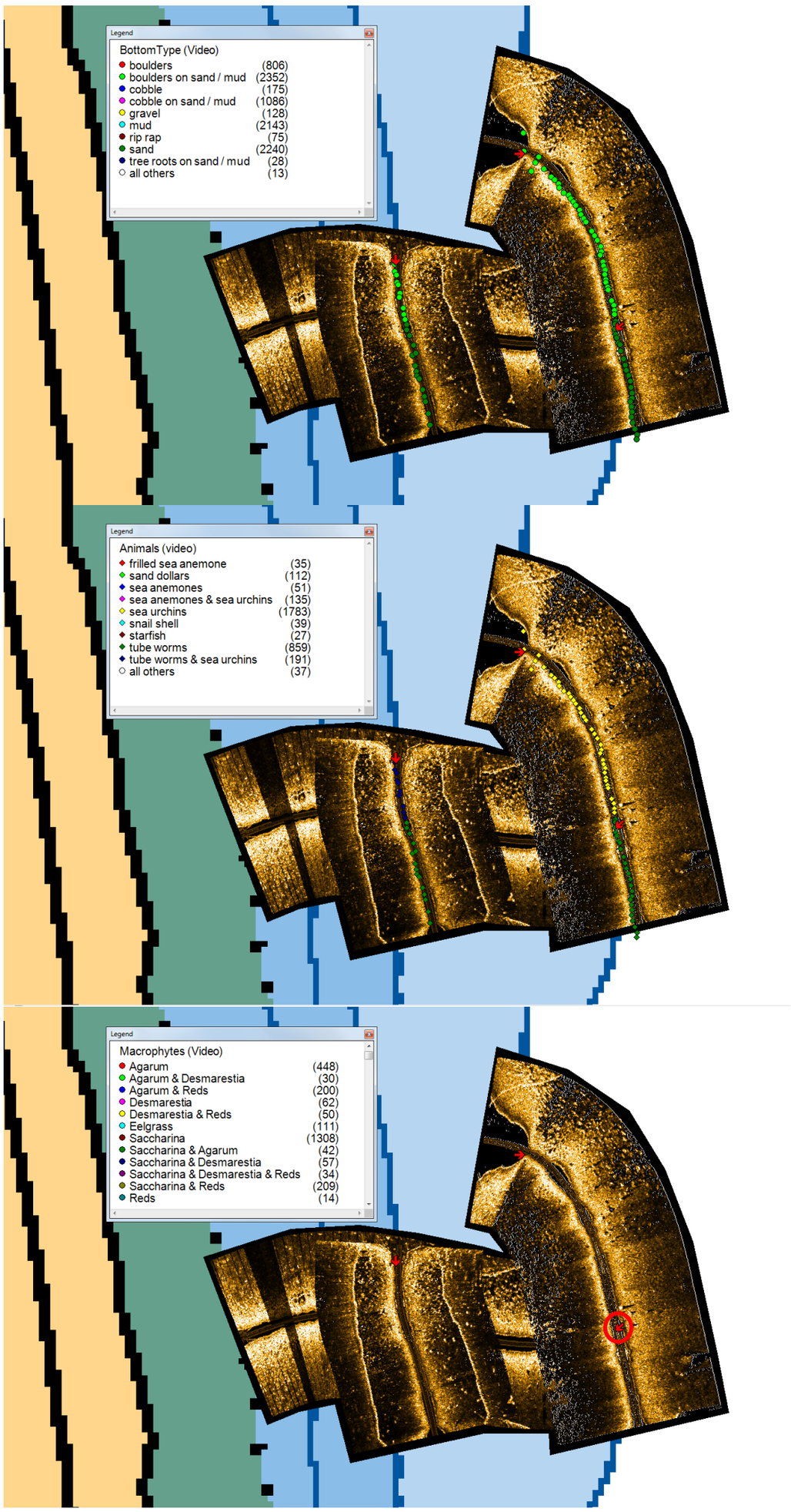


Figure 30: Transect BB23 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.700308N 63.659078W.

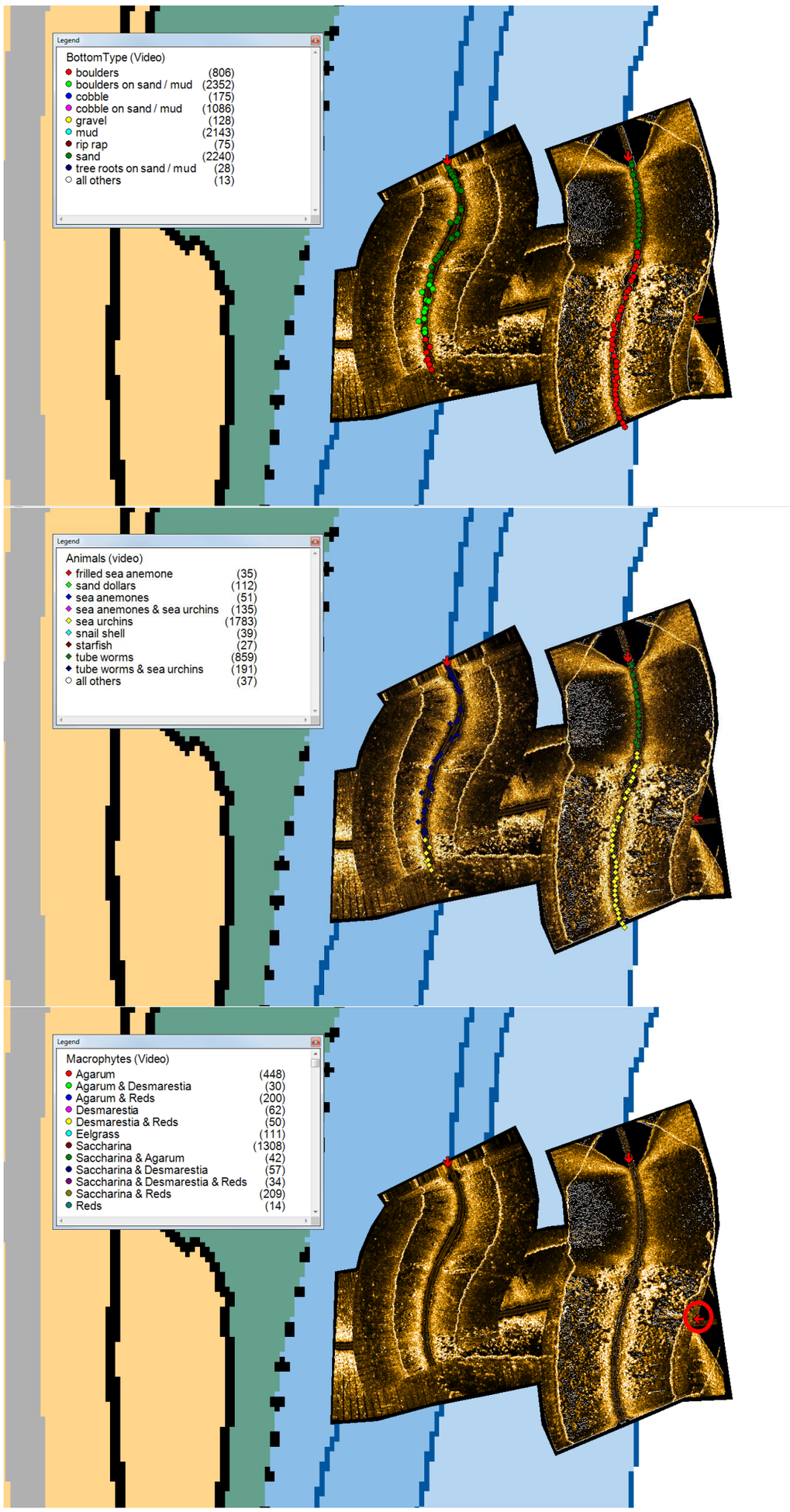


Figure 31: Transect BB24 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.694655N 63.659112W.

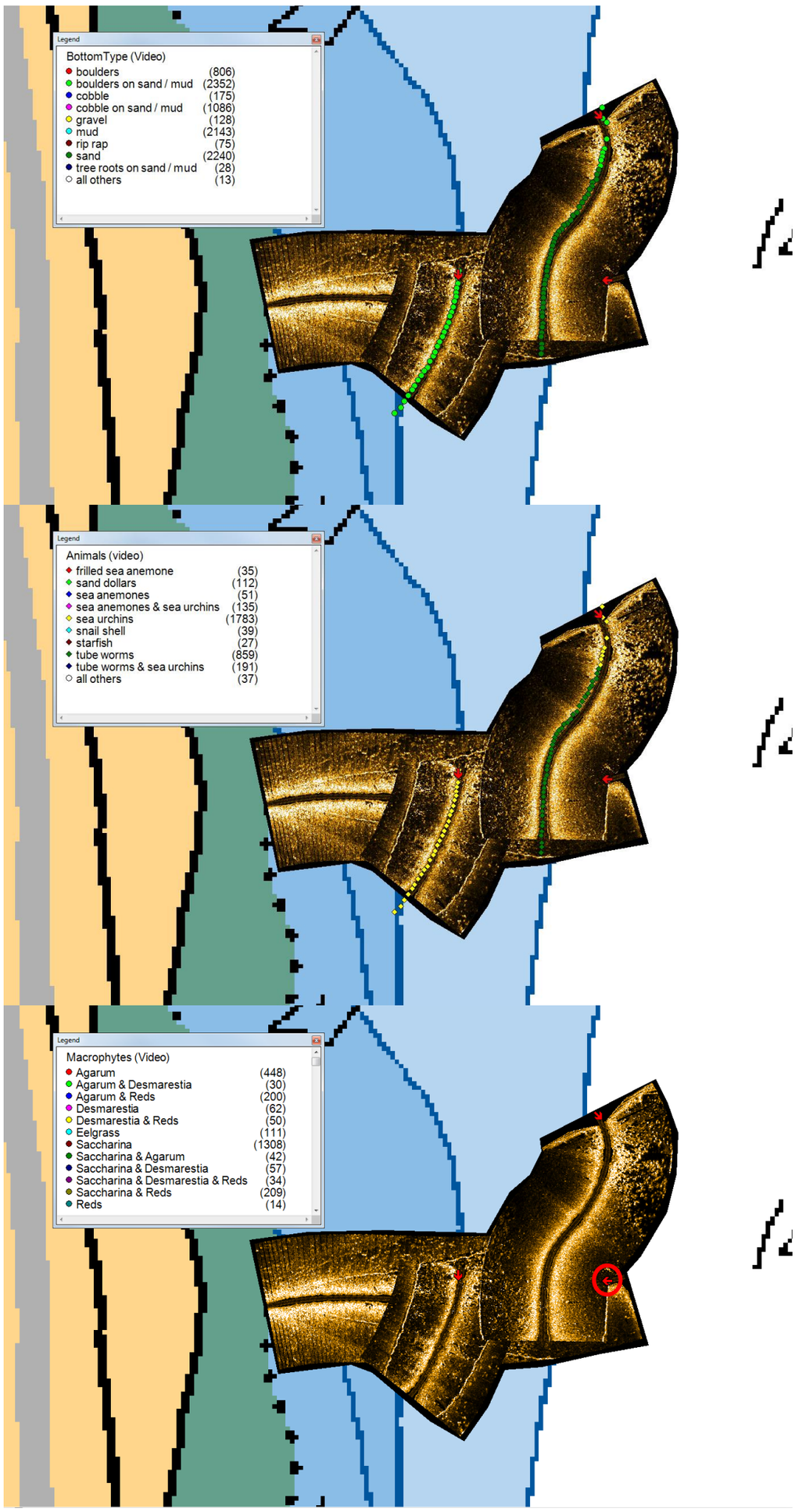


Figure 32: Transect BB25 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.687875N 63.657350W.

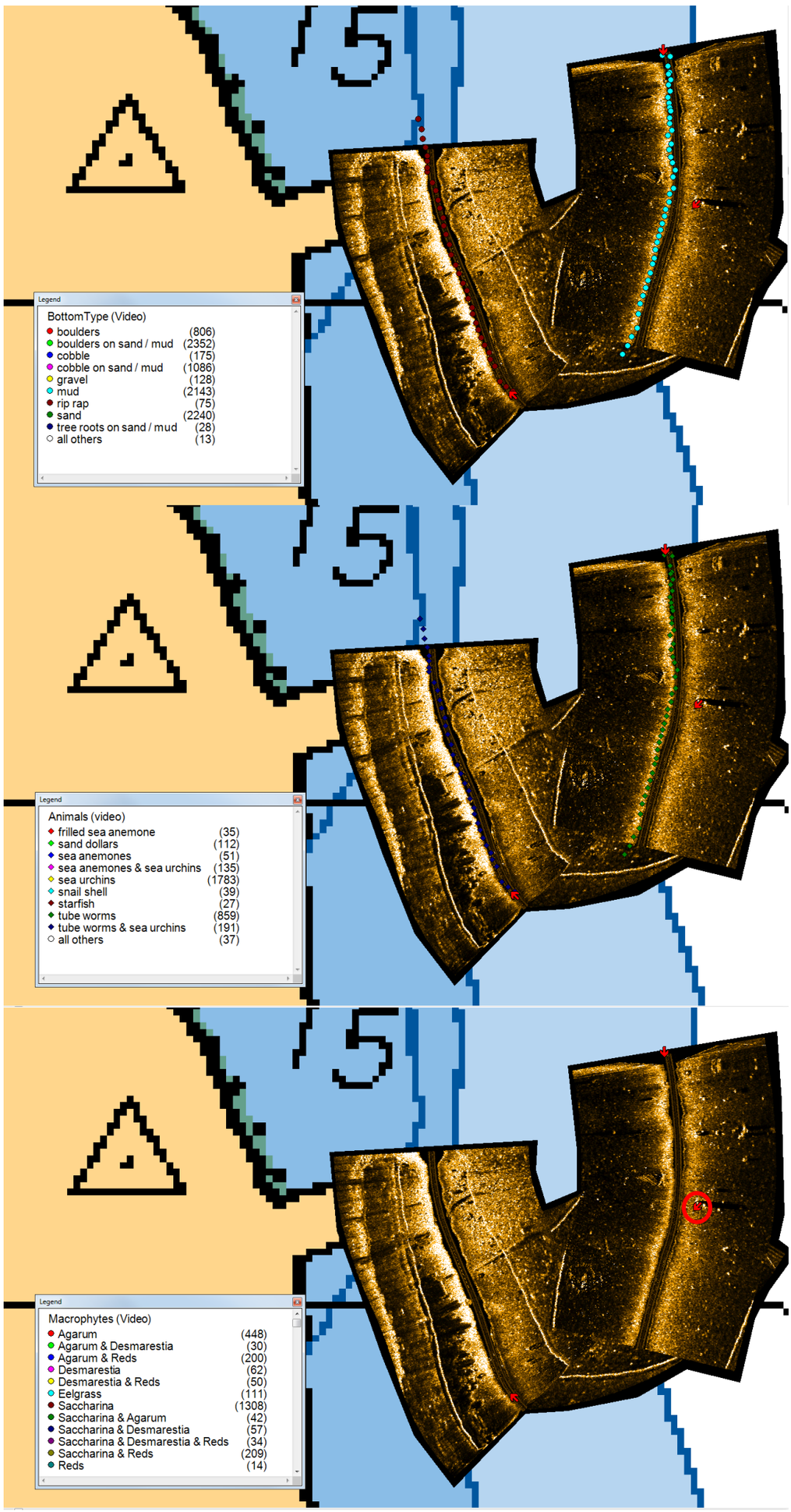


Figure 33: Transect BB26 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.683478N 63.658242W.

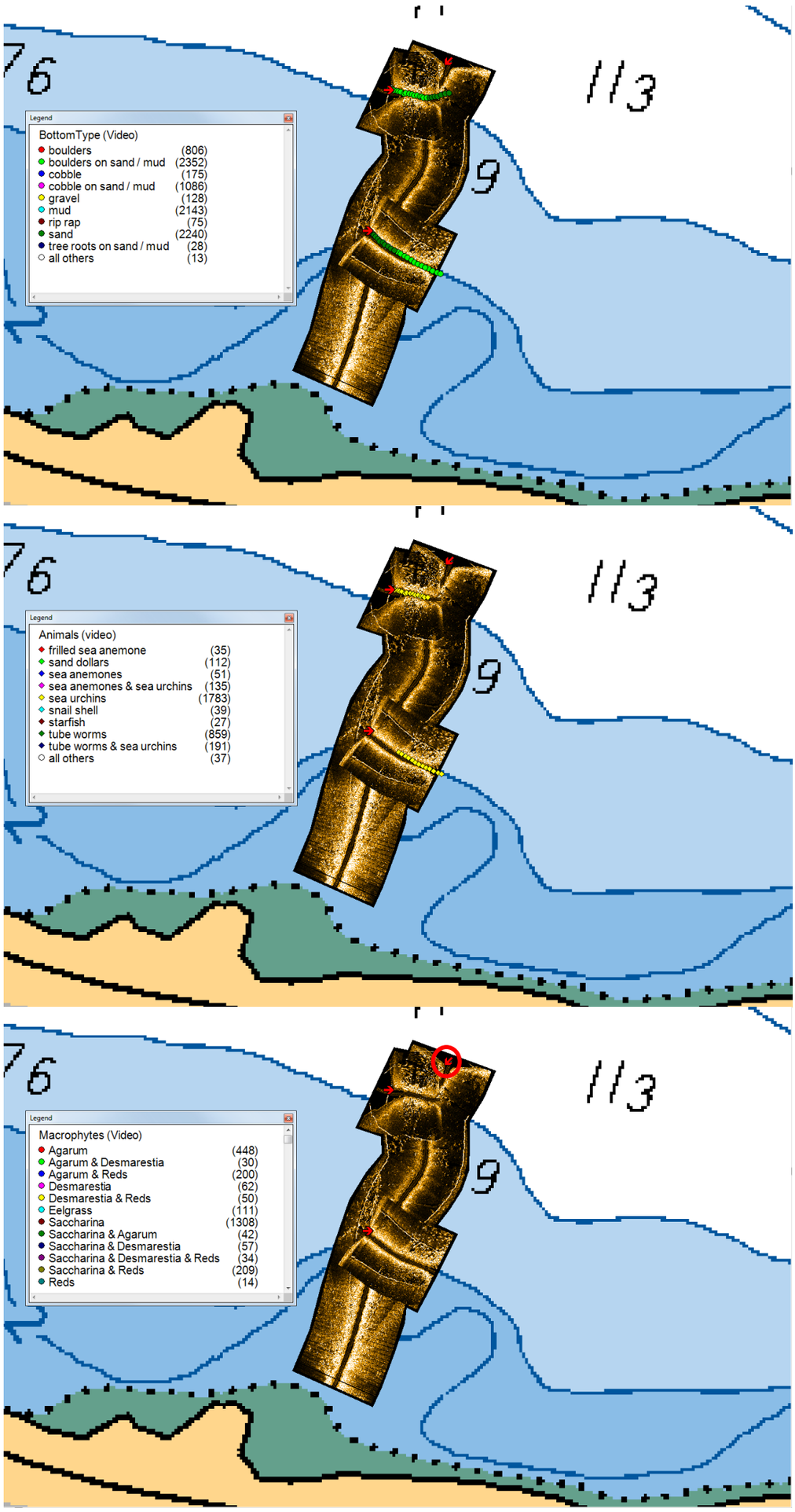


Figure 34: Transect BB27 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.681657N 63.653313W.

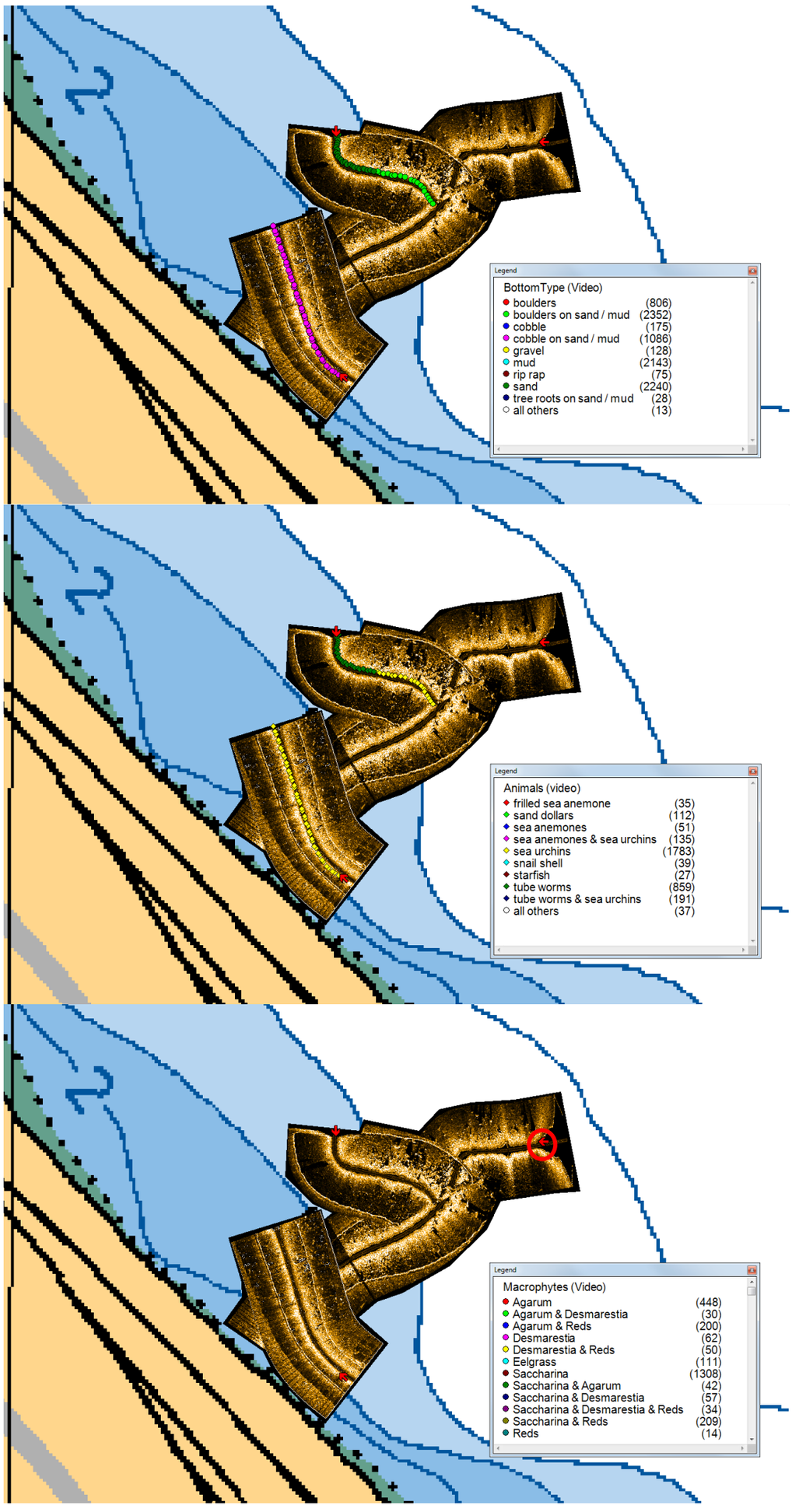


Figure 35: Transect BB28 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.679145N 63.647877W.

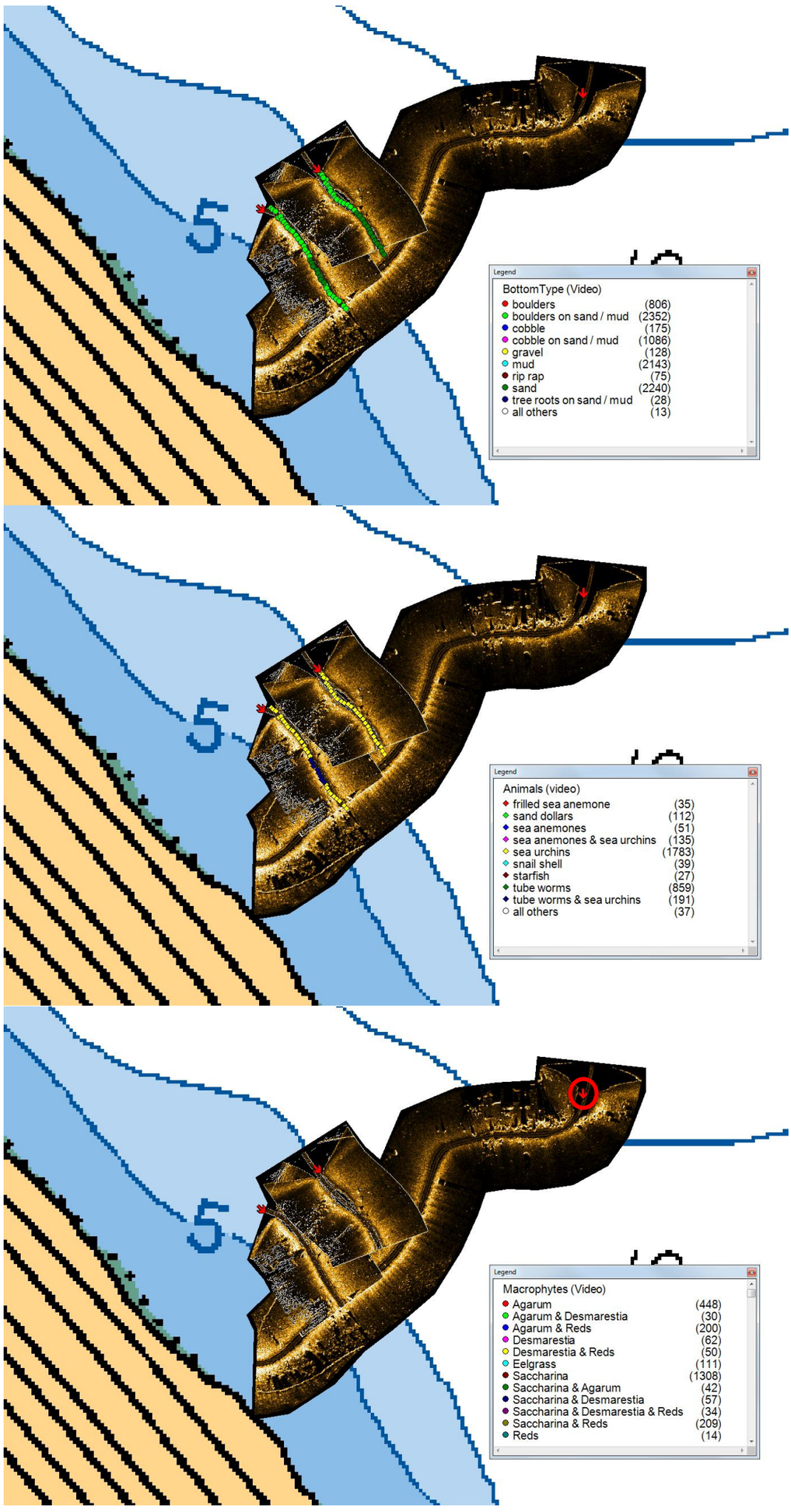


Figure 36: Transect BB29 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.675923N 63.643682W.

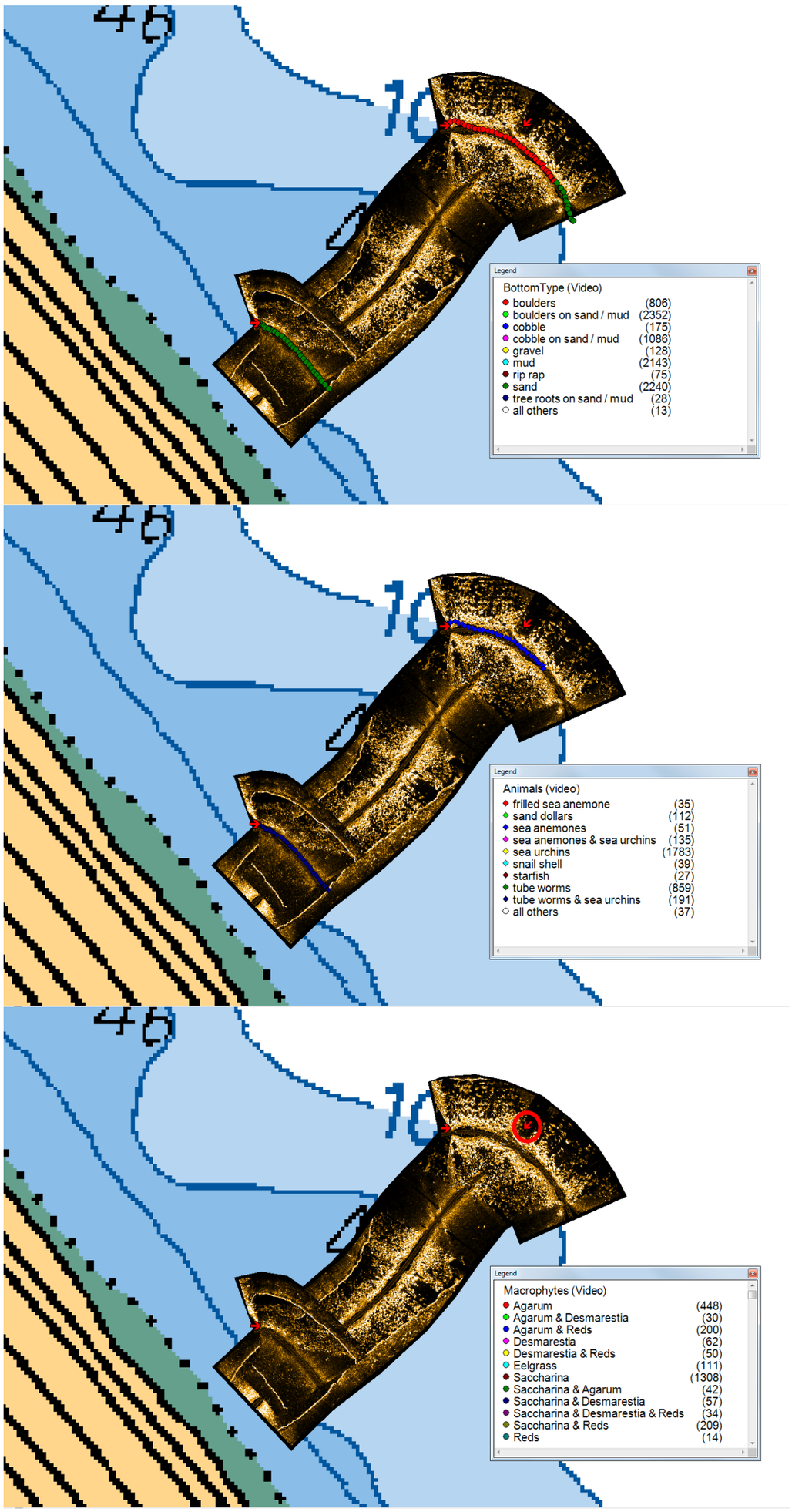


Figure 37: Transect BB30 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.671542N 63.639717W.

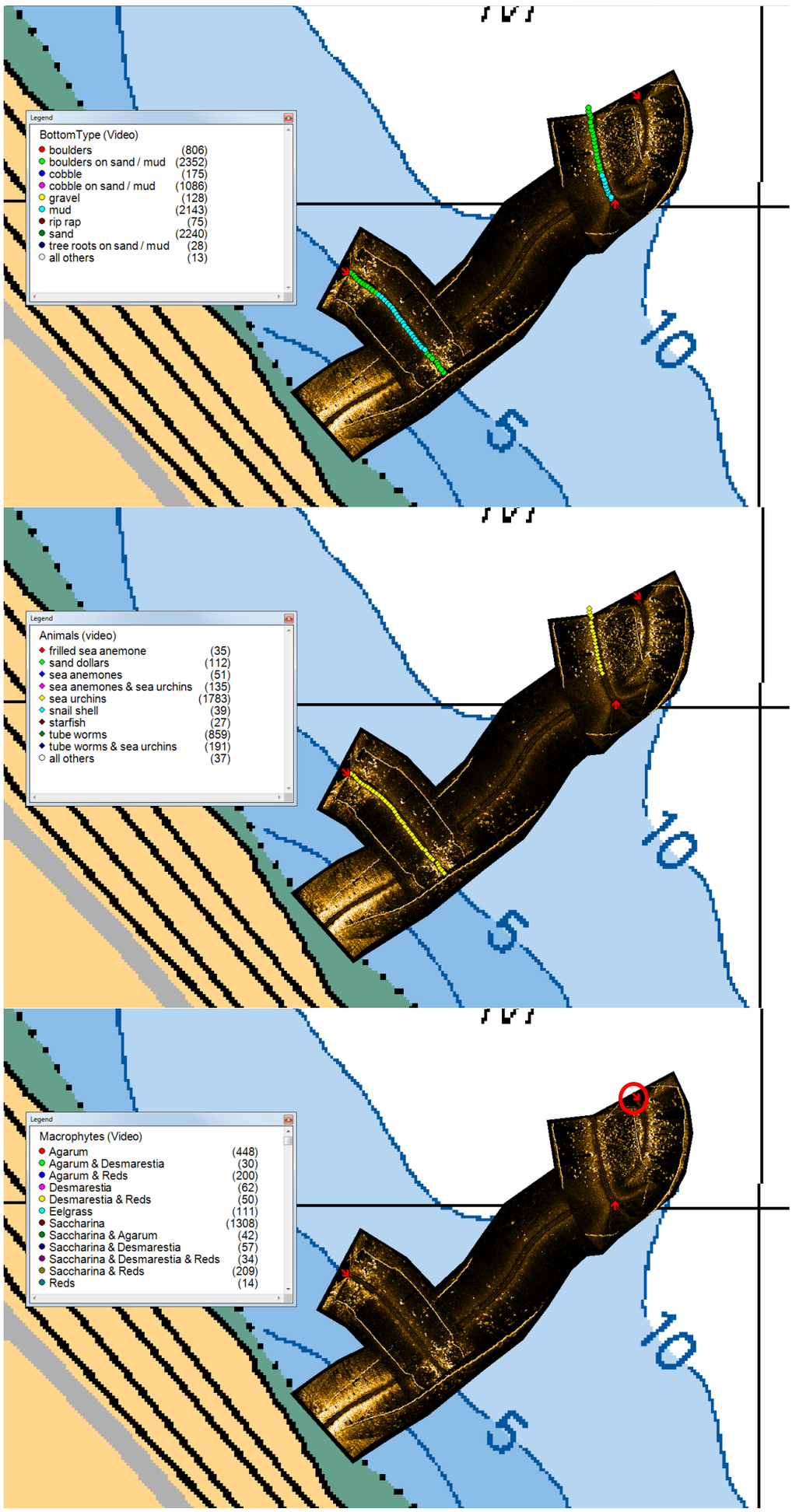
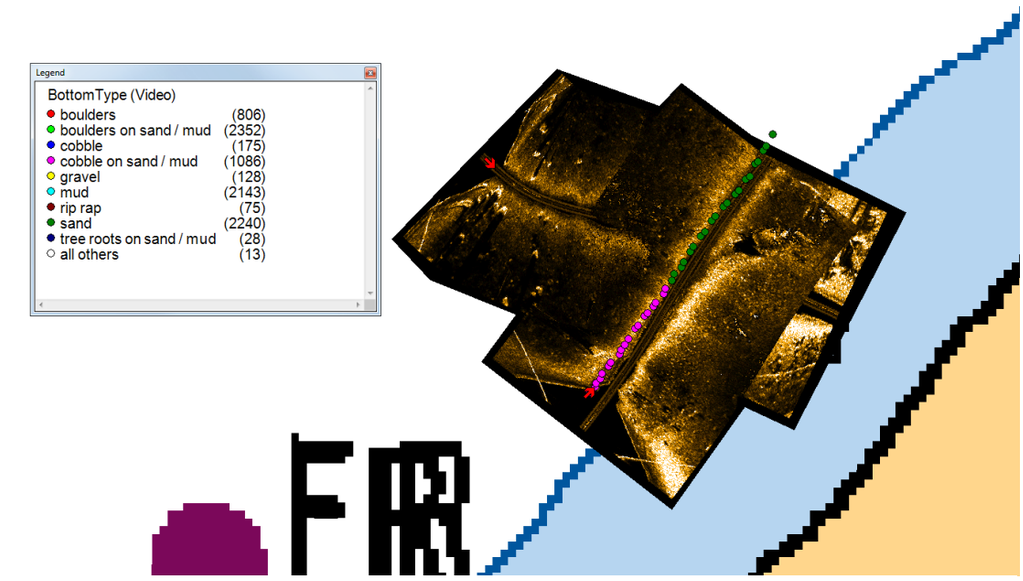
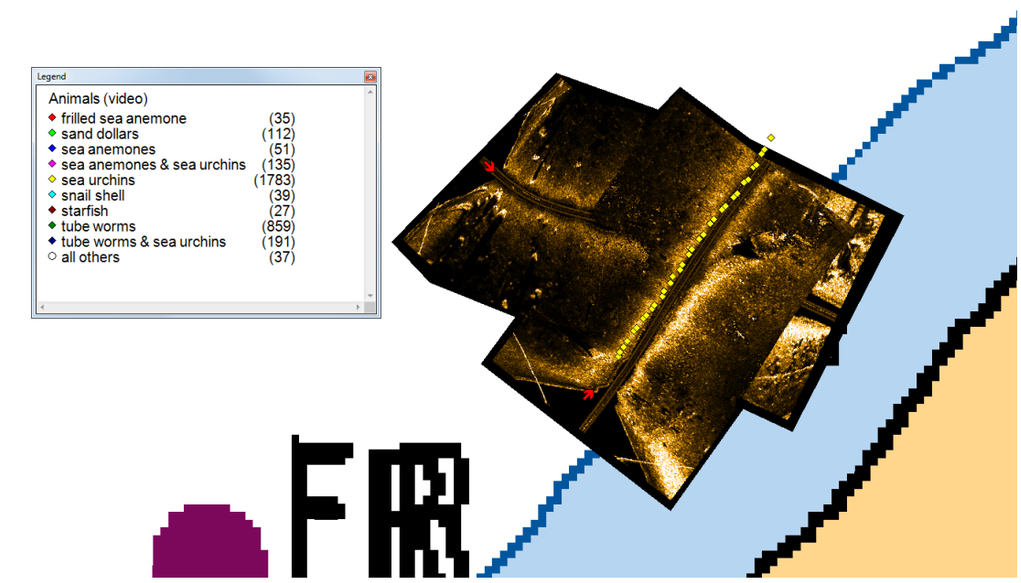


Figure 38: Transect BB31 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.667013N 63.633860W.





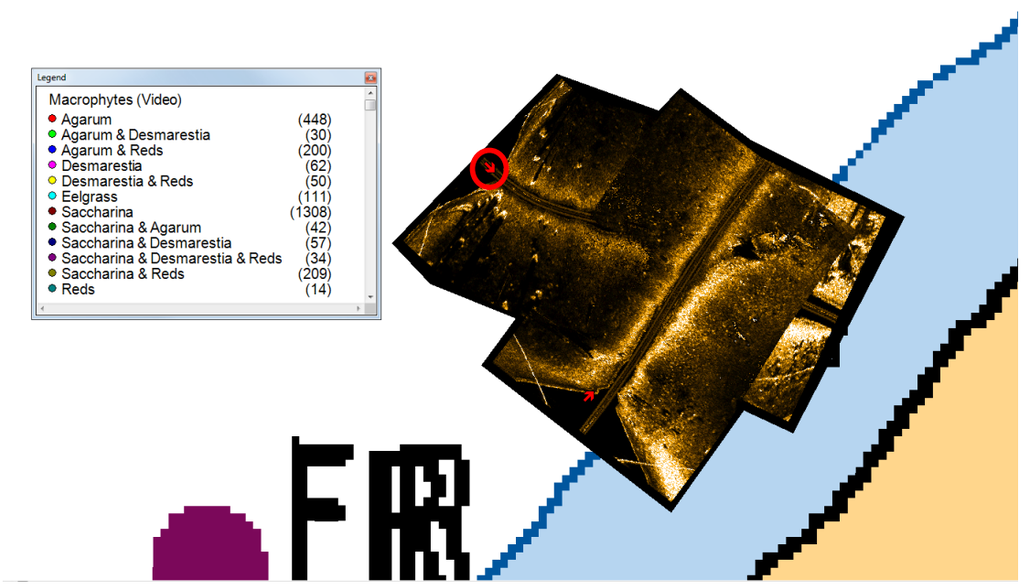


Figure 39: Transect BB32 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.671942N 63.624787W.

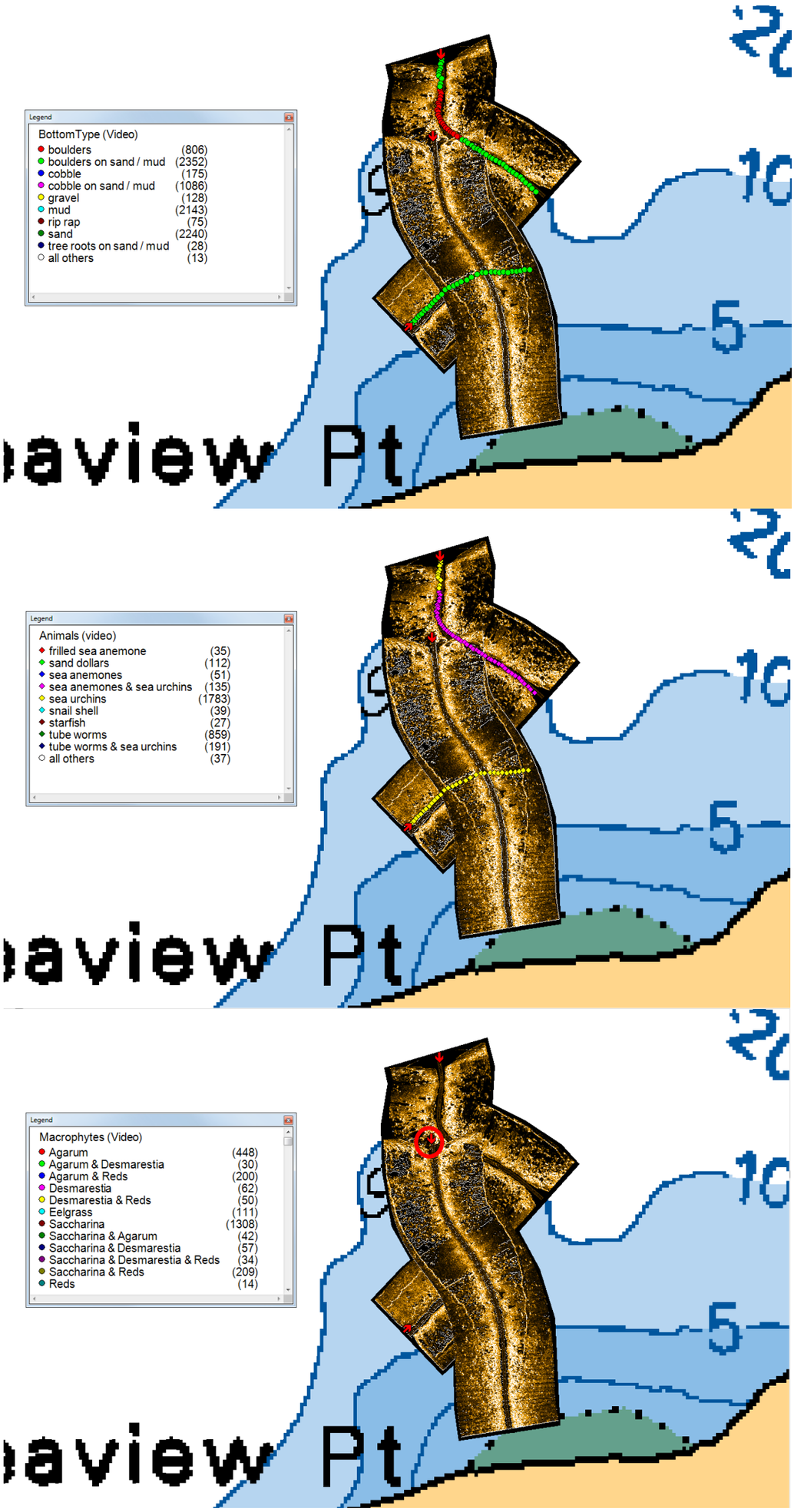


Figure 40: Transect BB33 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.676273N 63.618670W.

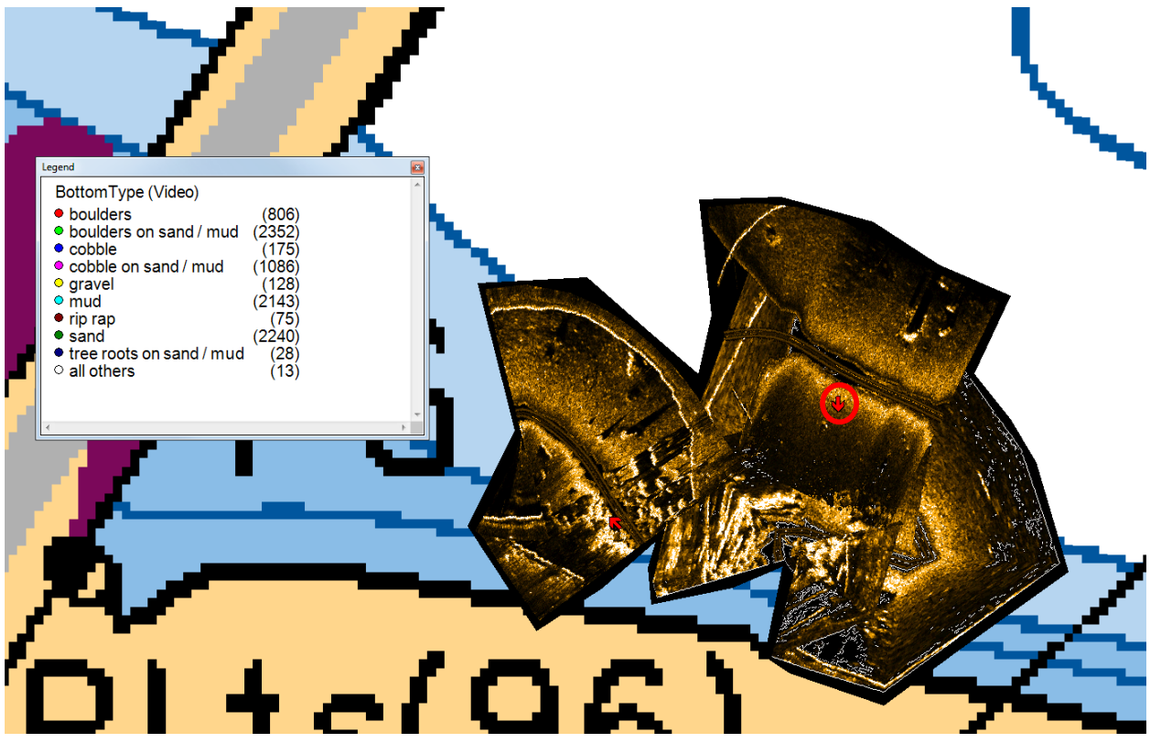


Figure 41: Transect IH01 - No video analysis or bottom classification due to poor quality of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.675845N 63.612535W.

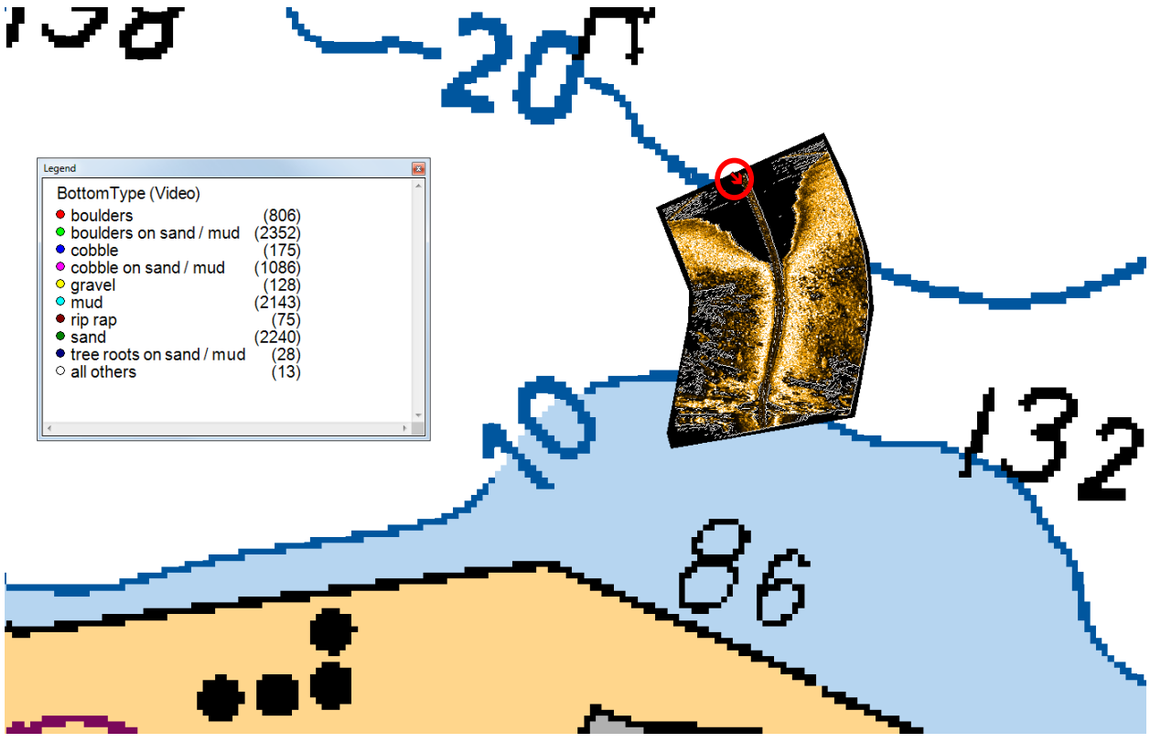


Figure 42: Transect IH02 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.675378N 63.605862W.

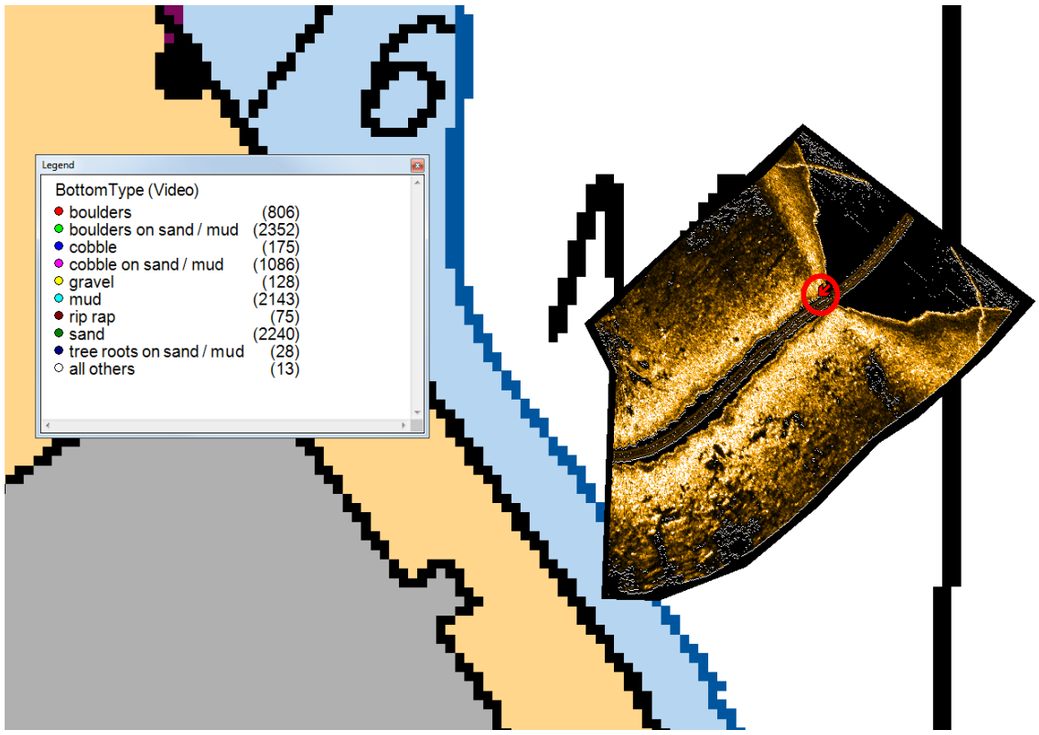


Figure 43: Transect IH03 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.672928N 63.600148W.

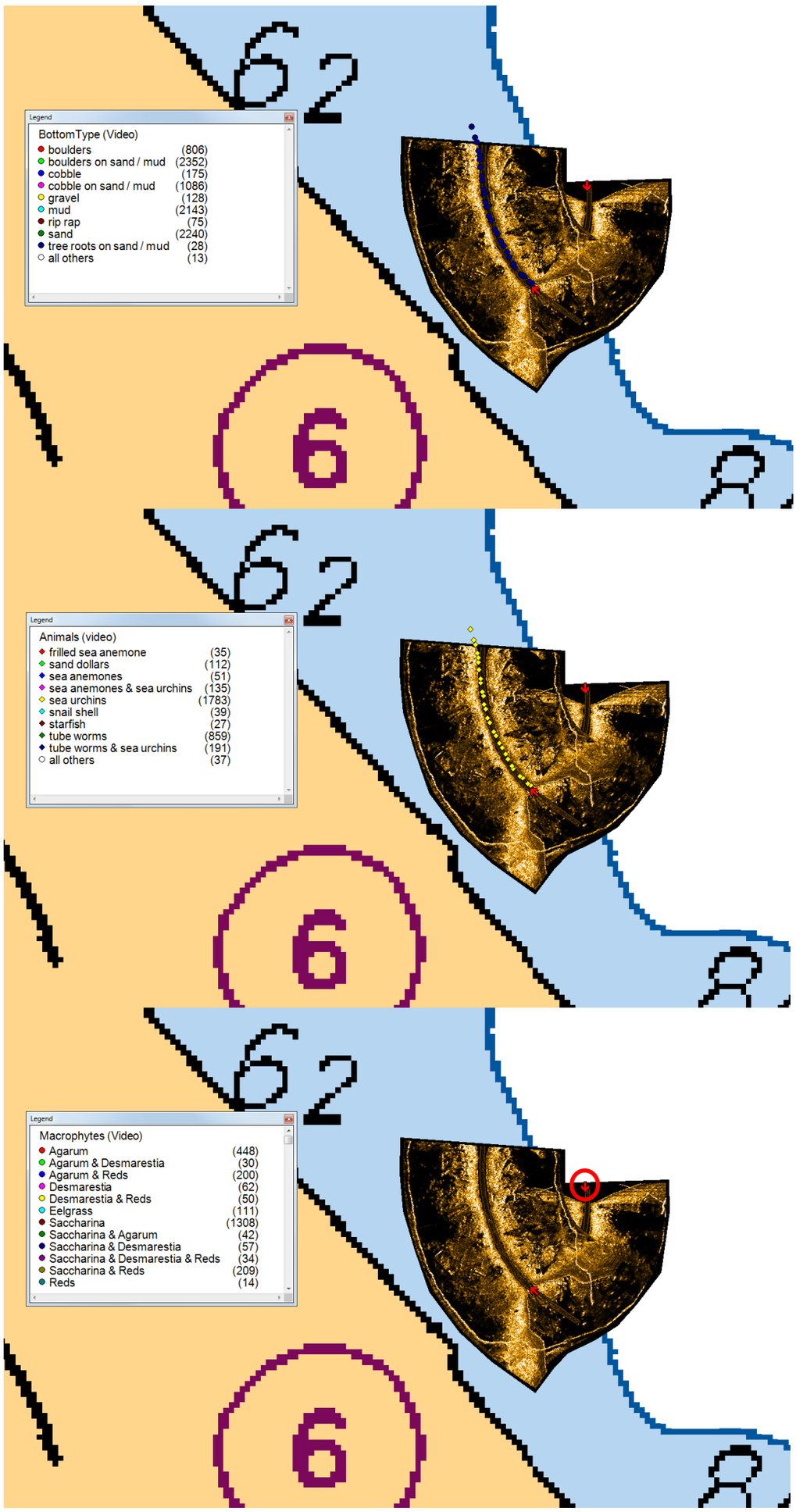


Figure 44: Transect IH04 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.669463N 63.597522W.

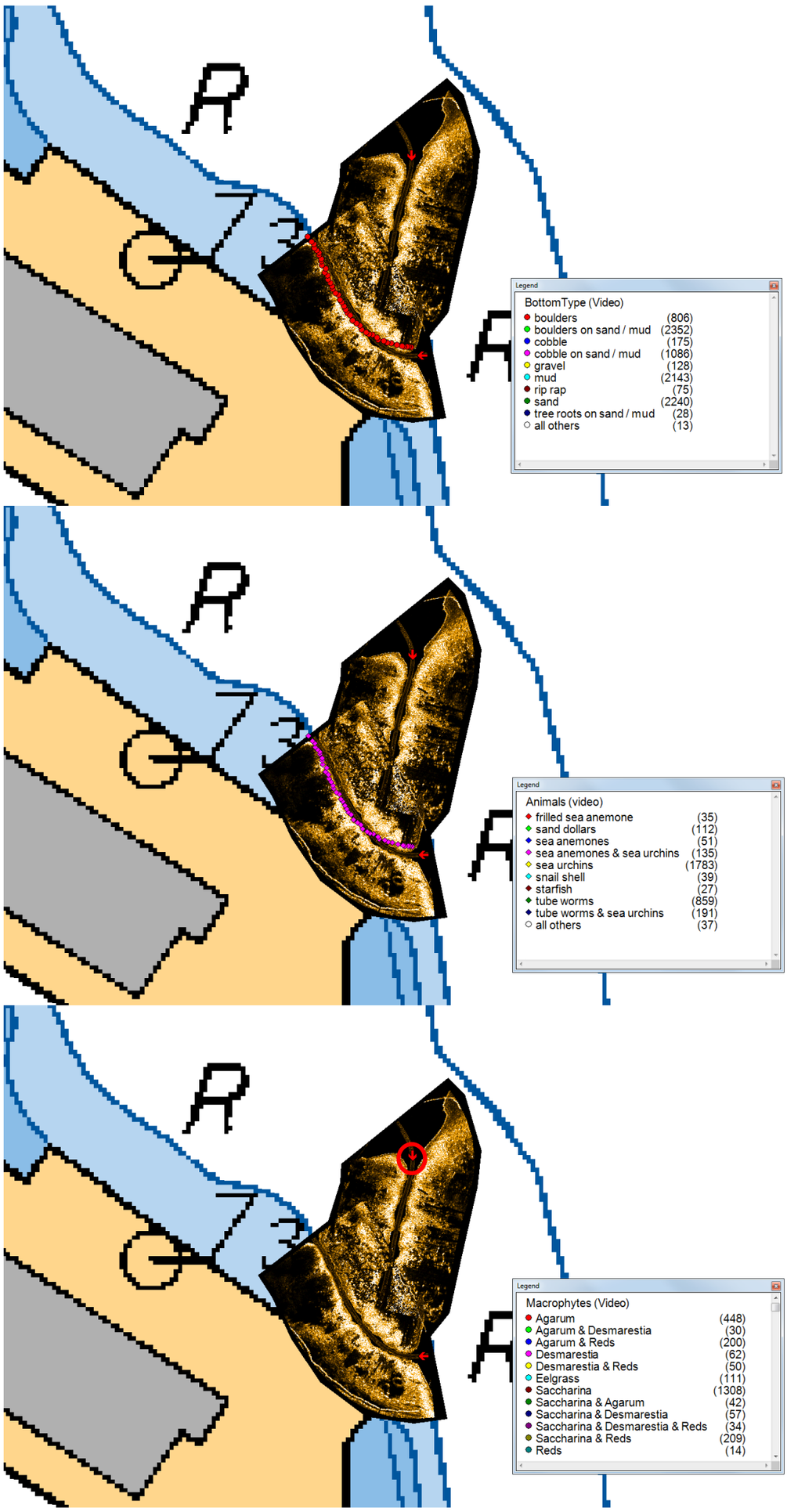


Figure 45: Transect IH05 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.666060N 63.591685W.

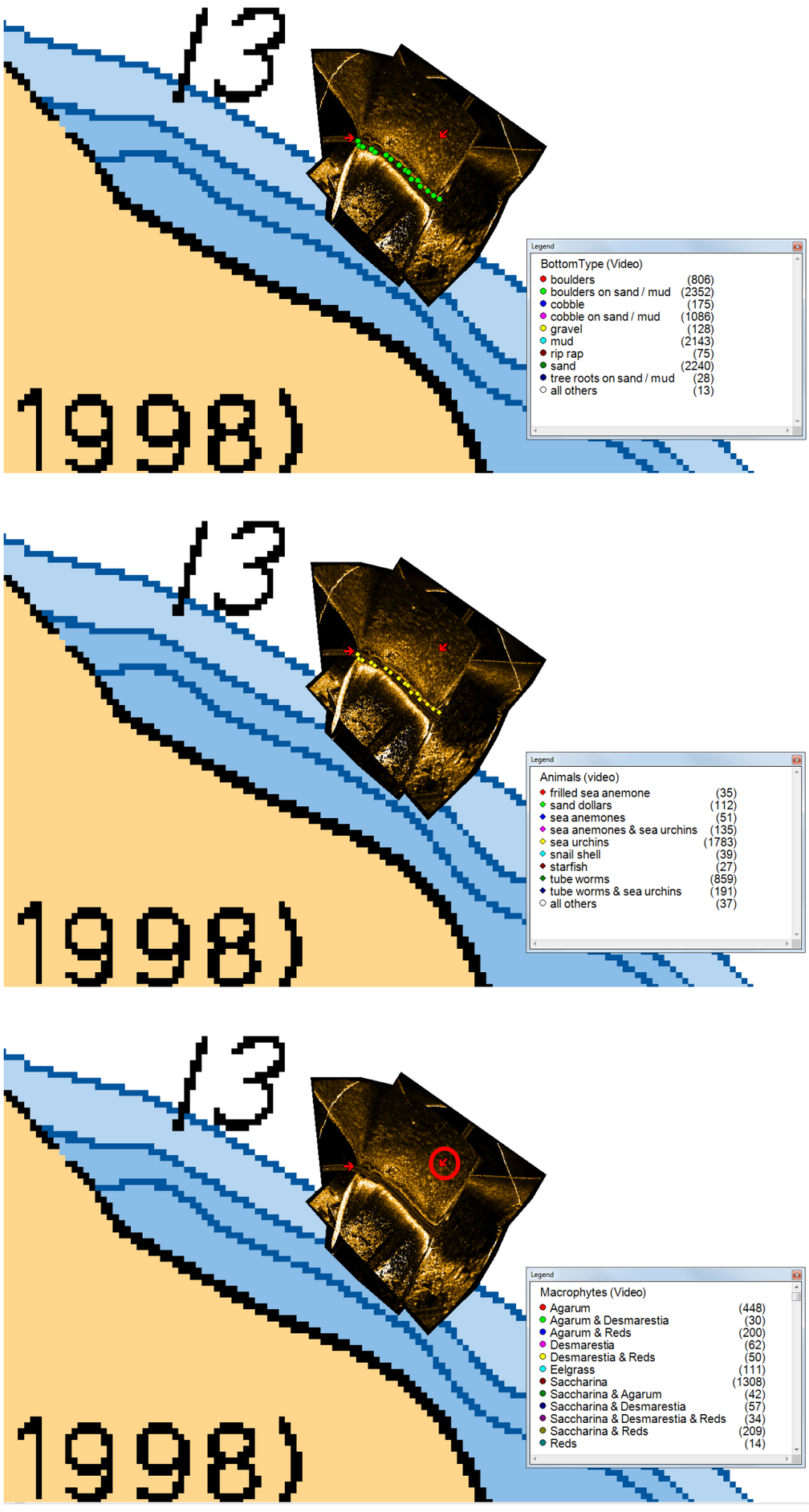


Figure 46: Transect IH06 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.653410N 63.574760W.

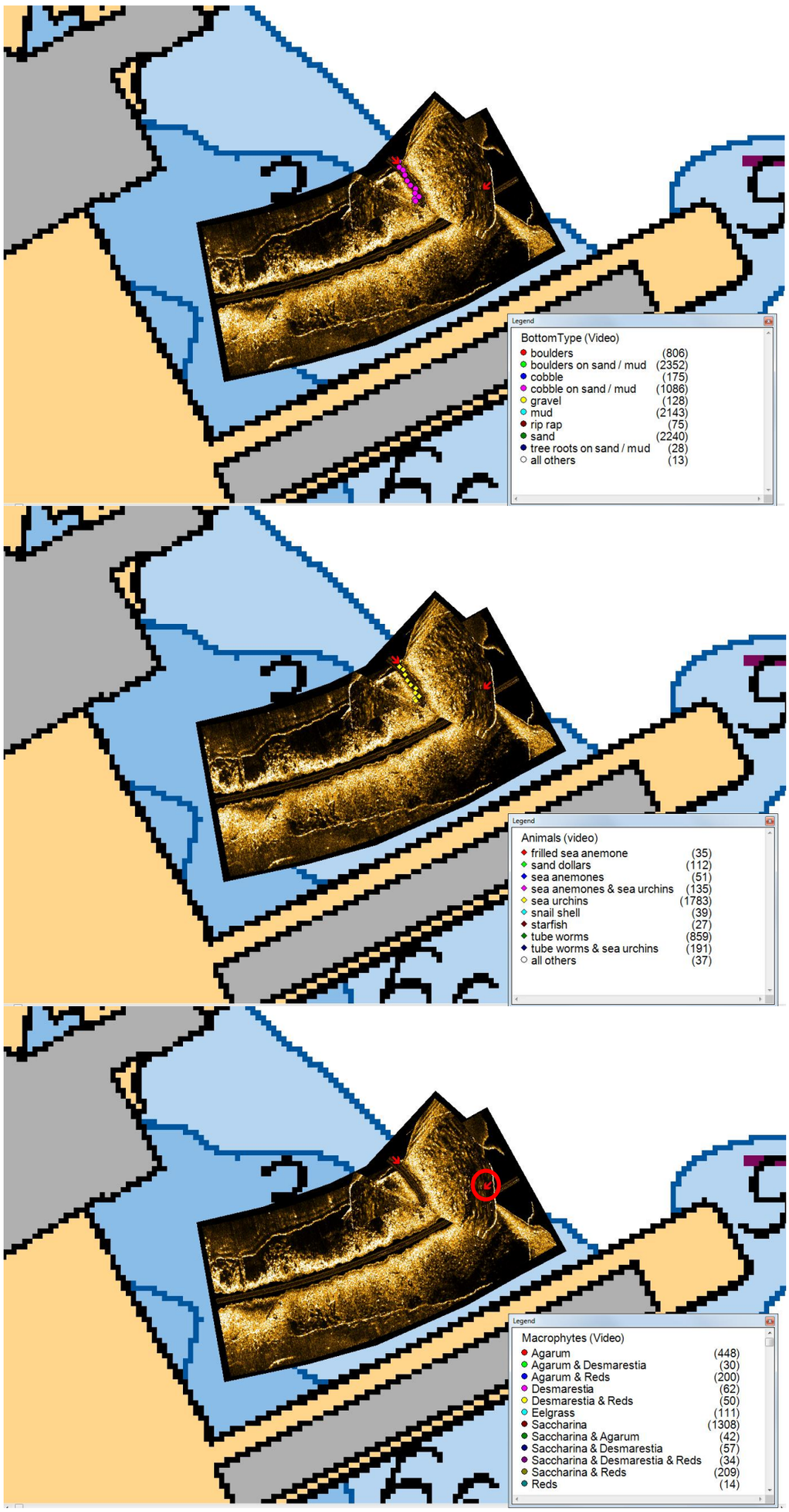


Figure 47: Transect IH07 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.649655N 63.570523W.

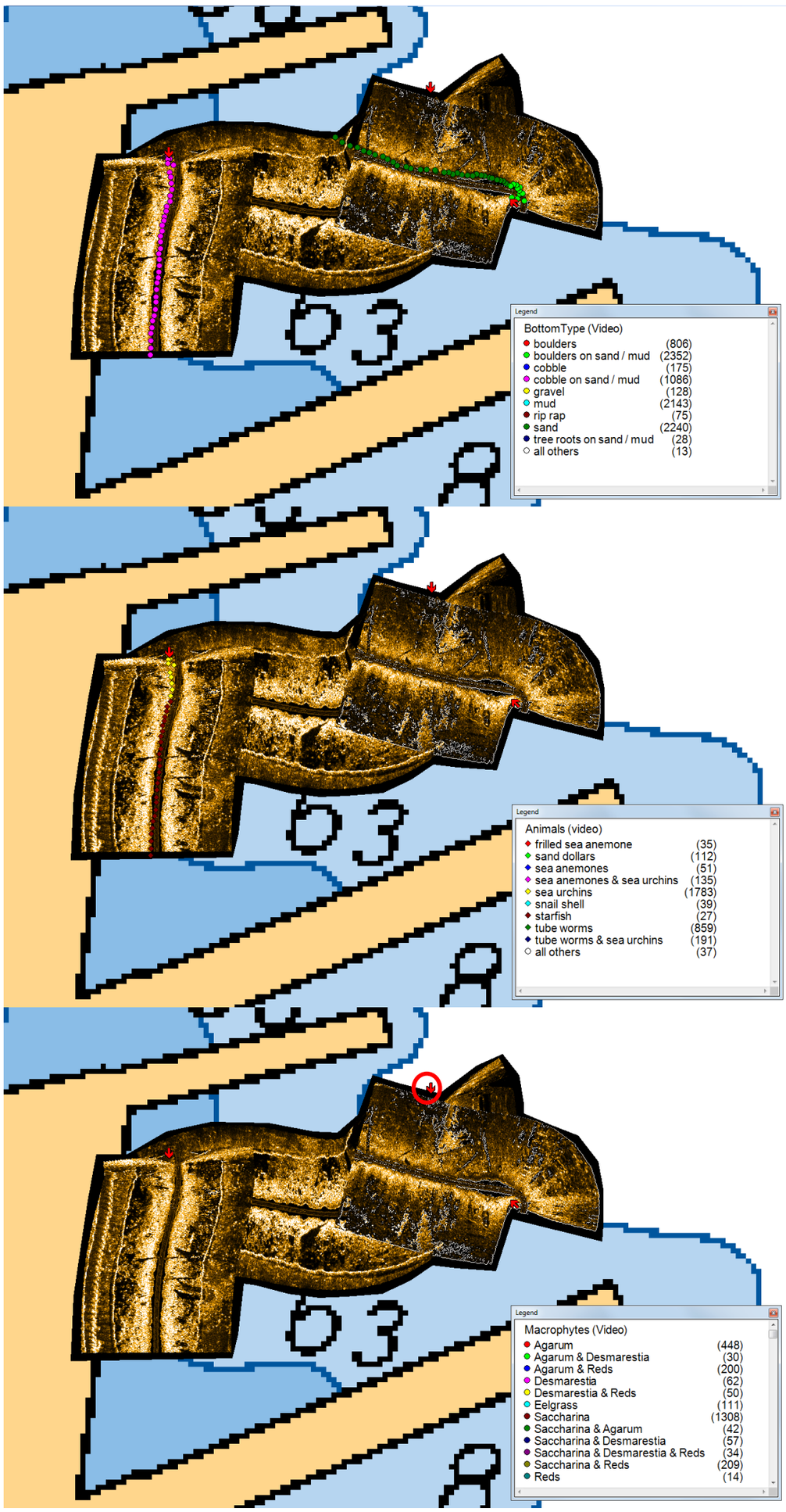


Figure 48: Transect IH08 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.646782N 63.568445W.

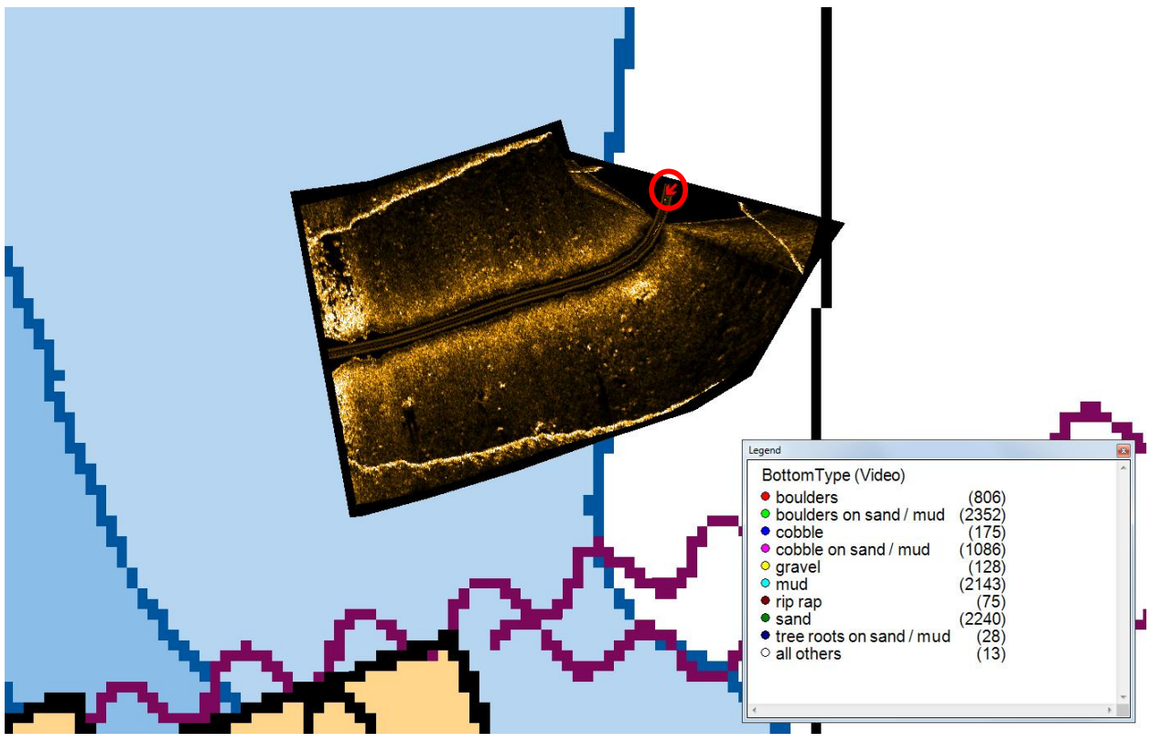


Figure 49: Transect IH09 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.643230N 63.566832W.

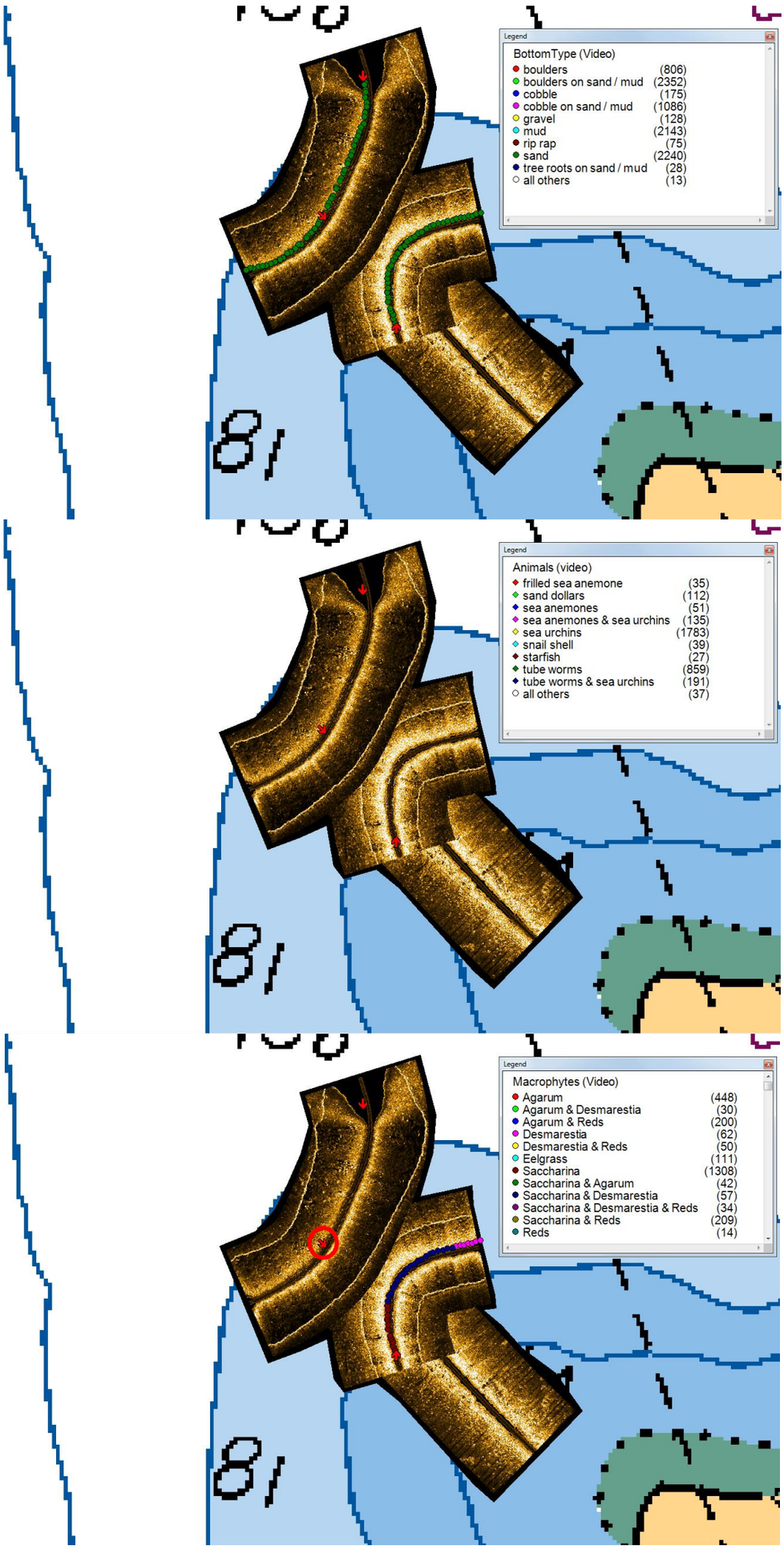


Figure 50: Transect IH10 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.642923N 63.562467W.

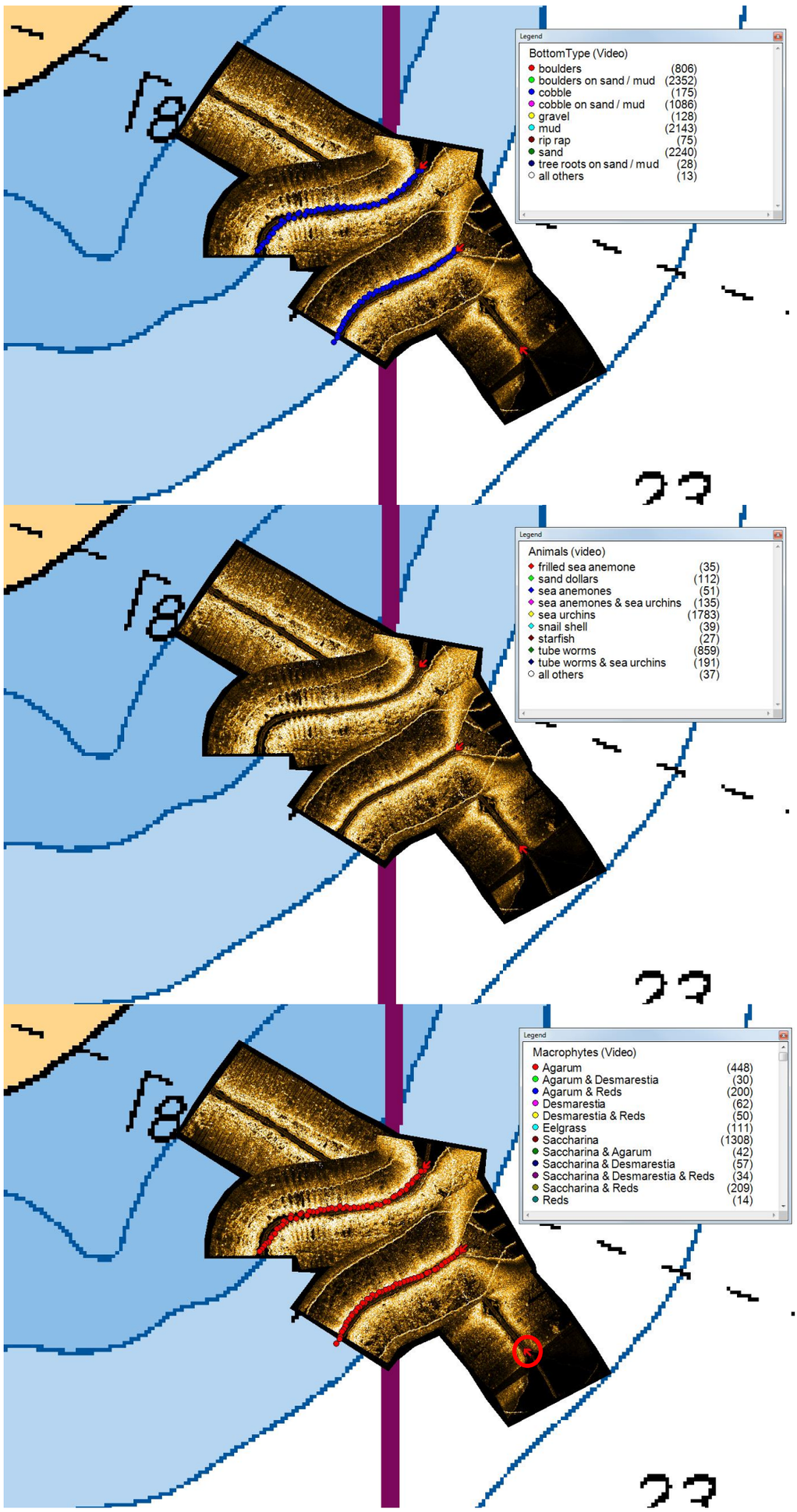


Figure 51: Transect IH11 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.639313N 63.556617W.

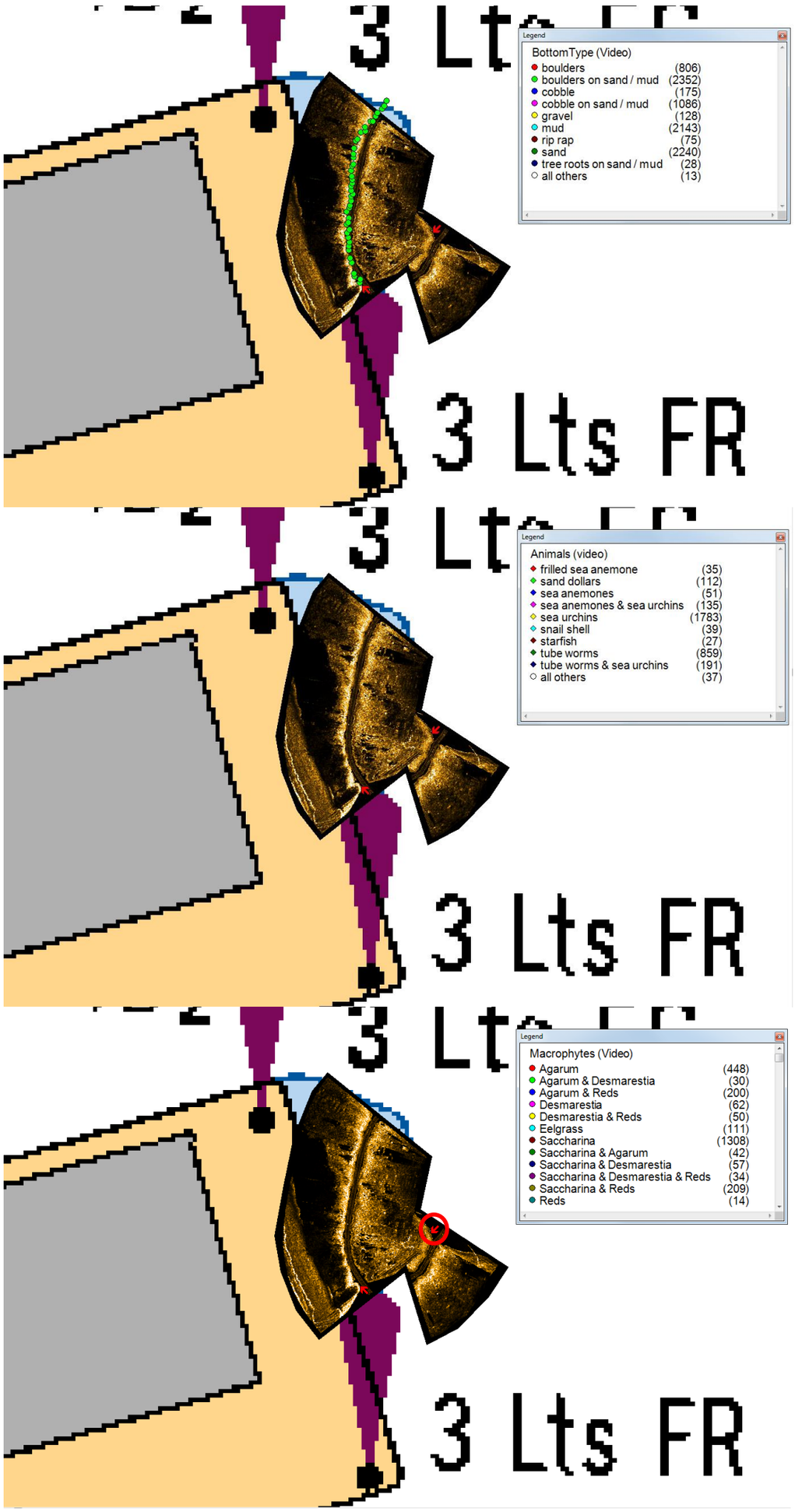


Figure 52: Transect IH12 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.635368N 63.562728W.

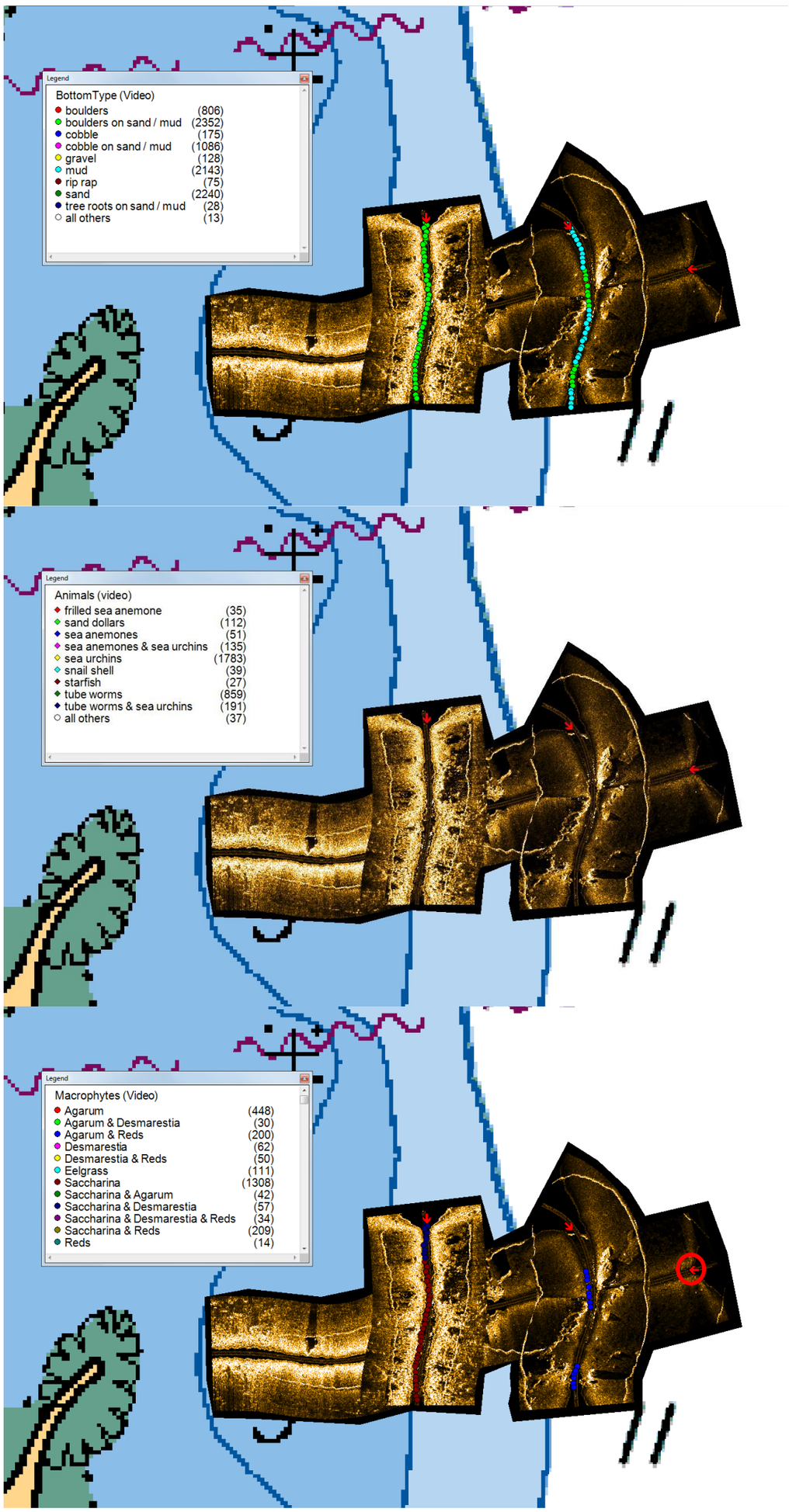


Figure 53: Transect IH13 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.624468N 63.561375W.

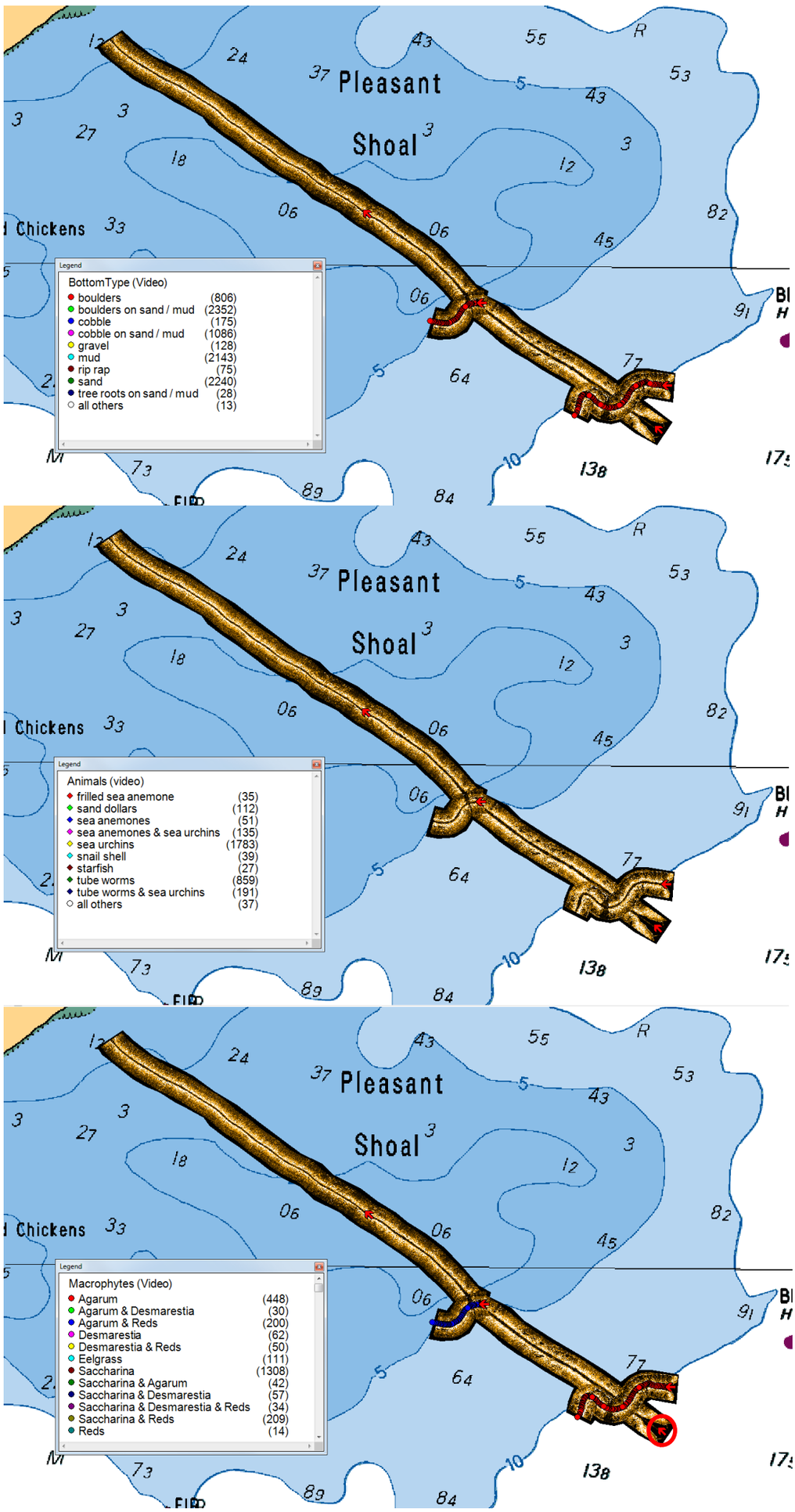


Figure 54: Transect IH14 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.614963N 63.554848W.

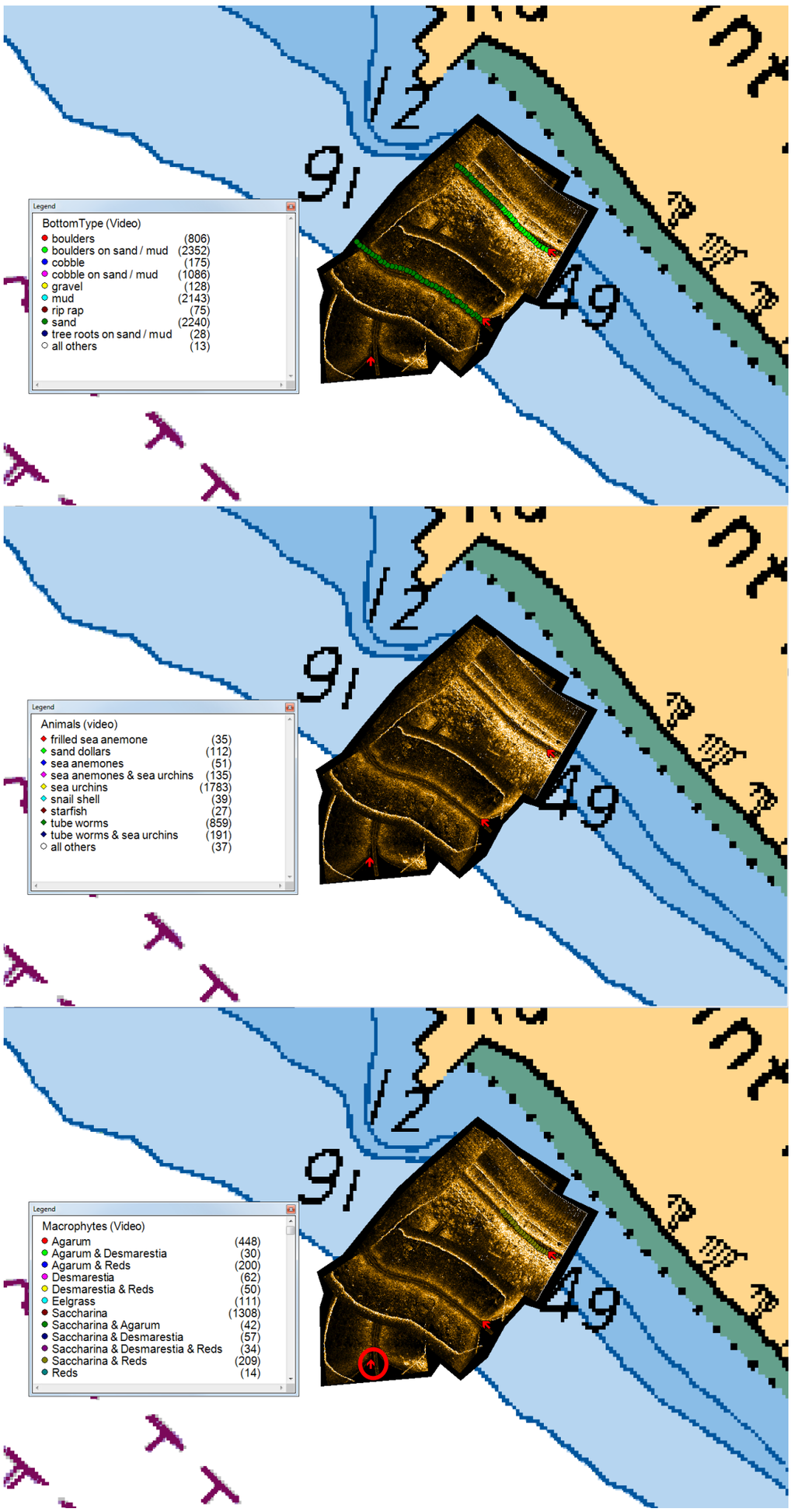


Figure 55: Transect IH15 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.617873N 63.569908W.

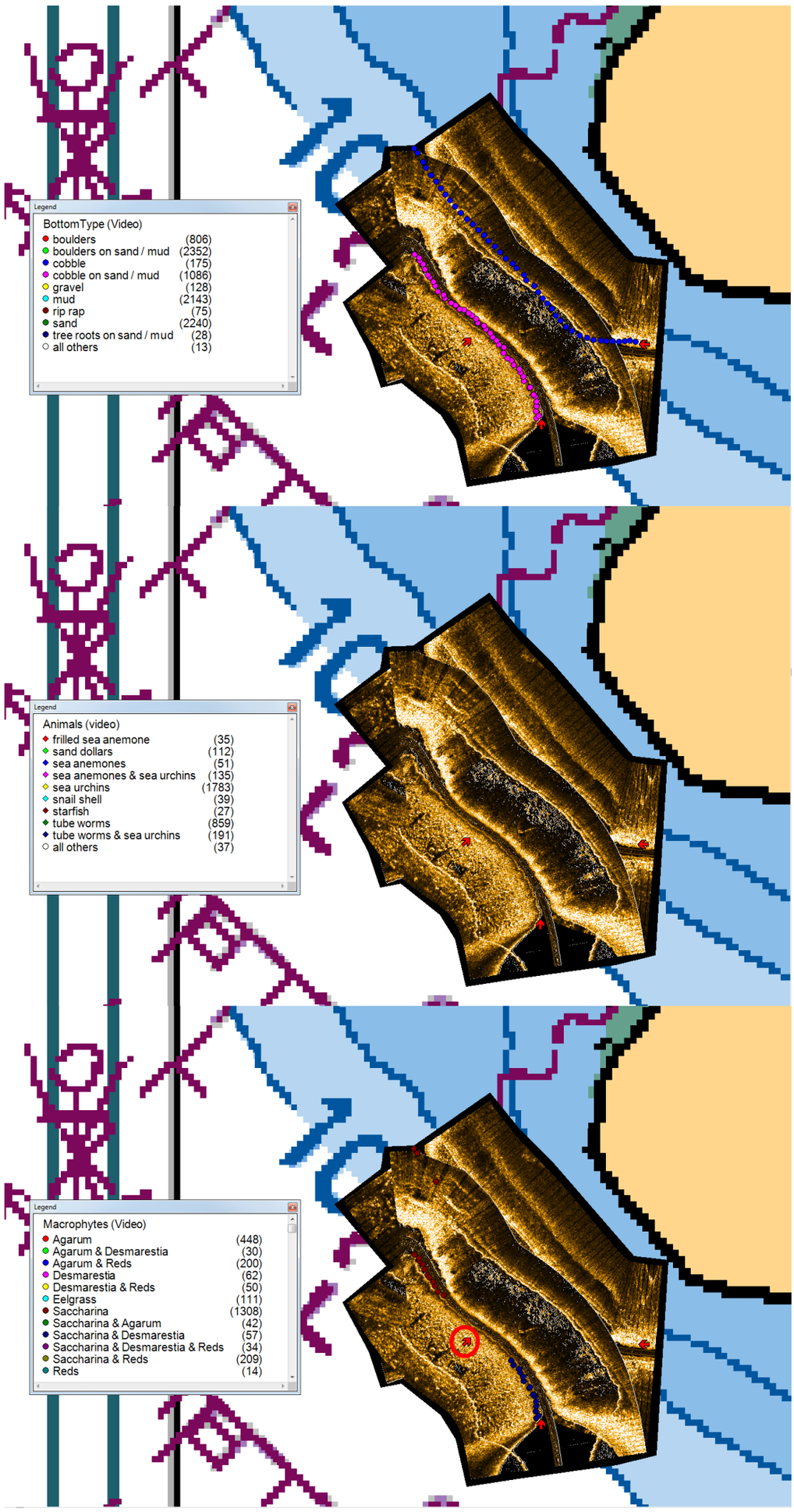


Figure 56: Transect IH16 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.620400N 63.574825W.

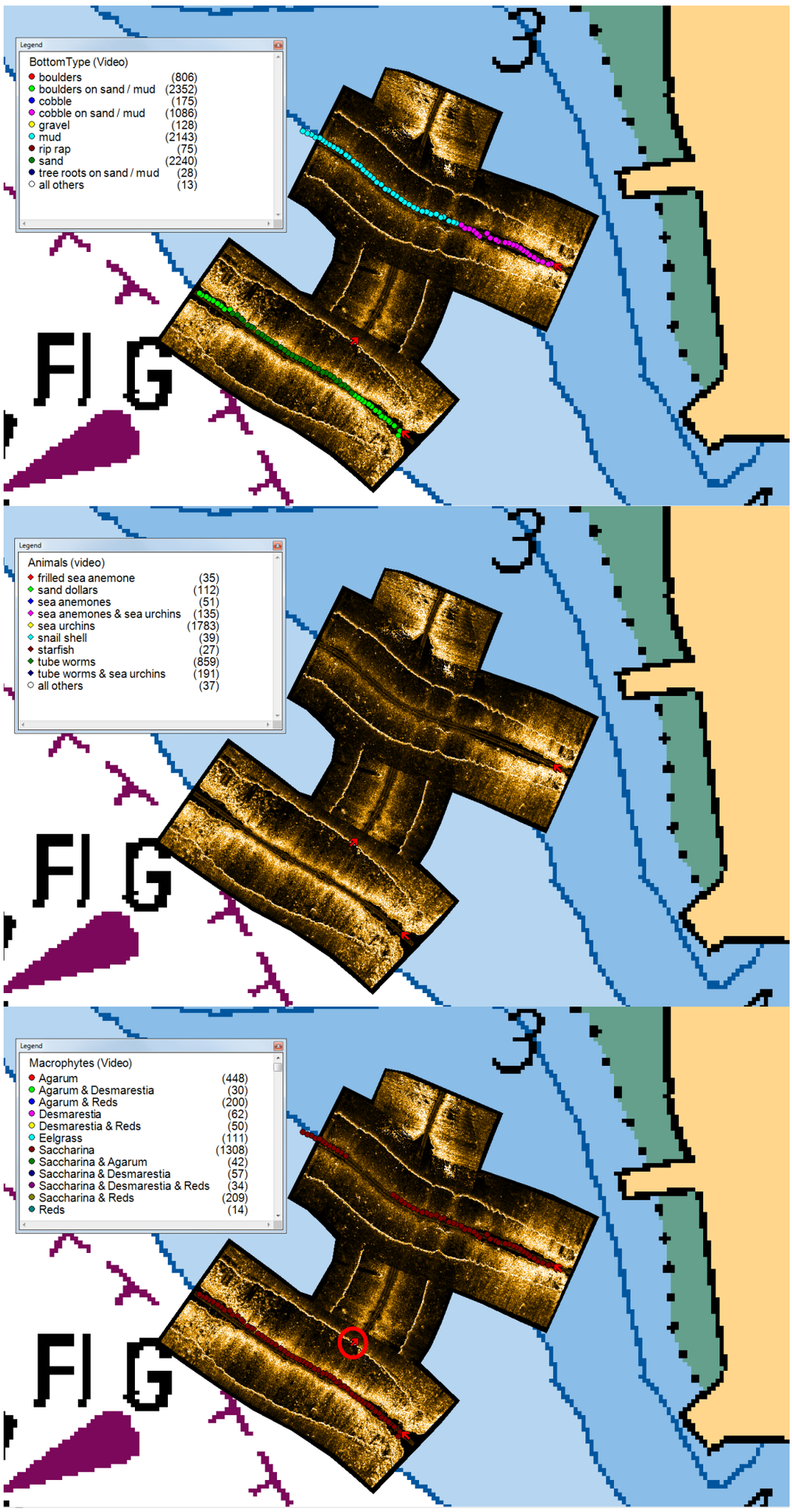


Figure 57: Transect IH17 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.623343N 63.578735W.

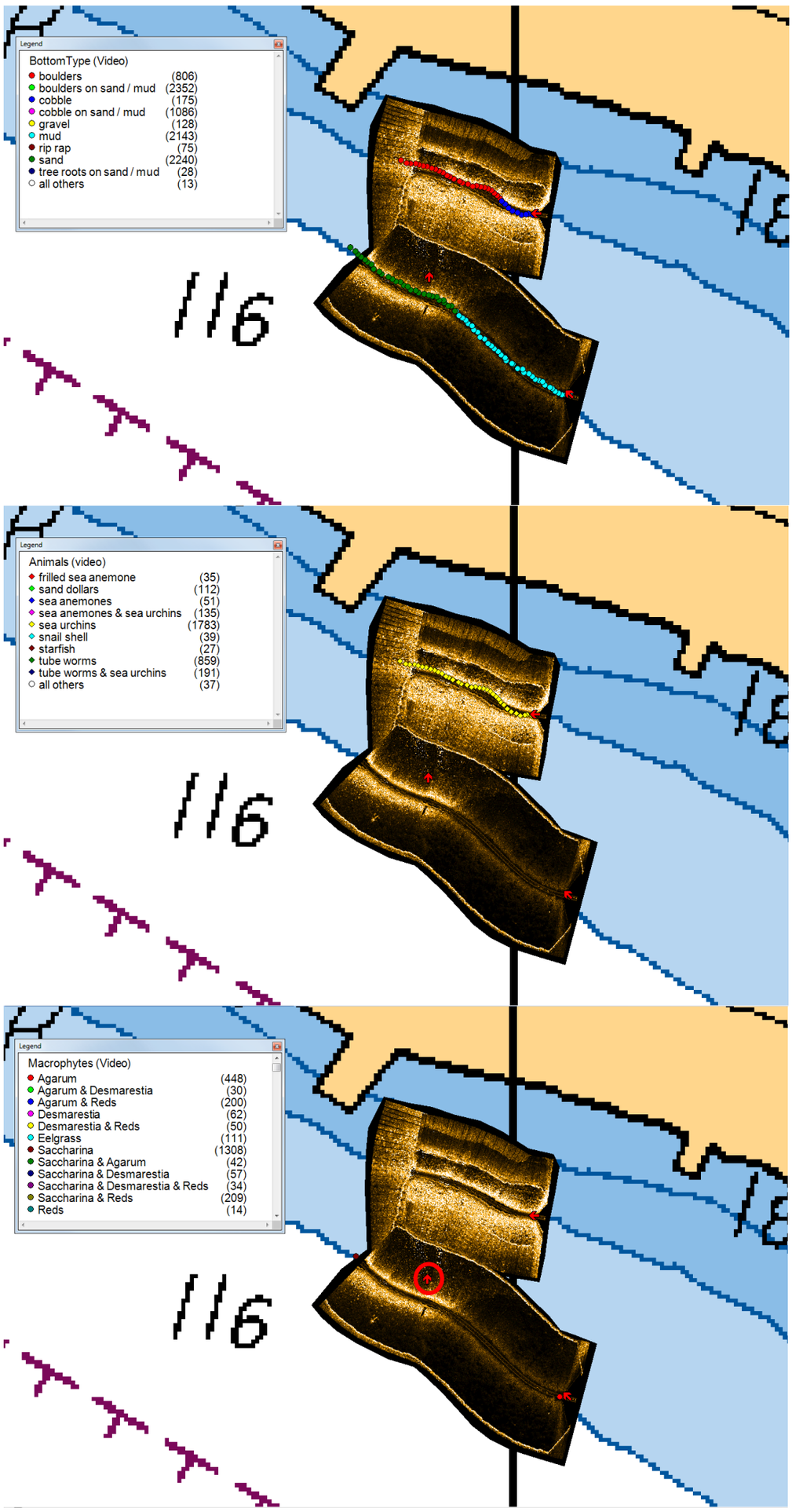


Figure 58: Transect IH18 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.626218N 63.583578W.

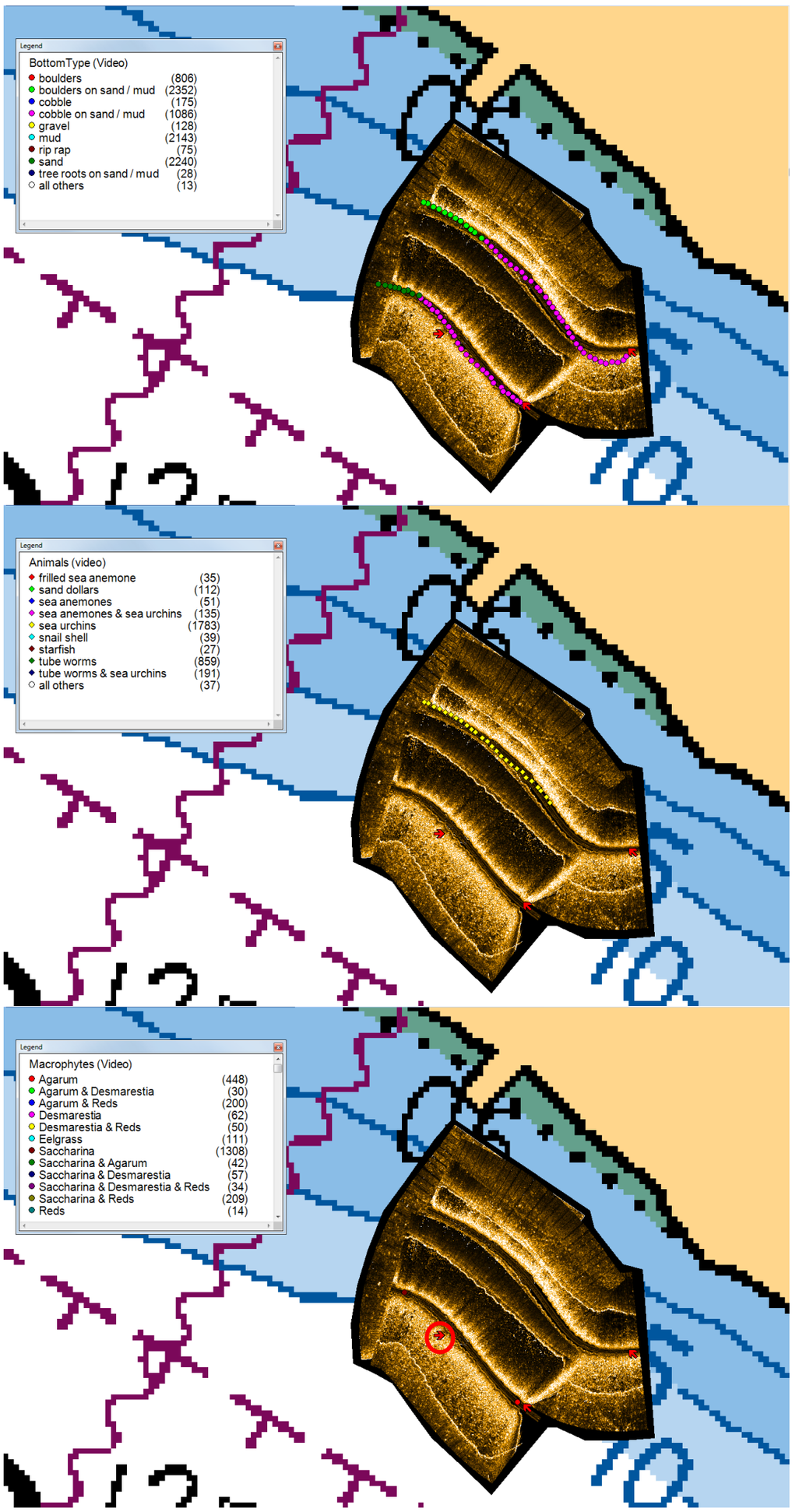


Figure 59: Transect IH19 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.628507N 63.589818W.

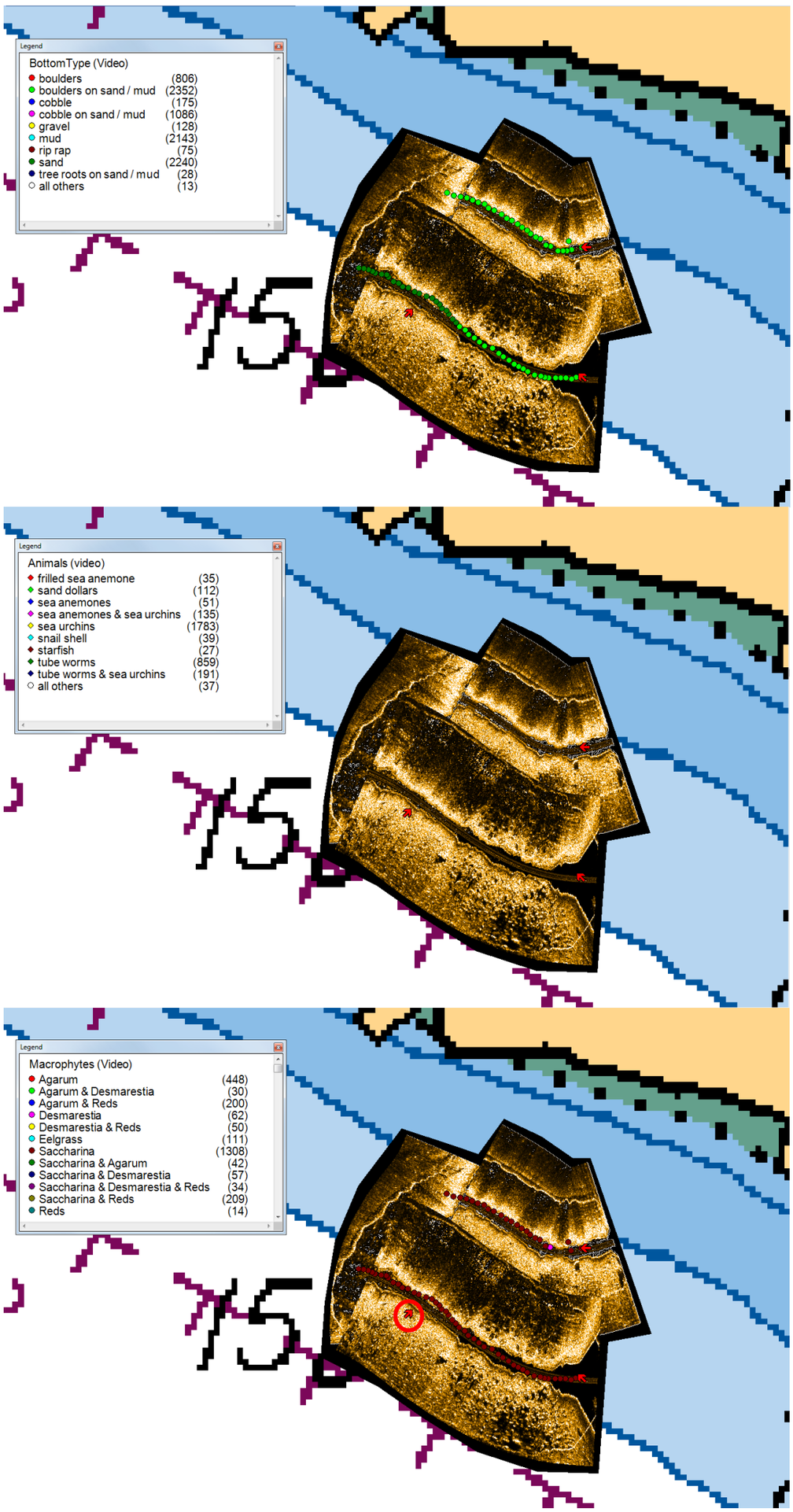


Figure 60: Transect IH20 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.631270N 63.594765W.

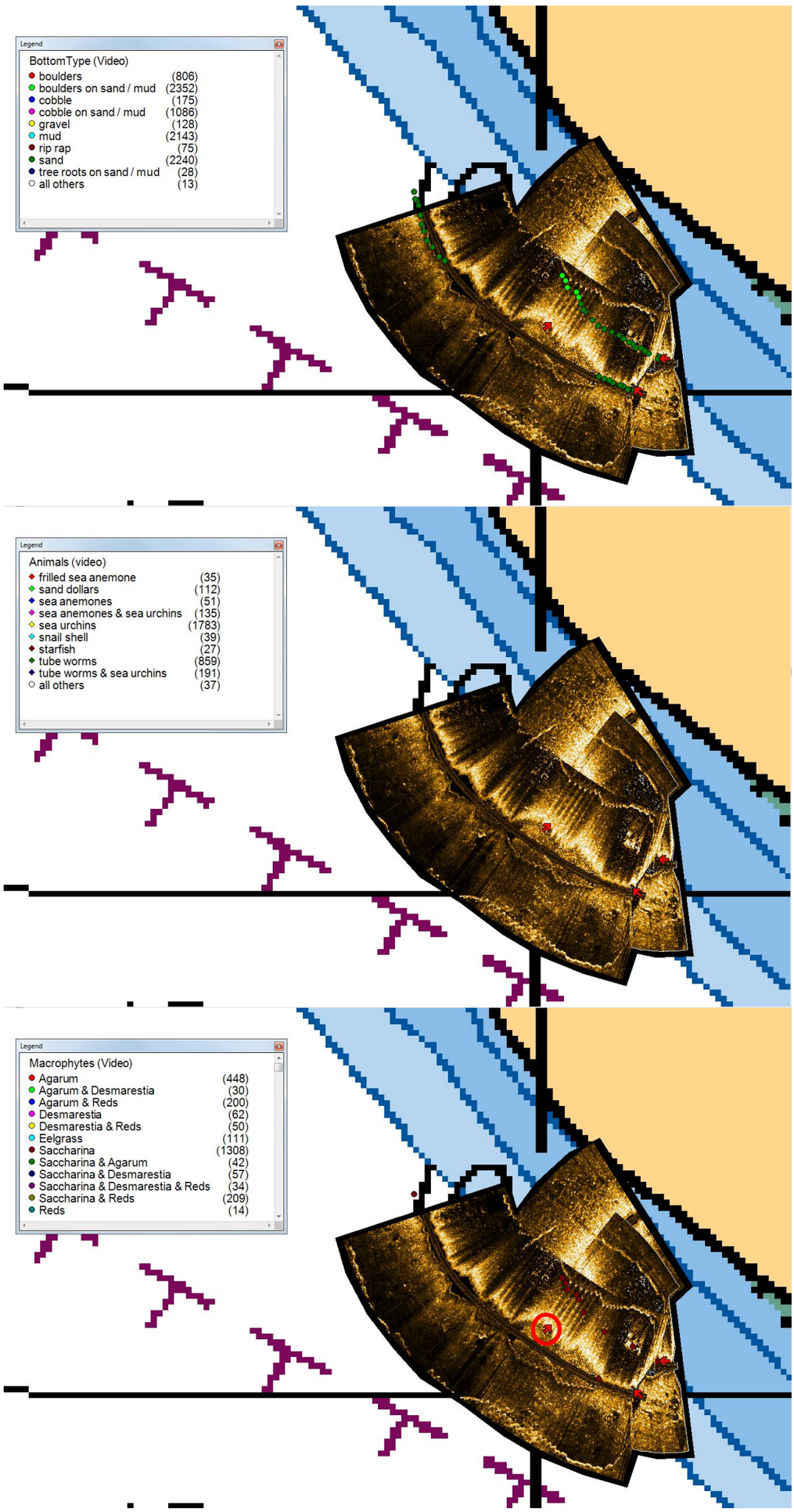


Figure 61: Transect IH21 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.633440N 63.599965W.

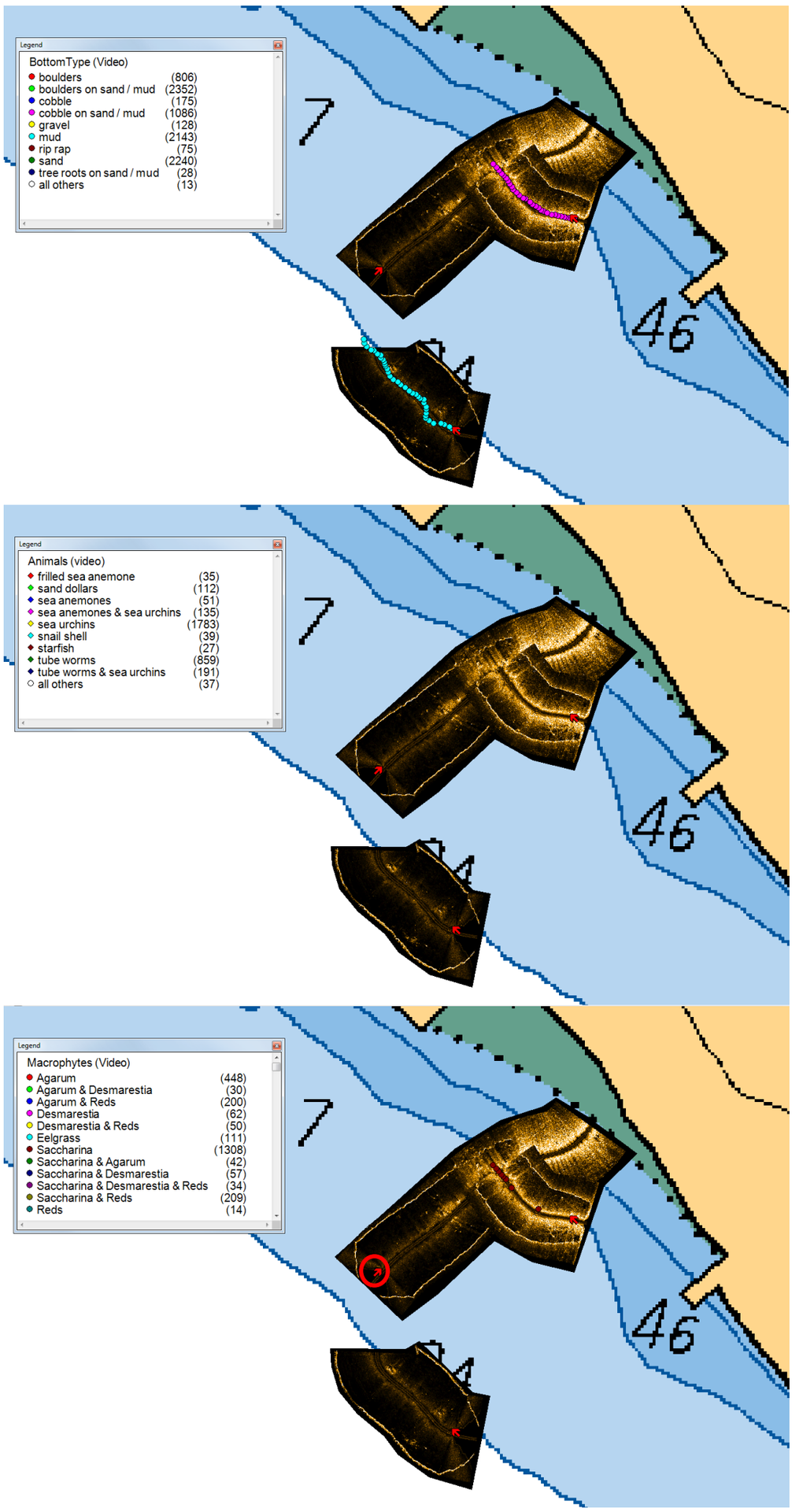


Figure 62: Transect IH22 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.636612N 63.604648W.

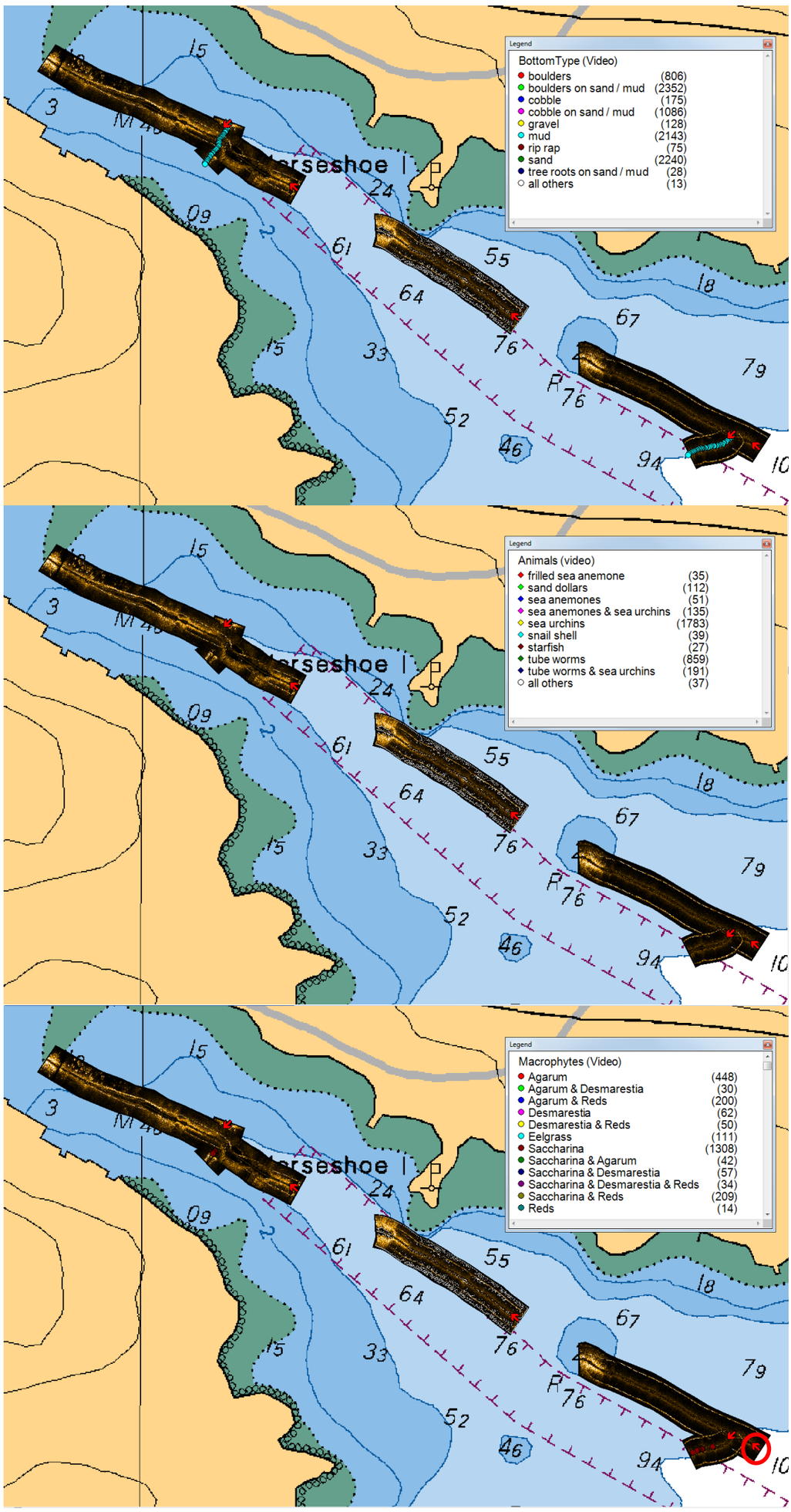


Figure 63: Transect IH23 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.637107N 63.609045W.

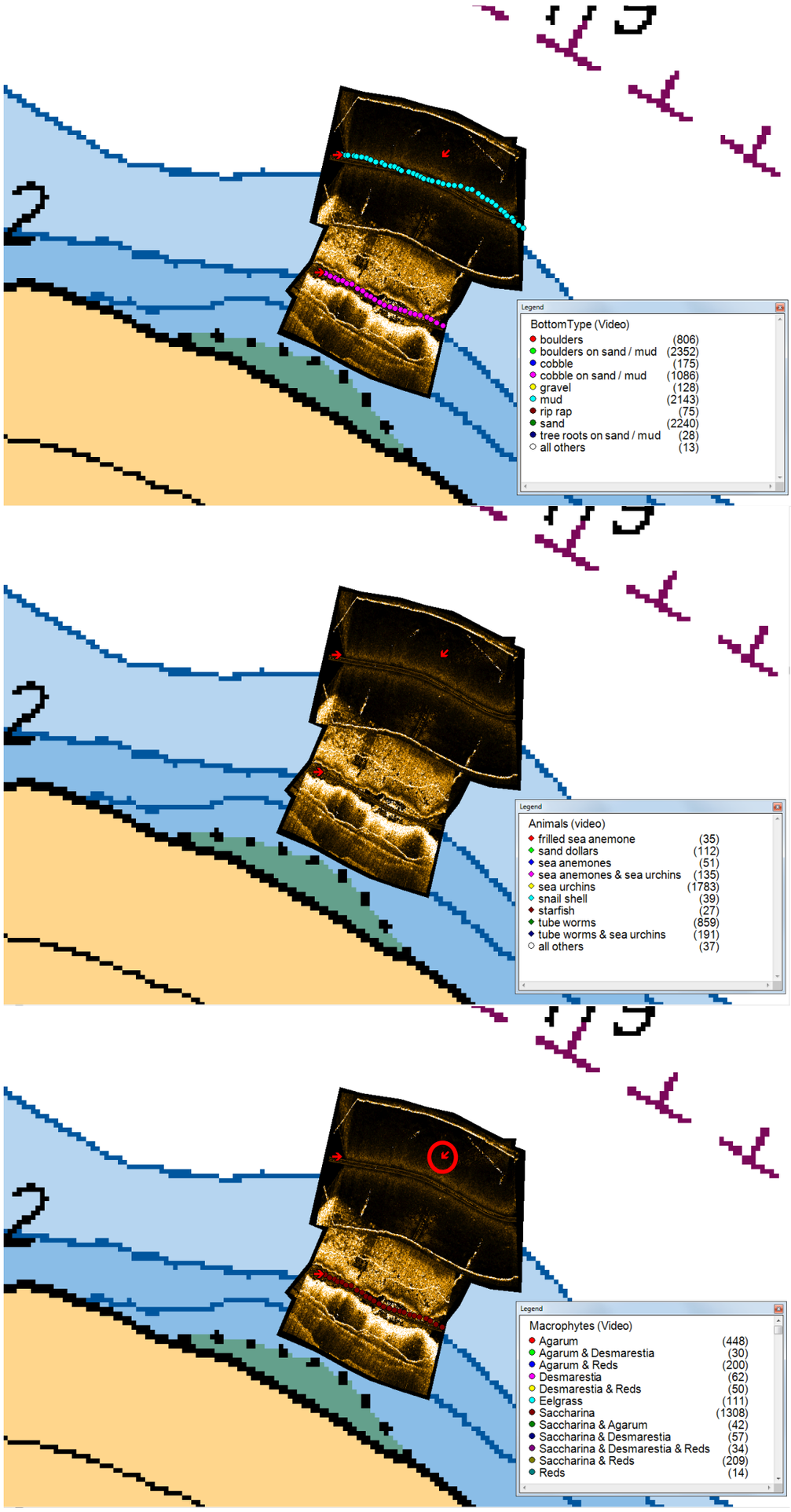


Figure 64: Transect IH24 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.635042N 63.607163W.

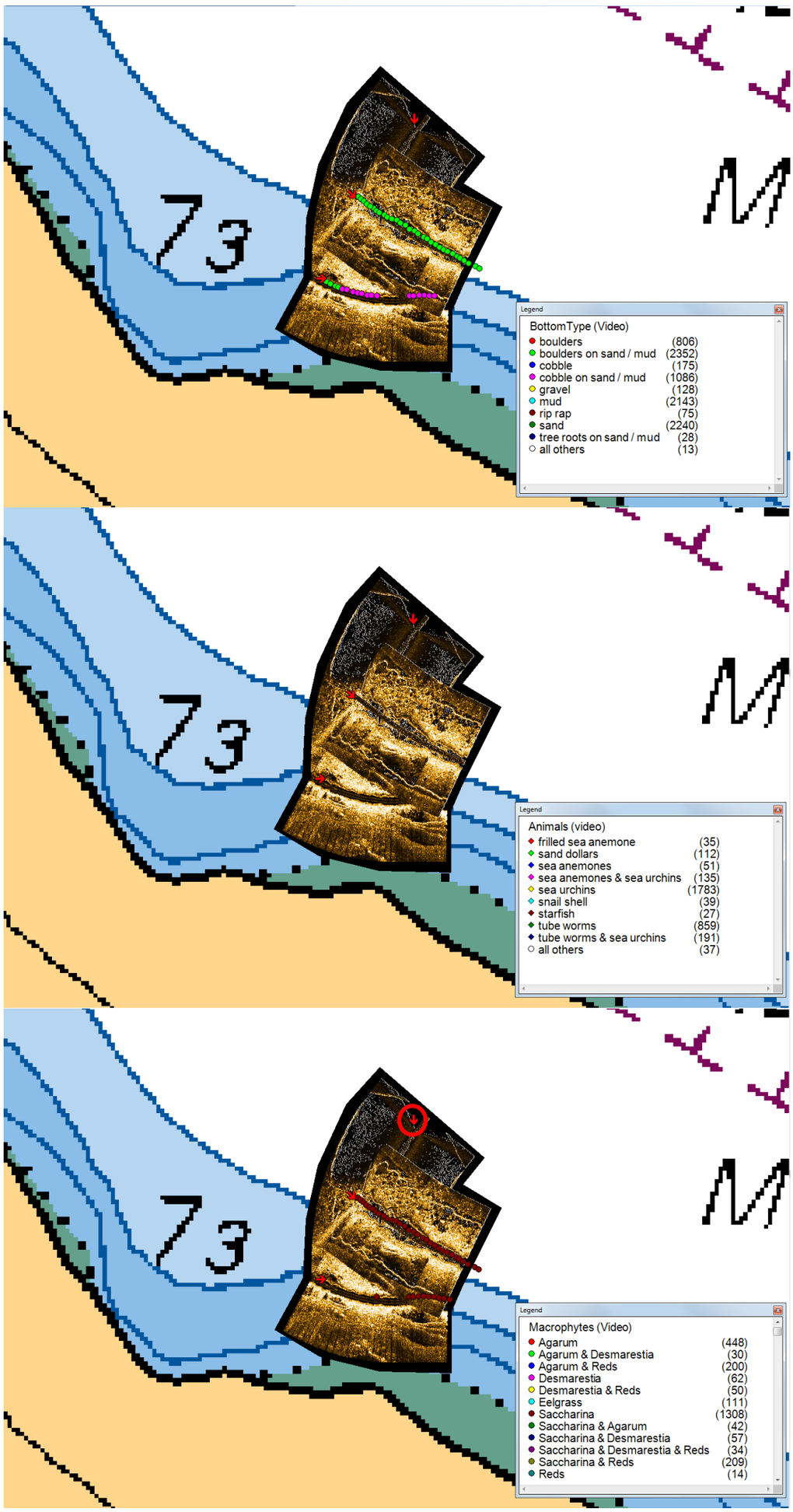


Figure 65: Transect IH25 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.632792N 63.601908W.

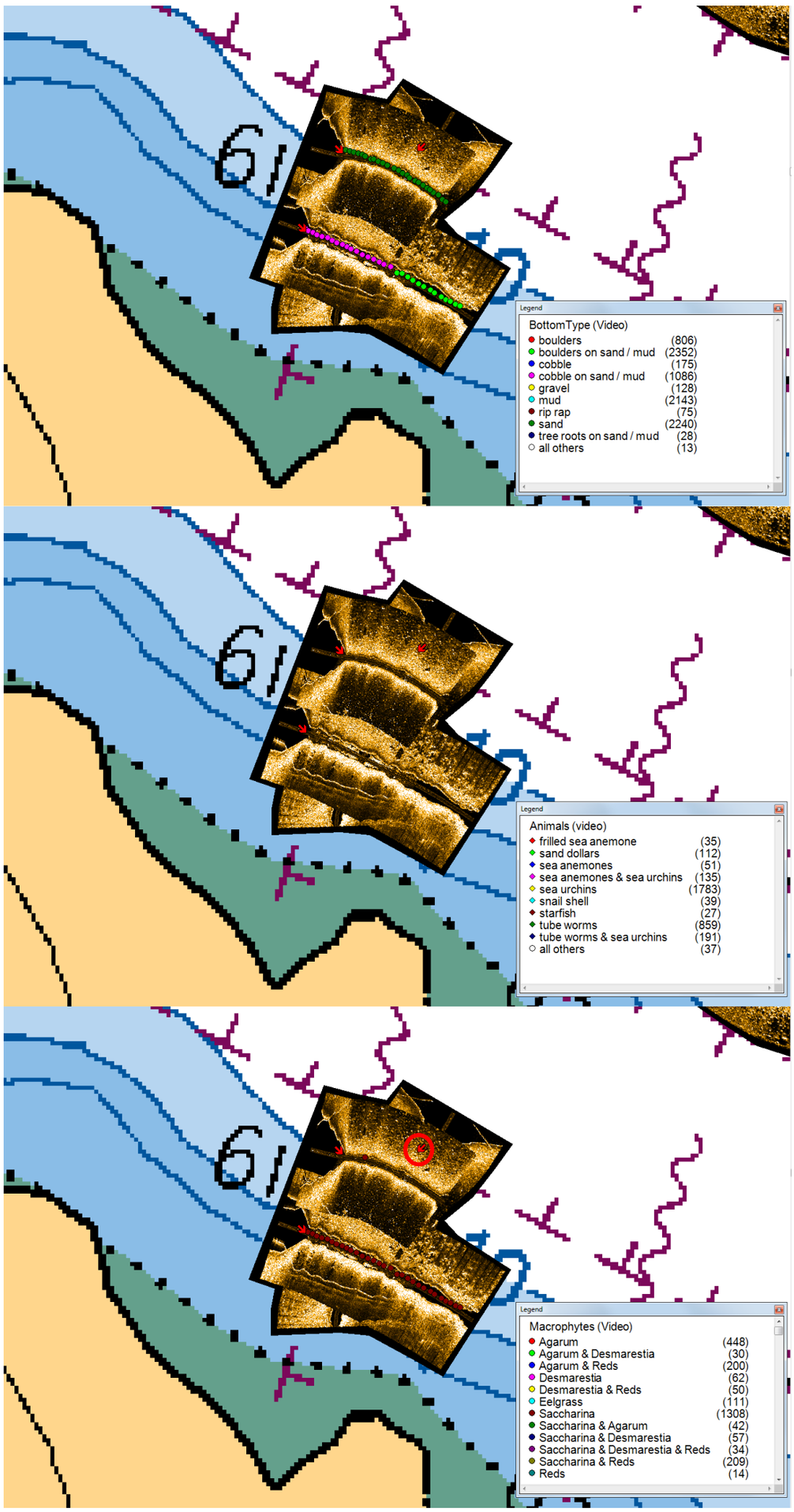


Figure 66: Transect IH26 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.630822N 63.595665W.

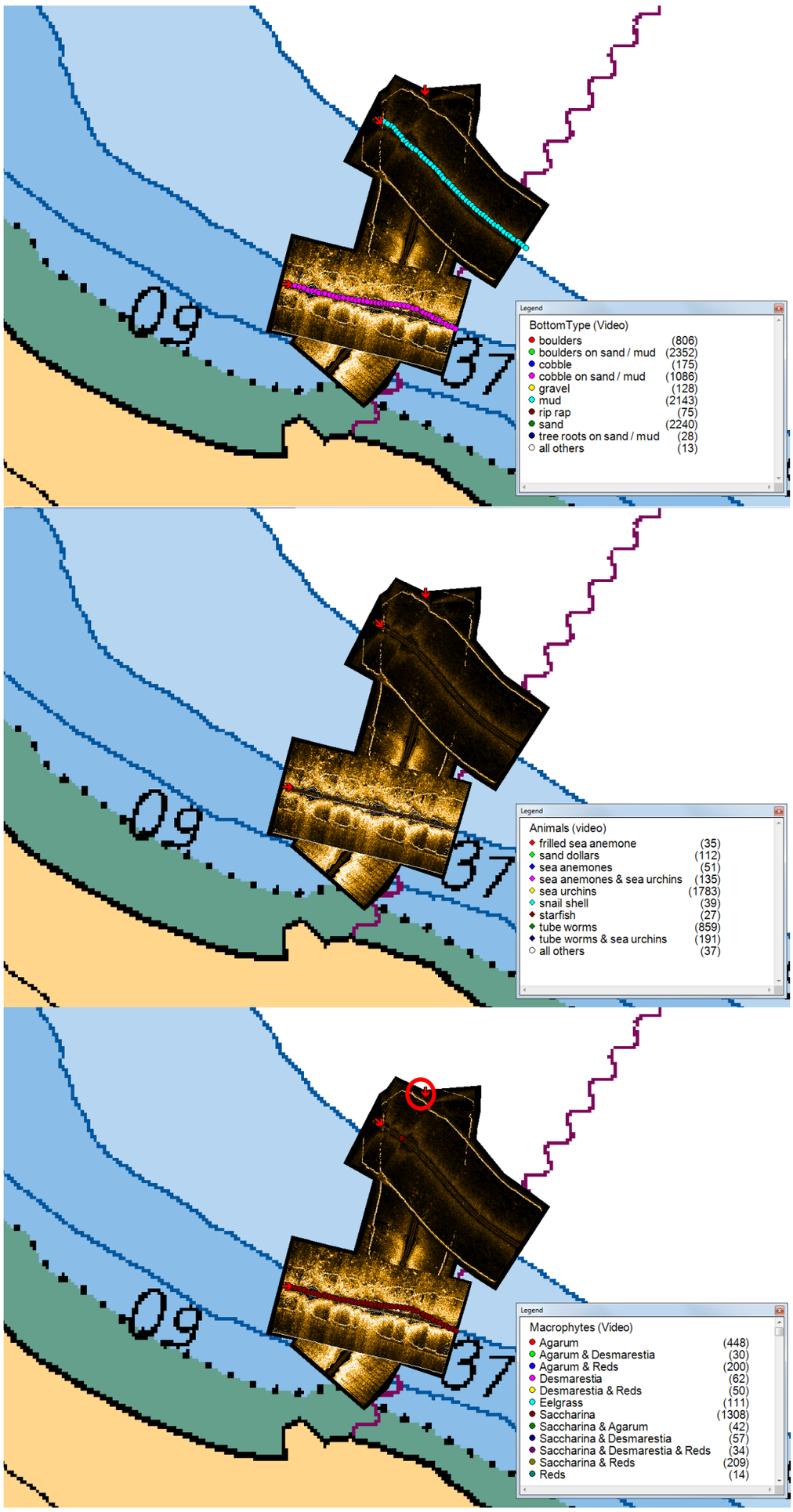


Figure 67: Transect IH27 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.627580N 63.591975W.

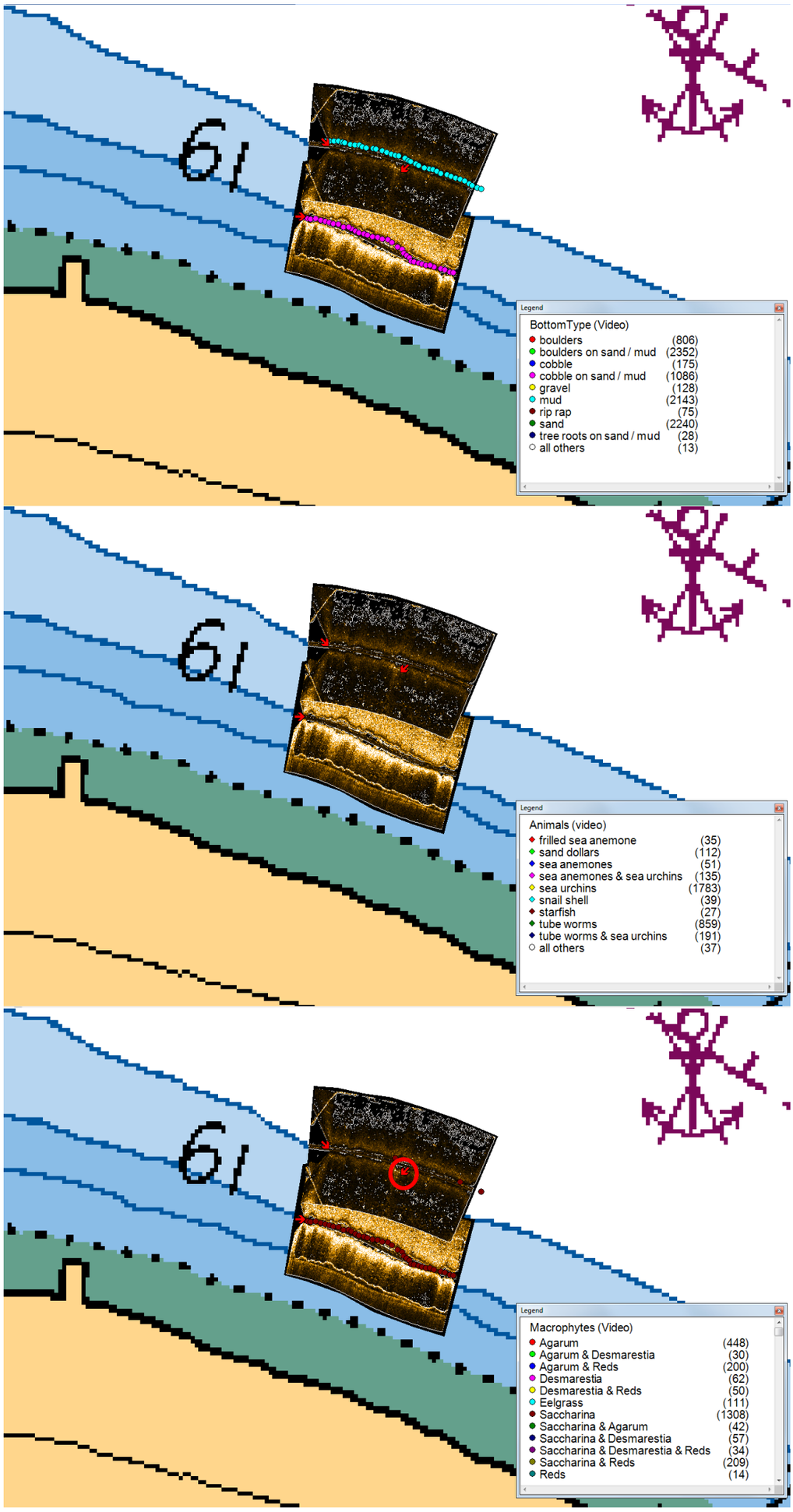


Figure 68: Transect IH28 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.625110N 63.585885W.

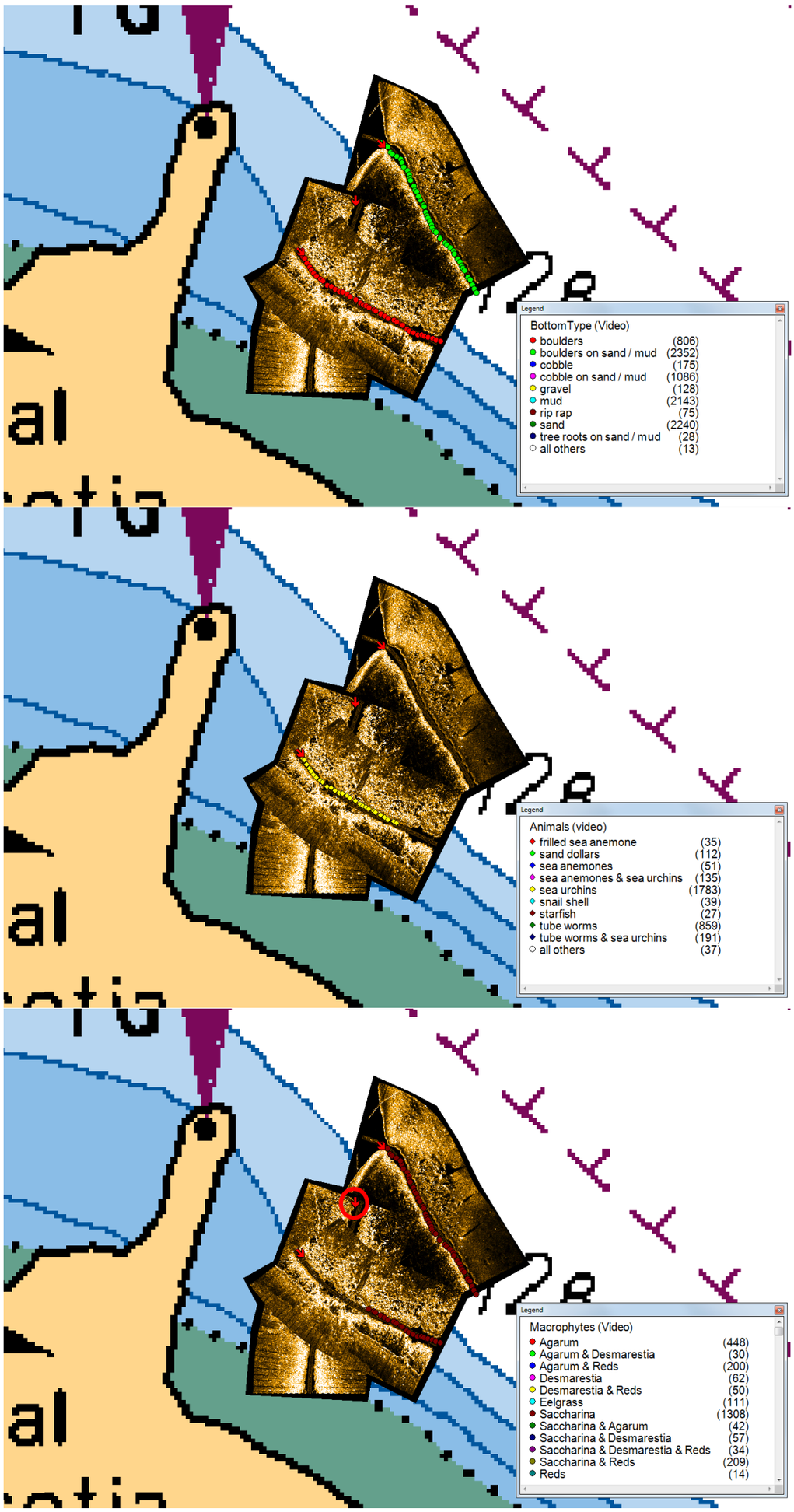


Figure 69: Transect IH29 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.621262N 63.578955W.

Figure 70: Transect IH30 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.617780N 63.573112W.

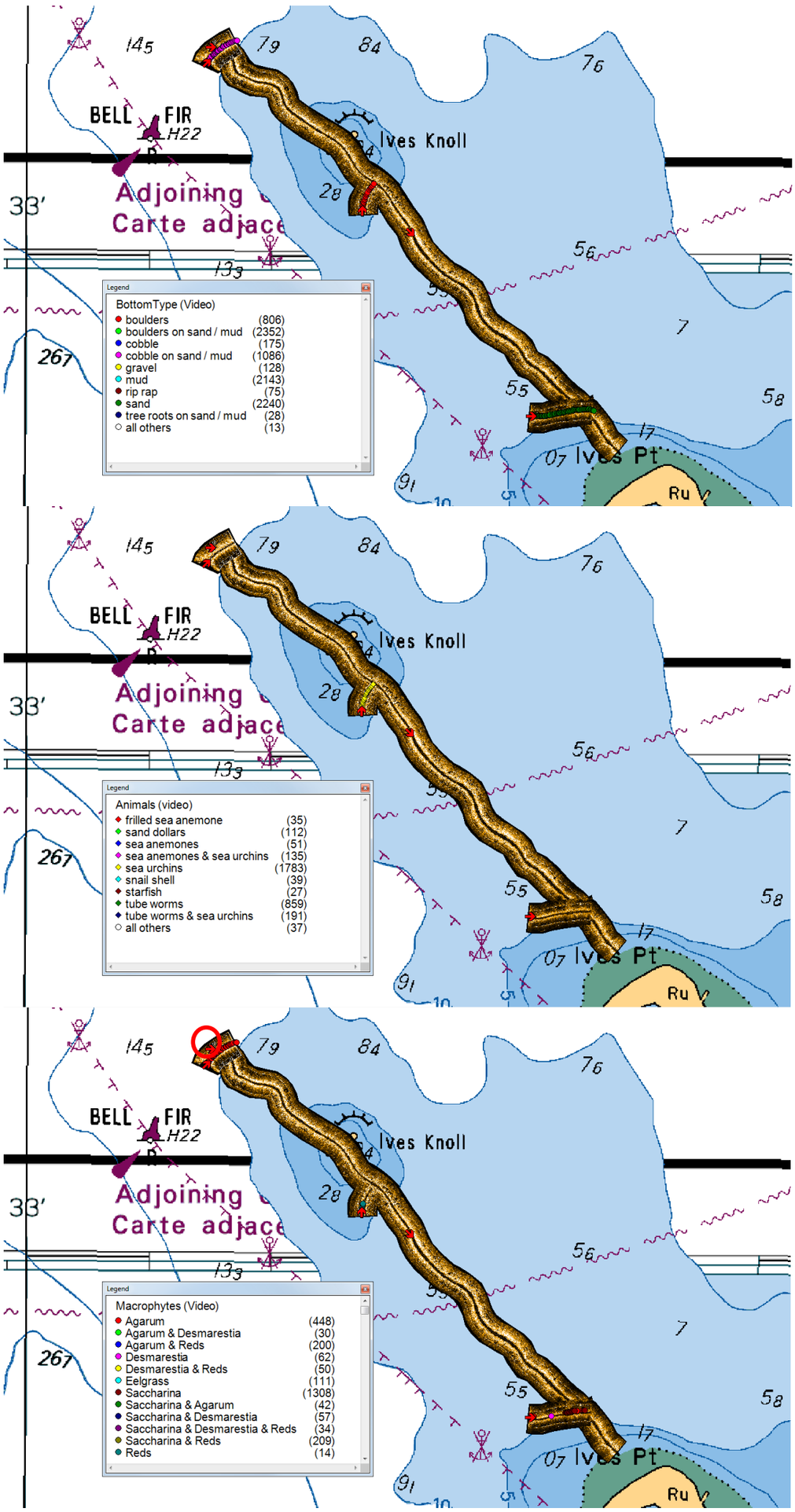


Figure 71: Transect IH31 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.628532N 63.547482W.

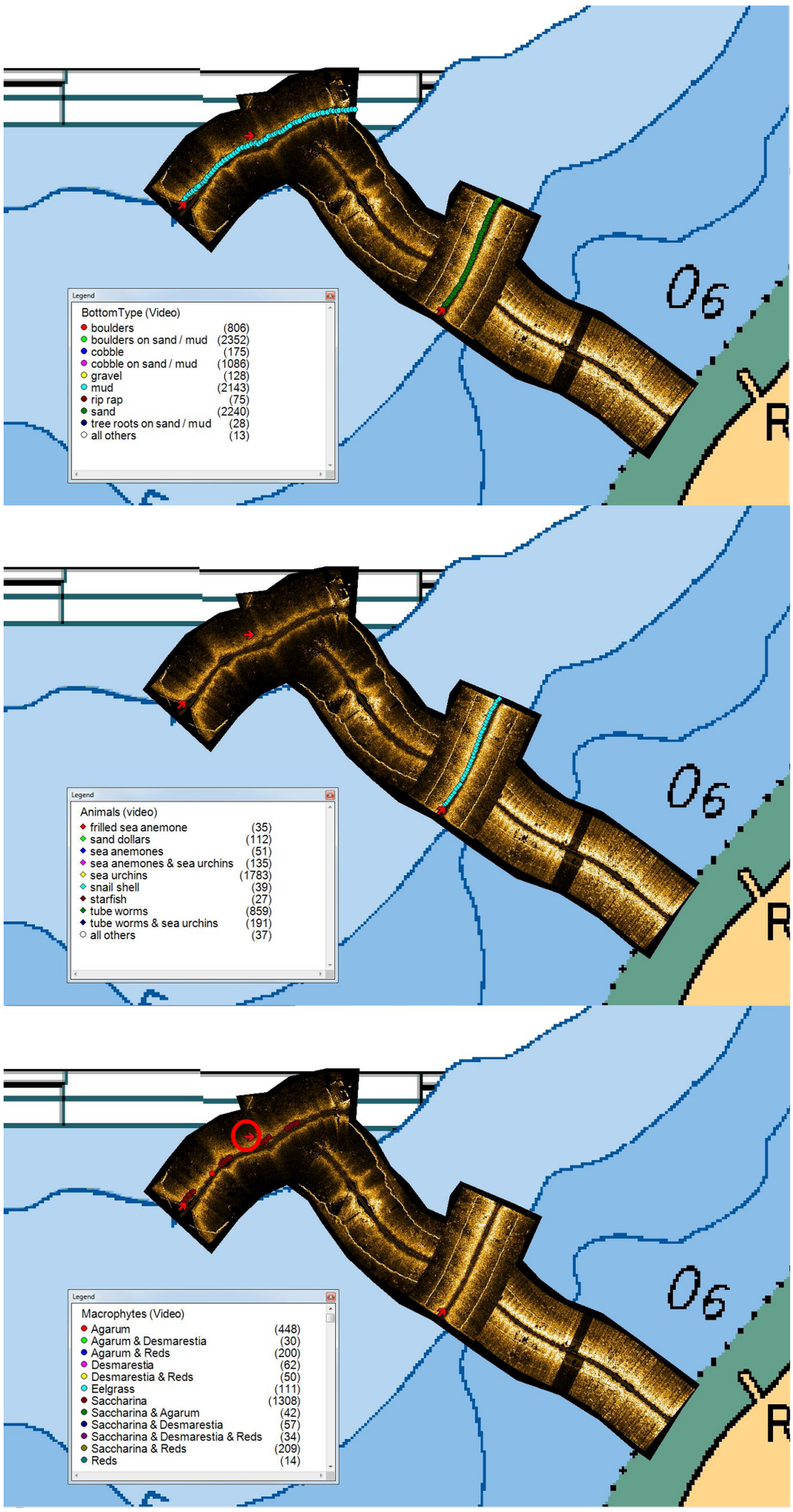


Figure 72: Transect IH32 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.626333N 63.537443W.

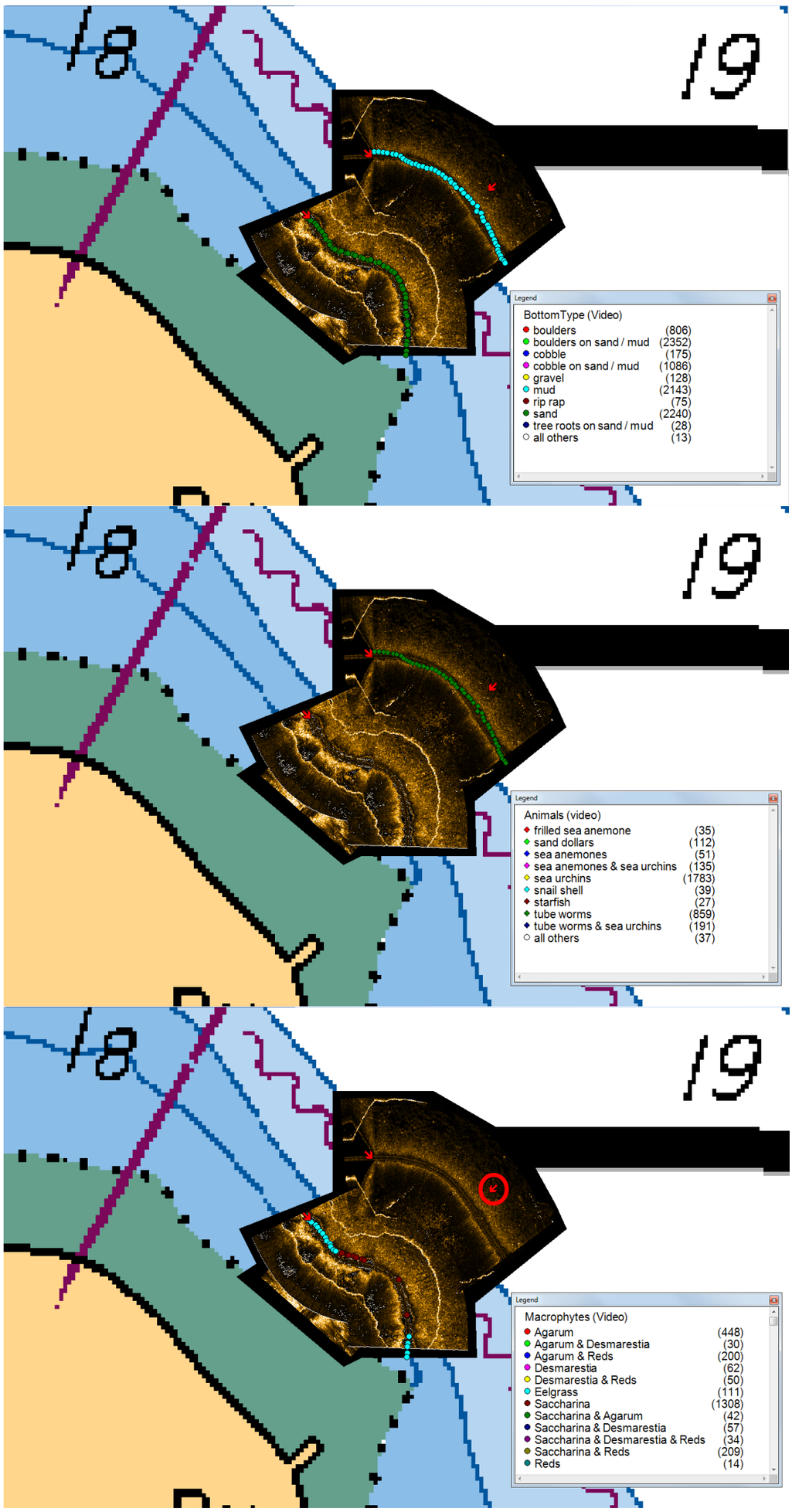


Figure 73: Transect IH33 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.627355N 63.528937W.

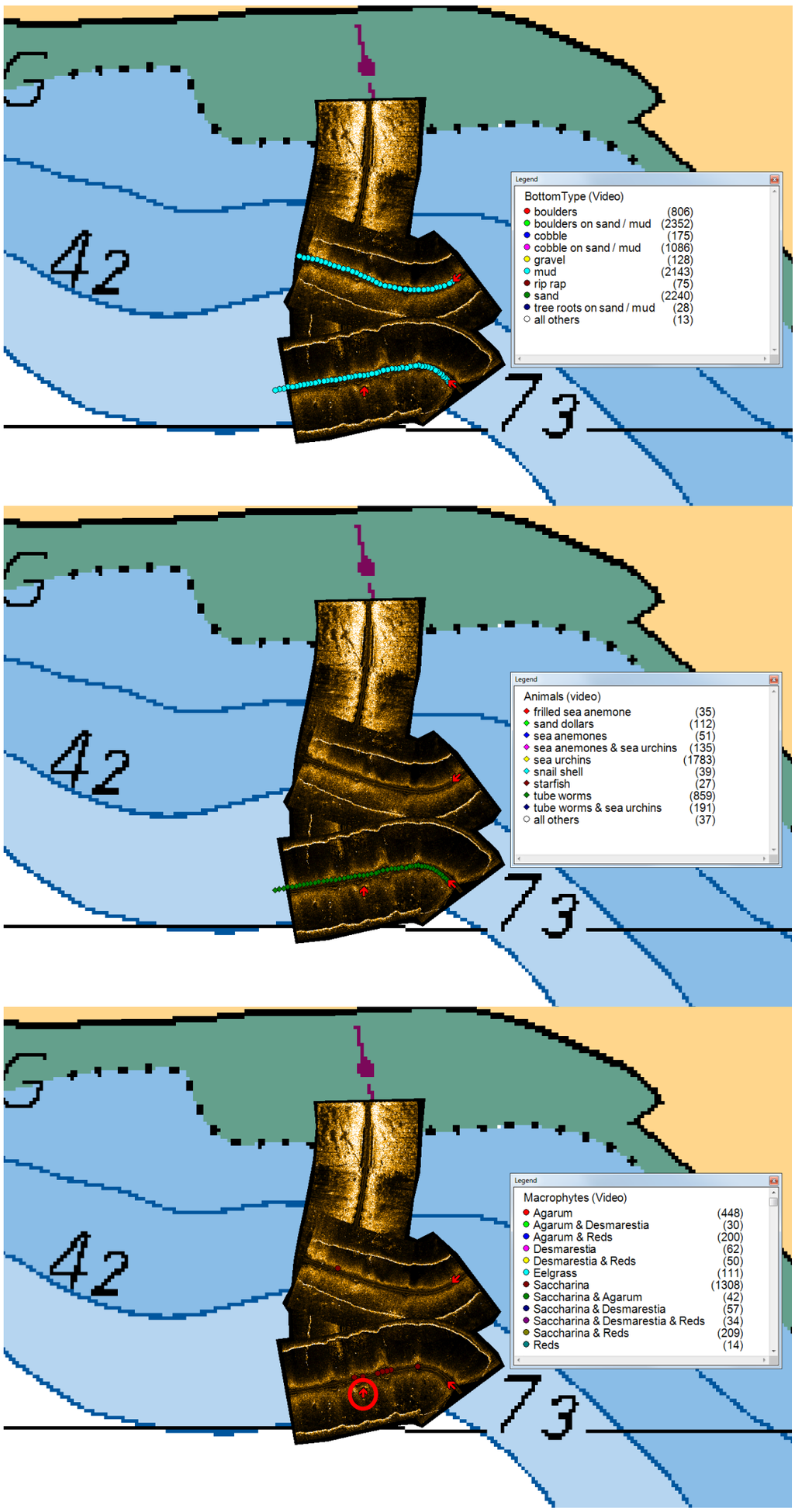


Figure 74: Transect IH34 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.633437N 63.528408W.

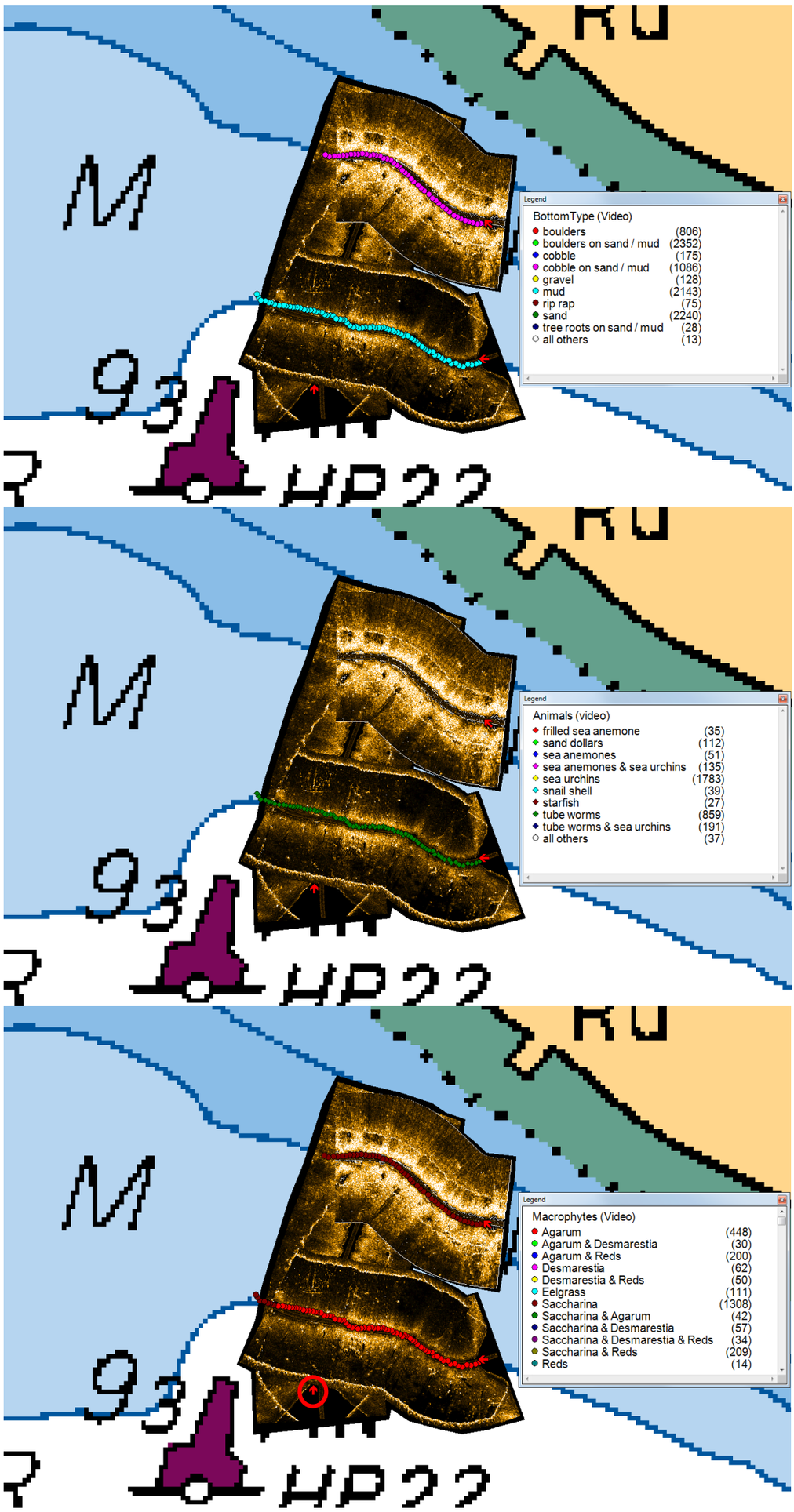


Figure 75: Transect IH35 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.634195N 63.532057W.

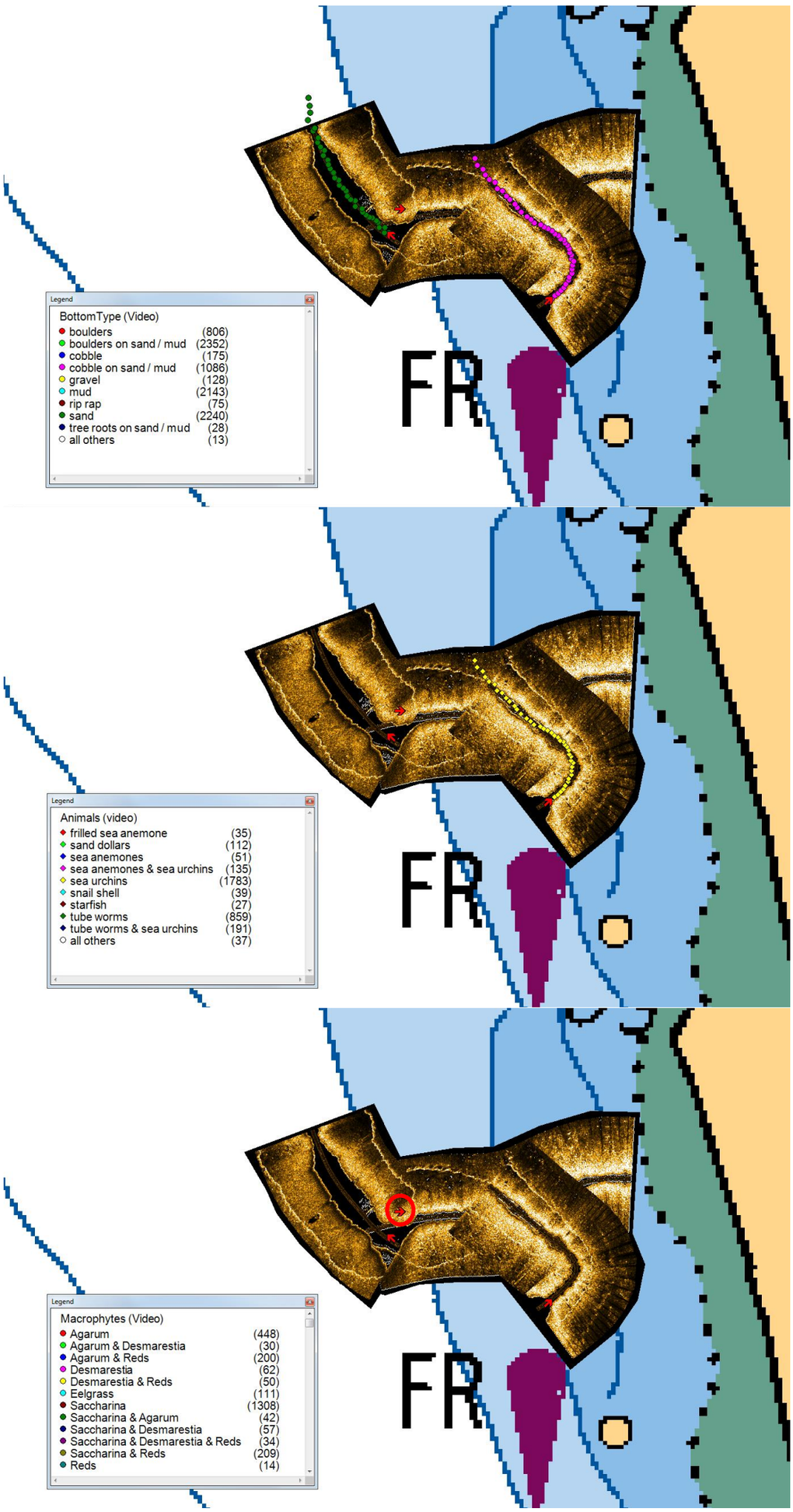


Figure 76: Transect IH36 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.641025N 63.543447W.

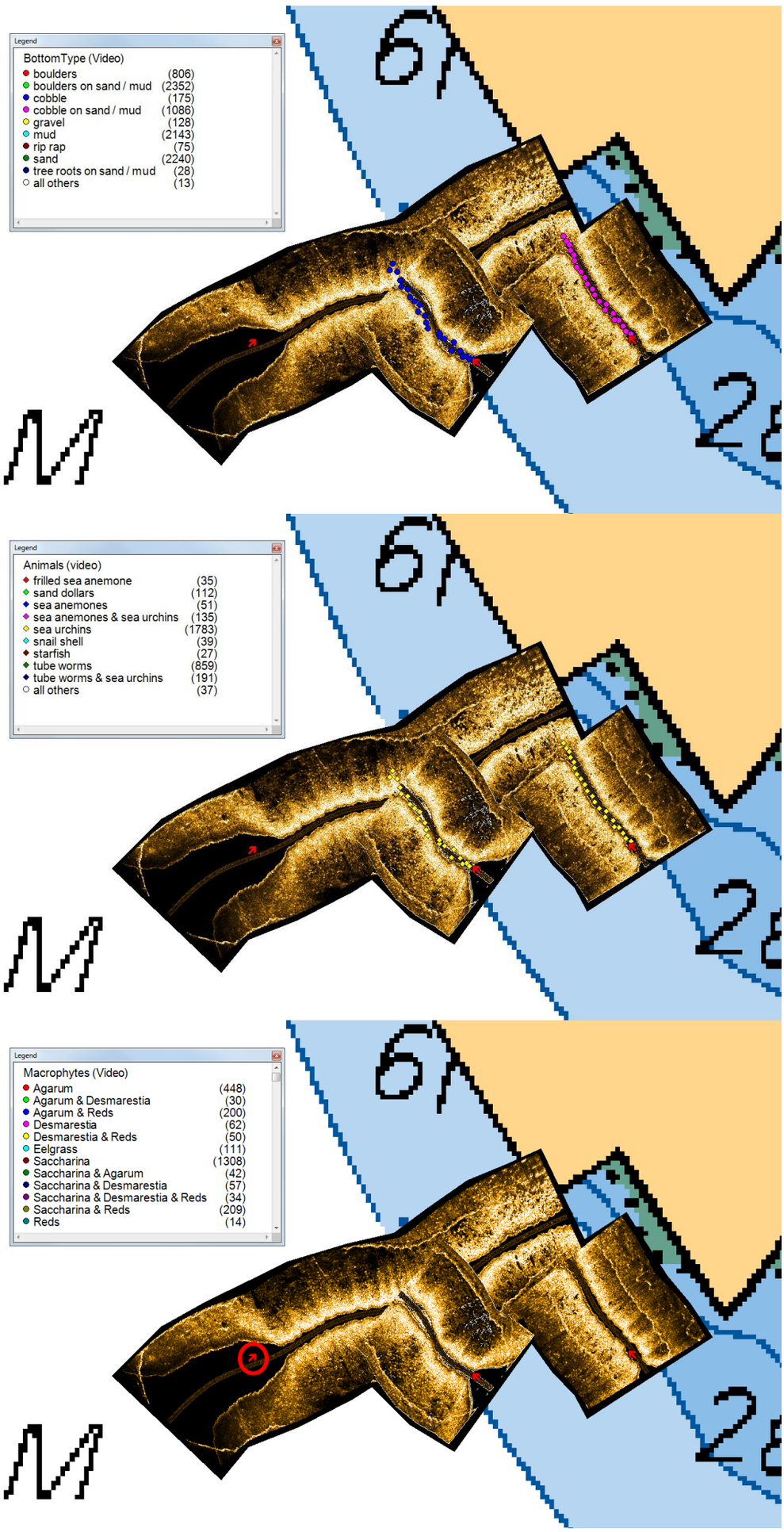


Figure 77: Transect IH37 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.645125N 63.547025W.

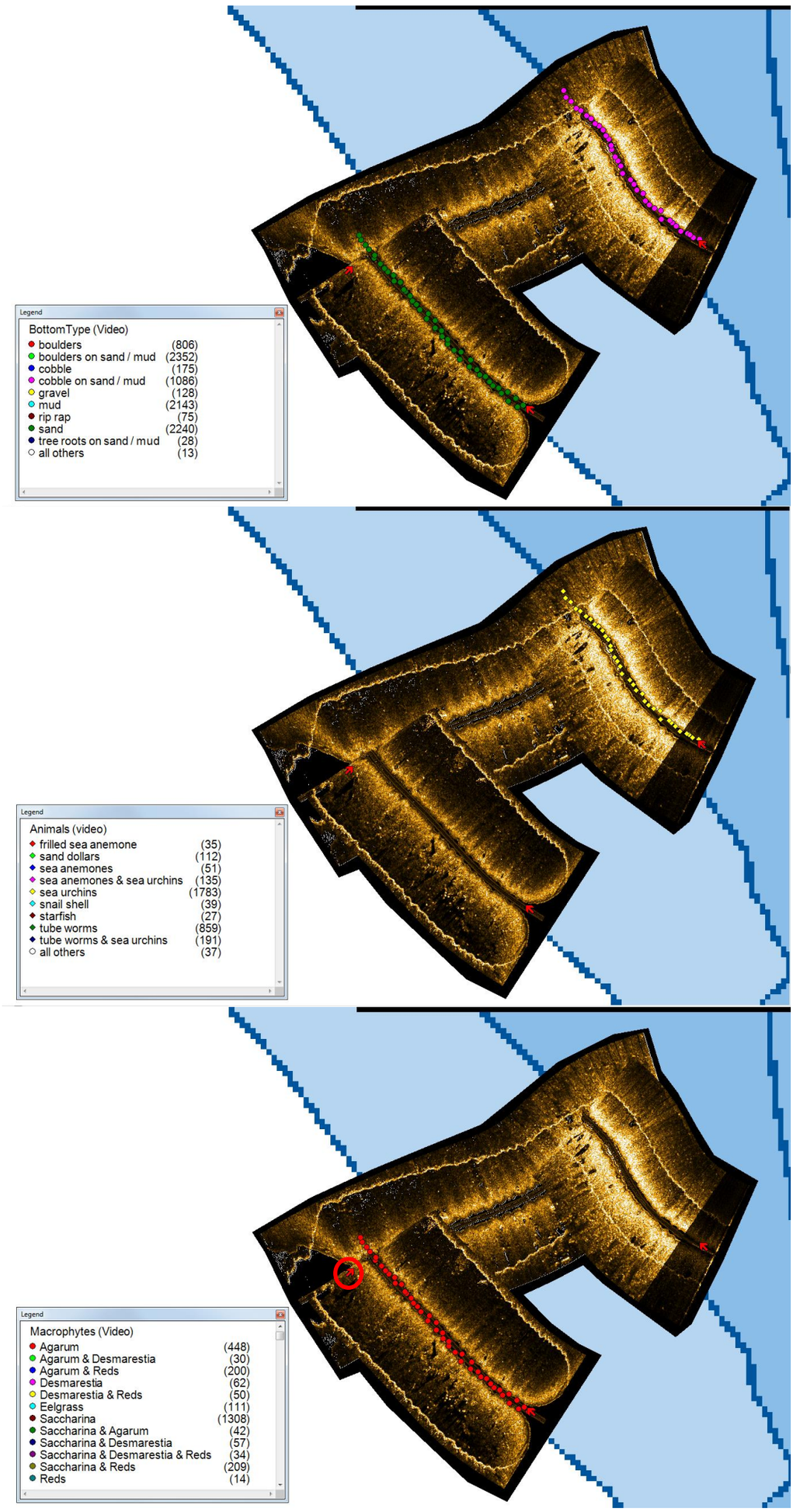


Figure 78: Transect IH38 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.649550N 63.551380W.

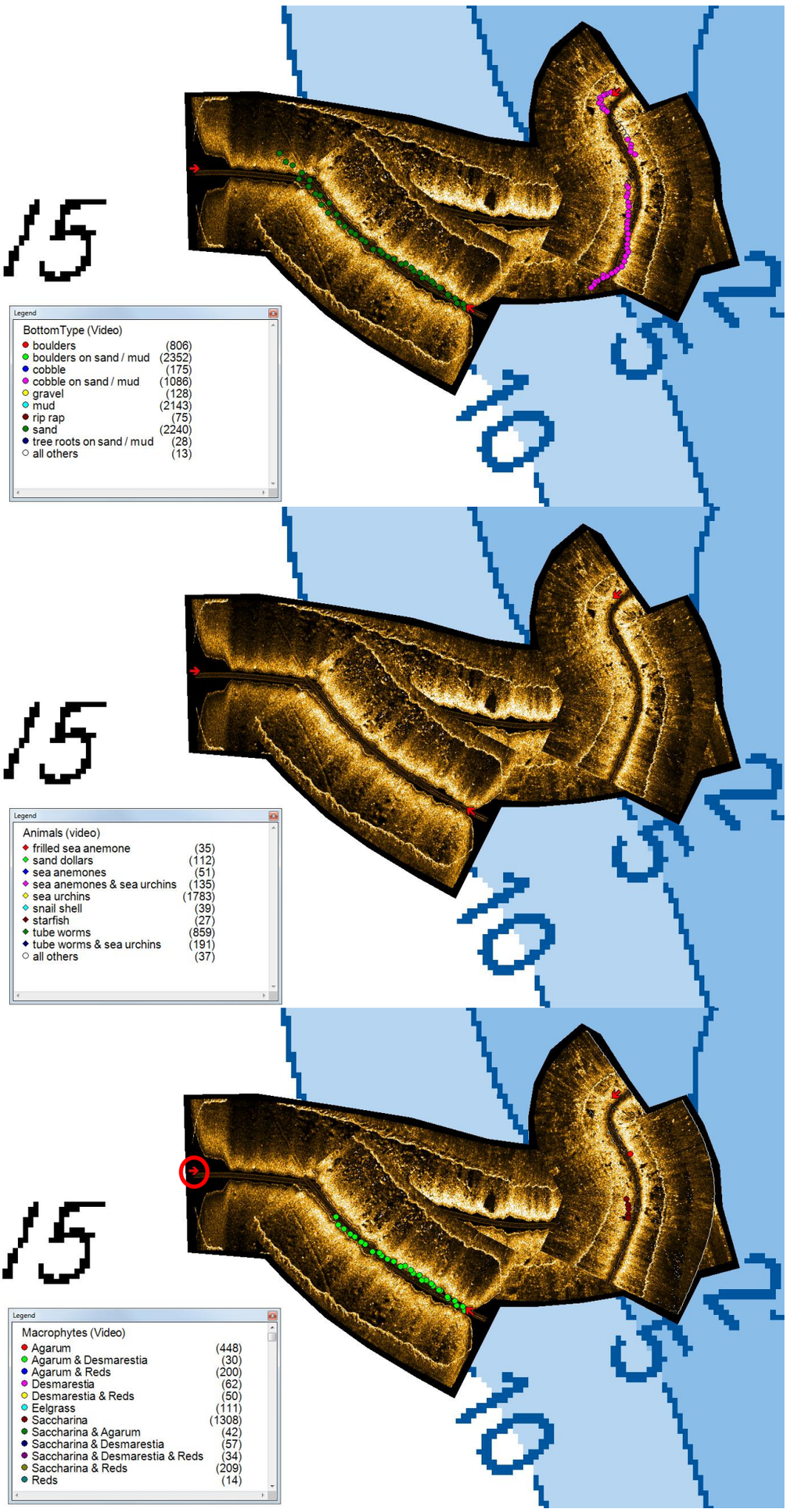


Figure 79: Transect IH39 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.654625N 63.555432W.

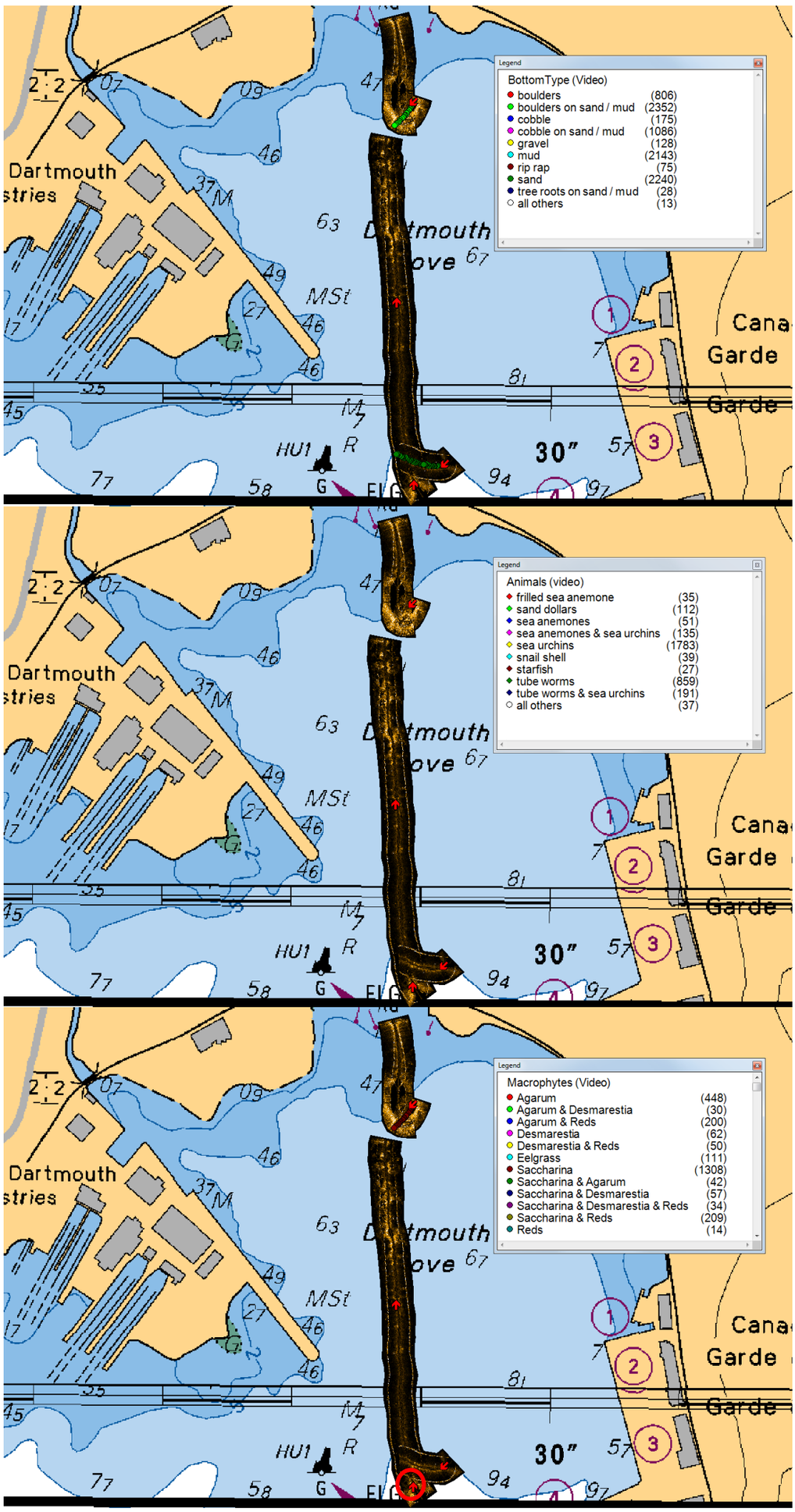


Figure 80: Transect IH40 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.661117N 63.560078W.

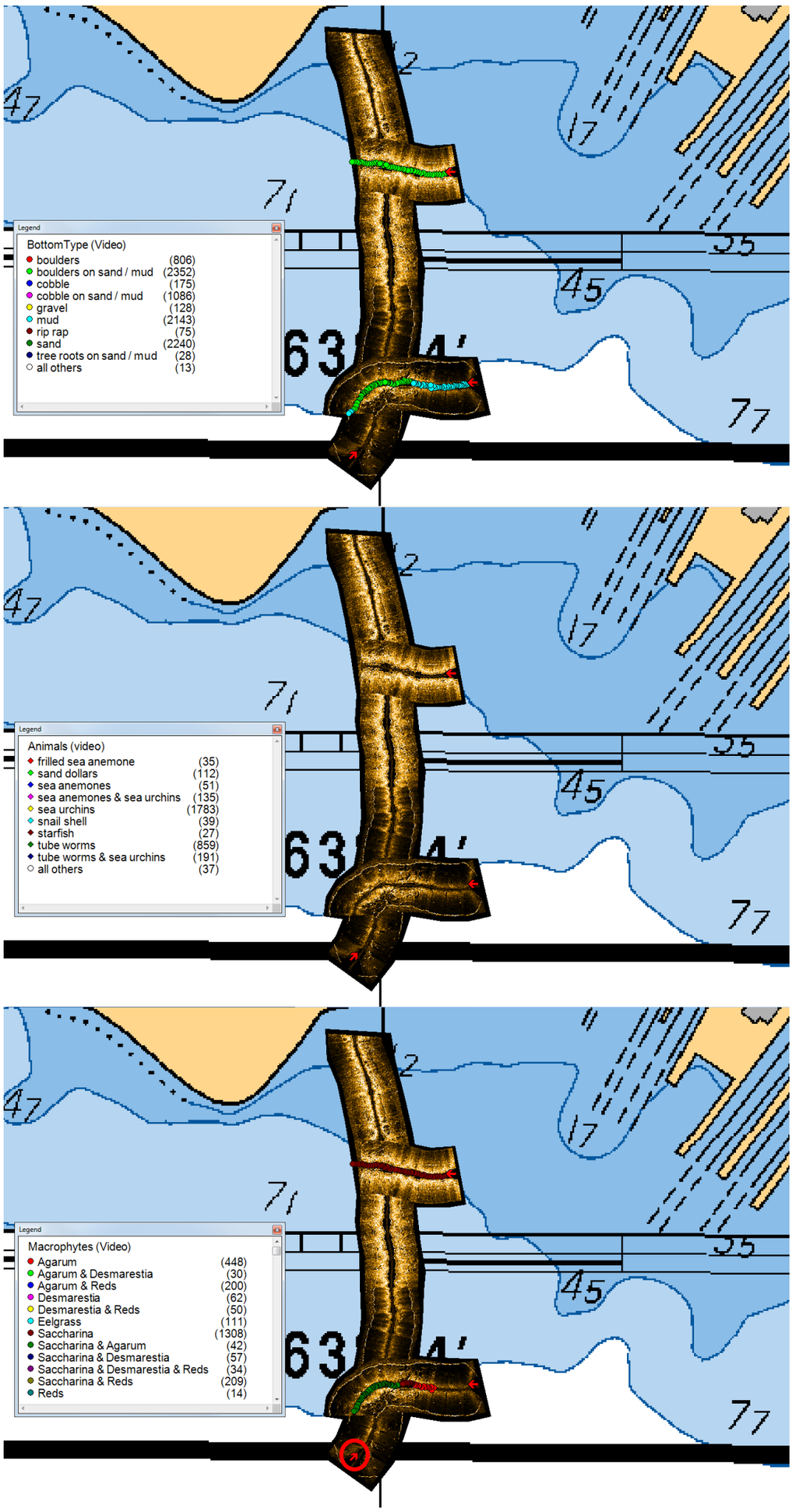


Figure 81: Transect IH41 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.660912N 63.566835W.

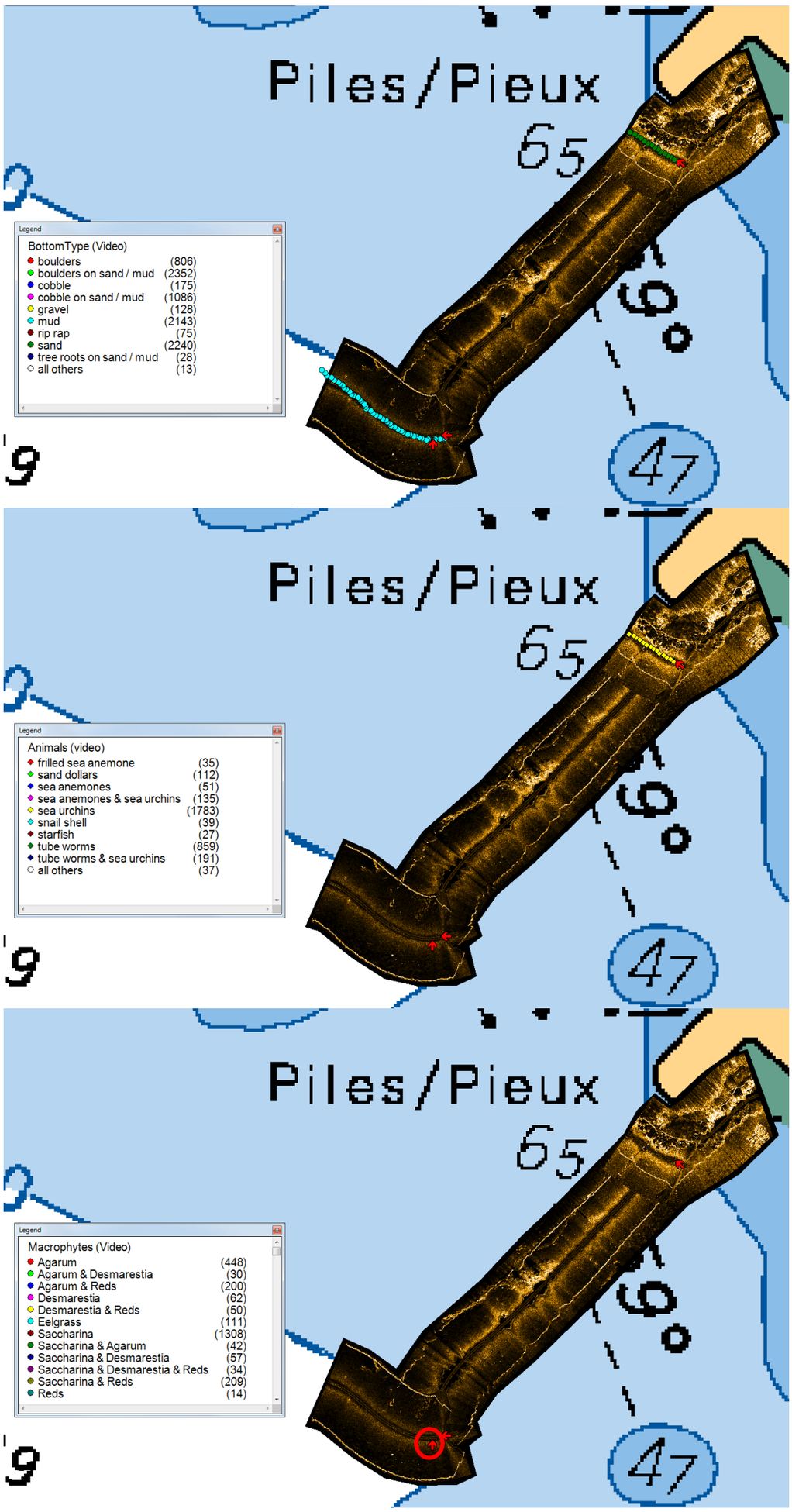


Figure 82: Transect IH42 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.663247N 63.573290W.

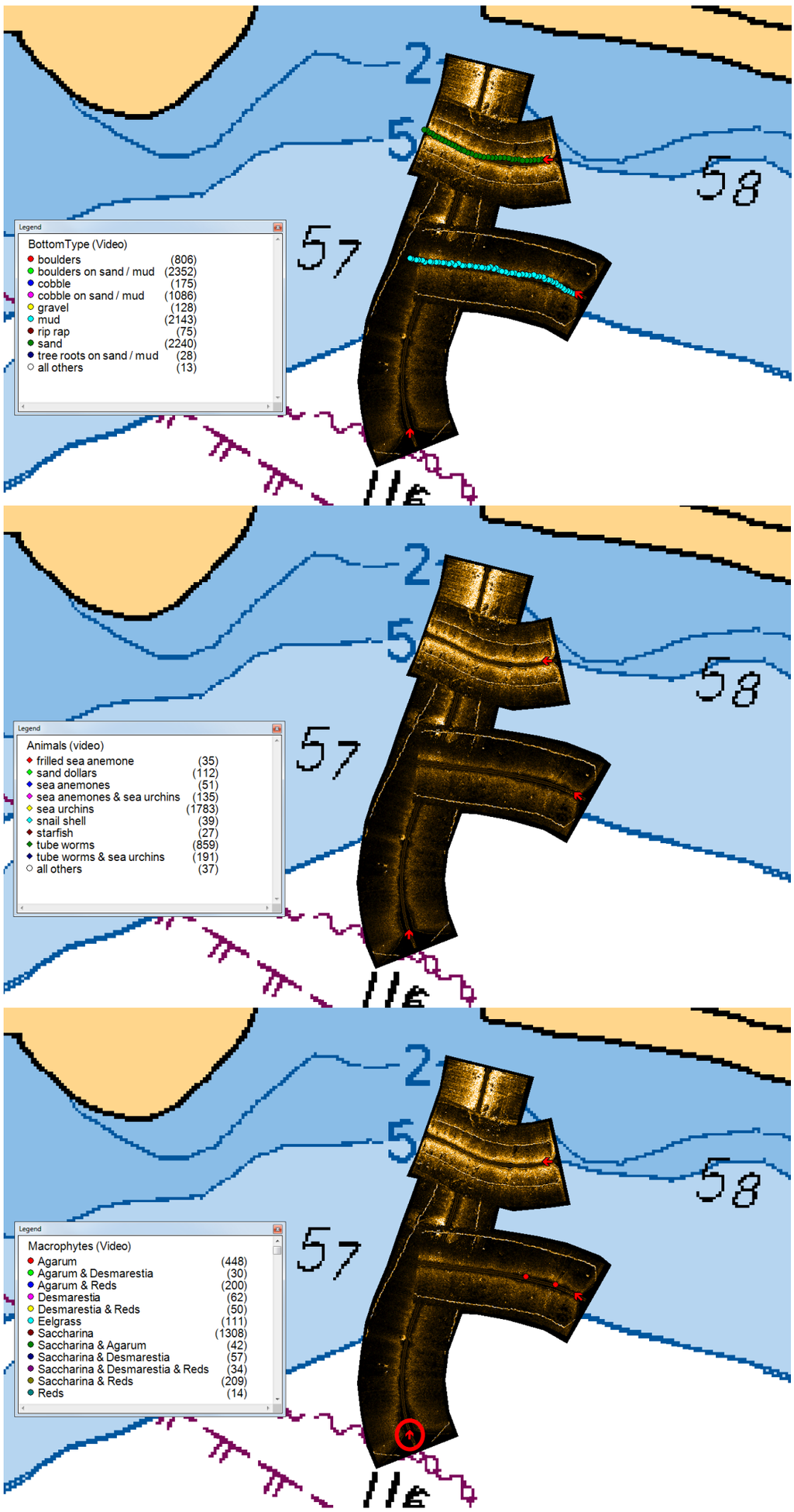


Figure 83: Transect IH43 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.664648N 63.579313W.

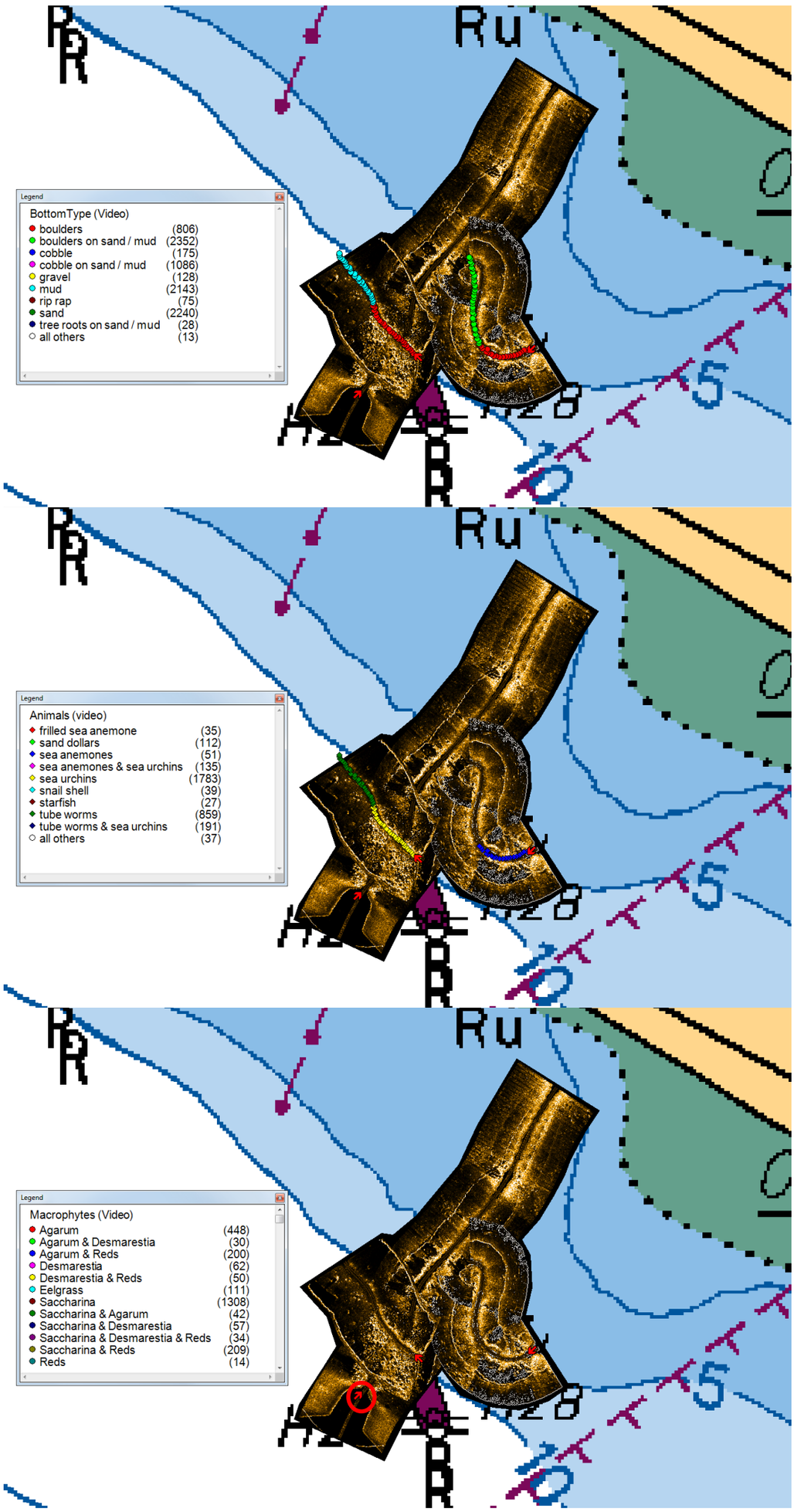


Figure 84: Transect IH44 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.669743N 63.590105W.

Figure 85: Transect IH45 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.674128N 63.595117W.

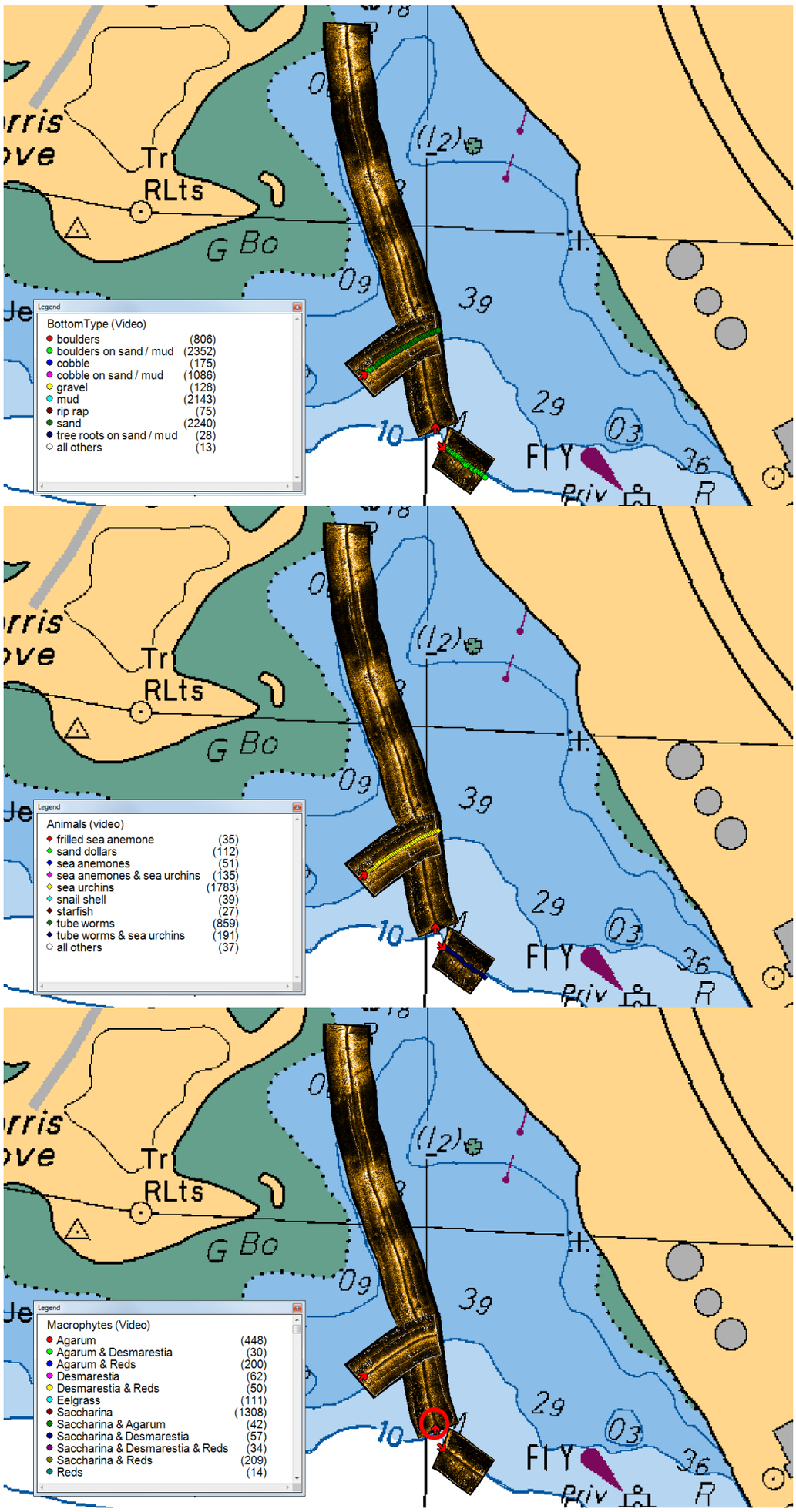


Figure 86: Transect IH46 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.676748N 63.599890W.

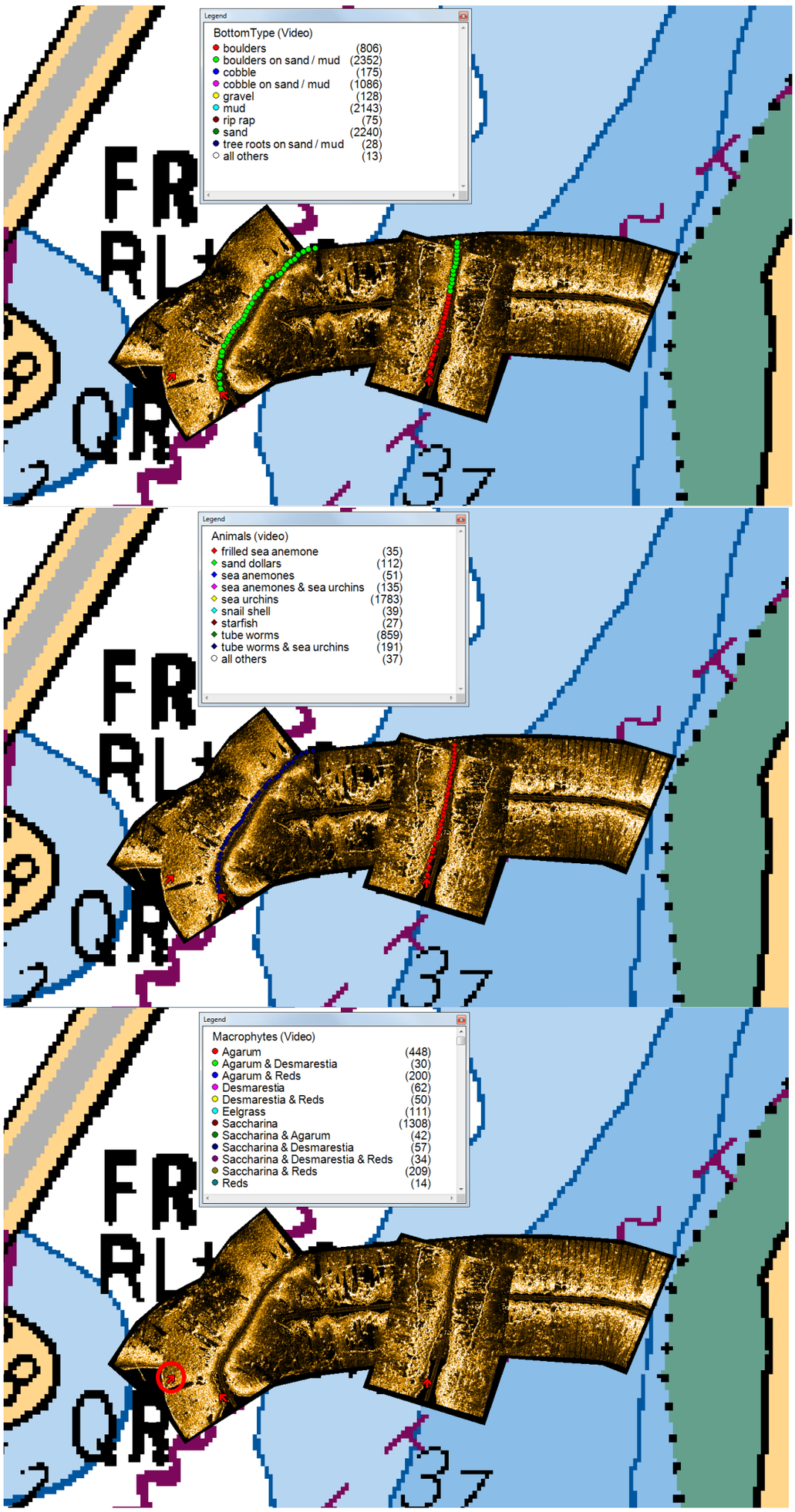


Figure 87: Transect IH47 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.678845N 63.610088W.

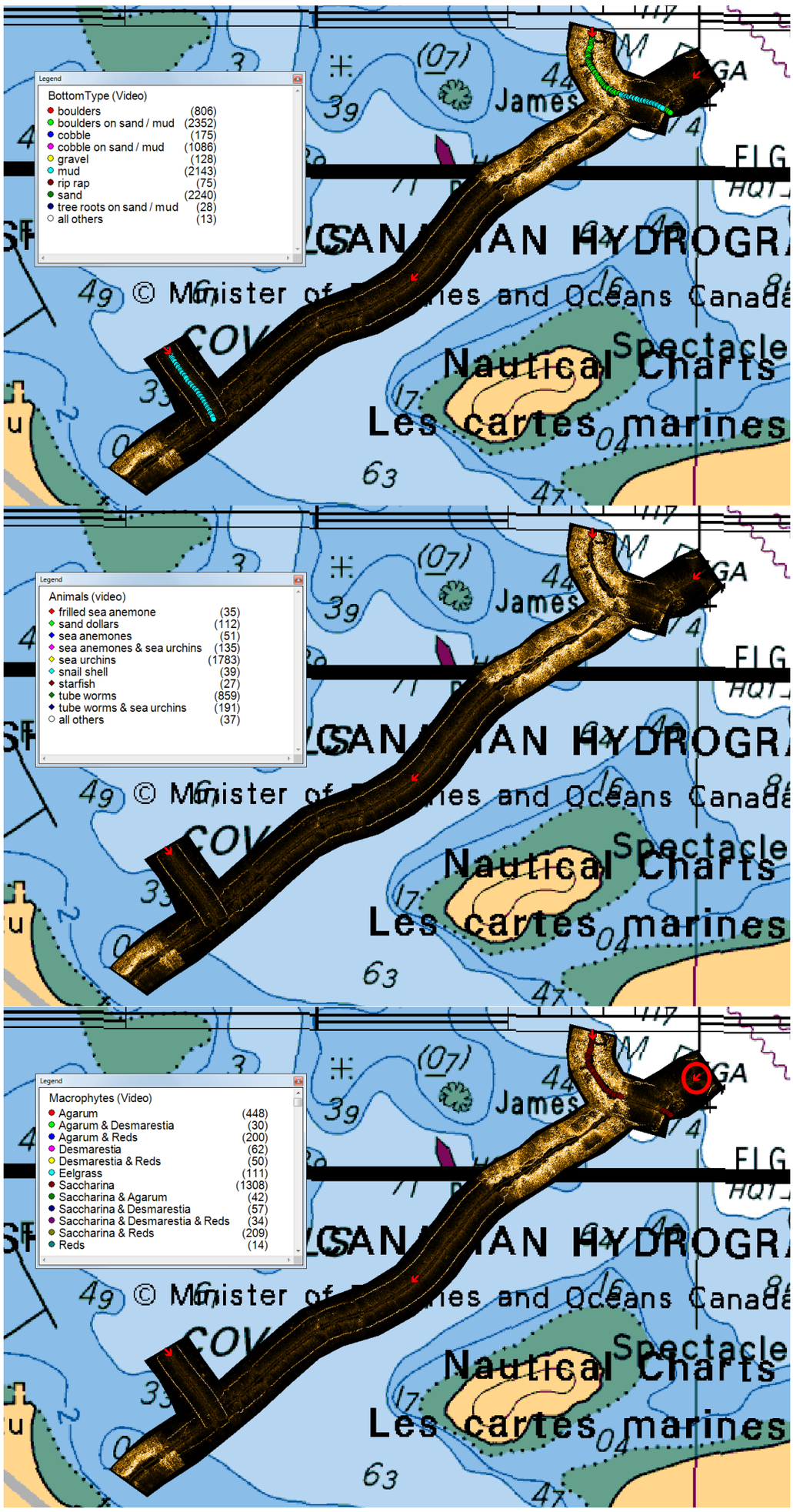


Figure 88: Transect OH01 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.612398N 63.566663W.

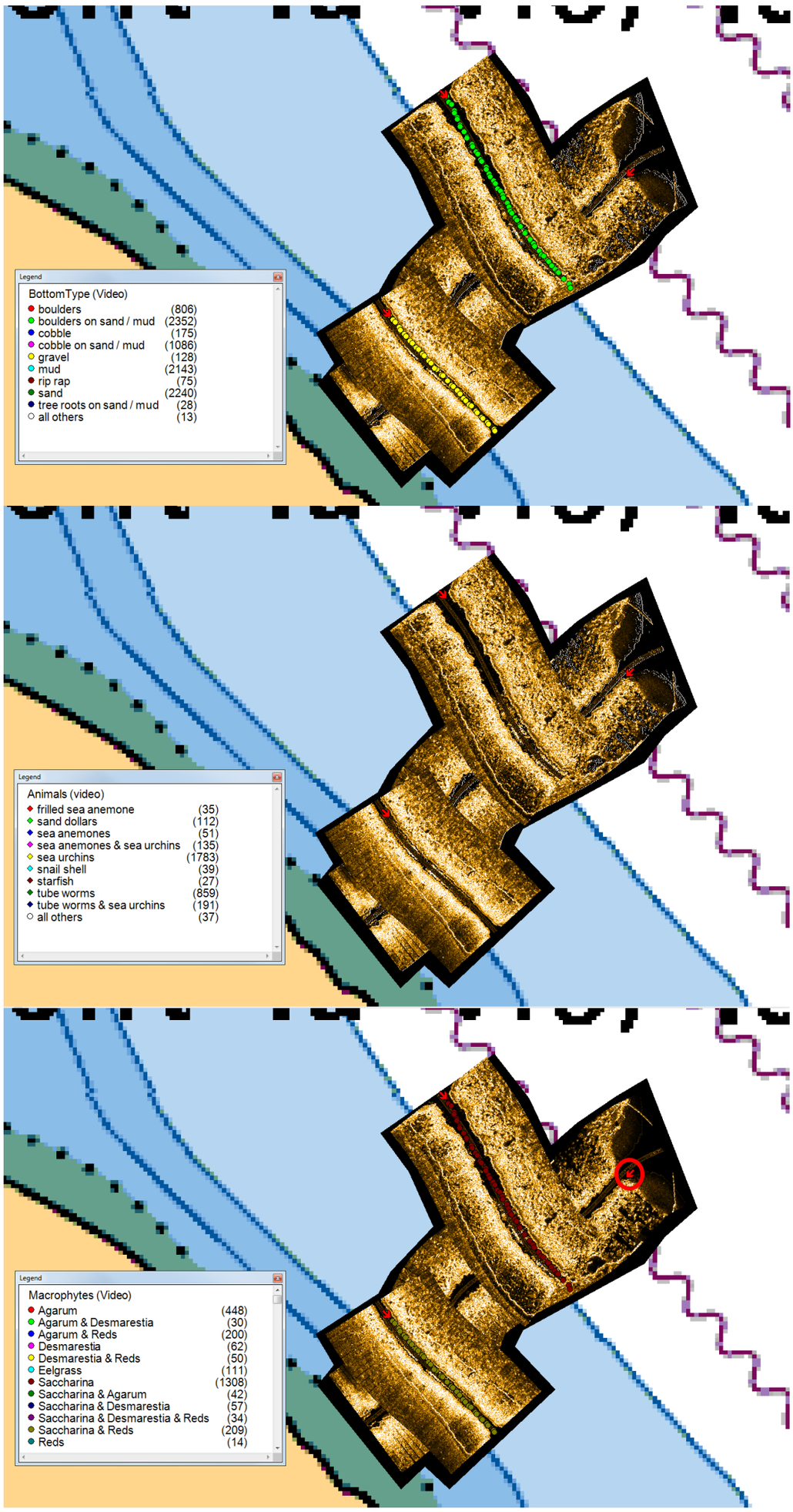


Figure 89: Transect OH02 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.609815N 63.562480W.

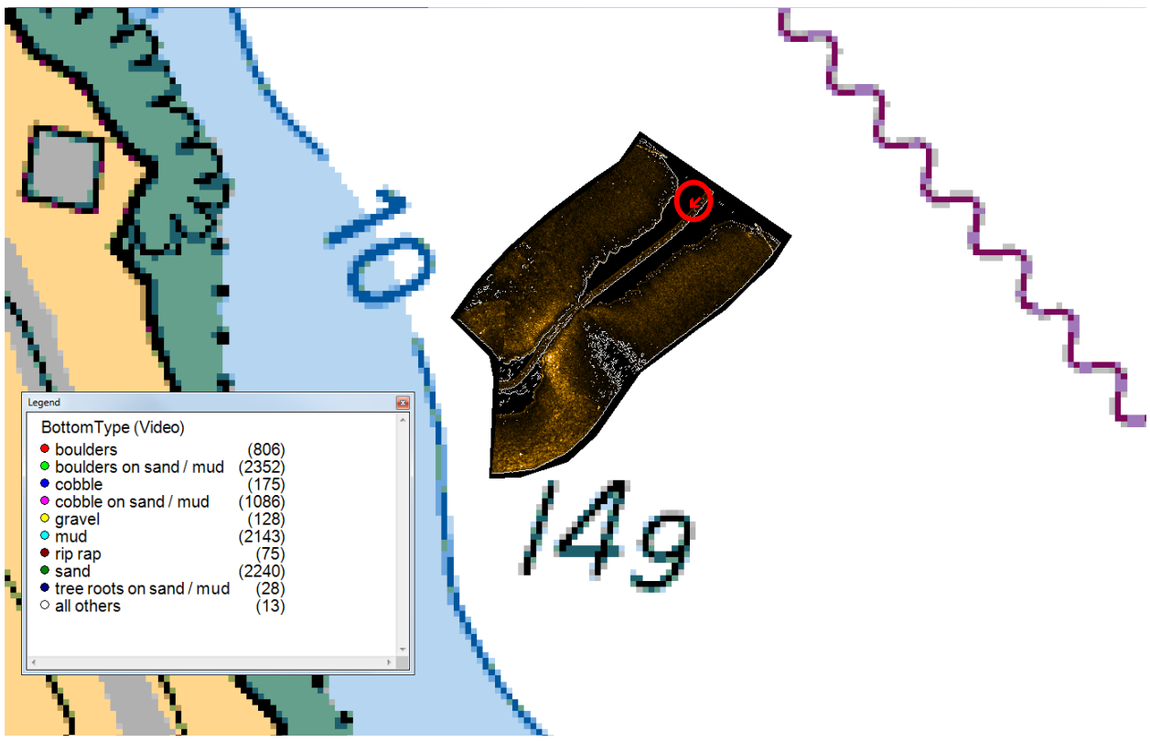


Figure 90: Transect OH03 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.605565N 63.557898W.

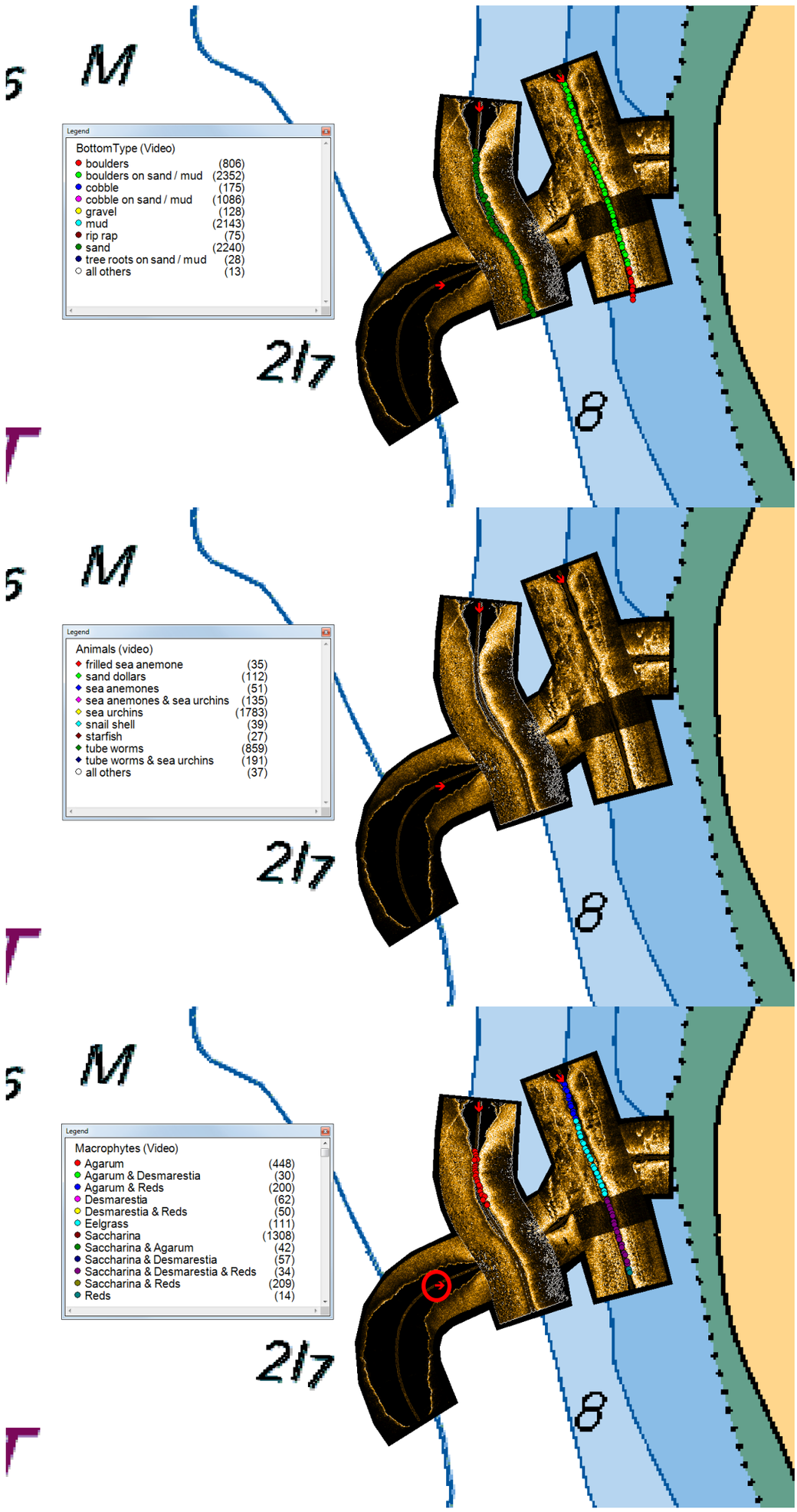


Figure 91: Transect OH04 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.621762N 63.544013W.

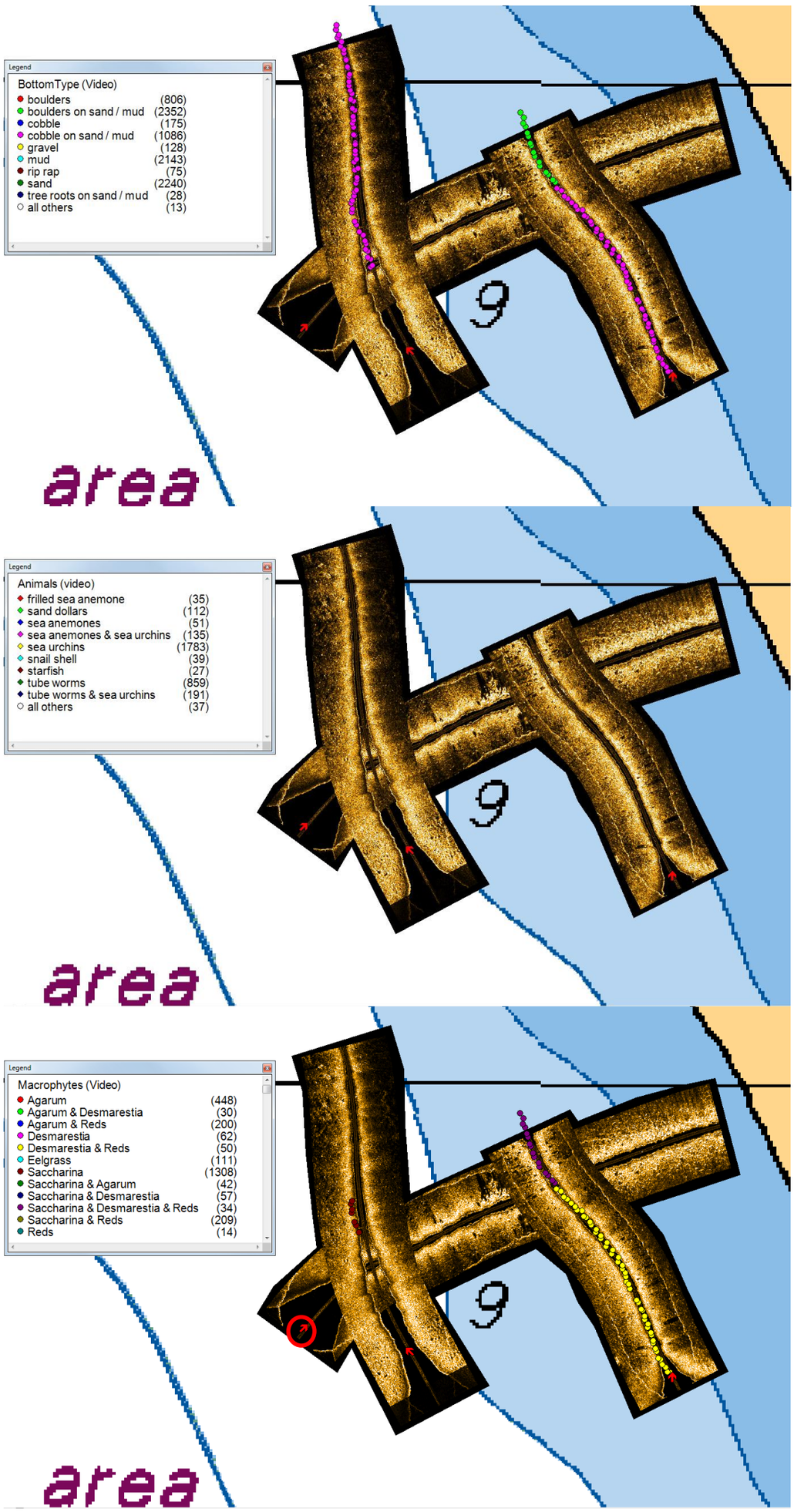


Figure 92: Transect OH05 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.615930N 63.541543W.

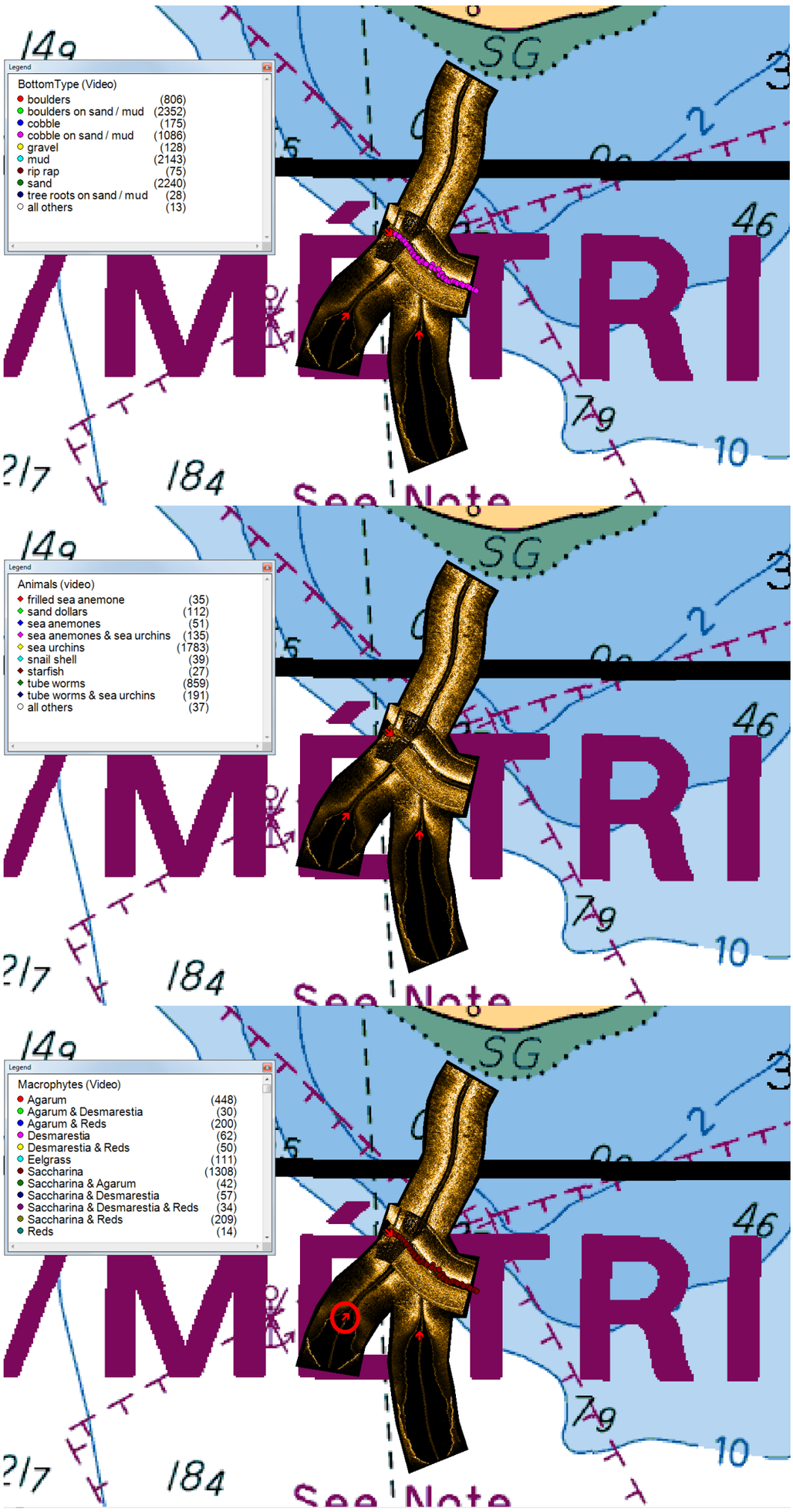


Figure 93: Transect OH06 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.611075N 63.536357W.

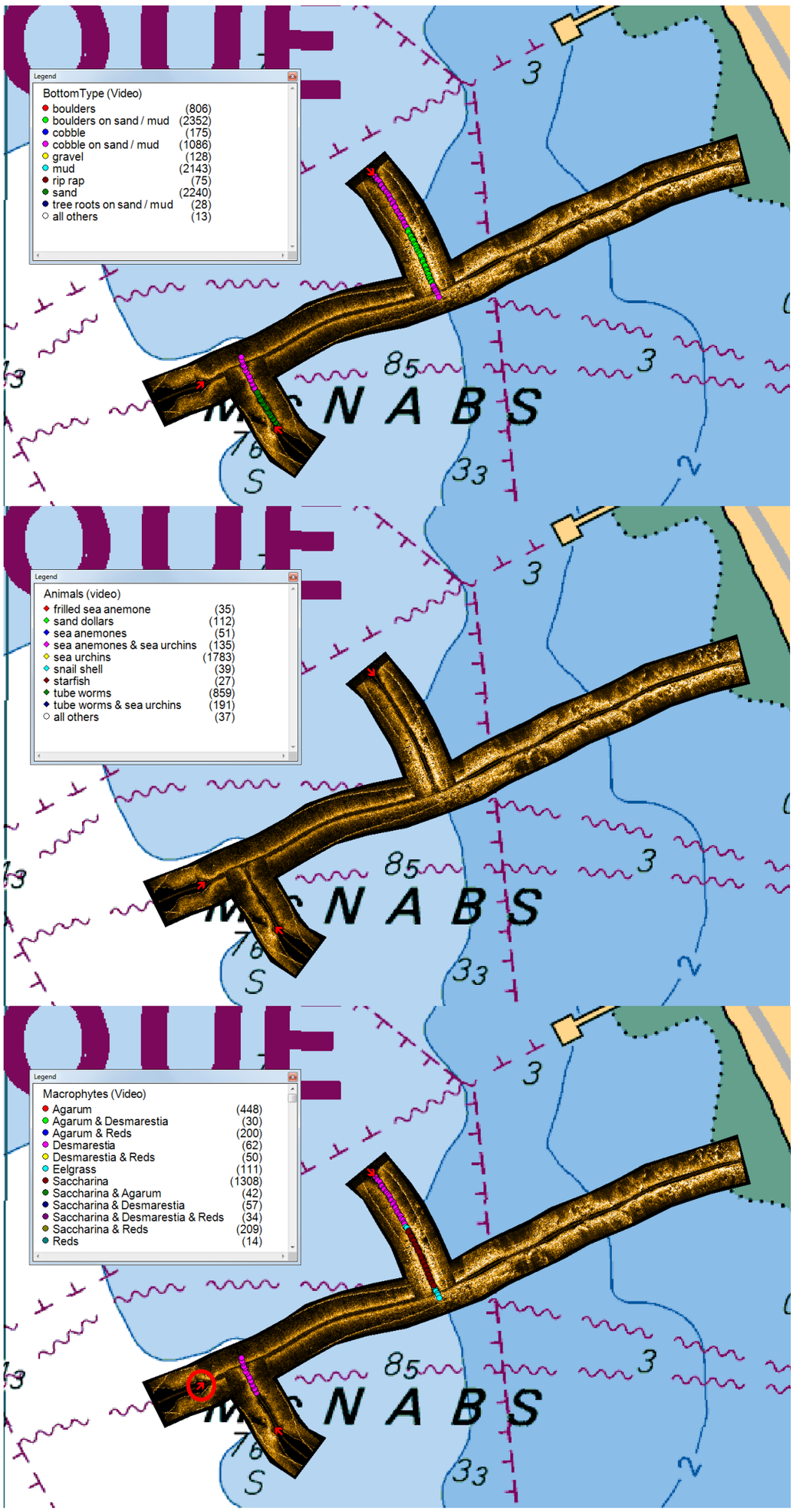


Figure 94: Transect OH07 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.609038N 63.531632W.

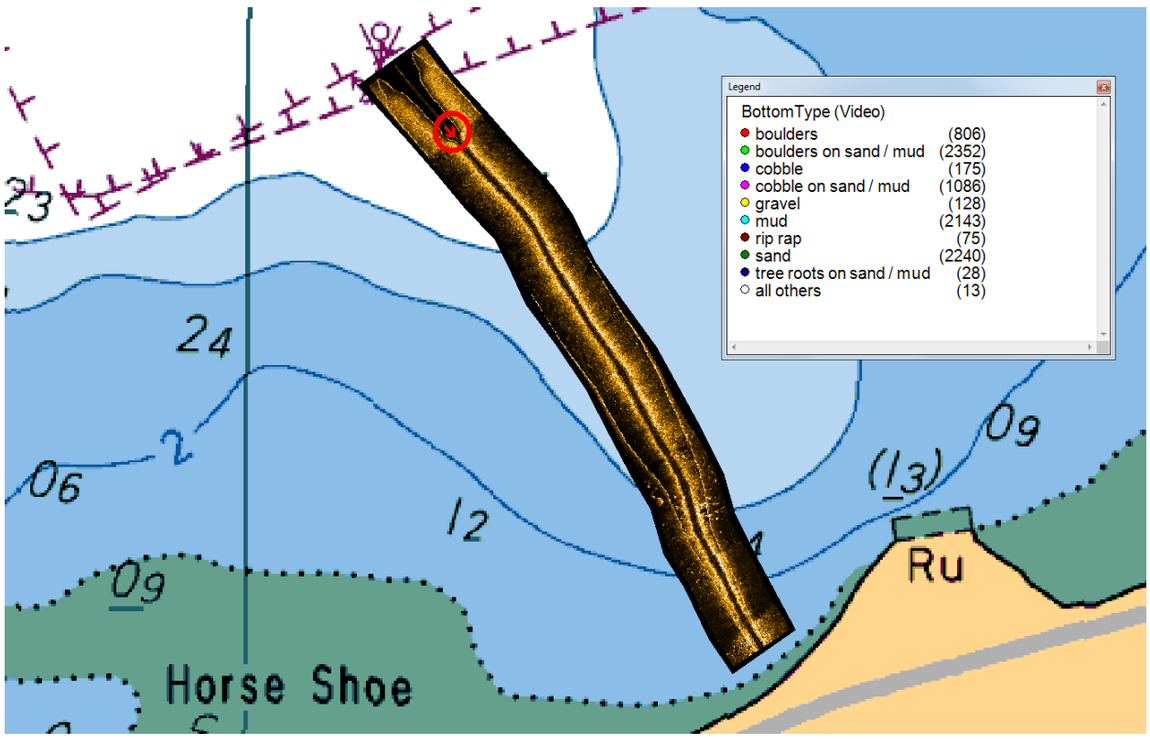


Figure 95: Transect OH08 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.605595N 63.532215W.

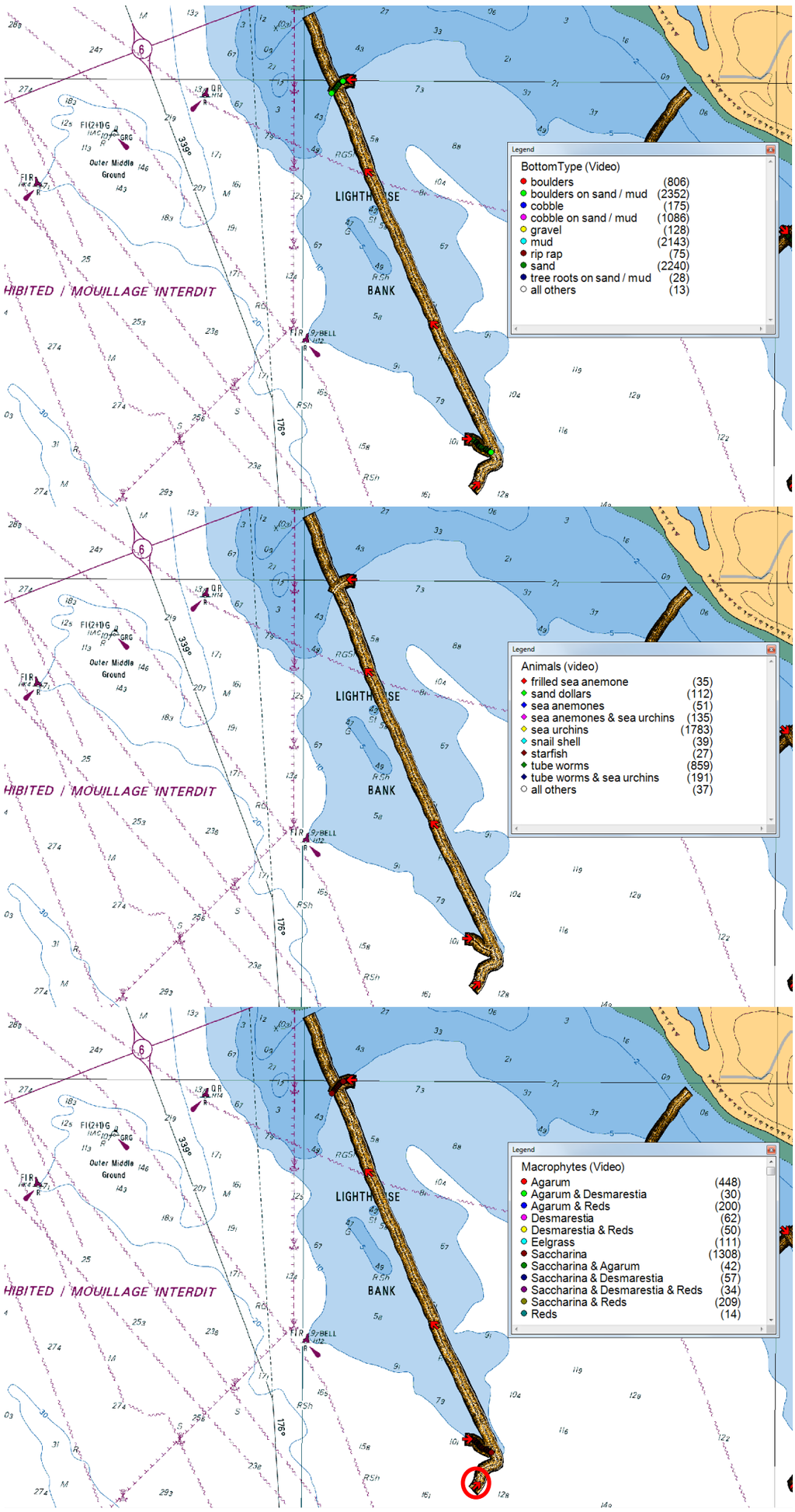


Figure 96: Transect OH09 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.589853N 63.527162W.

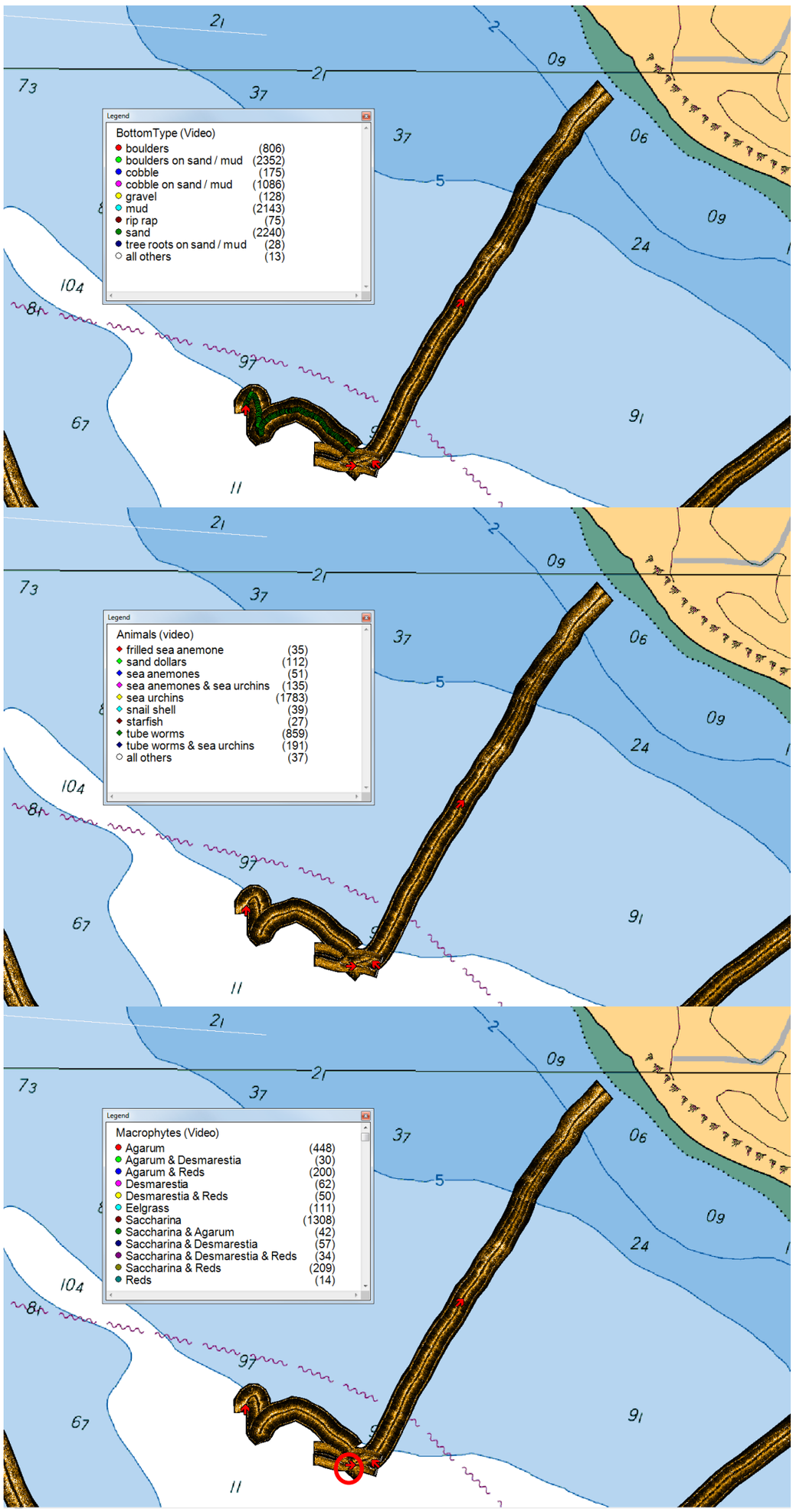


Figure 97: Transect OH10 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.595402N 63.523893W.

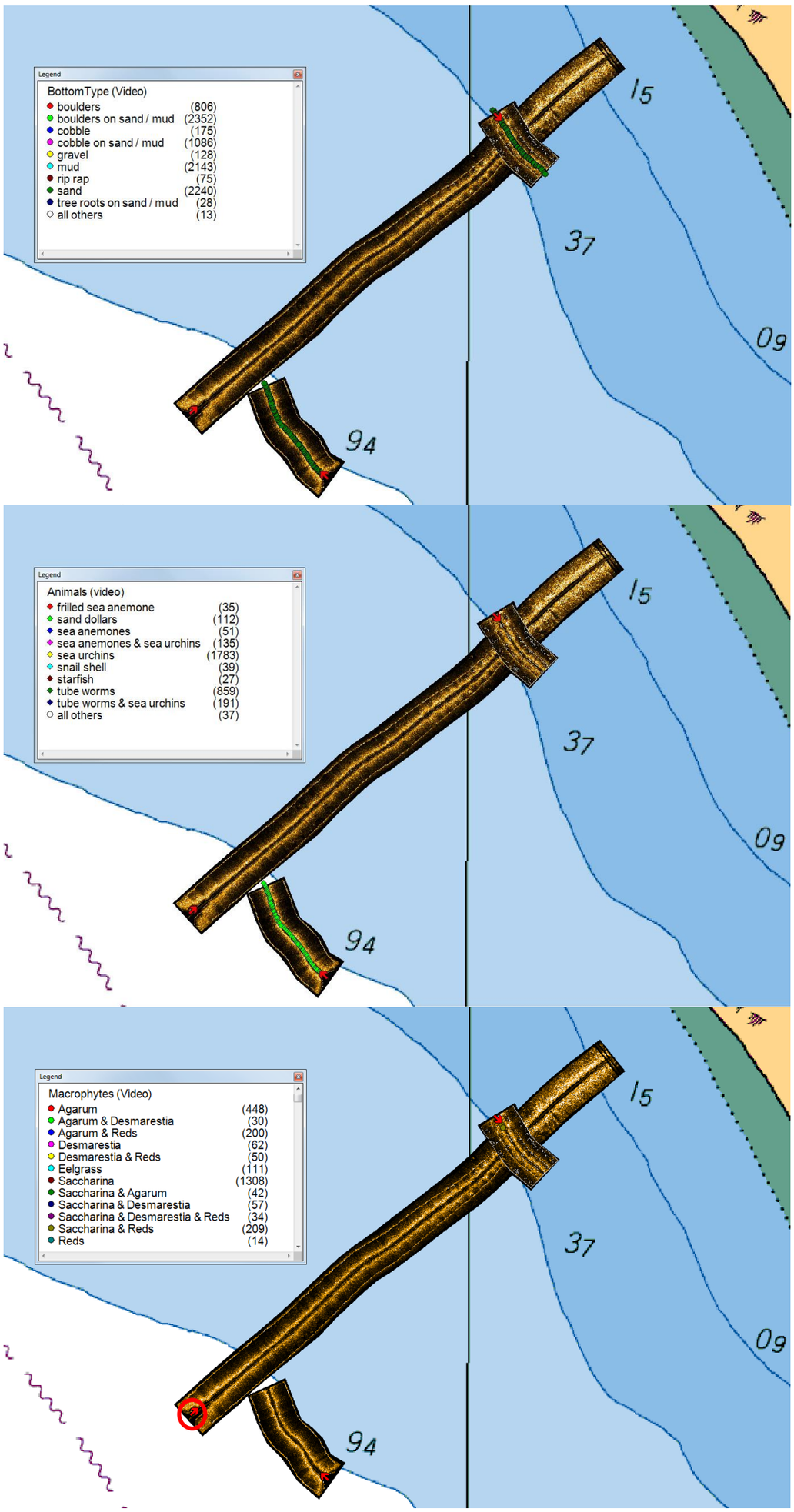


Figure 98: Transect OH11 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.594287N 63.519303W.

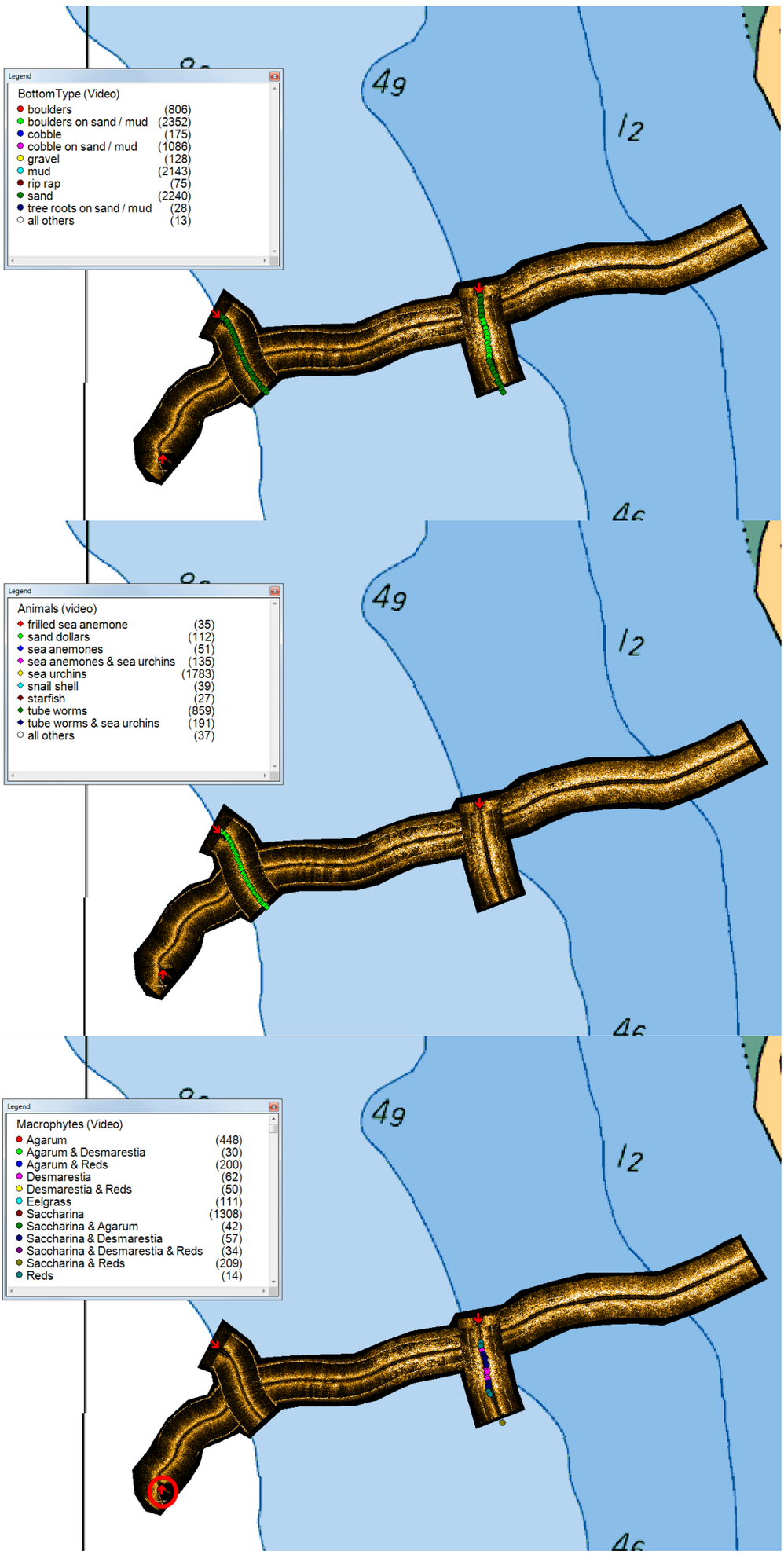


Figure 99: Transect OH12 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.589897N 63.515965W.

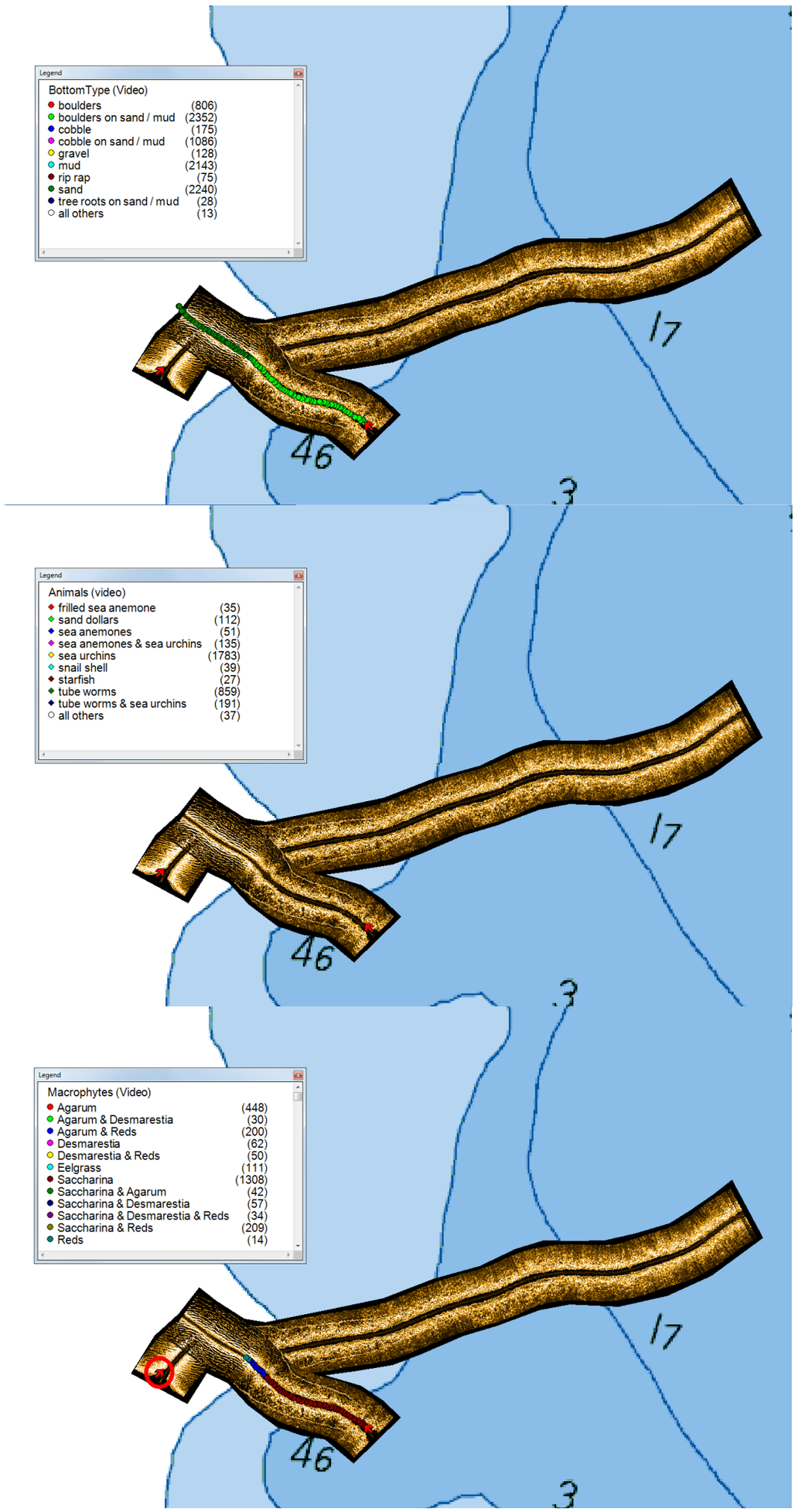


Figure 100: Transect OH13 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.585395N 63.514132W.

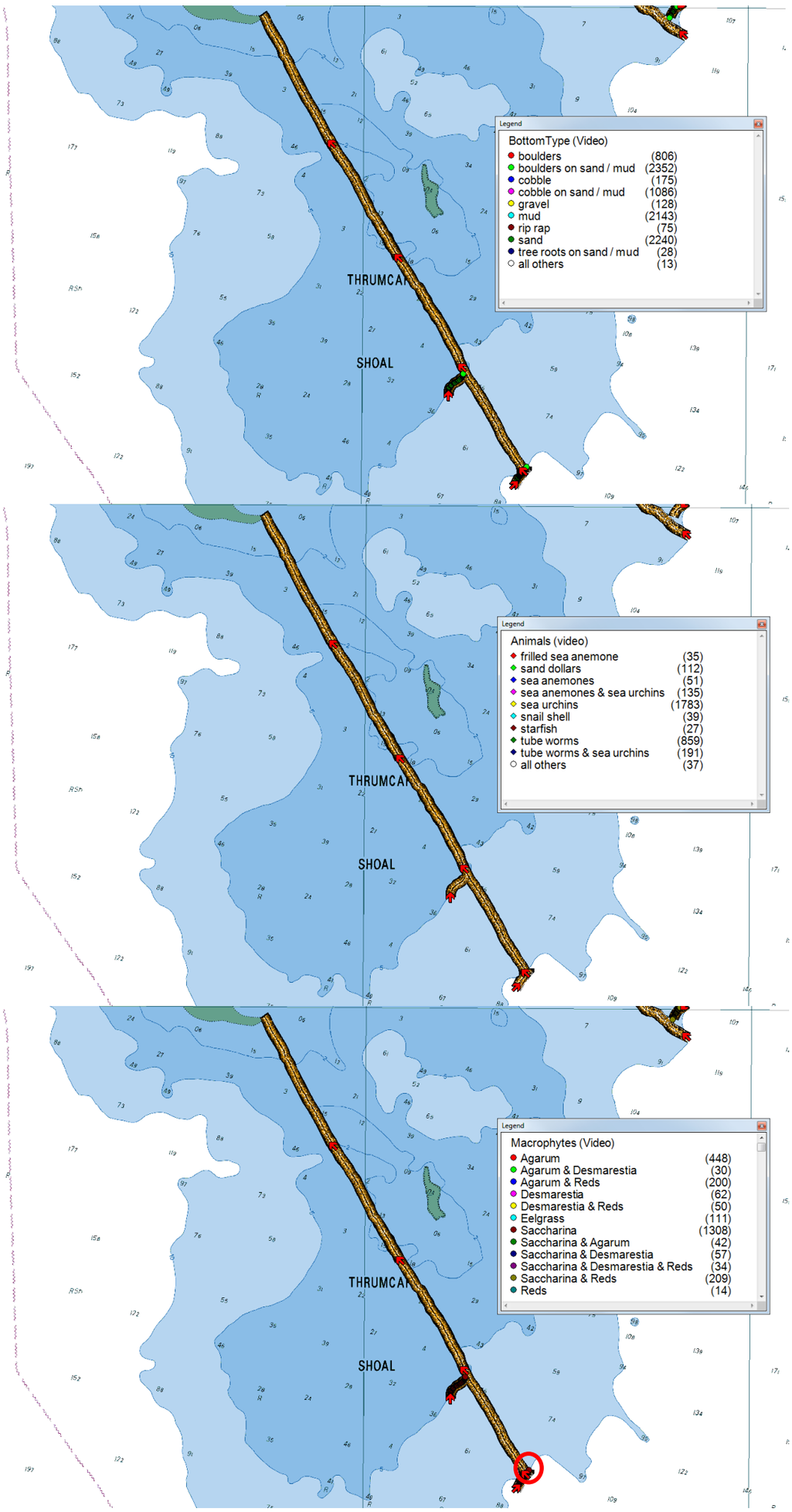


Figure 101: Transect OH14 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.568938N 63.492985W.

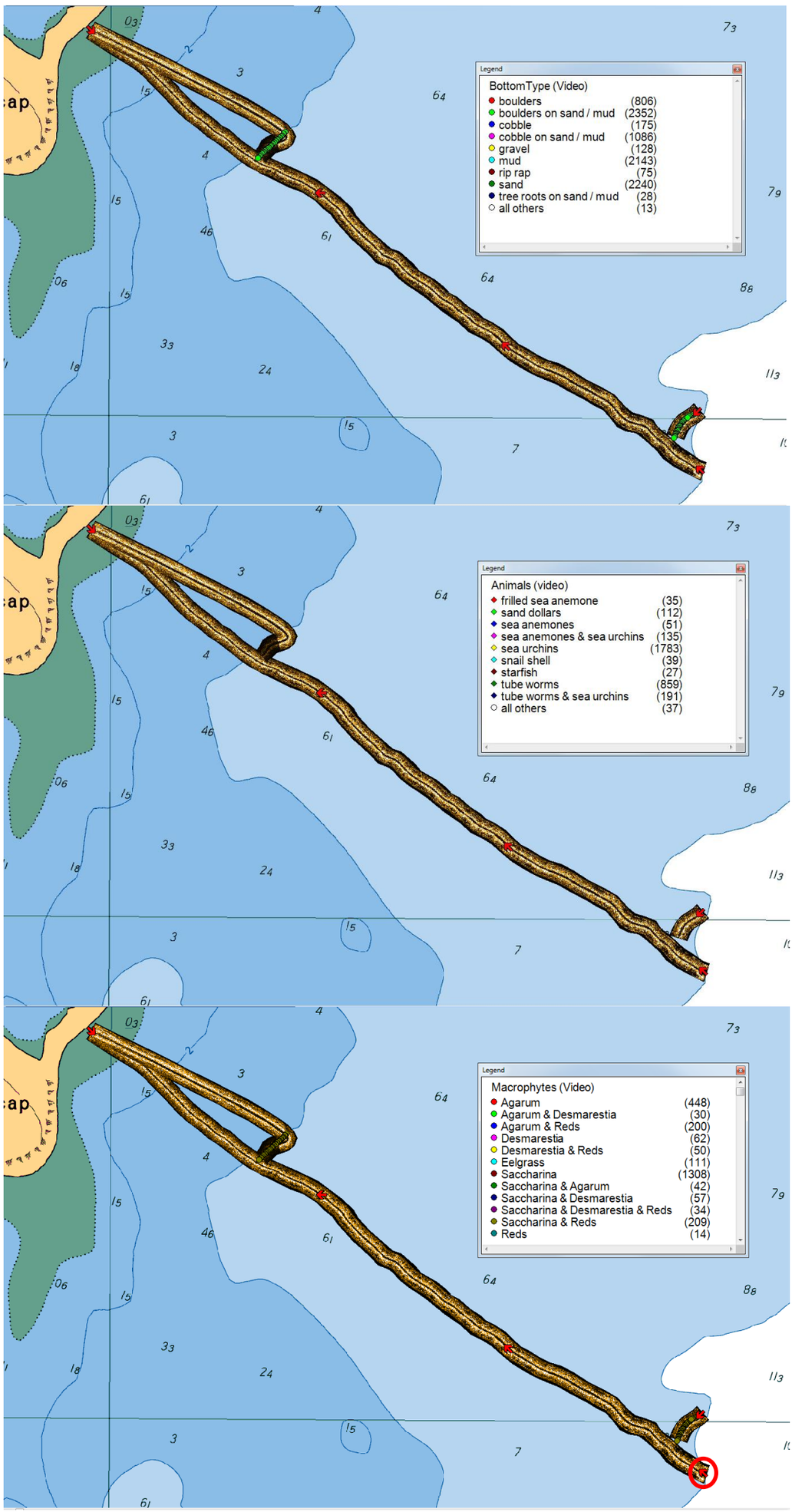


Figure 102: Transect OH15 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.582492N 63.486128W.

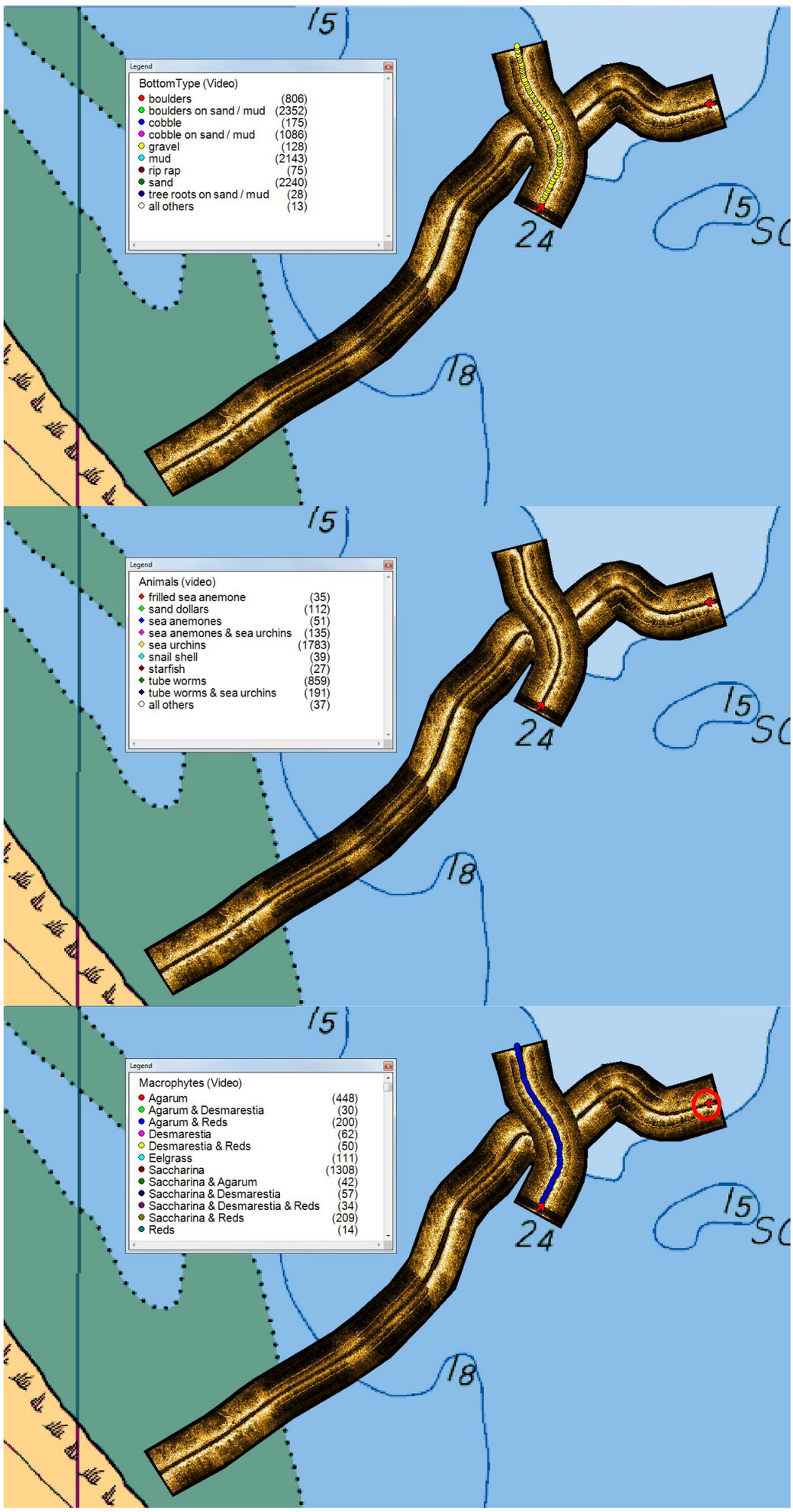


Figure 103: Transect OH16 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.595173N 63.495153W.

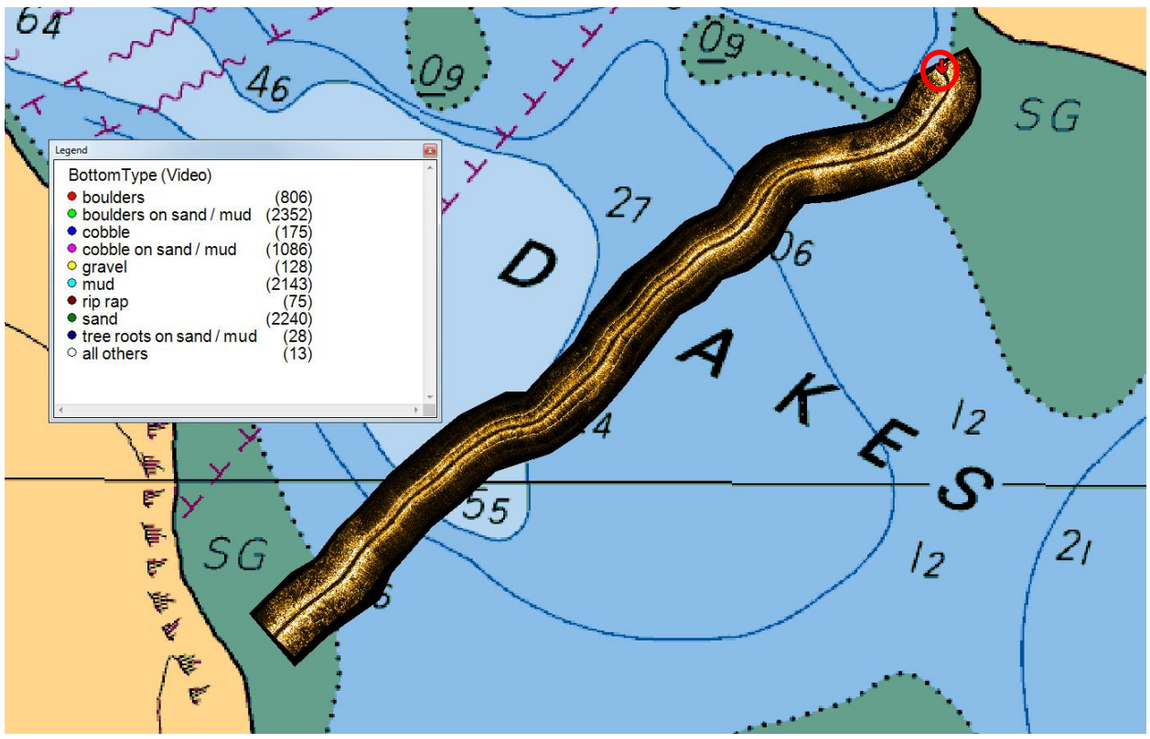


Figure 104: Transect OH17 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.601940N 63.501458W.

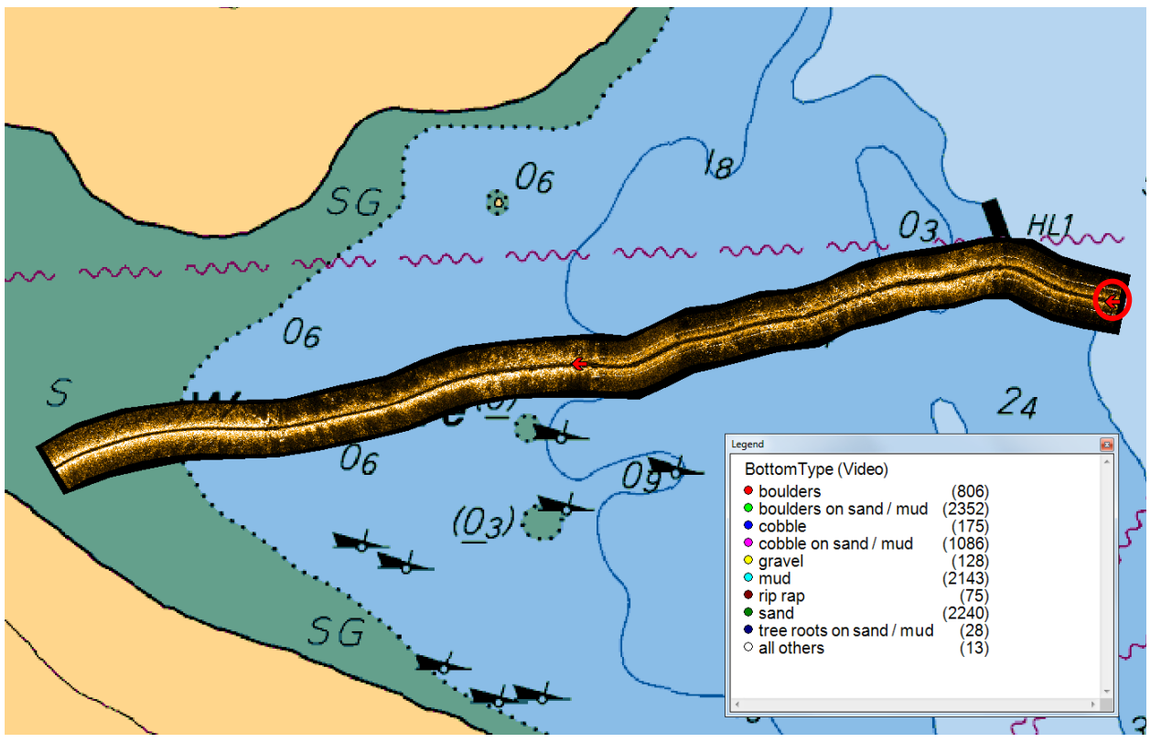


Figure 105: Transect OH18 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.605058N 63.507657W.

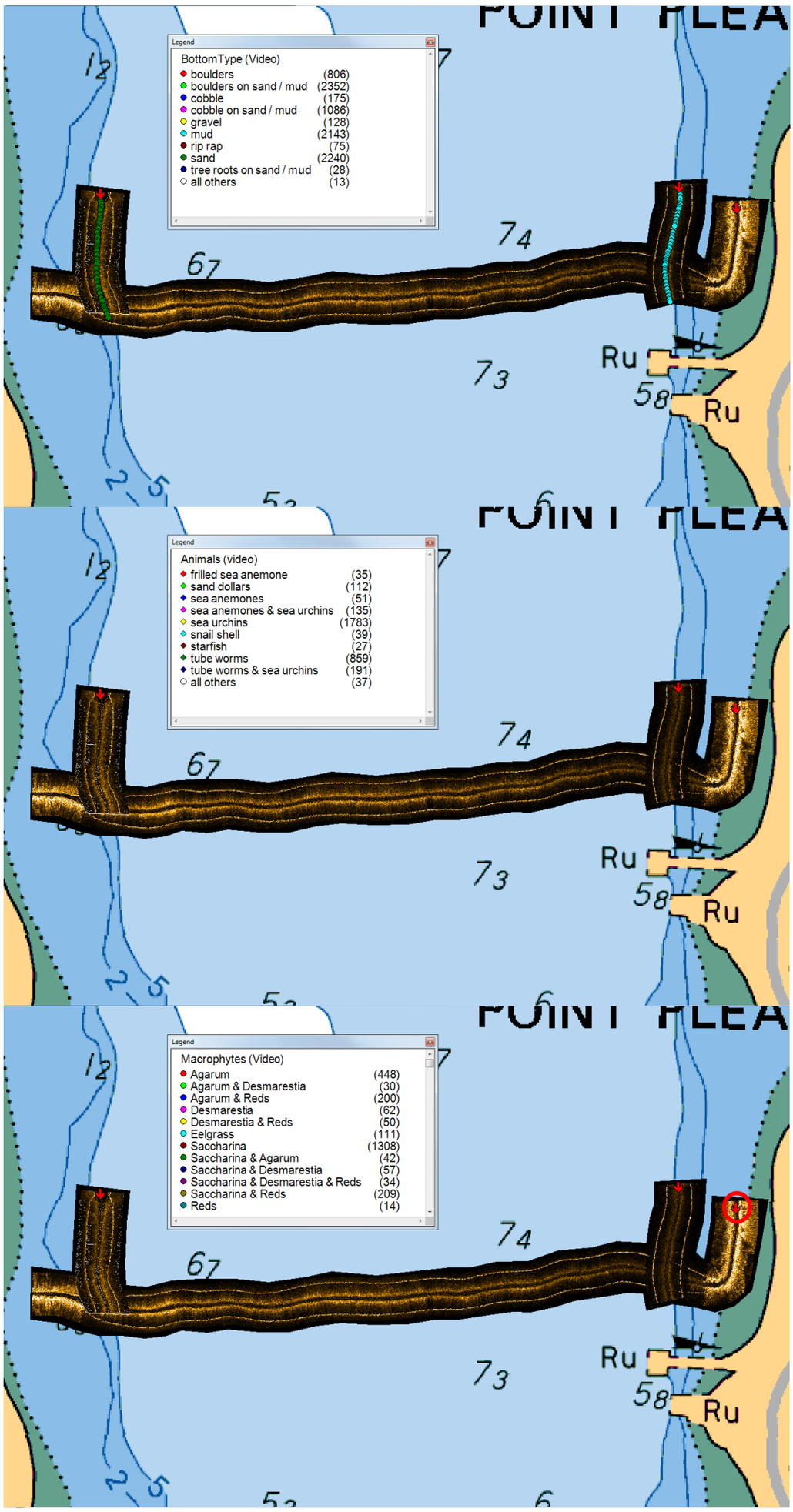


Figure 106: Transect OH19 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.608850N 63.504887W.

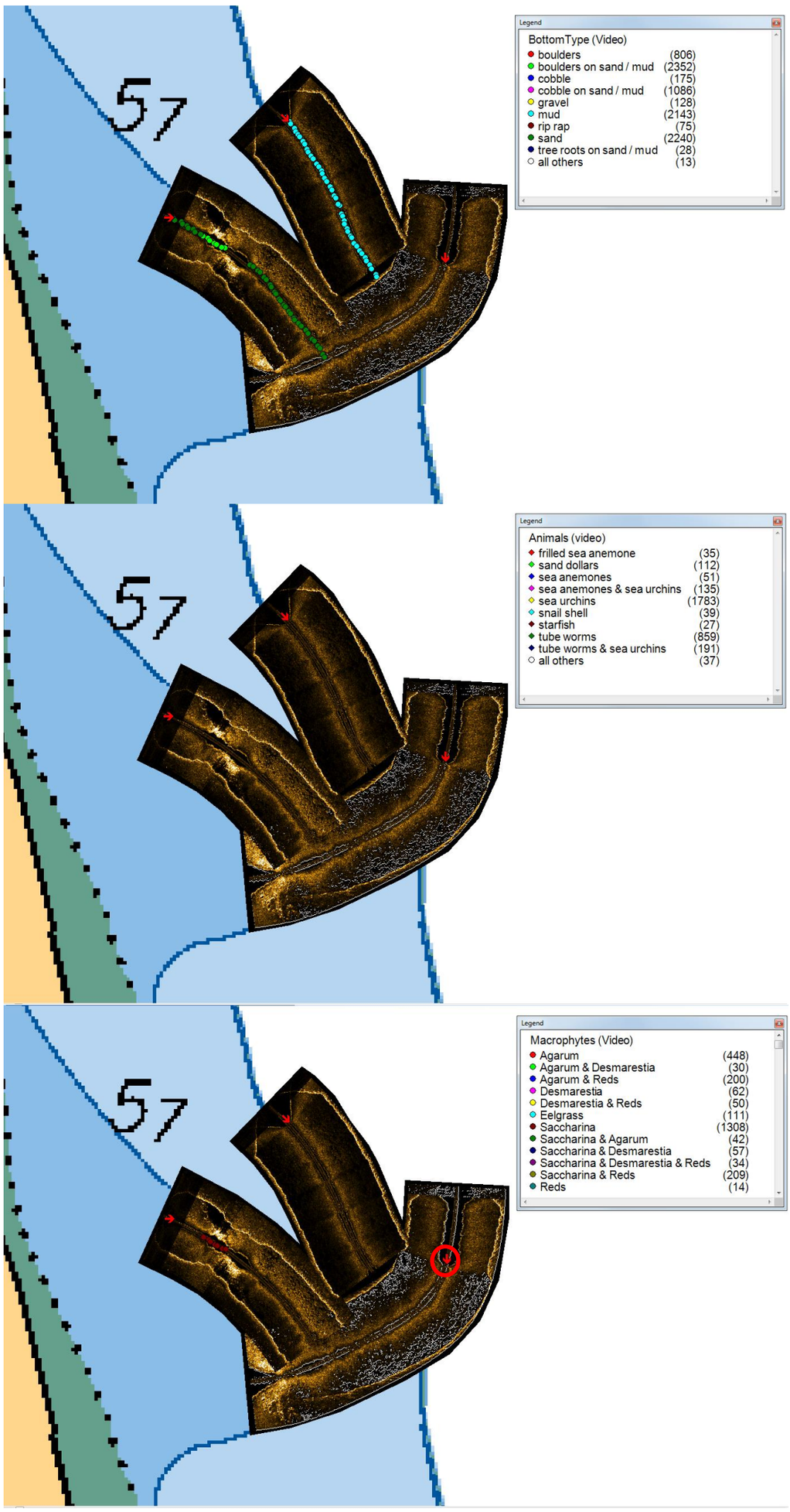


Figure 107: Transect OH20 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.613583N 63.510502W.

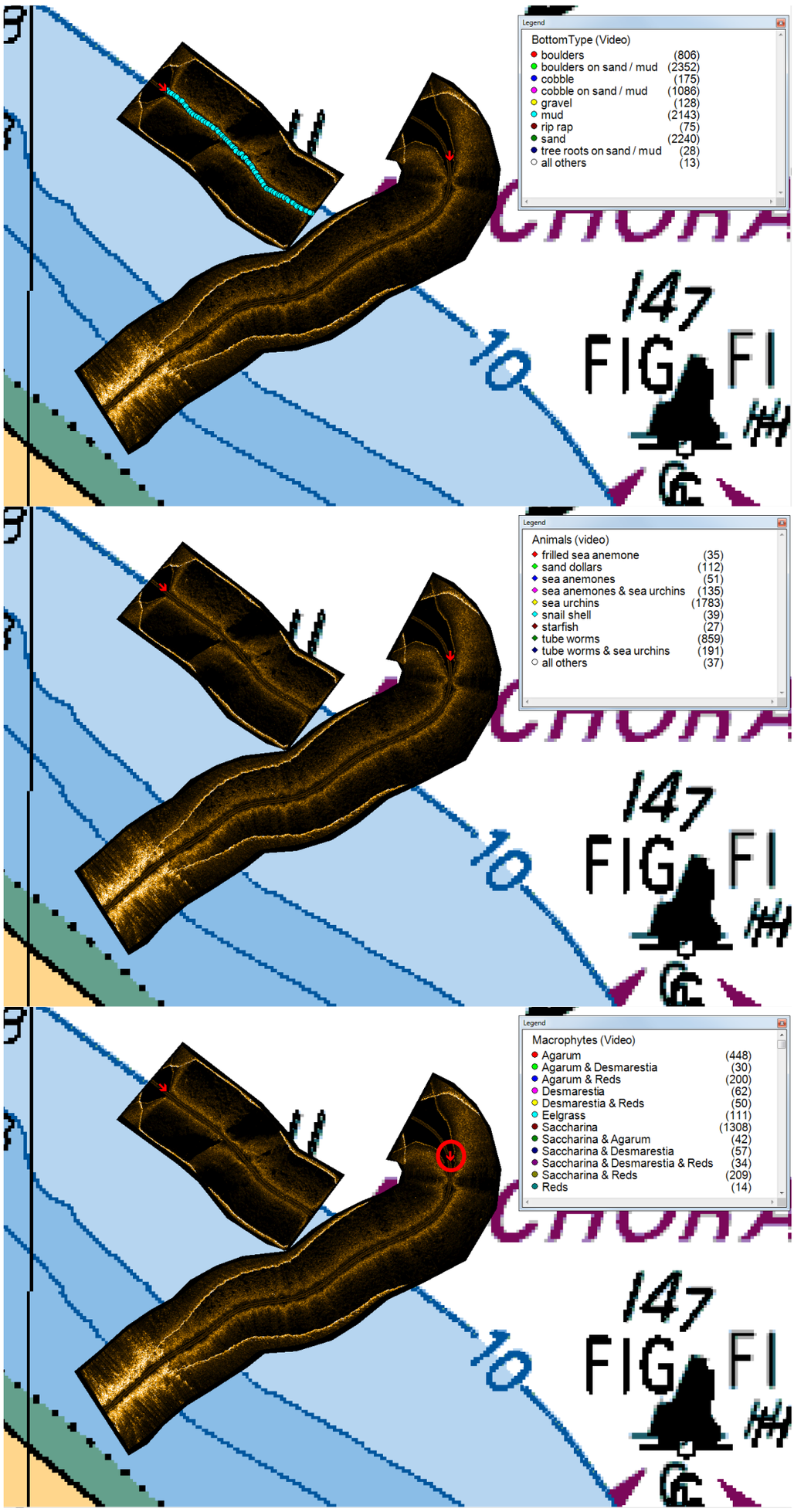


Figure 108: Transect OH21 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.619085N 63.514960W.

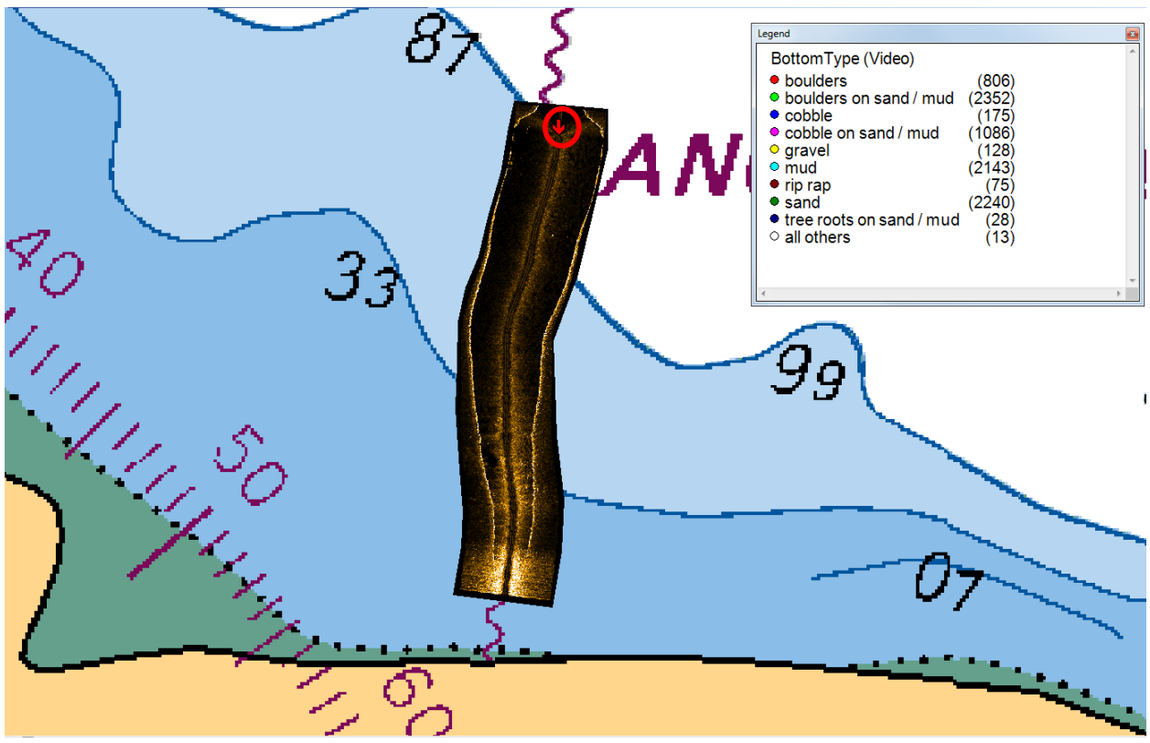


Figure 109: Transect OH22 - No video analysis or bottom classification due absence of cross run data. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.622208N 63.522993W.

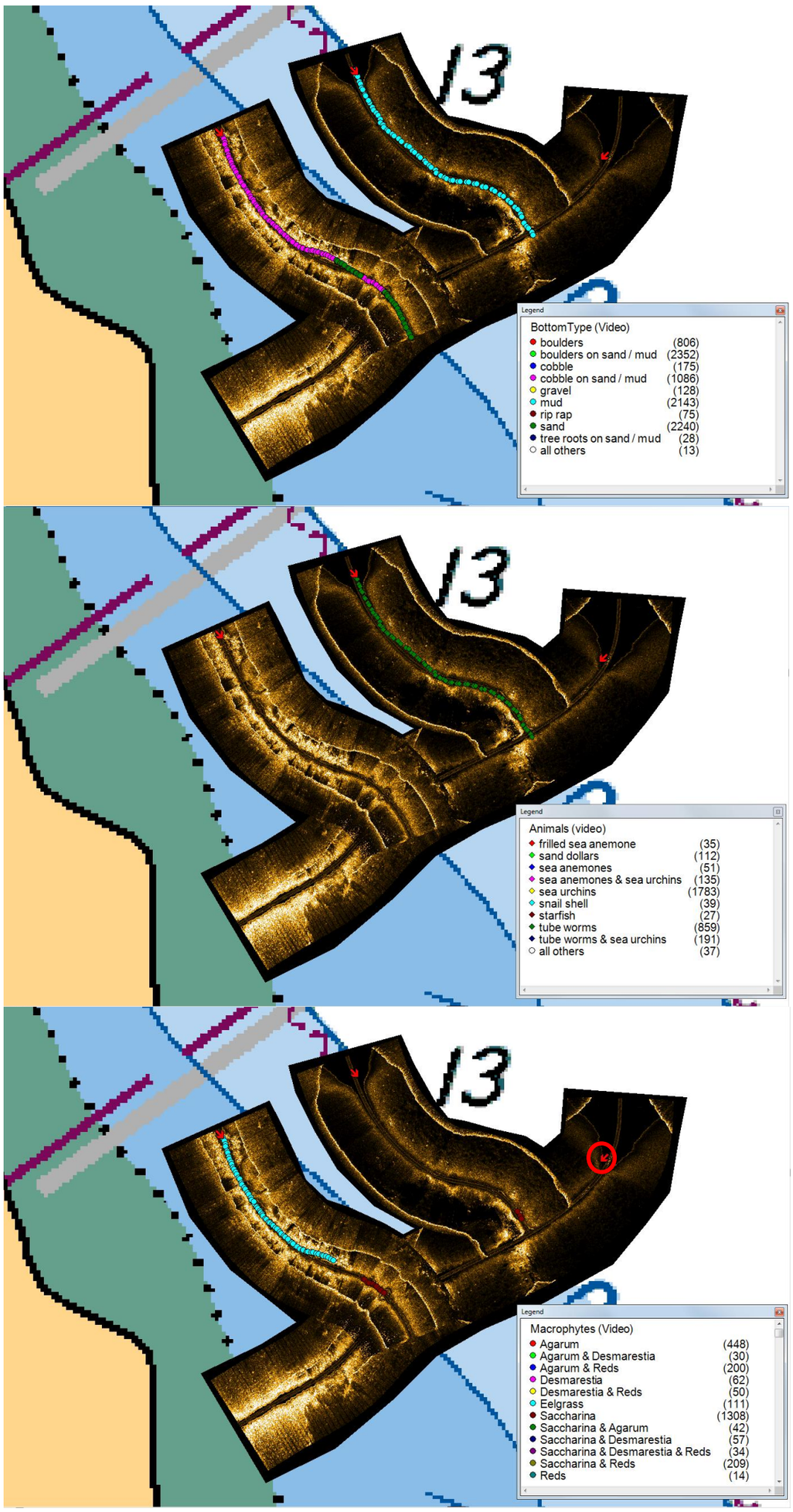


Figure 110: Transect OH23 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.625487N 63.526653W.

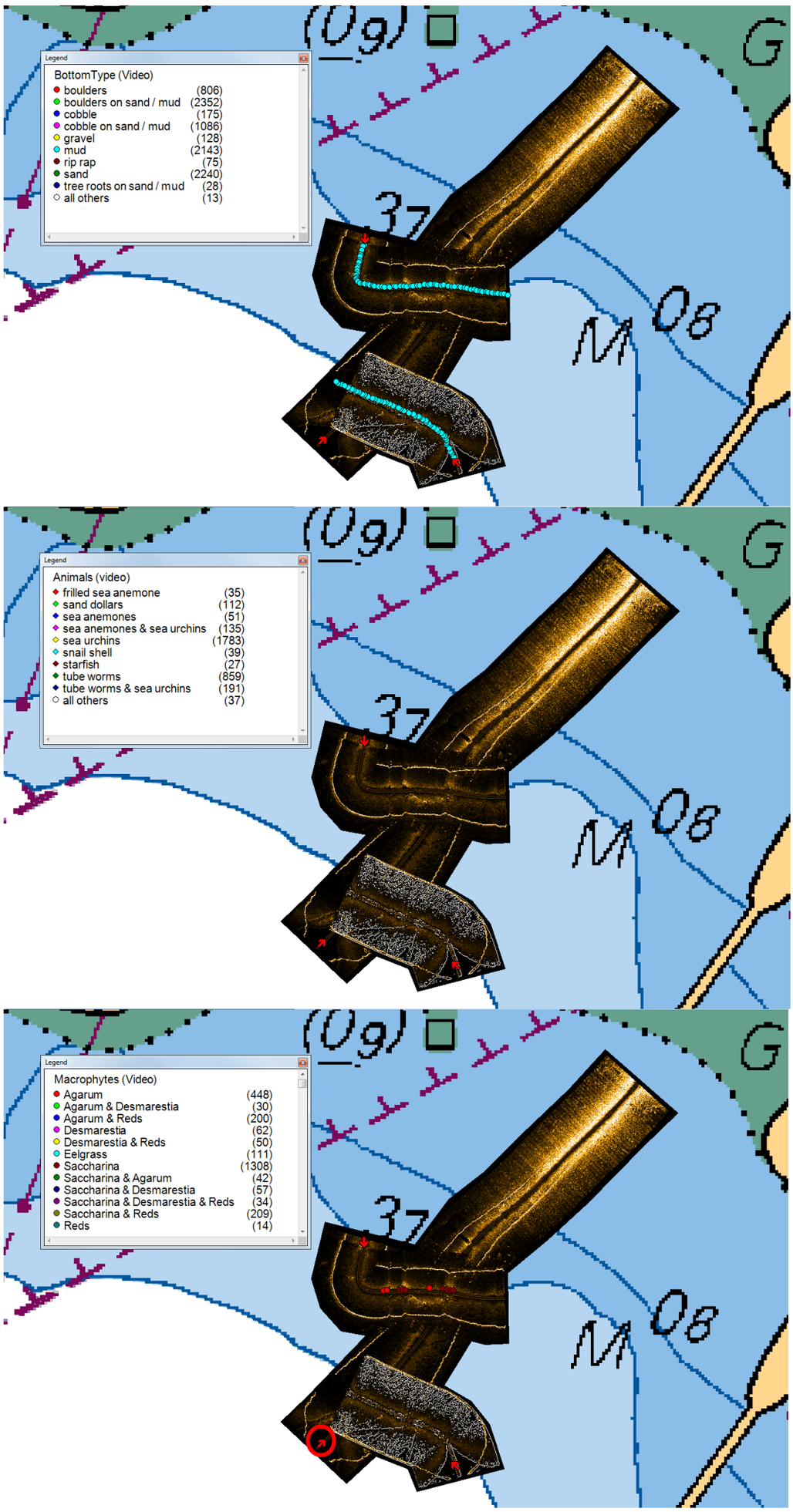


Figure 111: Transect OH24 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.622735N 63.513762W.

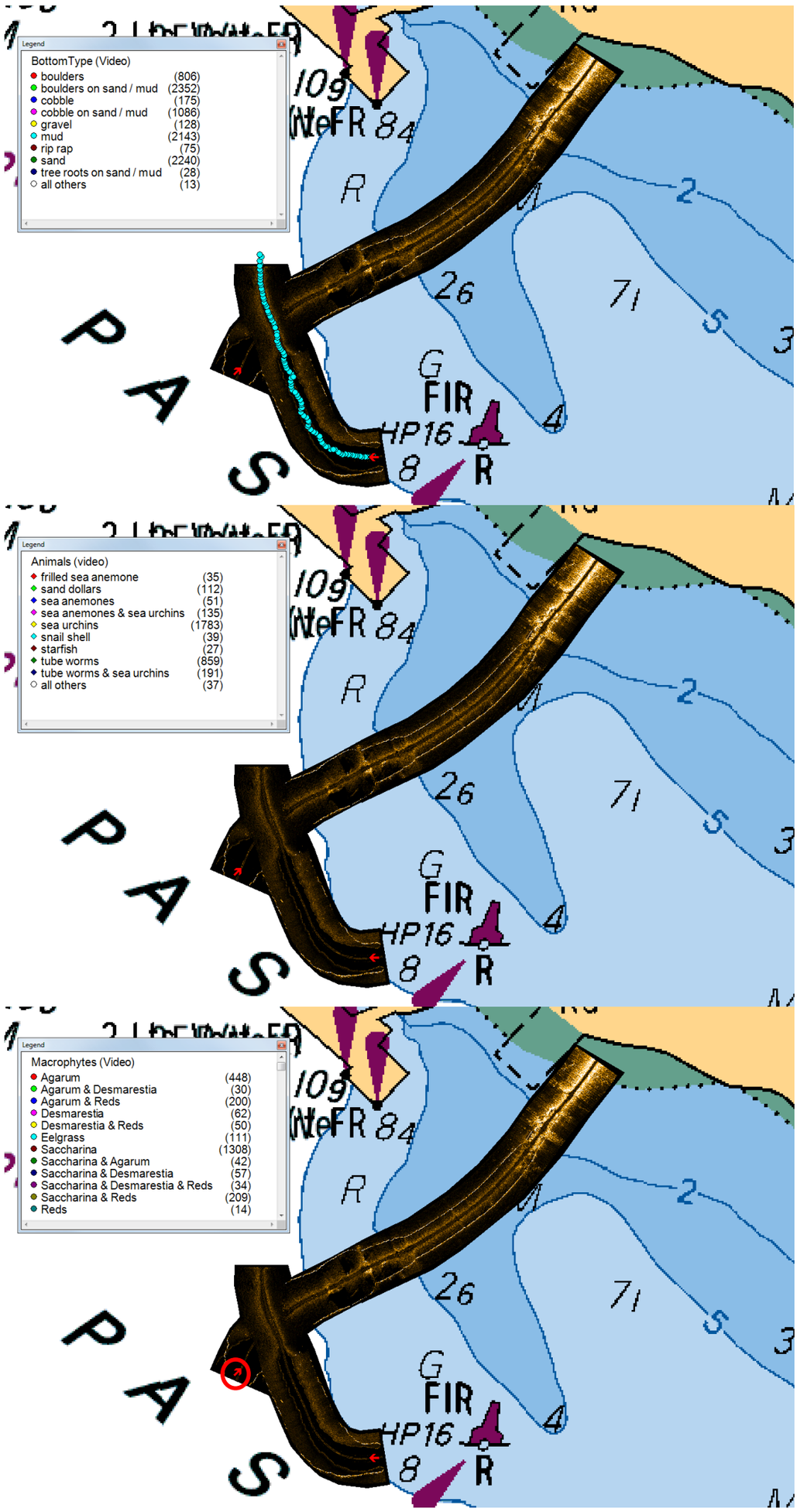


Figure 112: Transect OH25 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.617878N 63.510922W.

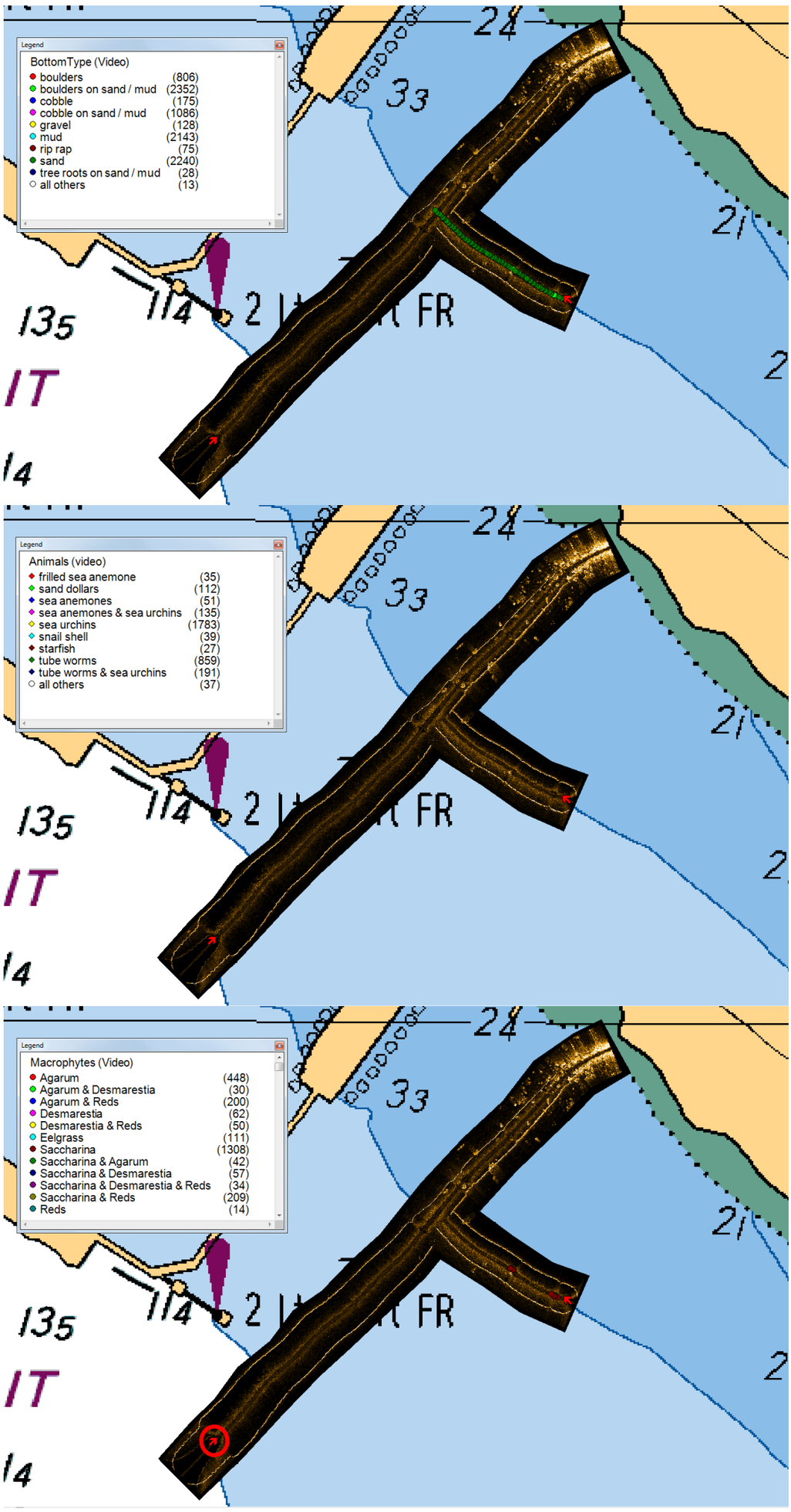


Figure 113: Transect OH26 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.614560N 63.505442W.

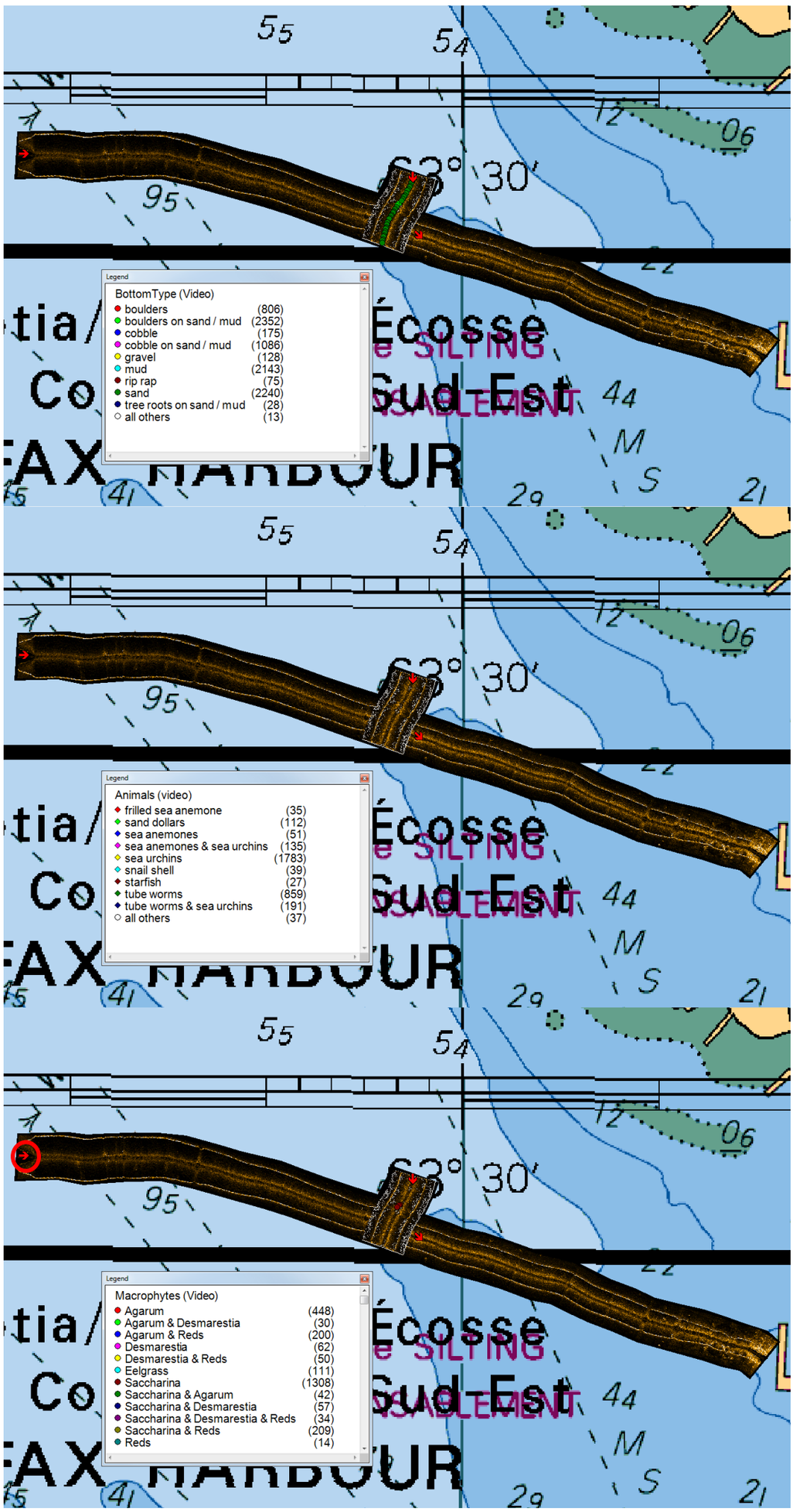


Figure 114: Transect OH27 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.612377N 63.503713W.

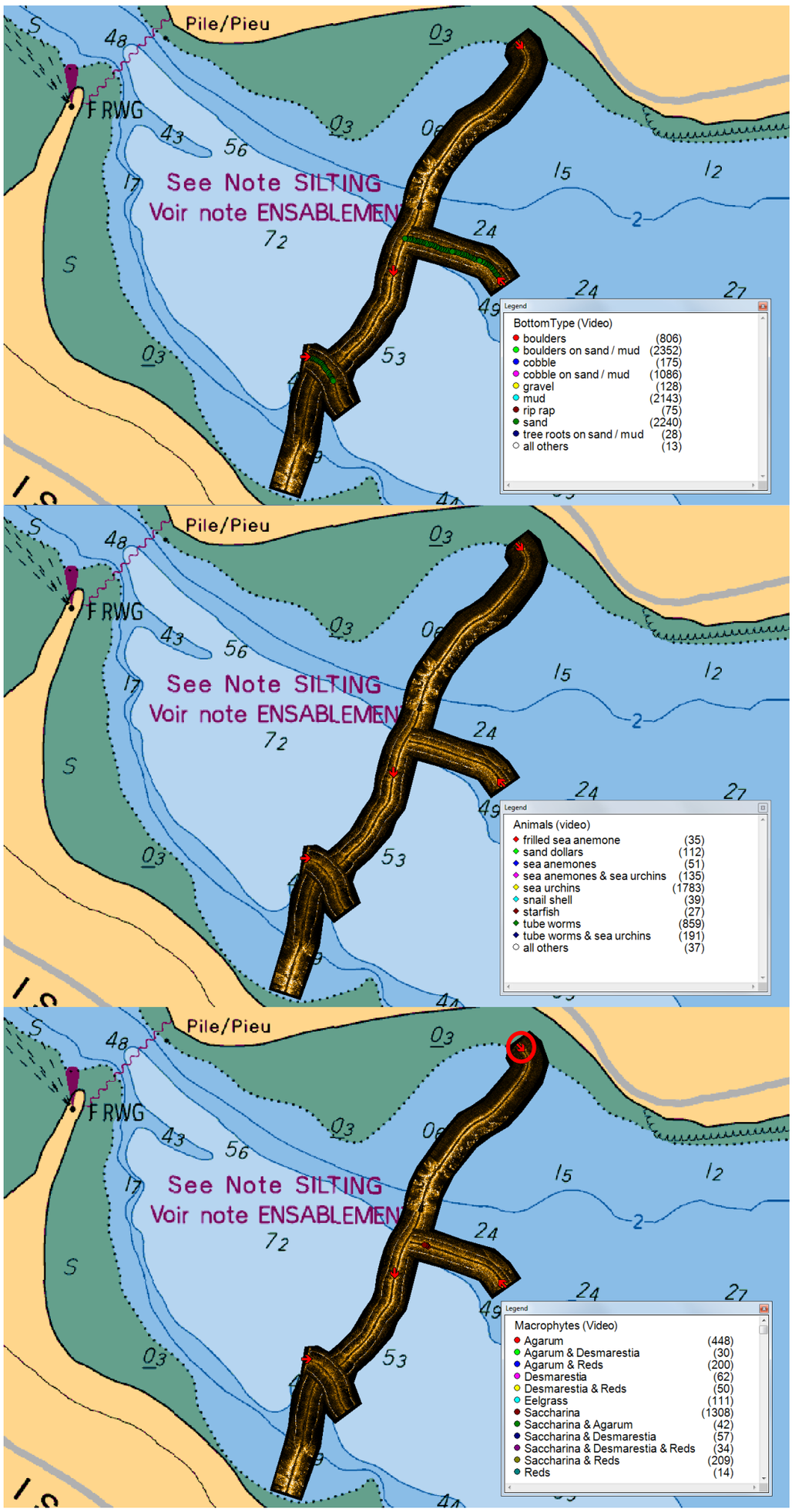


Figure 115: Transect OH28 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.606650N 63.490178W.

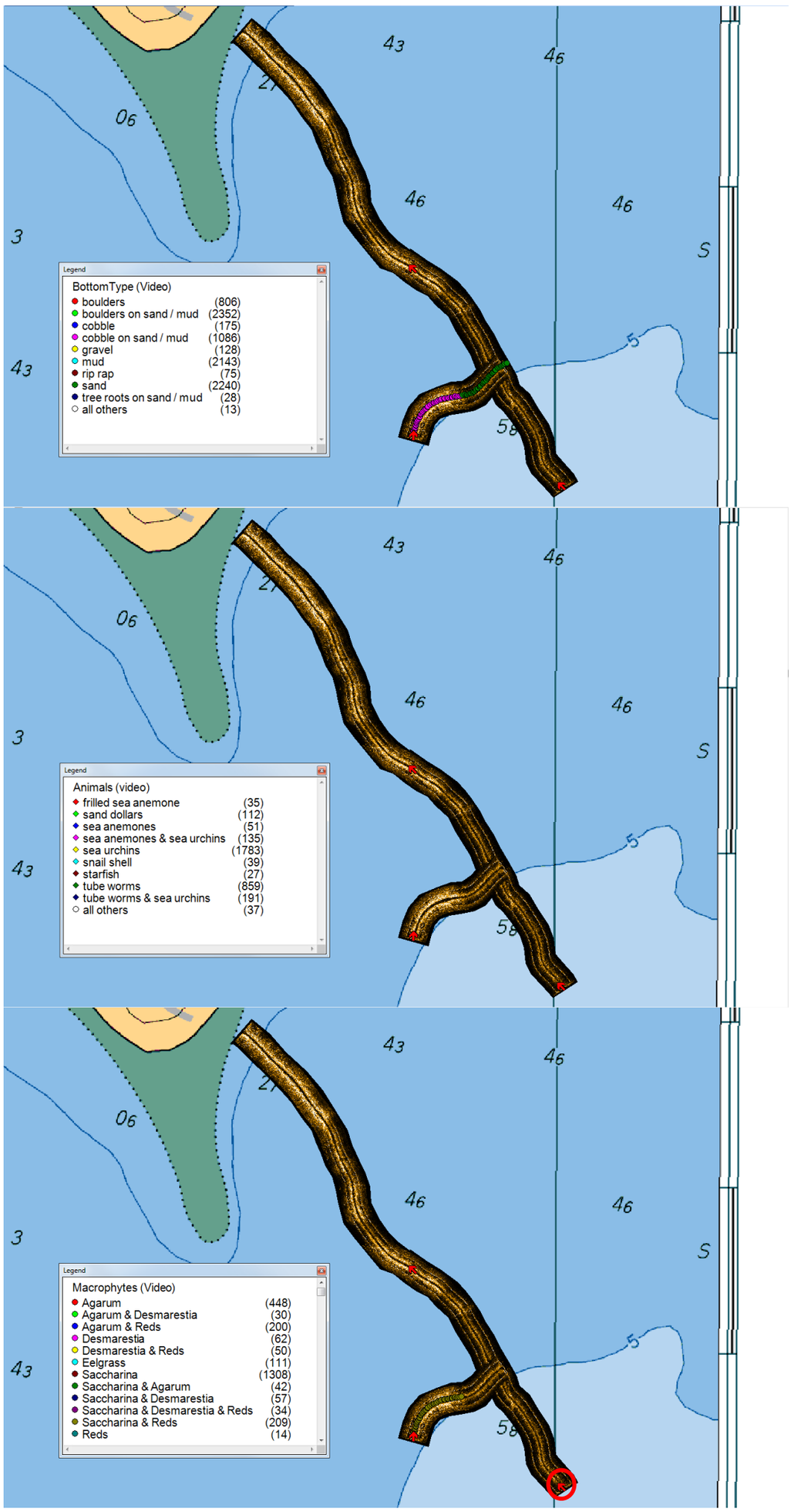


Figure 116: Transect OH29 showing towfish classification results. The red arrow start point for the main transect run (perpendicular to shore) is circled in red and located at 44.593673N 63.483215W.

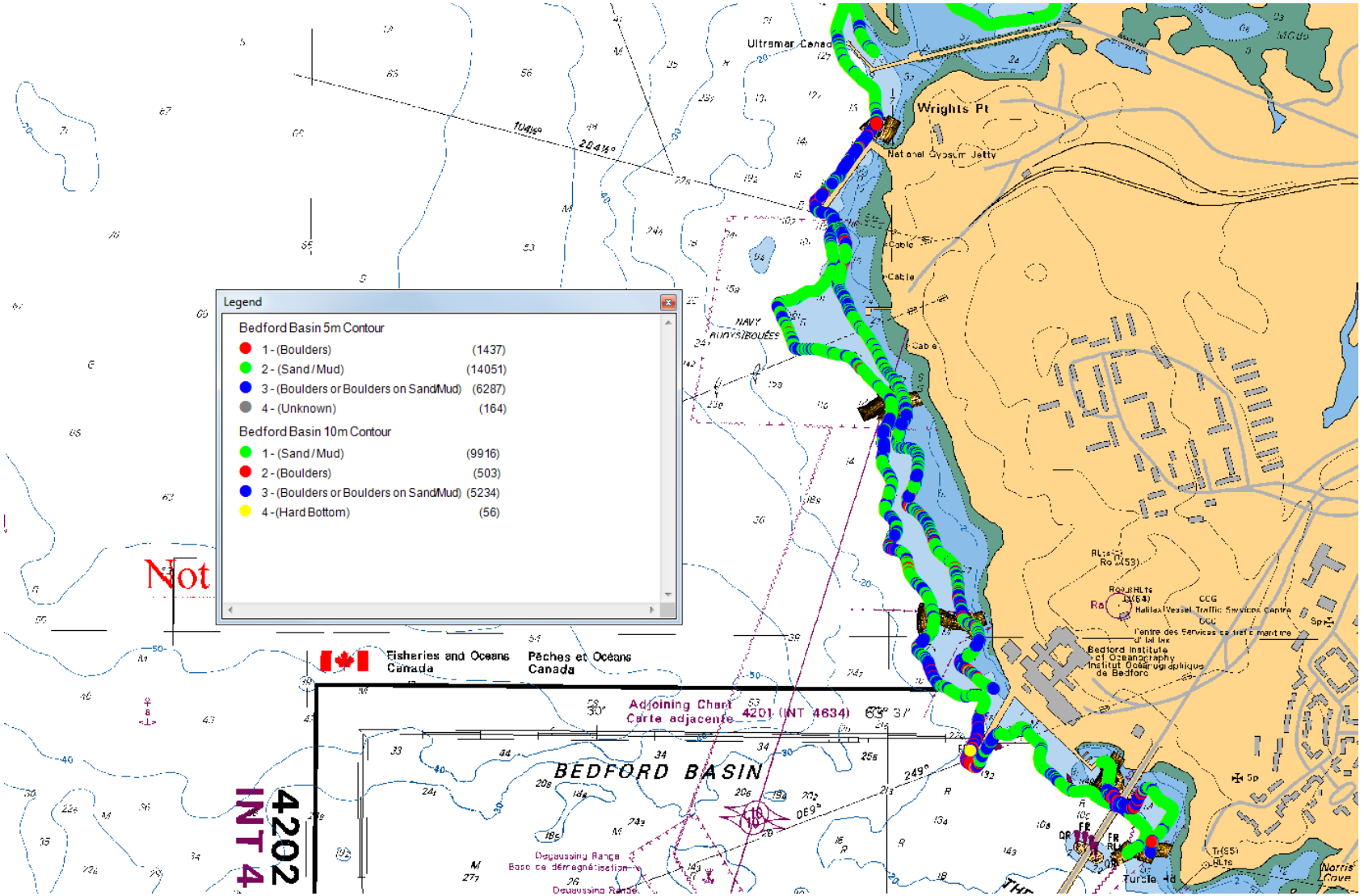


Figure 117: Bedford Basin VBT2 bottom classification results at 5 and 10 m from MacKay Bridge to Wrights Point.

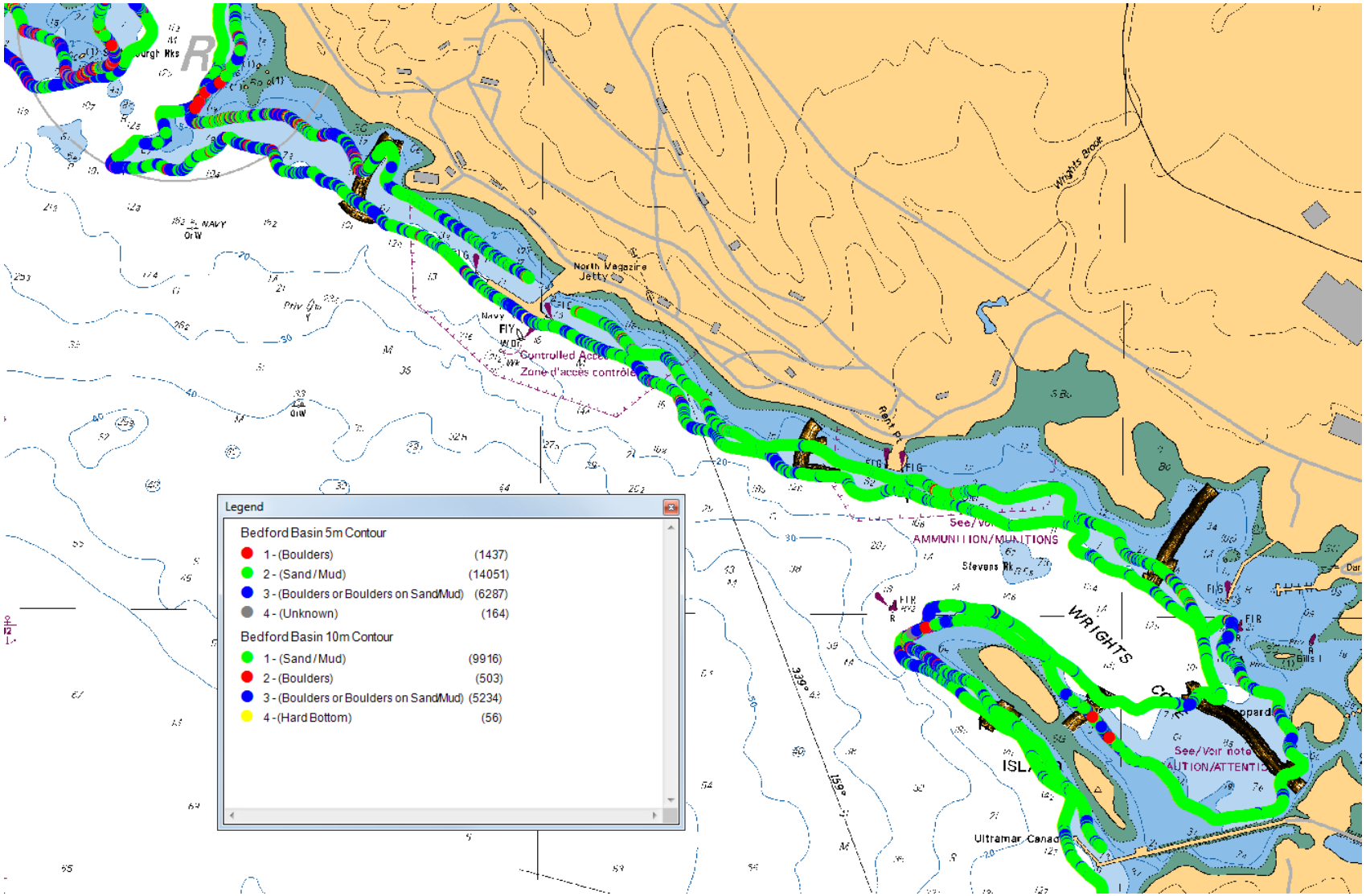


Figure 118: Bedford Basin VBT2 bottom classification results at 5 and 10 m from Wrights Point to Shattelburgh Rocks.

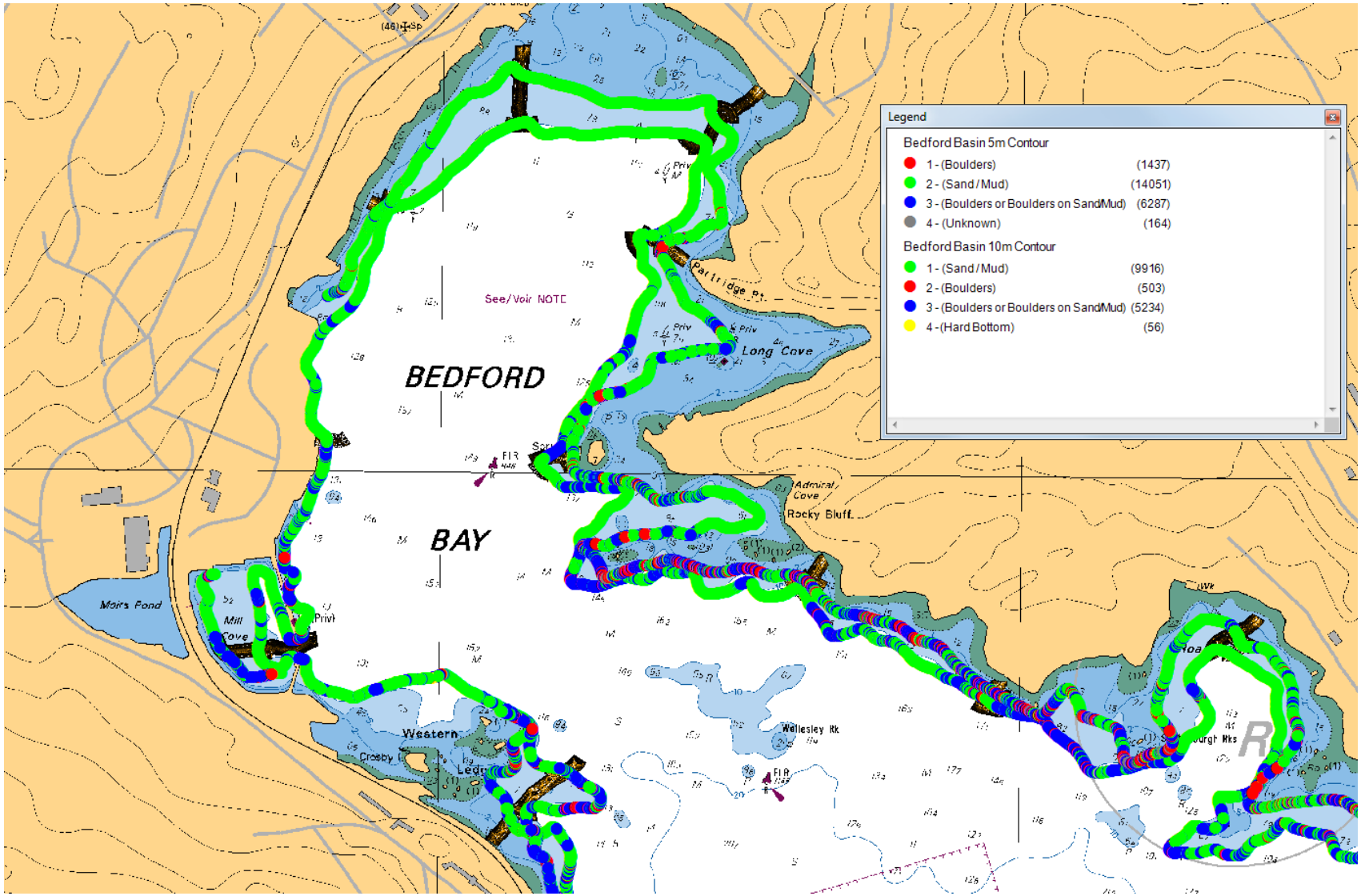


Figure 119: Bedford Basin VBT2 bottom classification results at 5 and 10 m from Shattelburgh Rocks to the Western Ledges.

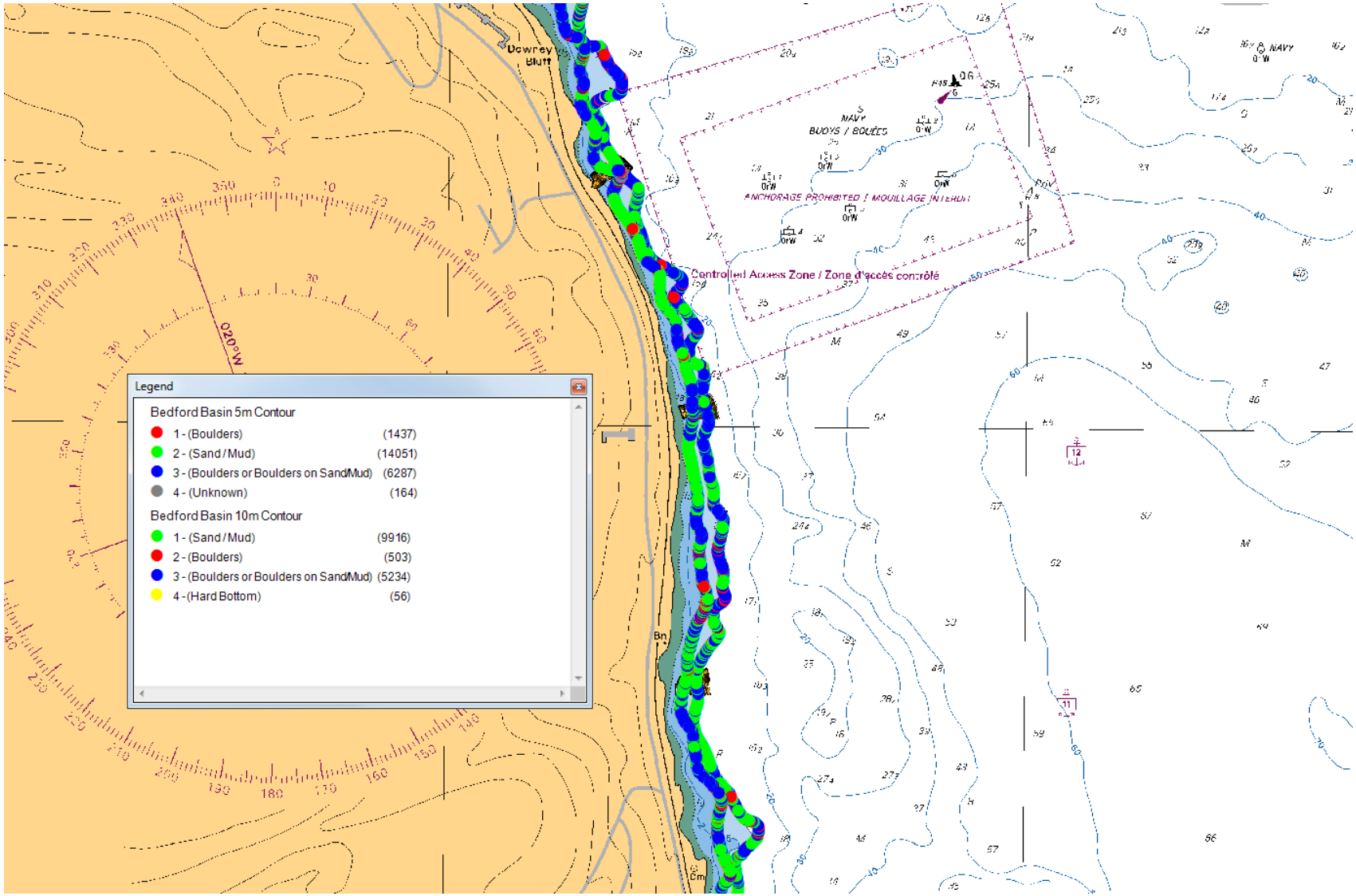


Figure 120: Bedford Basin VBT2 bottom classification results at 5 and 10 m from the Western Ledges to shore near Jonquiere Bank.

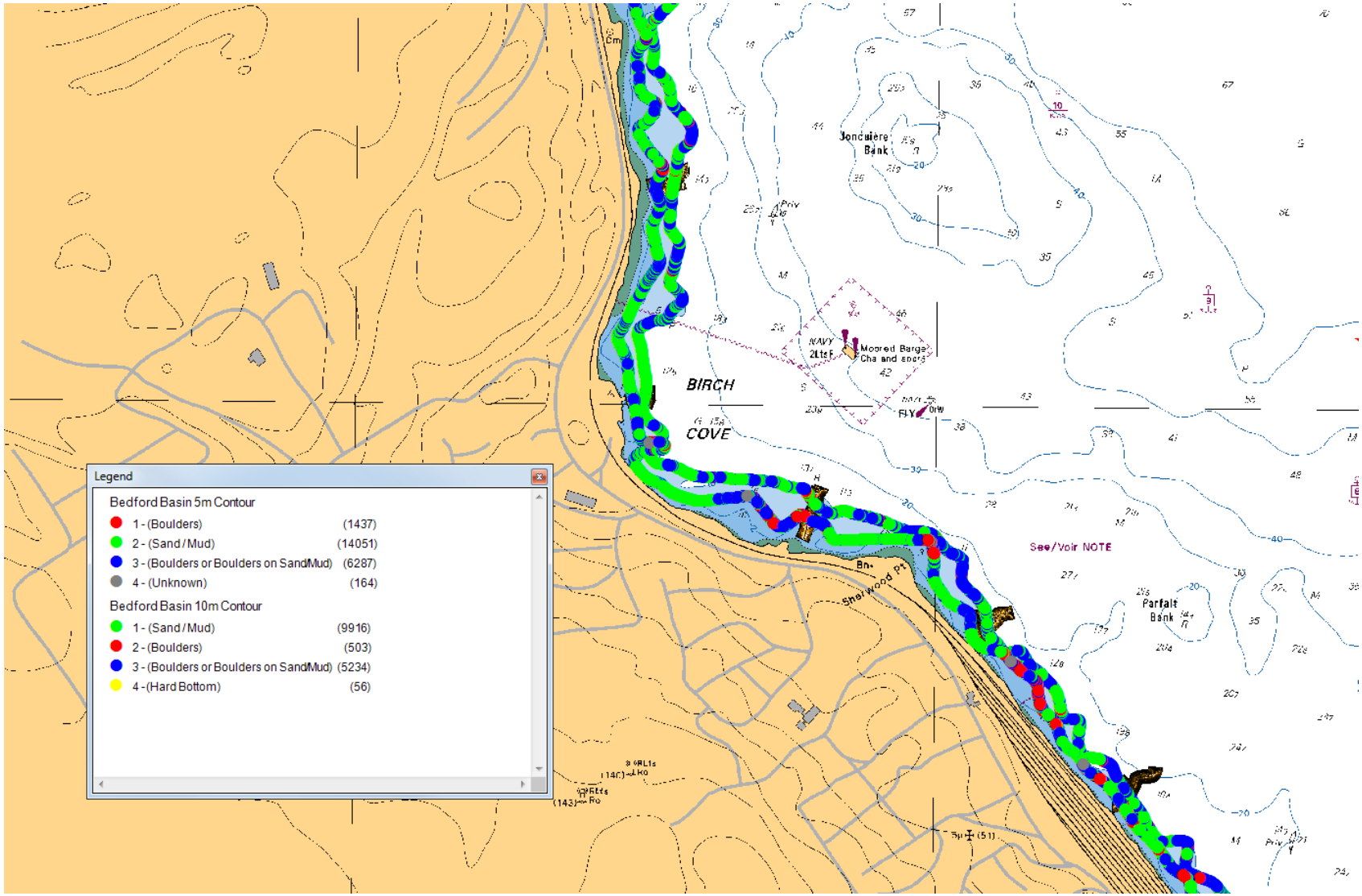


Figure 121: Bedford Basin VBT2 bottom classification results at 5 and 10 m from the shore near Jonquiere Bank to BB29.

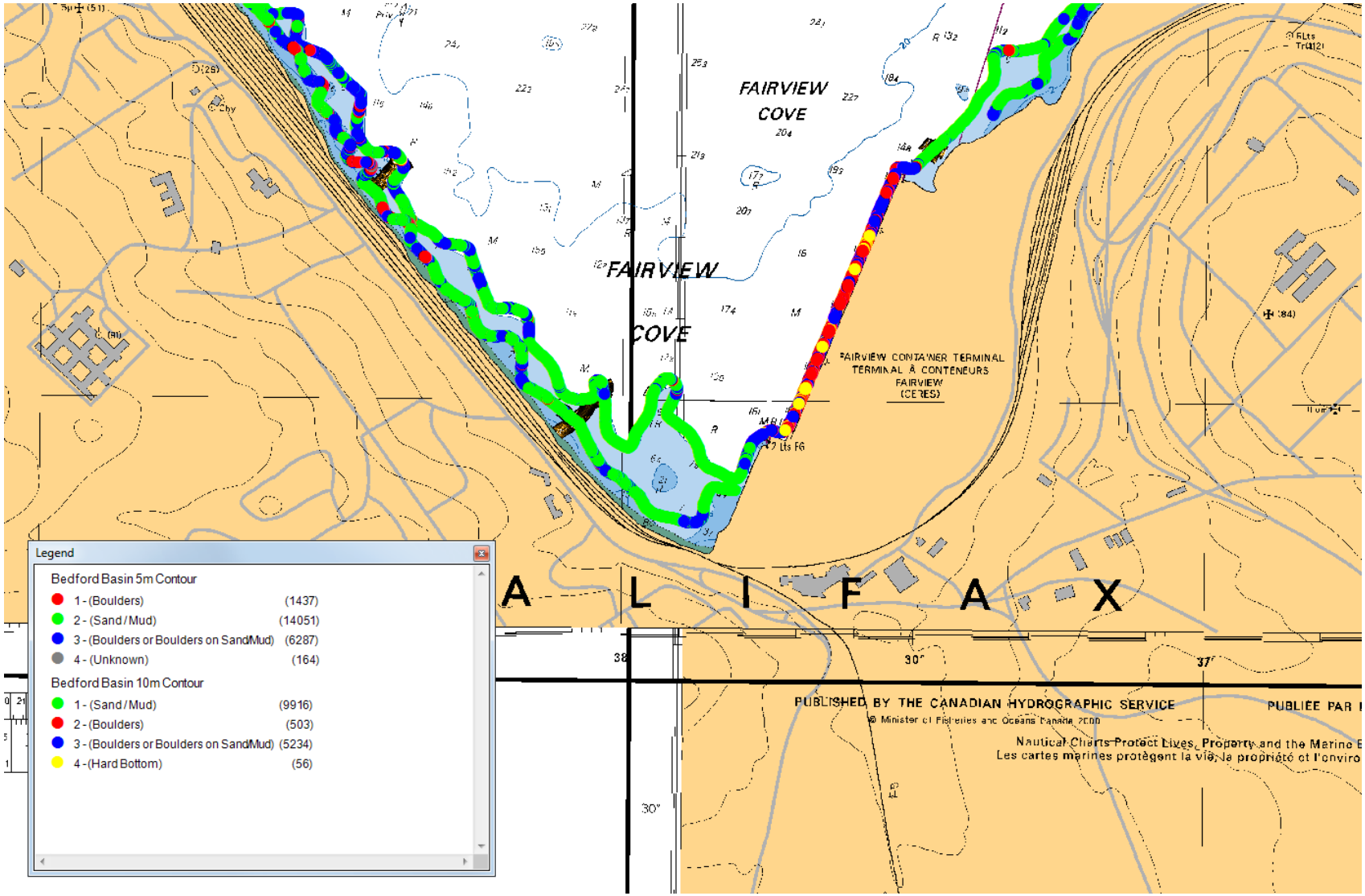


Figure 122: Bedford Basin VBT2 bottom classification results at 5 and 10 m from BB29 to near Seaview Point.

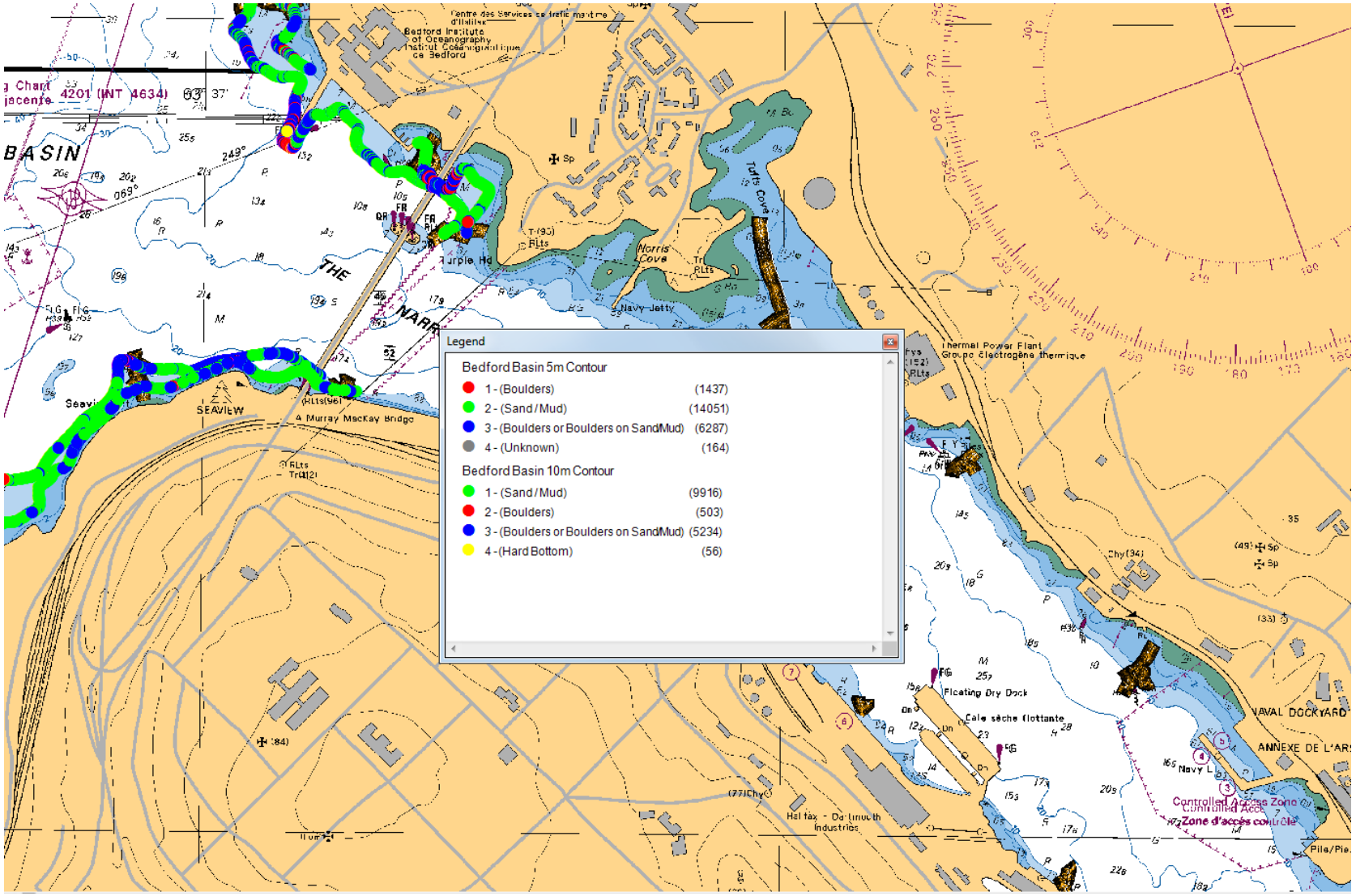


Figure 123: Bedford Basin VBT2 bottom classification results at 5 and 10 m from near Seaview Point to MacKay Bridge.

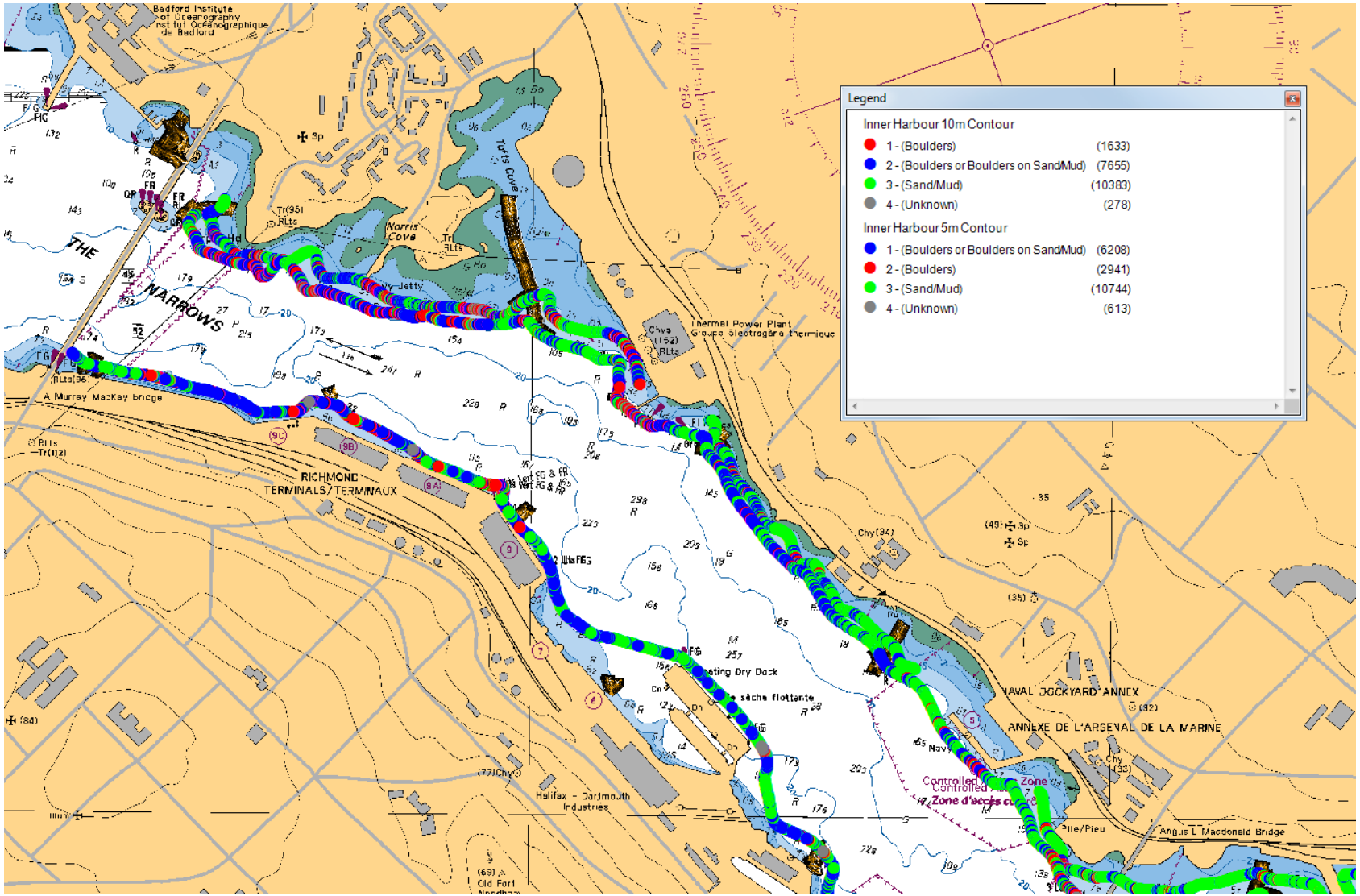


Figure 124: Inner Harbour VBT2 bottom classification results at 5 and 10 m from MacKay Bridge to the controlled access zone for the naval yards.

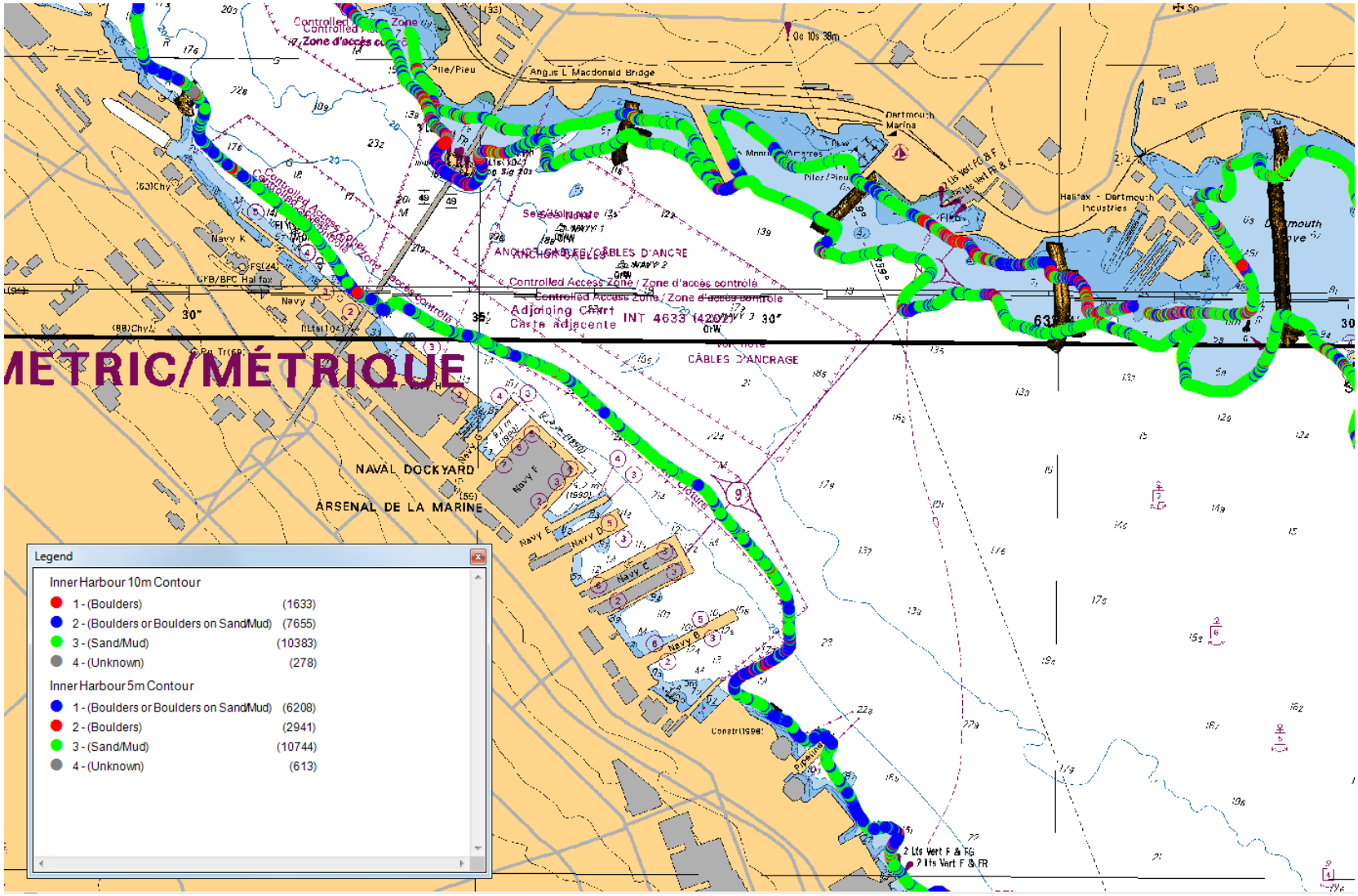


Figure 125: Inner Harbour VBT2 bottom classification results at 5 and 10 m from the controlled access zone for the naval yards to Dartmouth Cove.

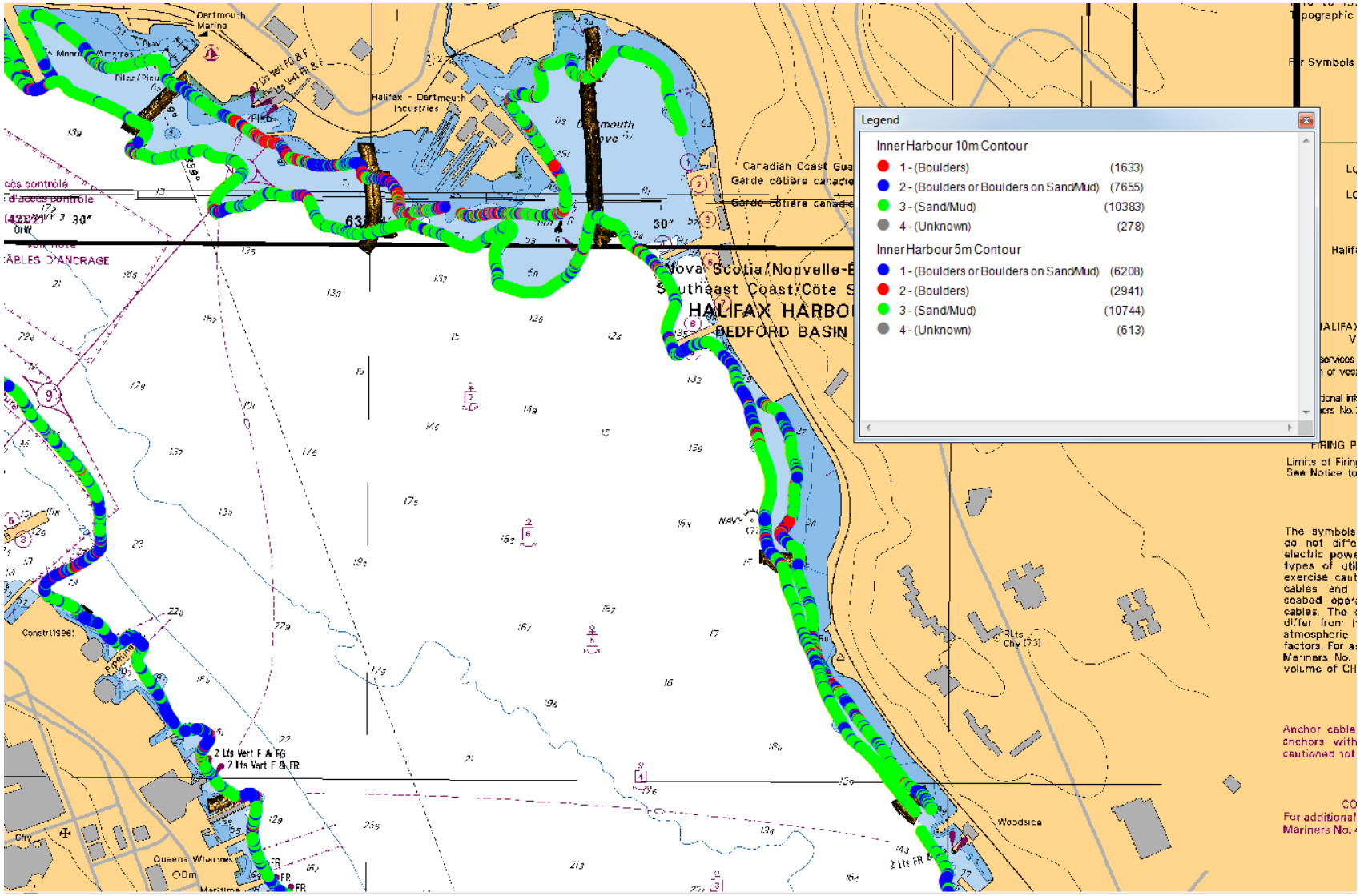


Figure 126: Inner Harbour VBT2 bottom classification results at 5 and 10 m from Dartmouth Cove to Woodside.

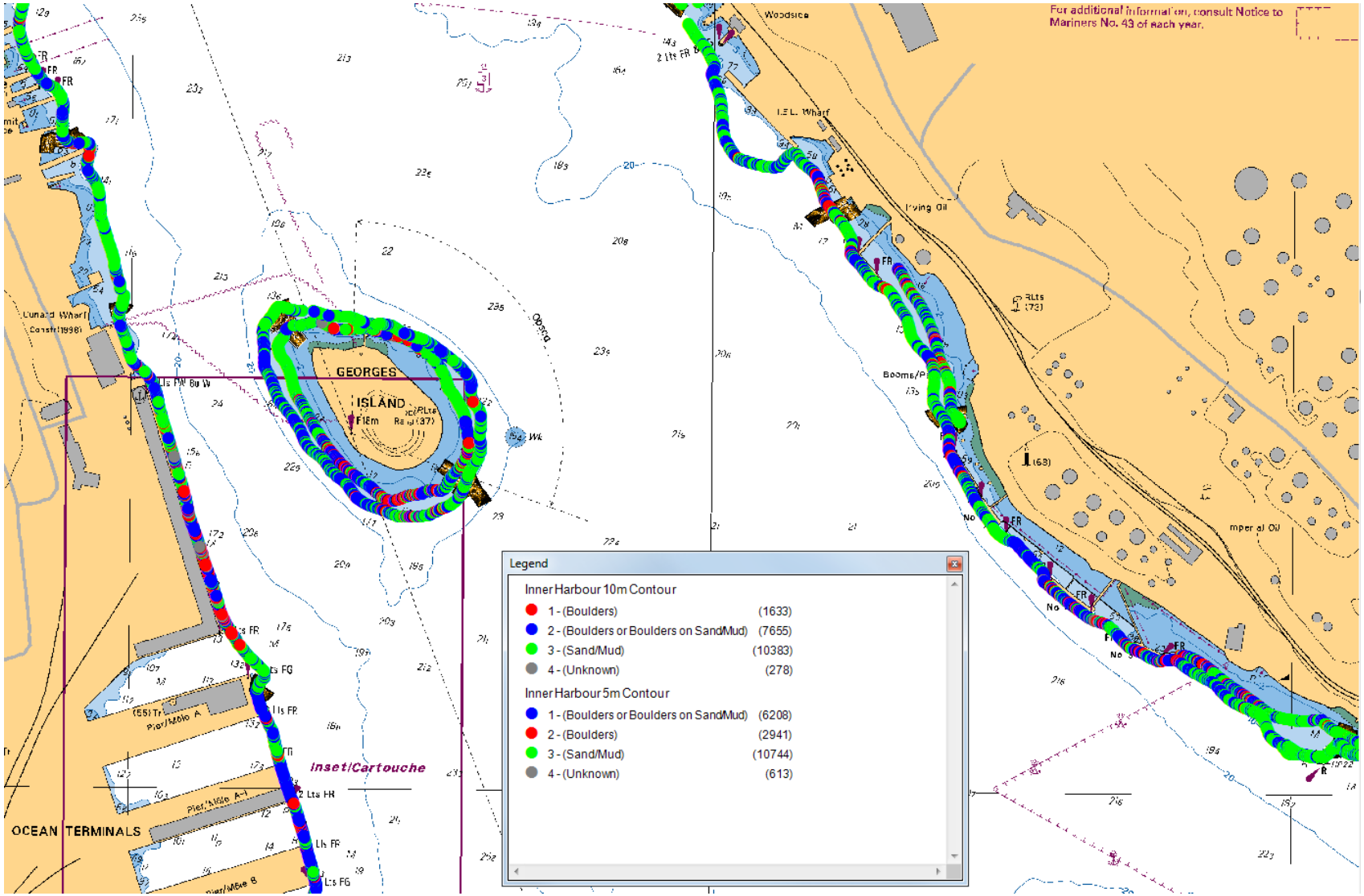


Figure 127: Inner Harbour VBT2 bottom classification results at 5 and 10 m from Woodside to just outside of Eisner Cove.

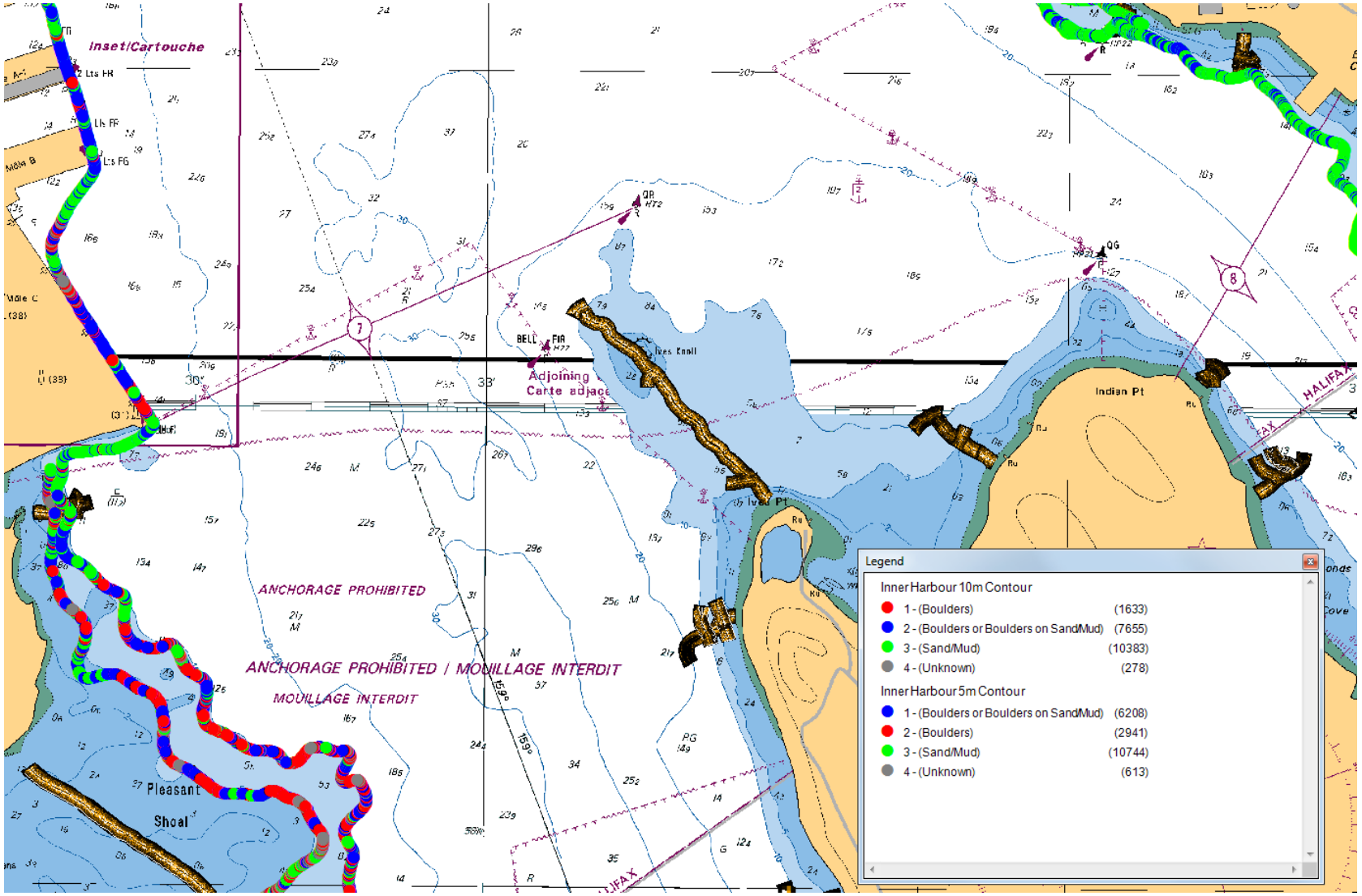


Figure 128: Inner Harbour VBT2 bottom classification results at 5 and 10 m from Ocean Terminals to Pleasant Shoal.

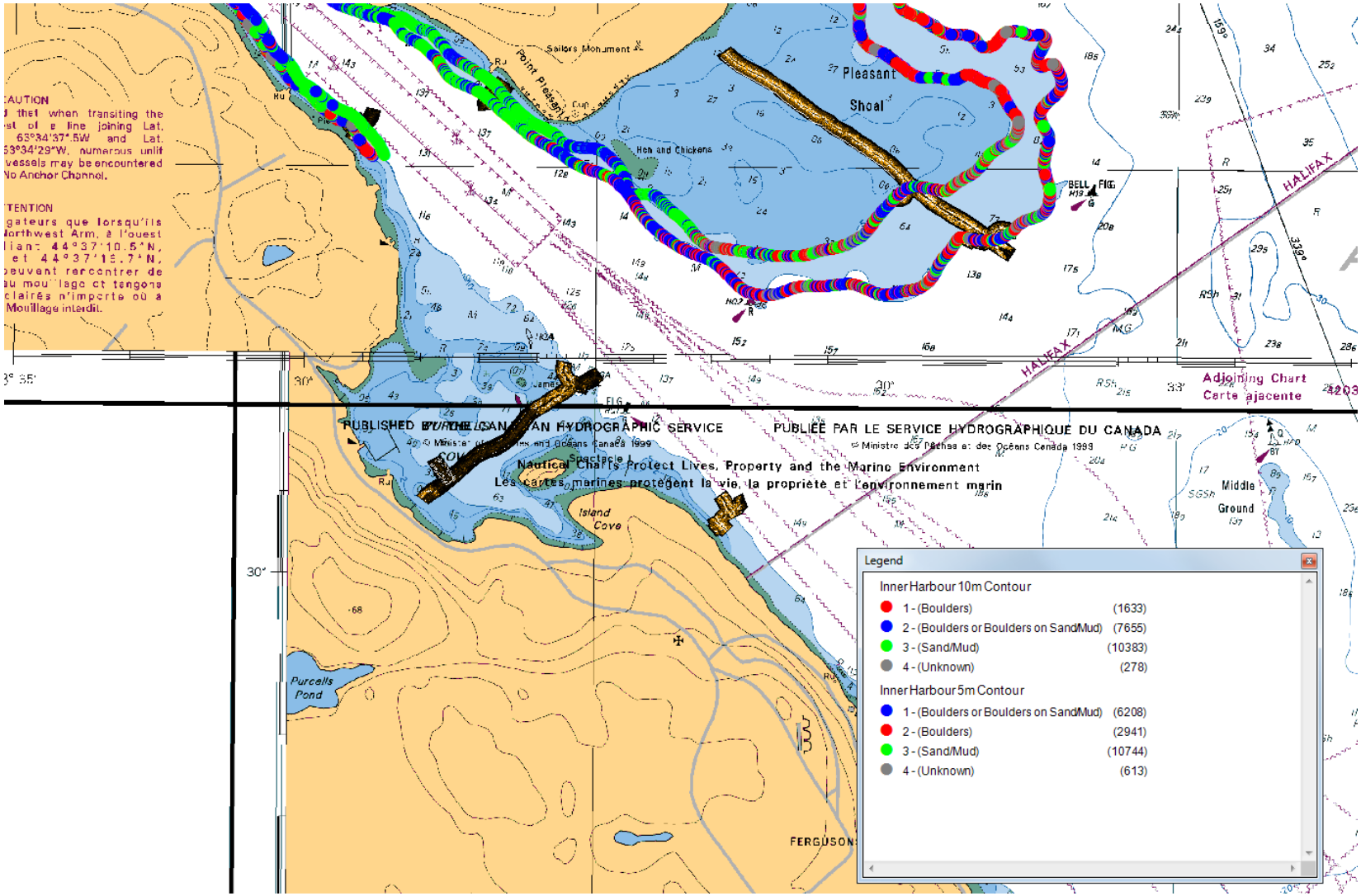


Figure 129: Inner Harbour VBT2 bottom classification results at 5 and 10 m from Pleasant Shoal to entrance of Northwest Arm.

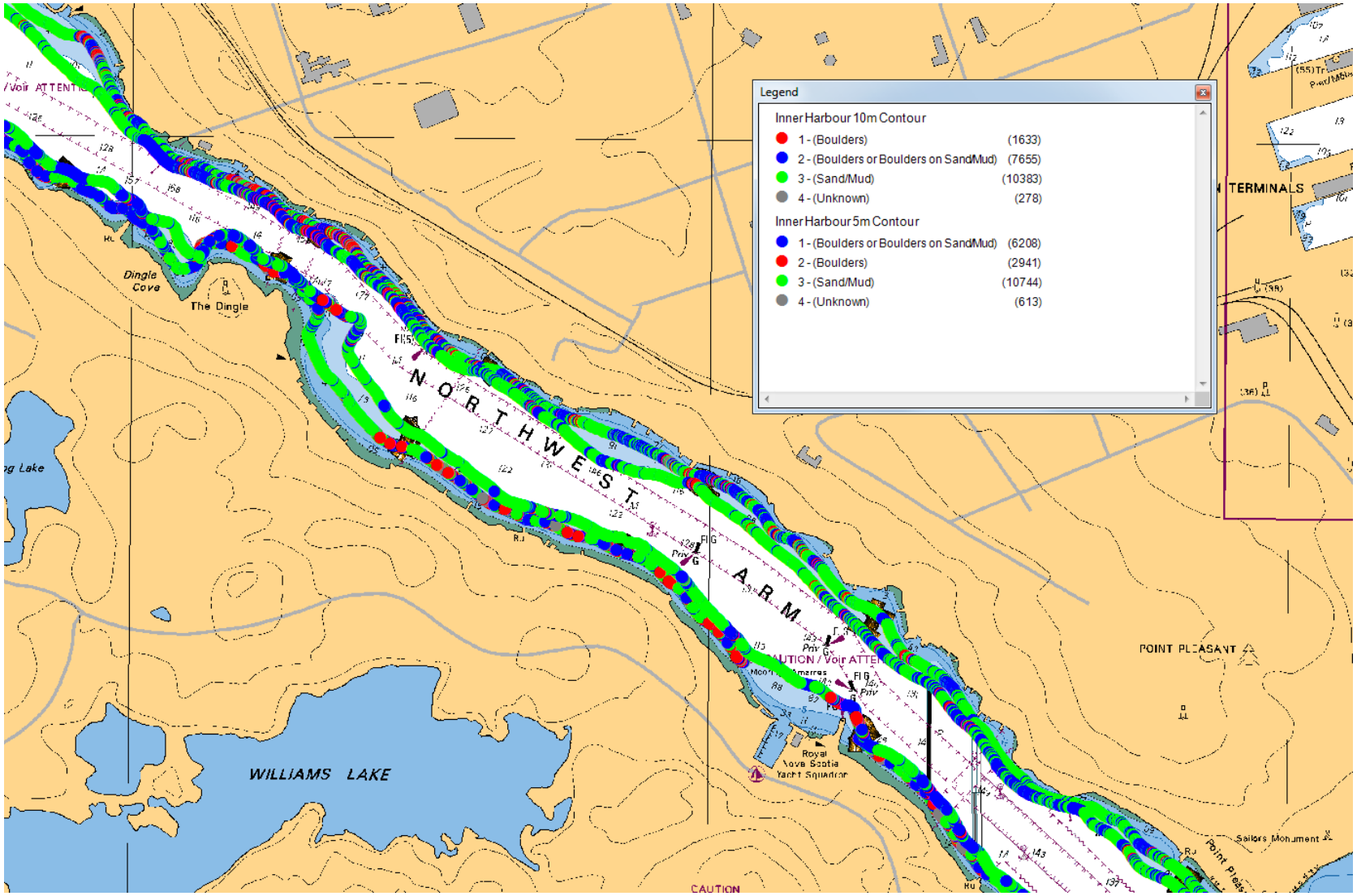


Figure 130: Inner Harbour VBT2 bottom classification results at 5 and 10 m for middle of Northwest Arm.

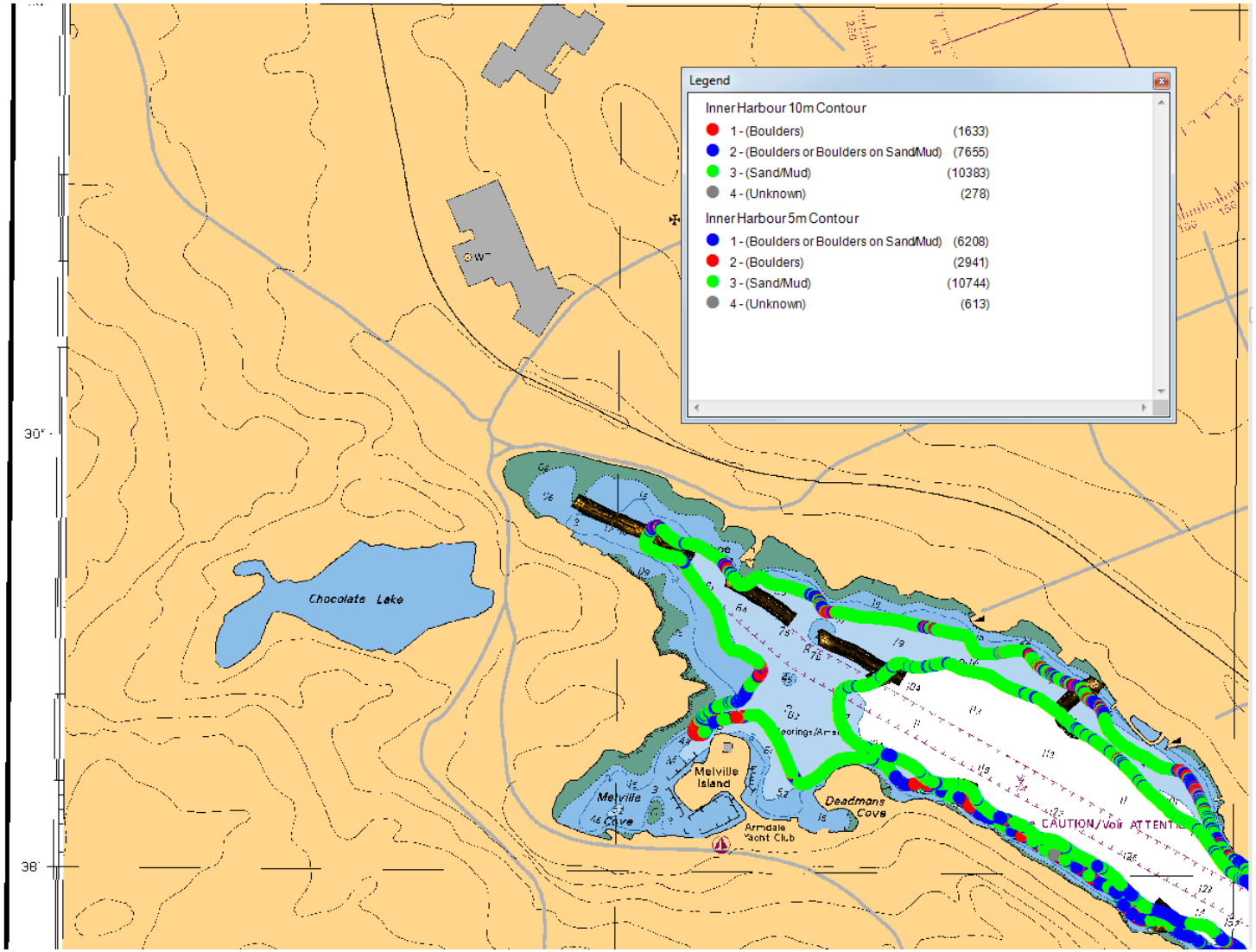


Figure 131: Inner Harbour VBT2 bottom classification results at 5 and 10 m for head of Northwest Arm.

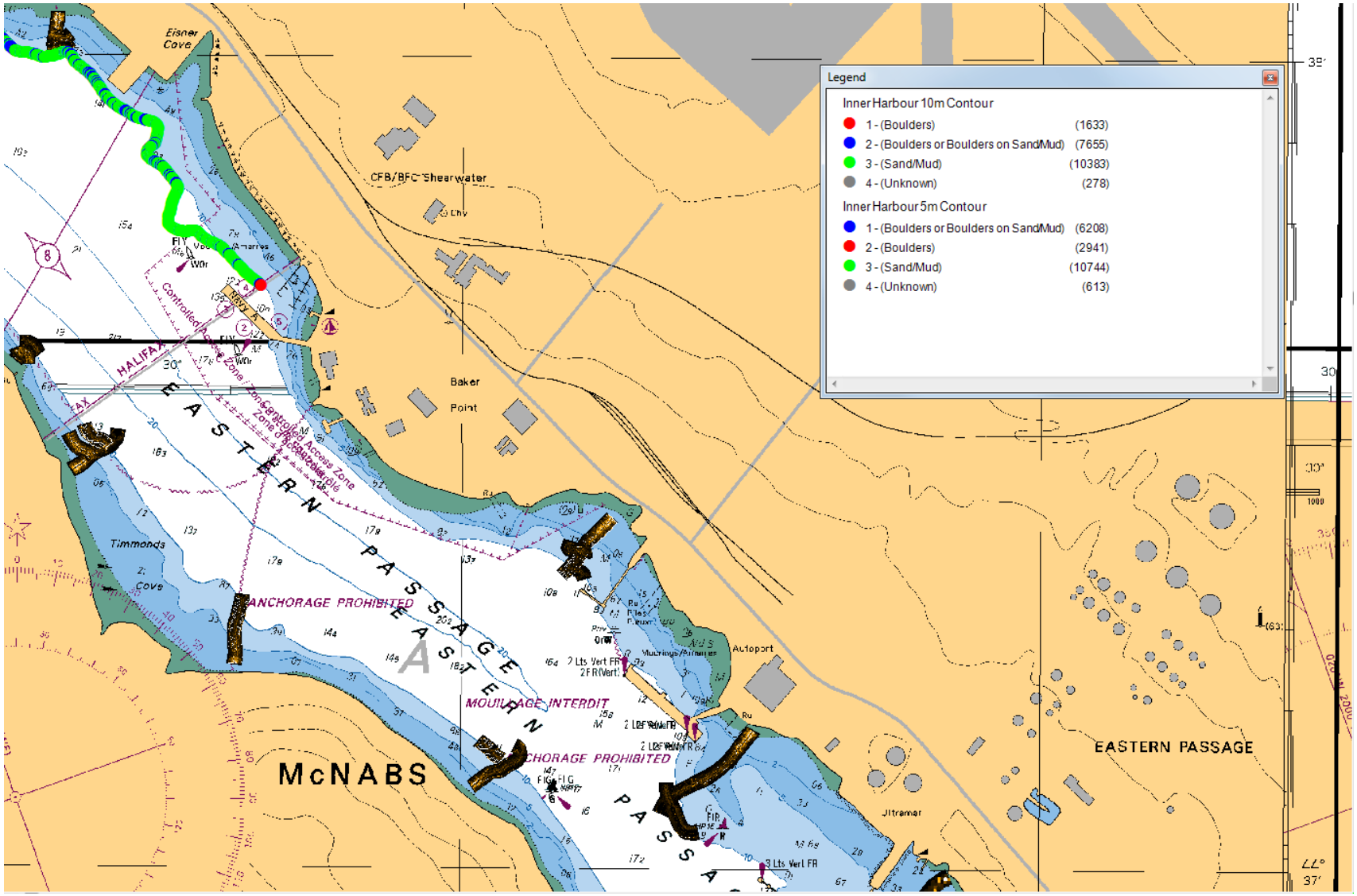


Figure 132: Inner Harbour VBT2 bottom classification results at 10 m for Eisner Cove area.

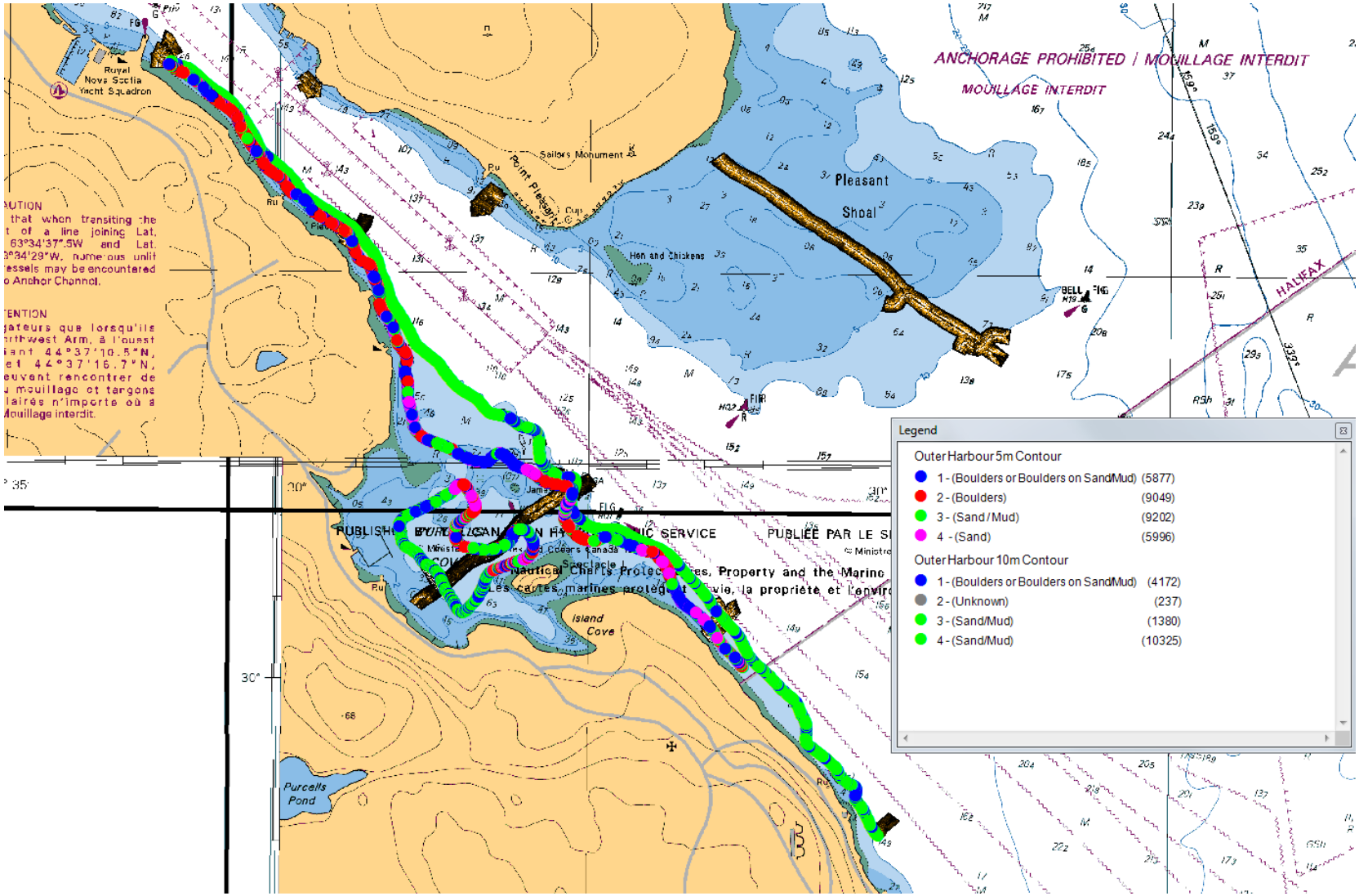


Figure 133: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the Purcells Cove area.

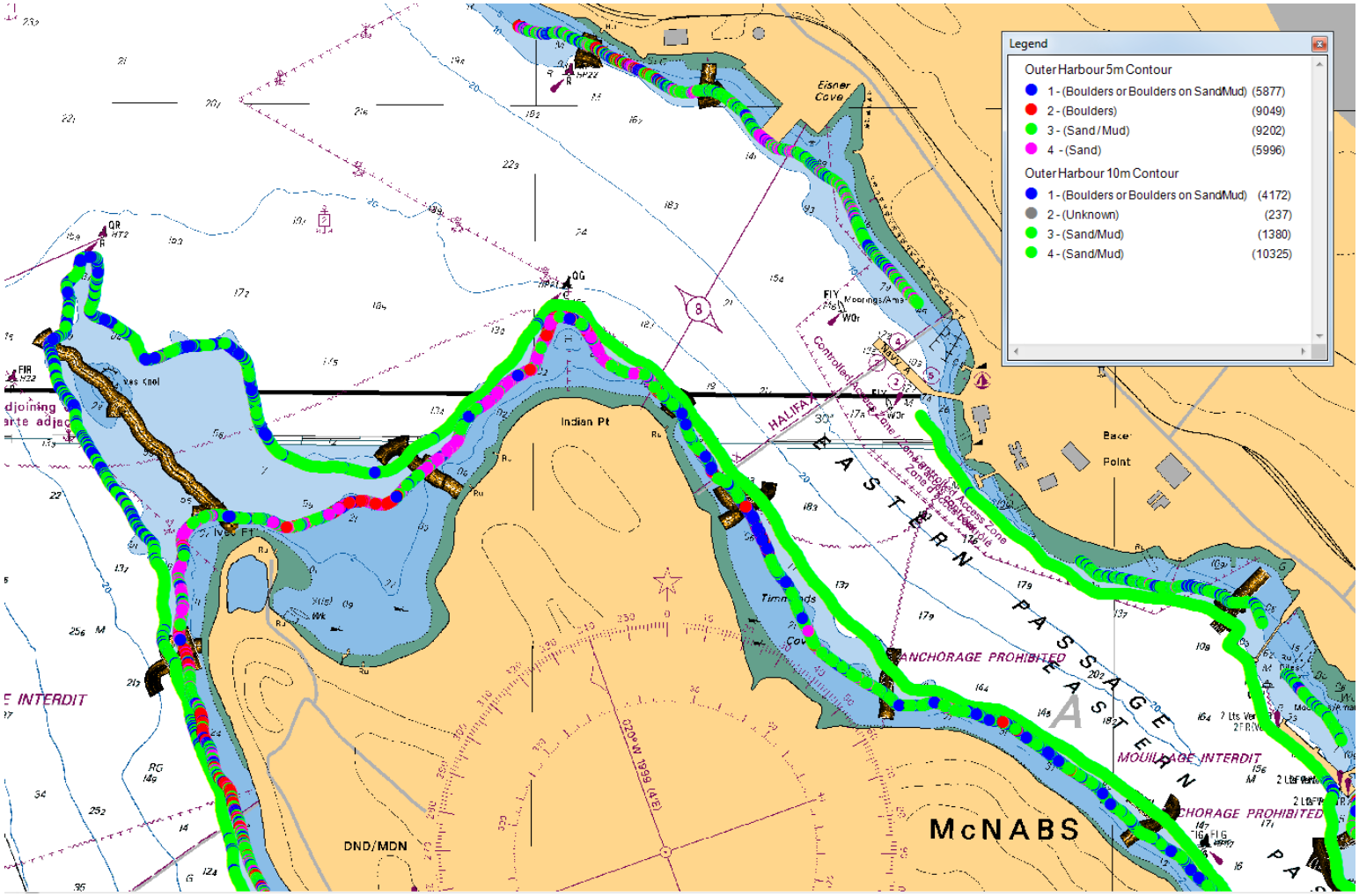


Figure 134: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the northern end of McNabs Island and Eastern Passage.

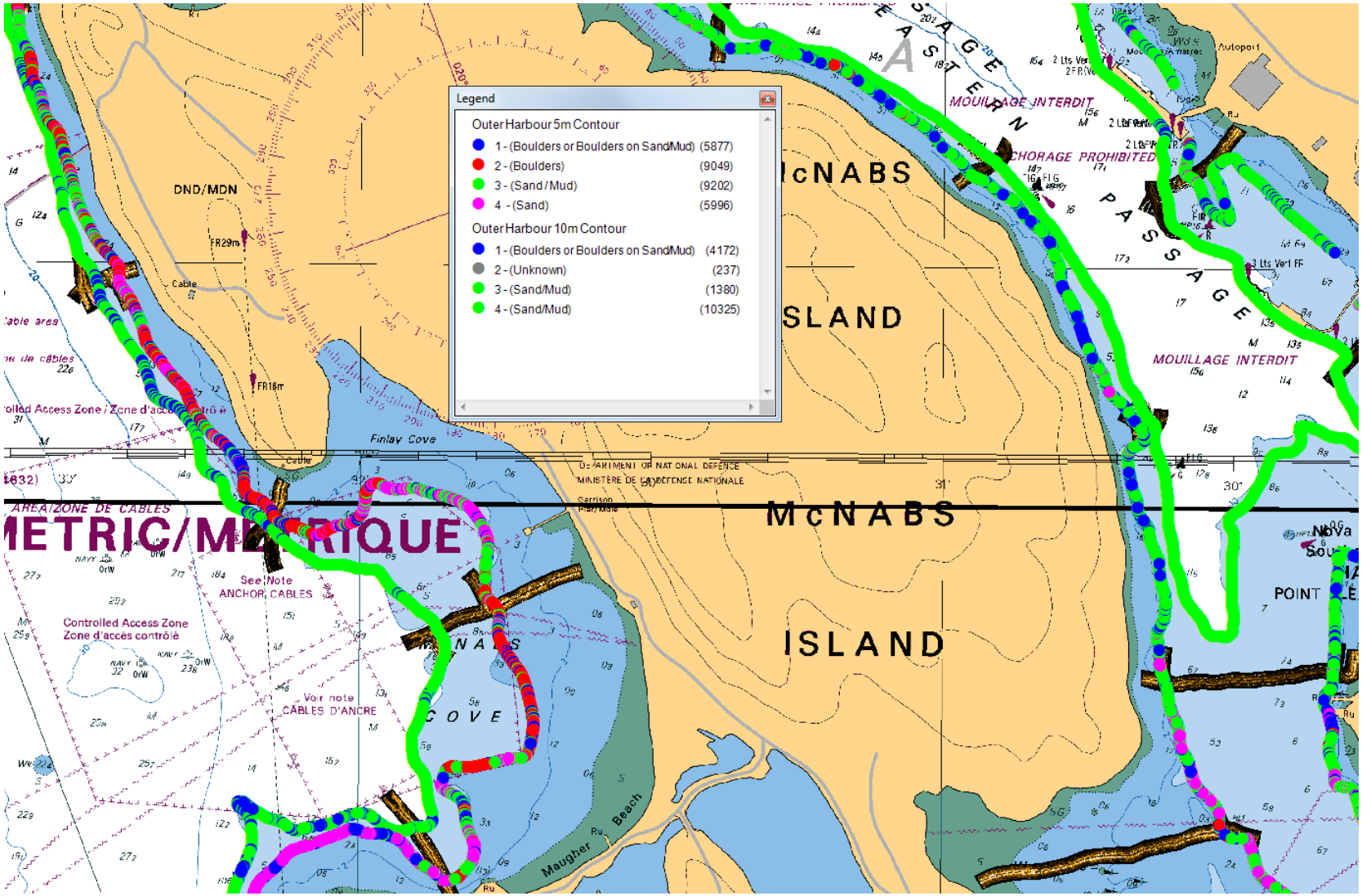


Figure 135: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the central portion of McNabs Island and Eastern Passage.

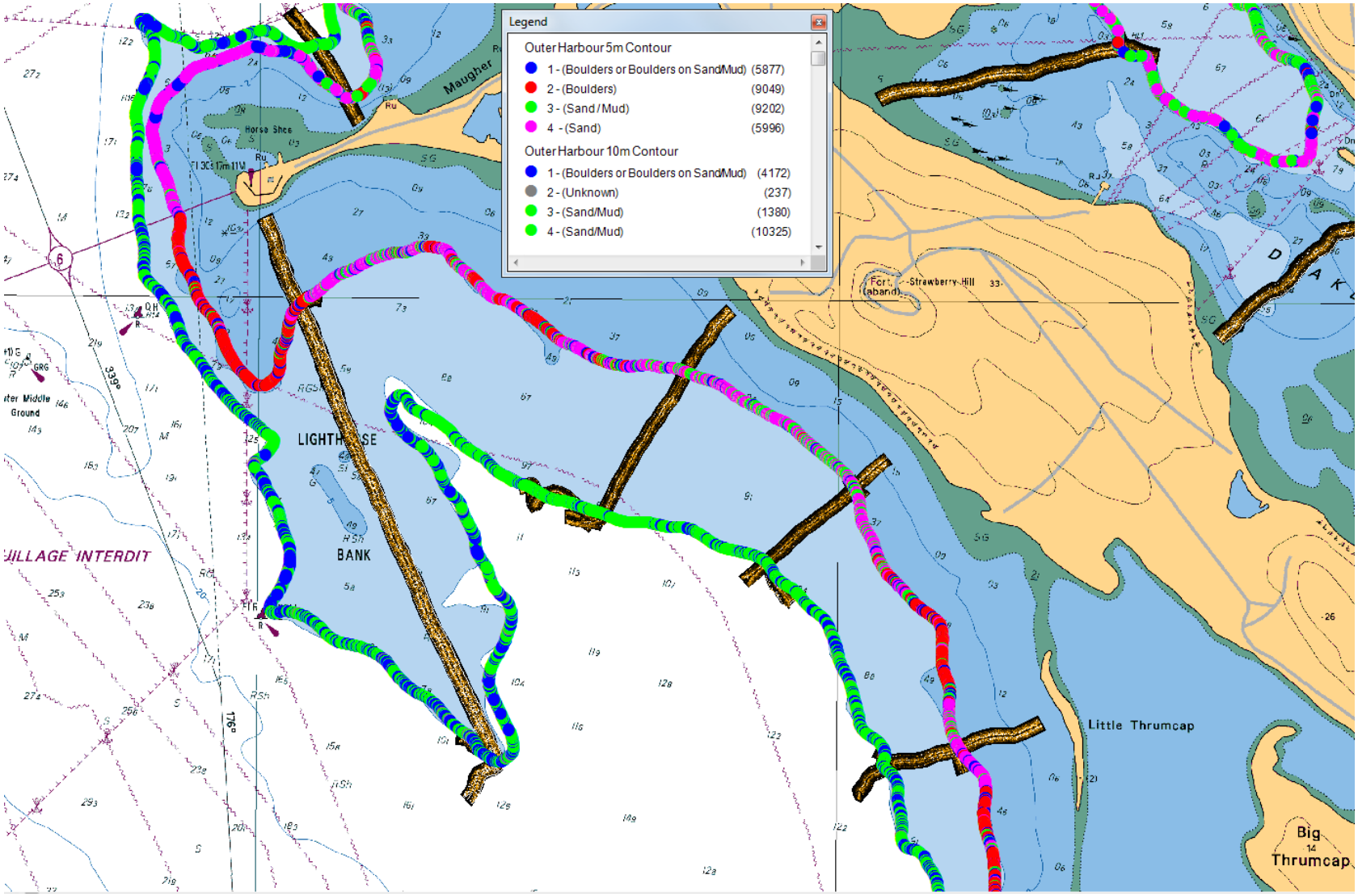


Figure 136: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the southern portion of McNabs Island.

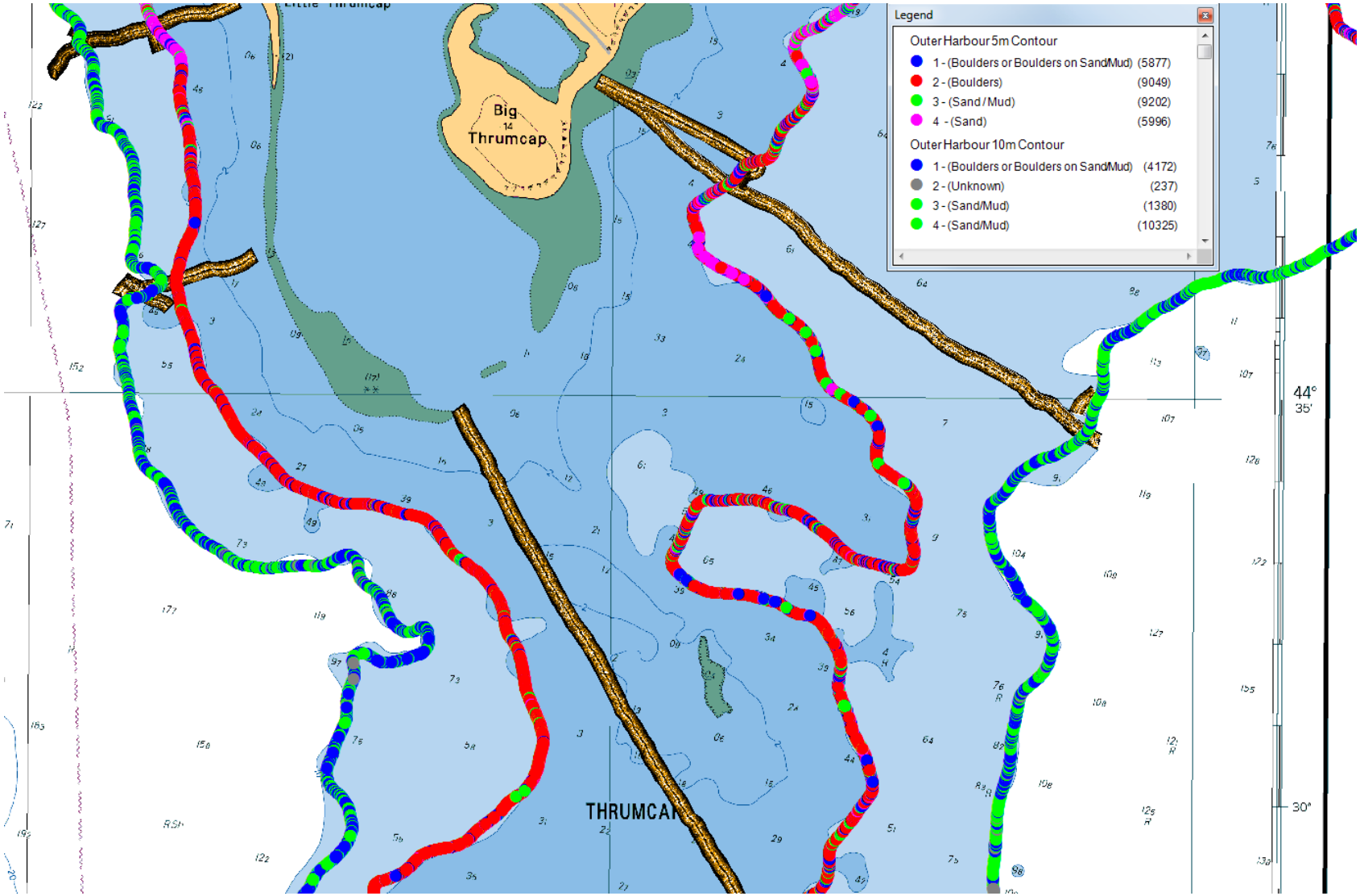


Figure 137: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the northern portion of Thrumcap Shoal.

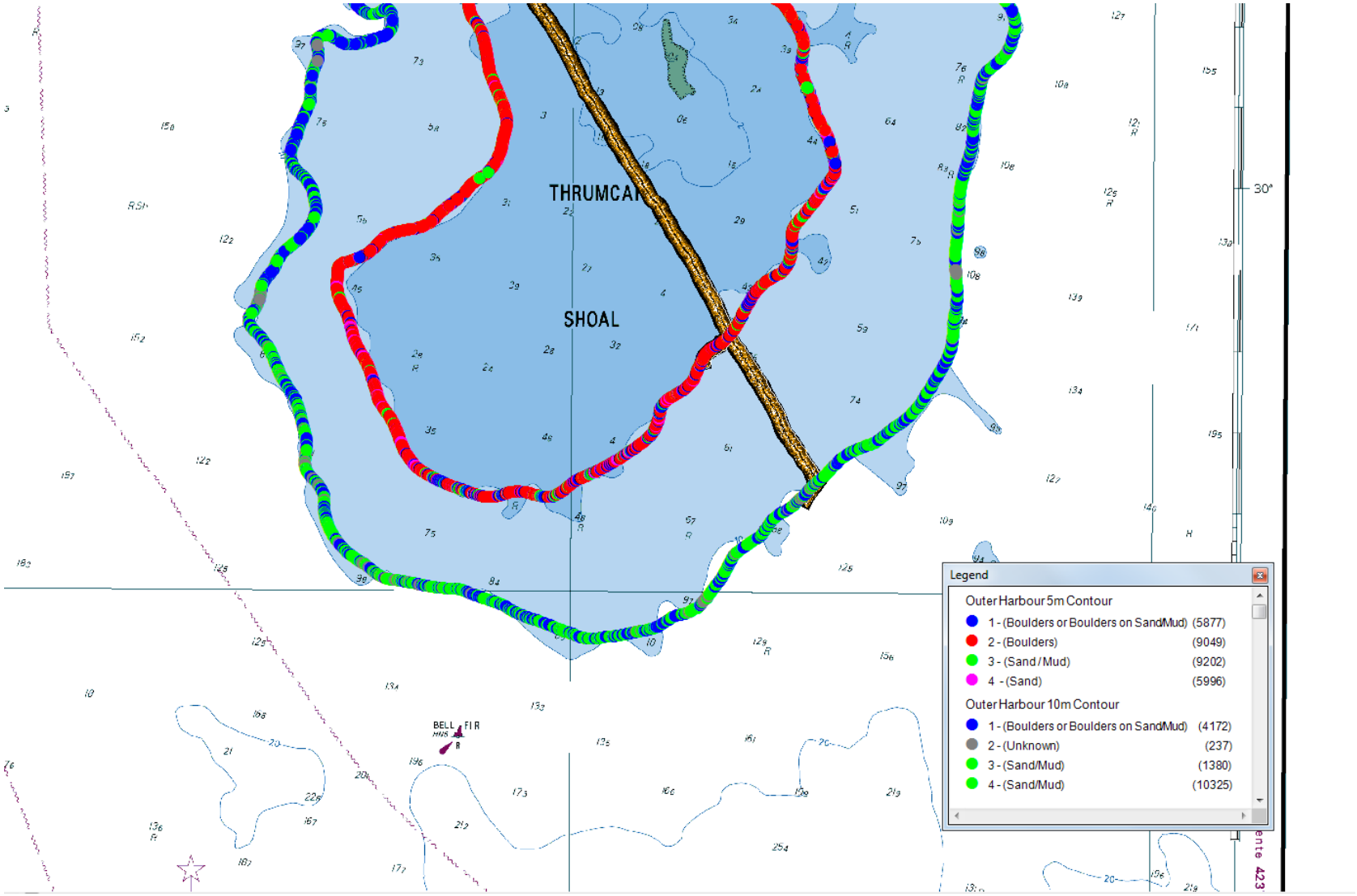


Figure 138: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the southern portion of Thrumcap Shoal.

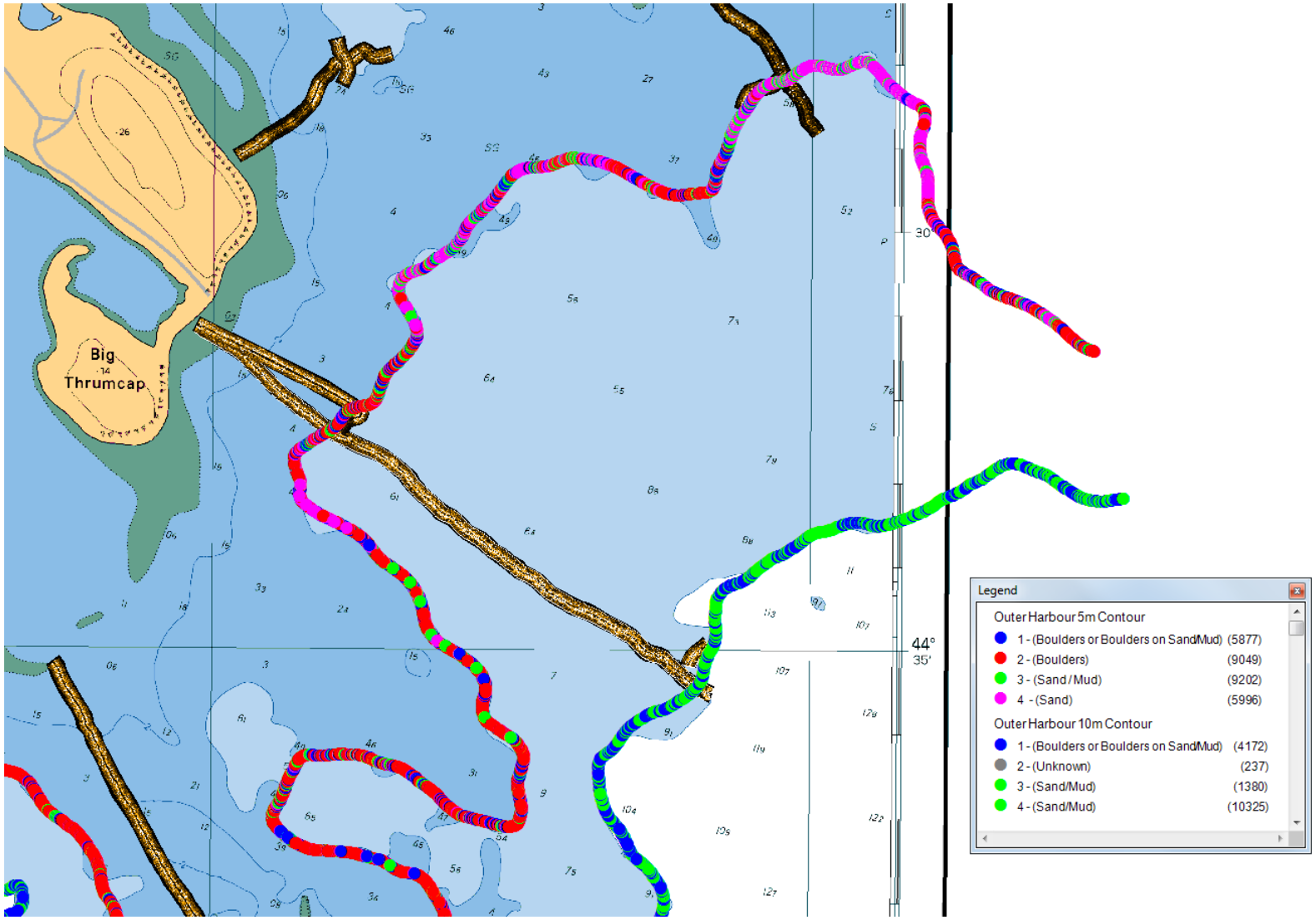


Figure 139: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the area east of Big Thrumcap.

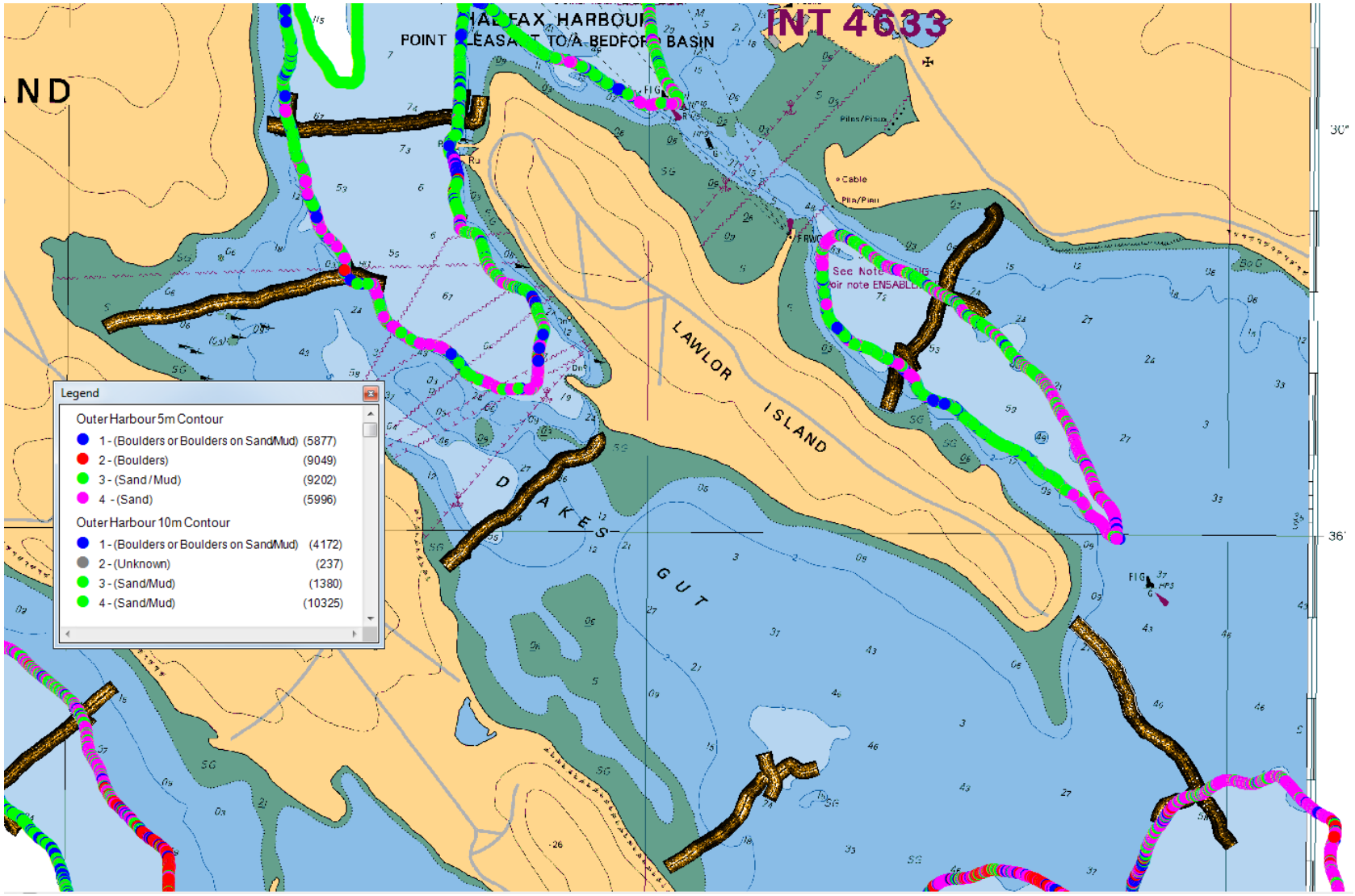


Figure 140: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the Lawlor Island area.

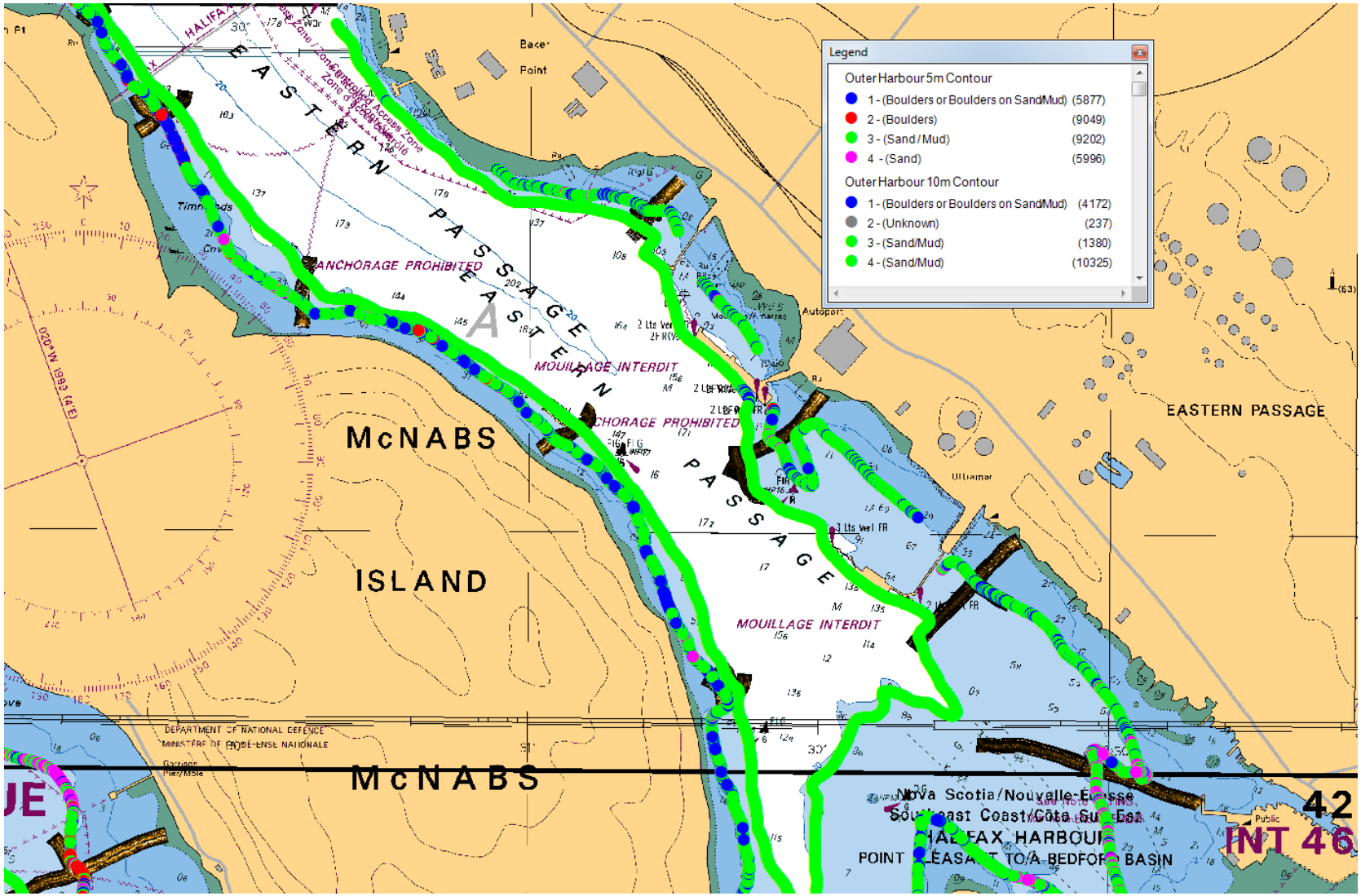


Figure 141: Outer Harbour VBT2 bottom classification results at 5 and 10 m for the southern portion of Eastern Passage.

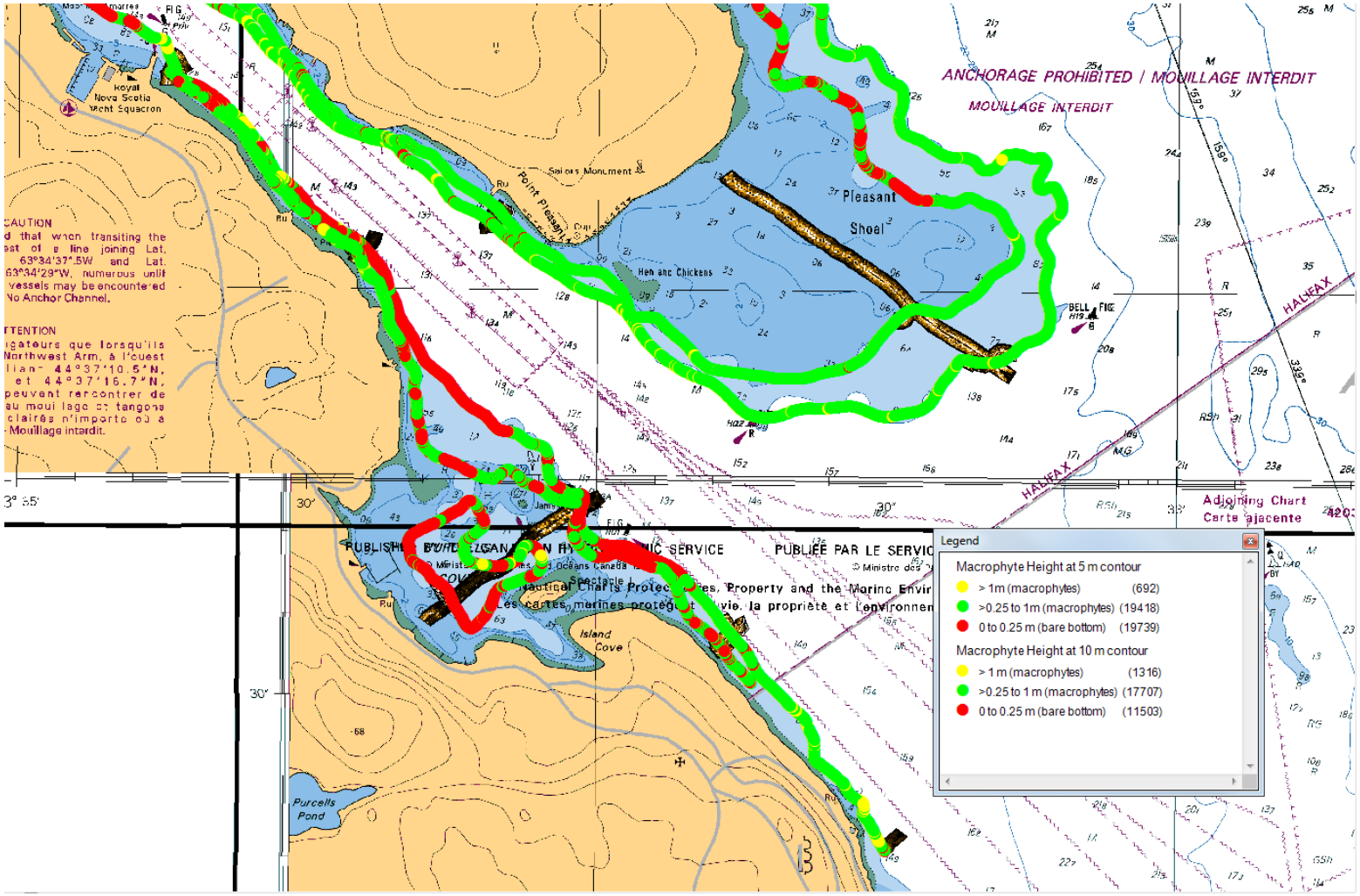


Figure 142: Outer Harbour EcoSAV classification results at 5 and 10 m for the Purcells Cove area.

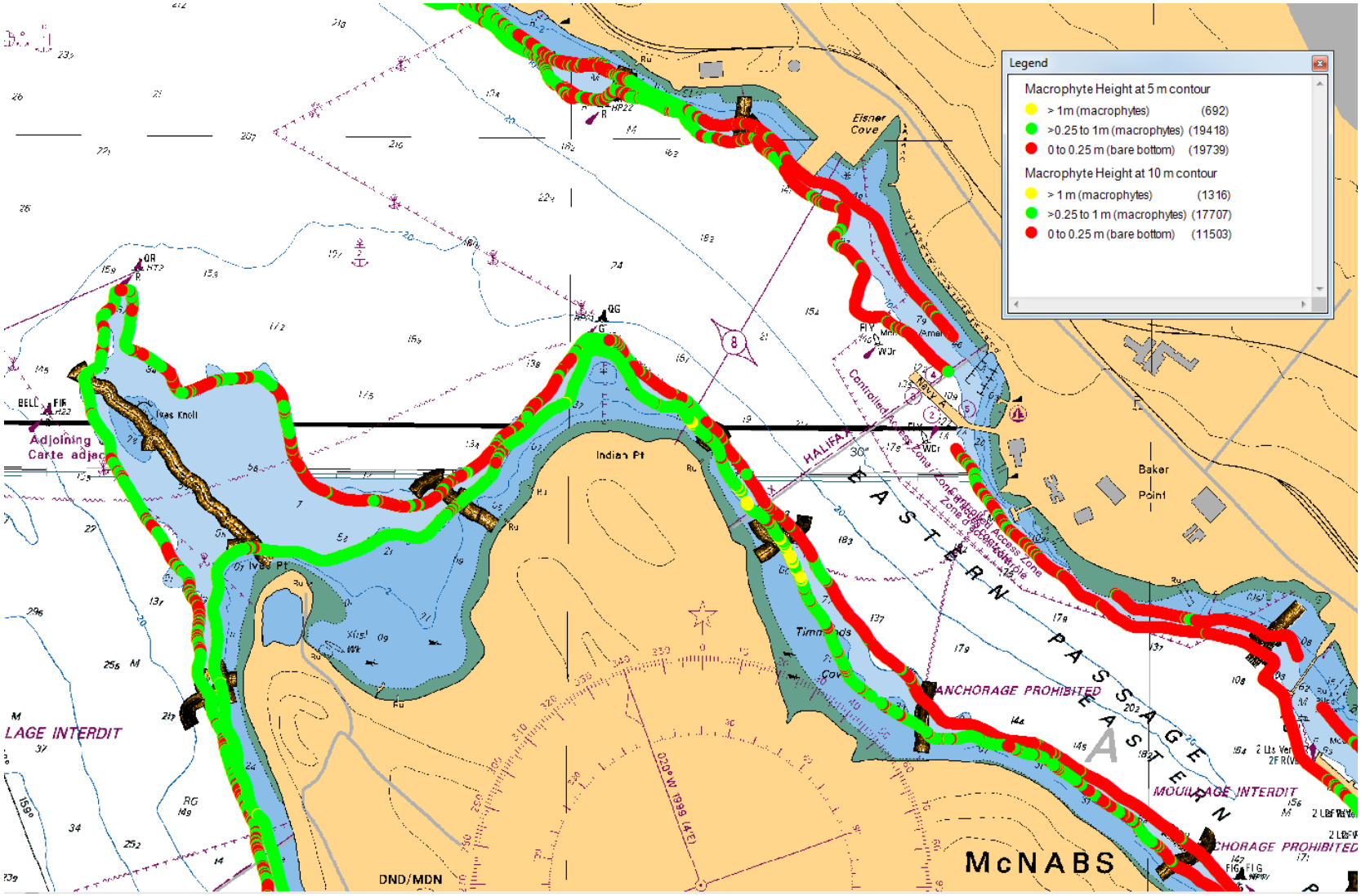


Figure 143: Outer Harbour EcoSAV classification results at 5 and 10 m for the northern end of McNabs Island and Eastern Passage.

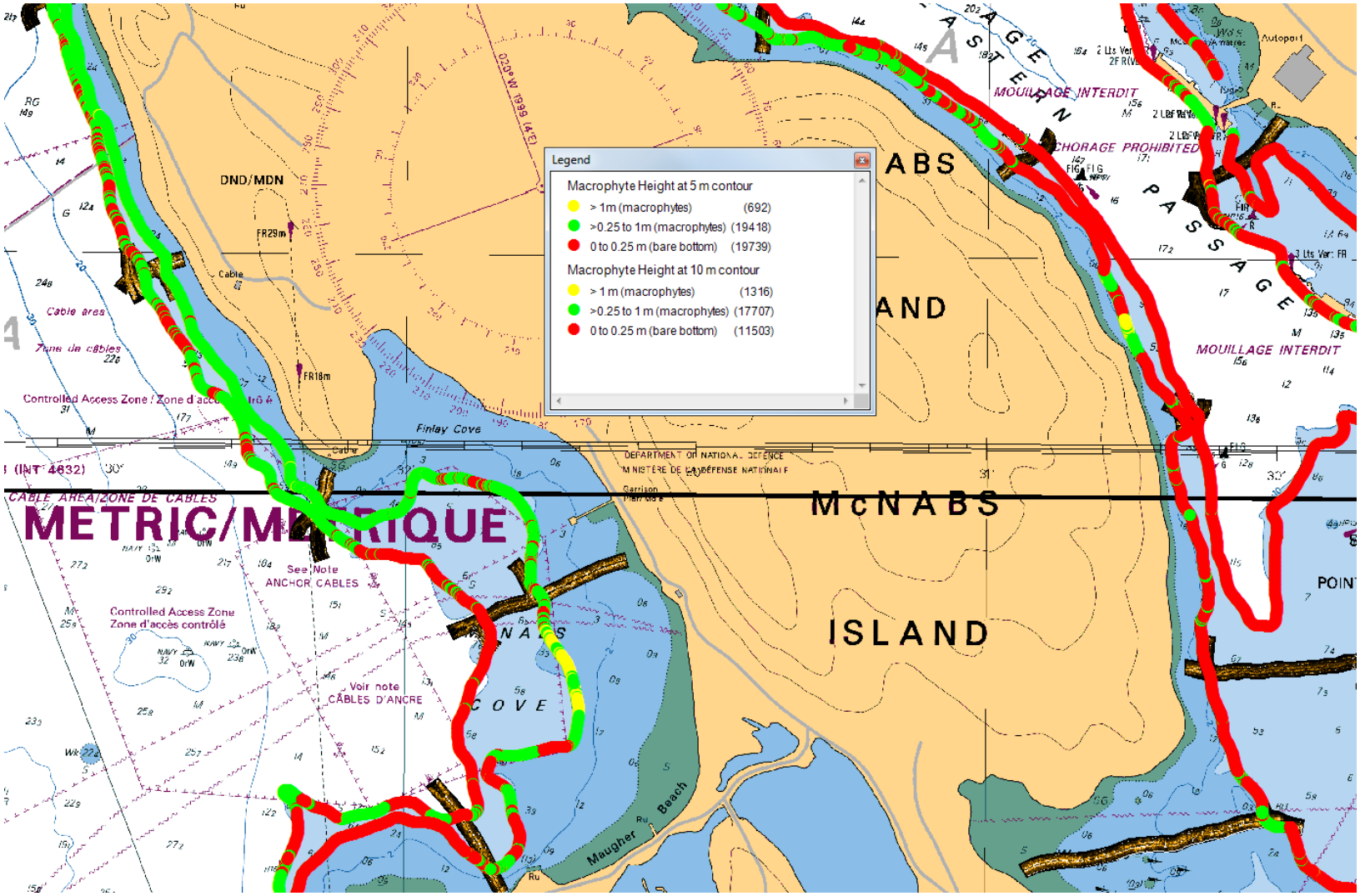


Figure 144: Outer Harbour EcoSAV classification results at 5 and 10 m for the central portion of McNabs Island and Eastern Passage.

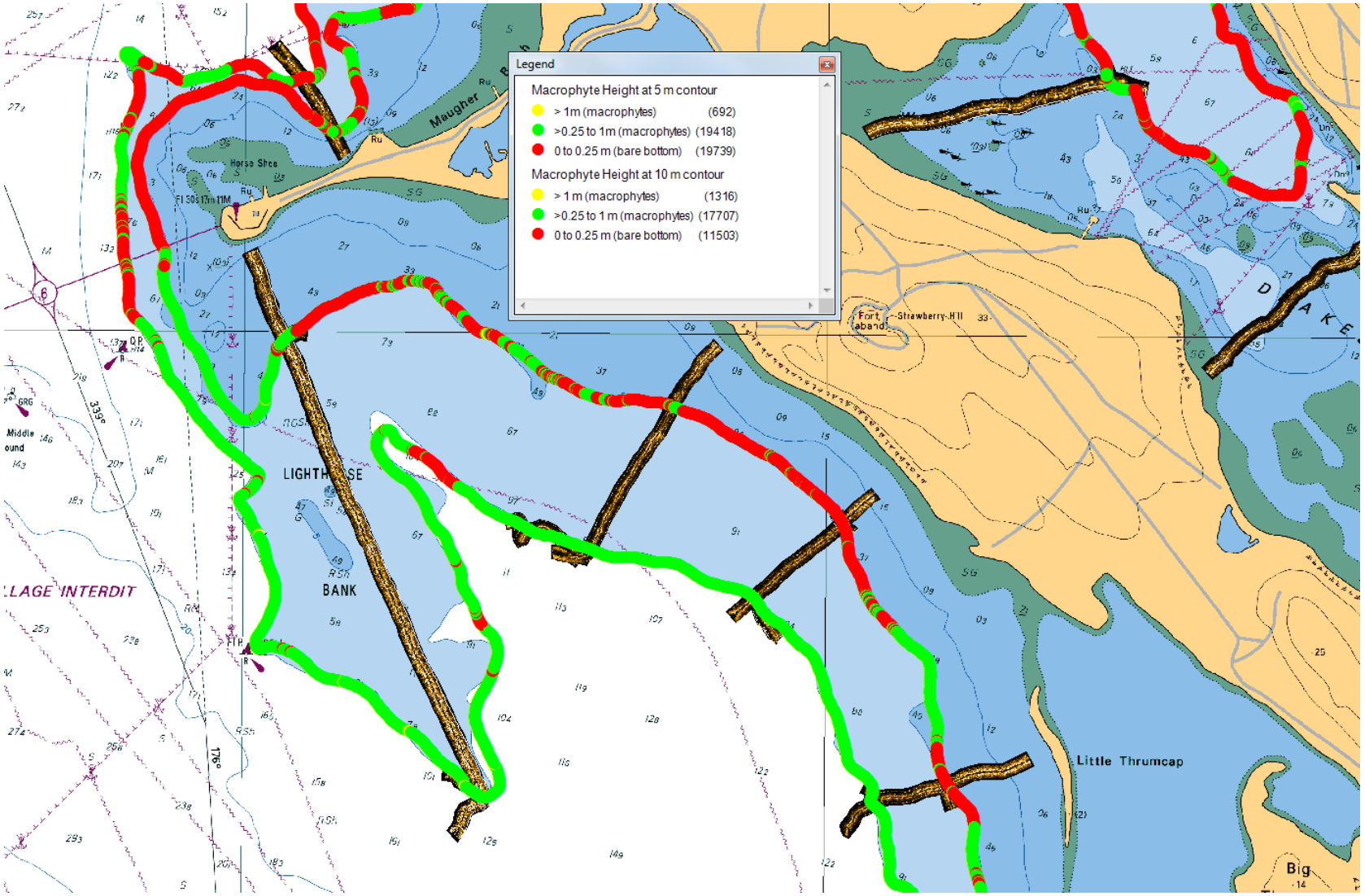


Figure 145: Outer Harbour EcoSAV classification results at 5 and 10 m for the southern portion of McNabs Island.

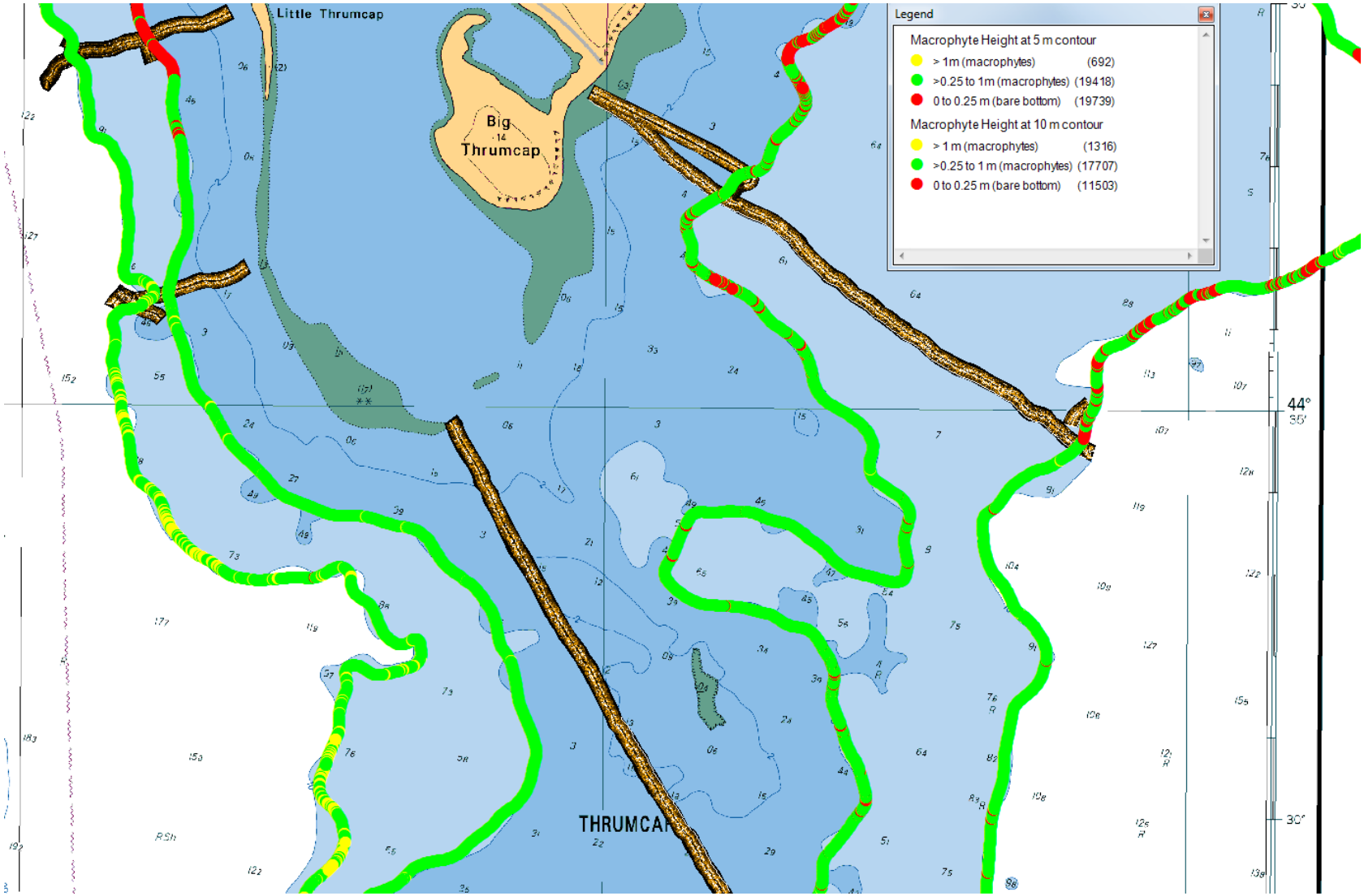


Figure 146: Outer Harbour EcoSAV classification results at 5 and 10 m for the northern portion of Thrumcap Shoal.

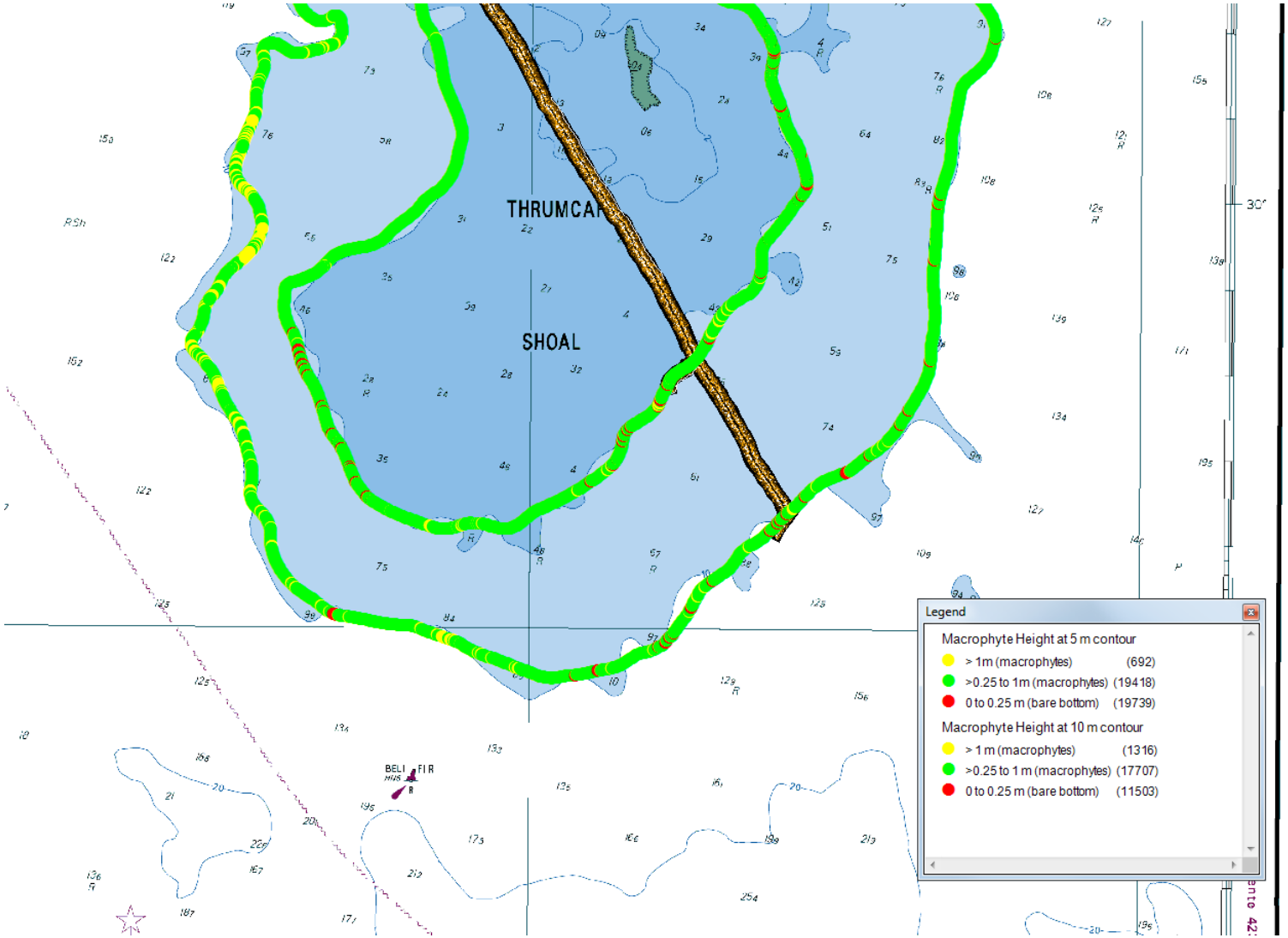


Figure 147: Outer Harbour EcoSAV classification results at 5 and 10 m for the southern portion of Thrumcap Shoal.

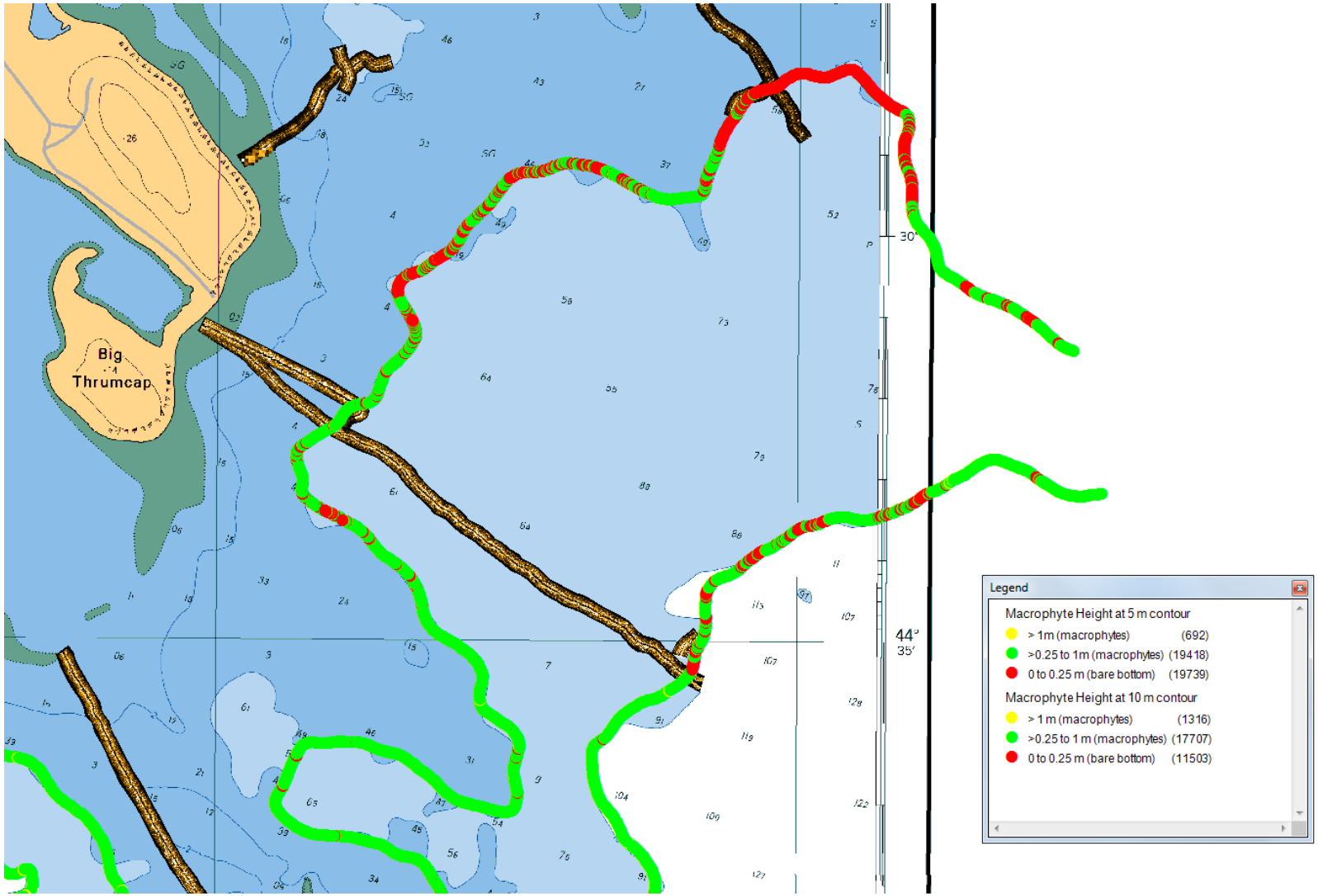


Figure 148: Outer Harbour EcoSAV classification results at 5 and 10 m for the area east of Big Thrumcap.

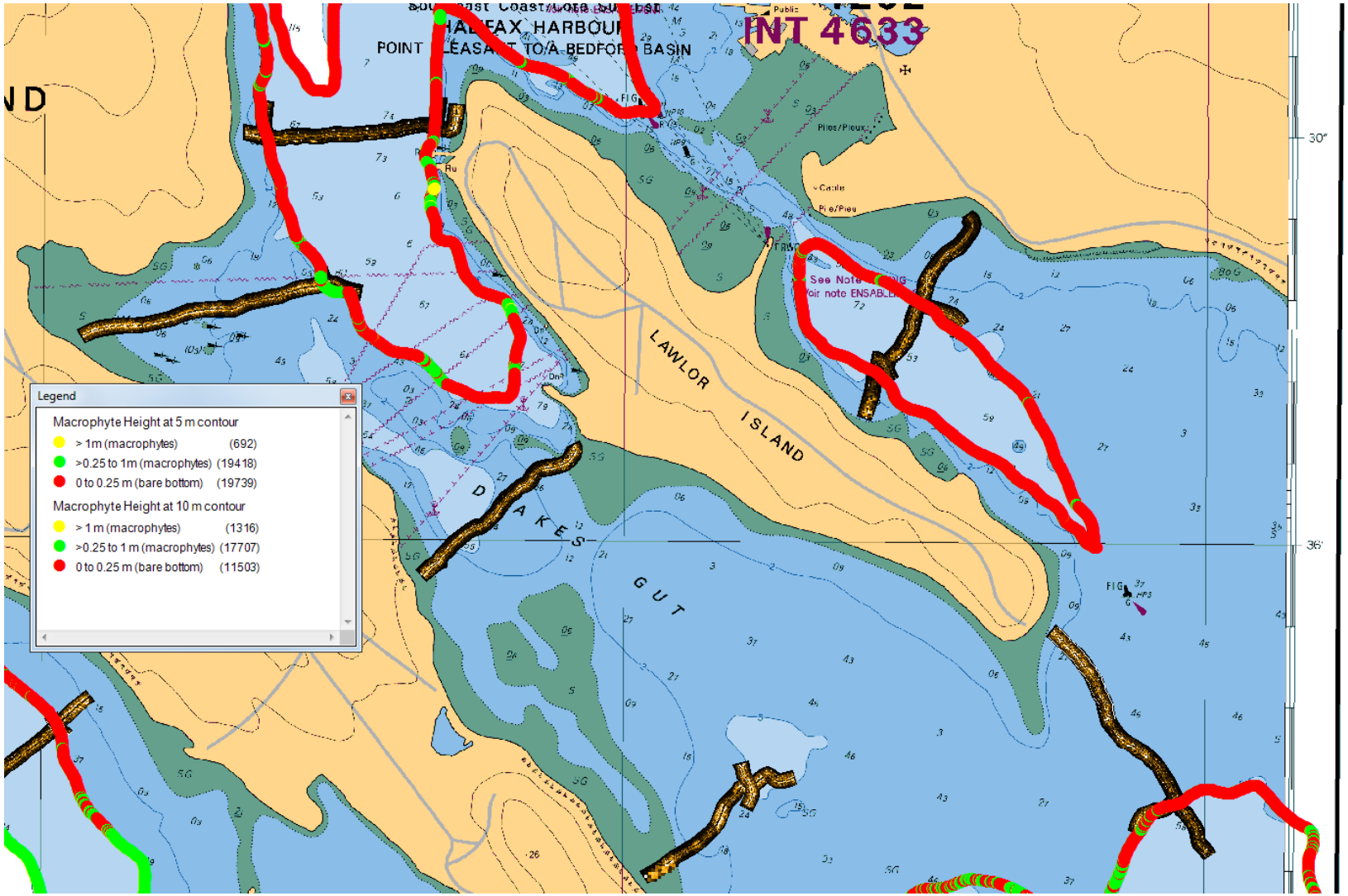


Figure 149: Outer Harbour EcoSAV classification results at 5 and 10 m for the Lawlor Island area.

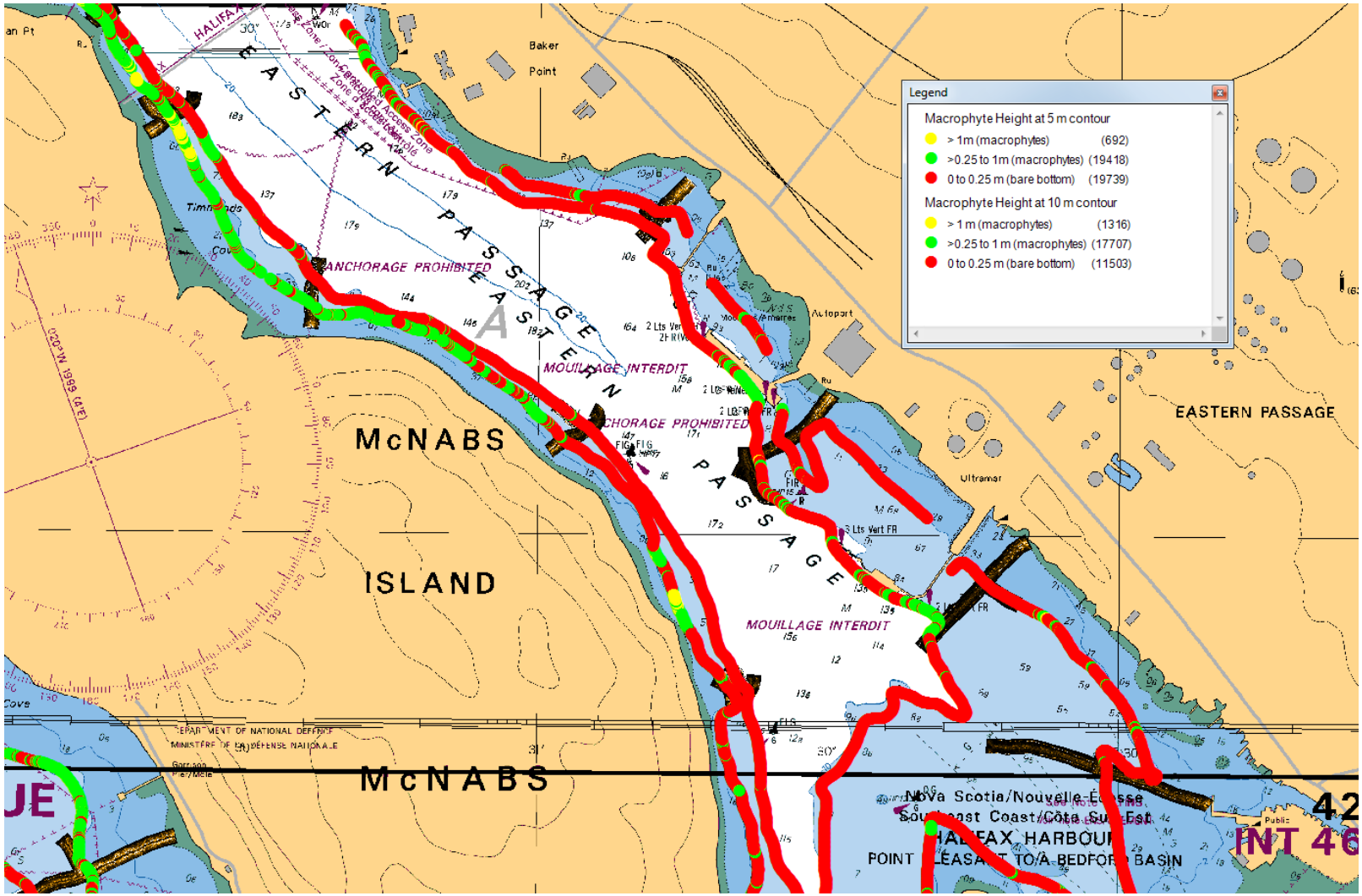


Figure 150: Outer Harbour EcoSAV classification results at 5 and 10 m for the southern portion of Eastern Passage.