ANDERSON MARINE SURVEYS

Report To: Dawnfresh Farming Limited

Issued By: [redacted]

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Little Cumbrae video survey

Summary

1. Habitats and species were as expected for a moderately tidal location in the Firth of Clyde. Physical disturbance of the seabed through trawling was considered to be of moderate severity, and anthropogenic debris was negligible.

2. No Priority Marine Features were observed.

3. Muddy sediments throughout the deeper parts of the survey area (>50m) were burrowed by *Nephrops norvegicus* and *Calocaris macandreae* (not observed but inferred from burrow characteristics). The burrowing crab *Goneplax rhomboides* and snake blenny *Lumpenus lampretaeformis* were also observed, although burrows were not conclusively identified. Very few seapens (all small *Virgularia mirabilis*) were observed; therefore this burrowed mud habitat does not constitute a specified PMF.

4. Density of *Nephrops* burrow systems increased with depth on all transects; although on Transects 2 and 3 the density of burrow systems decreased at the eastern (deepest) ends. This is most likely due to trawling effort; resulting in both removal of stock and destruction of burrow systems Maximum densities were 0.91 /m^2 on Transect 1, 1.05 /m^2 on Transect 2 and 1.19 /m^2 on Transect 3.

5. The maximum estimated burrow system density (1.19 /m^2) corresponds to a high density (>0.8 /m2) using the classification adopted by ICES for *Nephrops* stock assessment (ICES, 2011). Most of the surveyed *Nephrops* ground from the present study would be classified as low-medium burrow density (<0.3 /m2); and regarded as typical of densities recorded from *Nephrops* grounds in the Clyde sea area.

Introduction

Dawnfresh are considering development of a new cage site north-west of Little Cumbrae, Firth of Clyde (Figure 1). This report describes findings of a video transect survey carried out in September 2018; with reference to general seabed habitat and condition, visible biota, and the presence of any Priority Marine Features[1].

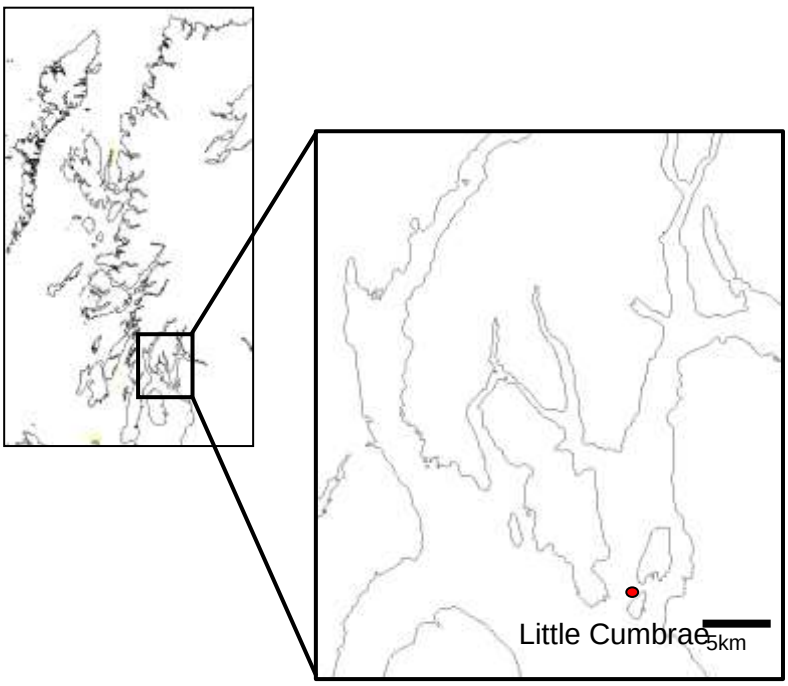

Figure 1
Little Cumbrae

The survey was also carried out in accordance with SEPA guidance *BASELINE SURVEY, VISUAL – STANDARD* (15/09/2008).

[1] Listed in Priority Marine Features in Scotlands Seas, SNH 2014. https://www.nature.scot/sites/default/files/2018-05/Priority%20Marine%20Features%20in%20Scotlands%20seas.pdf accessed 17/12/2018

Methods

The survey comprised three transects, and was originally carried out in January 2018. Video quality from that survey was considered inadequate and the survey was repeated on 01 September 2018. Weather conditions were fair, wind S2, overcast. Benthic sampling was carried out on the following day.

Survey operations were carried out from AMSL's 6.7m survey vessel *Mollie B*. Positioning and depth data were provided by a Simrad NSS7 evo.2 with fixes at 1s intervals logged directly to PC.

Transects were defined by start and end points (Figure 2). Cross-transects (T2 and T3) were run from east to west (shallow-deep), reaching maximum depths of 50.9m and 39.9m respectively.

Video survey of defined transects was carried out using a camera frame fitted with a Bowtech DIVECAM-550C-AL-I4 camera, GoPro video camera and four high intensity LED lights. The system was also equipped with two parallel laser pointers at 20cm separation. The camera frame was towed along a pre-determined transect line at approximately 0.5 knots just above the seabed, and allowed to settle briefly on the seabed at frequent intervals.

Site descriptor, position, elapsed time and depth were overlaid on the video post-survey, and deployment and recovery periods edited from the final video files in mp4 format.

Video footage has been examined and interpreted in 2-minute segments. Fauna was identified using standard sources (primarily Southward and Campbell 2006, Naylor 2011, Porter 2012, Wood 2013, Hayward and Ryland 2017, Bowen et al. 2018). Still images of representative views and individual species were captured from the video.

Nephrops burrow entrances were counted in 2-minute intervals of all transects and drops, and converted to density by estimating observed seabed area from cumulative track distance (between 1s GPS fix intervals) and estimated average field of view (0.6m). Burrow entrance density was converted to burrow system density, assuming a mean value of three entrances per burrow (see Discussion). Assessment of *Nephrops* abundance from burrow counts is dependent on four key assumptions: 1. Based on species-specific burrow entrance features, that burrows are accurately ascribed to *Nephrops*. 2. A cluster of openings judged to be related represents one burrow system. 3. Degraded, partially collapsed burrows are unoccupied and so are ignored. 4. Each burrow system contains one animal.

Results

Total transect lengths, calculated as cumulative distance between successive fixes were:

Transect 1 1184m
Transect 2 485m
Transect 3 452m

Positions of individual 2-minute transect segments are shown in Figures 3-5. Descriptive notes for each segment are tabulated in Appendix A.
Still images are listed in Appendix B and are available on accompanying electronic media.

Substrate along Transect 1 consisted of silty sand, grading gradually to fine silt. Water depths along transect 1 increased gradually from 28.9m to 59.2m. Transects 2 and 3 covered a greater bathymetric range, 20.4 to 50.7 m, with sediments grading from gravel and sands at shallower depths to soft mud at depths >40 m.

Light linear scarring of the sediment surface was observed in parts of Transects 2 and 3; this was superficial (around 1-2 cm, Figure 20) and most likely resulted from trawling activities. No significant anthropogenic debris was observed.

Muddy sediments throughout the deeper parts of the survey area (>30m) were burrowed by *Nephrops norvegicus* (Figures 10, 14) and *Calocaris macandreae* (the latter inferred from burrow characteristics). A single crustacean observed on the sediment surface (Figure 13) was tentatively identified as *Calocaris macandreae* outside a burrow; this would be a very unusual observation. Individuals of the angular crab *Goneplax rhomboides* were observed on Transect 1 (Figures 8, 11) and possibly transect 2. Very few seapens (all *Virgularia mirabilis*) were observed; therefore this habitat does not constitute a specified PMF.

Density of *Nephrops* burrow systems increased with depth on all transects (Figure 6); although on Transects 2 and 3 the density of burrow systems decreased at the eastern (deepest) ends. This is most likely due to trawling effort; resulting in both removal of stock and destruction of burrow systems Maximum densities were 0.91 /m^2 on Transect 1, 1.05 /m^2 on Transect 2 and 1.19 /m^2 on Transect 3.

Common species on silty sands and silts included the hydroid *Nemertesia antennina* and soft coral *Alcyonium digitatum* (Figure 7); both attached to pebbles or shells in the sediment. Also frequent were tubes thought to be those of the fanworm *Sabella pavonina* (Figure 12), squat lobster *Munida rugosa* (abundant; Figure 12), hermit crab *Pagurus sp*. (probably *bernhardus*), swimming crab *Liocarcinus spp* (probably both *L. depurator* and *L. holsatus* would be present), starfish *Asterias rubens* (sometimes in dense aggregations), scallop *Pecten maximus*, queen scallop *Aequipecten opercularis*, and gastropod *Turritella communis* (many of which may have been shells occupied by hermit crabs). These were all present at densities considered typical of natural habitat of this type.

In shallower sands and gravels on Transects 2 and 3, the burrowing anemone *Cerianthus lloydi* (Figures 15, 19), tubeworms *Spirobranchus* sp. and *Lanice conchilega*, sponge *Hymedesmia paupertas* (Figure 18), urchin *Echinus esculentus*, starfish *Marthasterias glacialis* and *Luidia ciliaris*, and sea squirts *Ascidiella aspersa* and *Ciona intestinalis* were recorded. Egg masses, possibly of nudibranchs, were also observed.

Other epifaunal species recorded occasionally or singly included seapen *Virgularia mirabilis,* brown crab *Cancer pagurus*, eyelash worm *Myxicola infundibulum* and whelk *Buccinum undatum*.

Two cephalopod species were recorded: octopus (probably *Eledone cirrhosa*, Figure 9) and cuttlefish (probably little cuttle *Sepia atlantica,* Figure 17).

Fish observed included dragonet *Callionymus lyra*, gurnard *Eutrigla gurnardus*, gadiids *Trisopterus sp*., haddock *Melanogrammus aeglefinus*, solenette *Buglossidium luteum*, dab *Limanda limanda* (Figure 16),and snake blenny *Lumpenus lampretaeformis* (which is a burrowing species).

Discussion

Habitats and species were as expected for a moderately tidal location in the Firth of Clyde. Physical disturbance of the seabed in deeper parts of the survey area through trawling was considered to be of moderate severity, and anthropogenic debris was negligible.

No Priority Marine Features were observed.

The conclusive identification of burrows relies on resin-casting (e.g. Rice & Chapman 1971; Atkinson 1986; Marrs et al. 1996). In the present visual survey, burrows attributable to the thalassinid *Calocaris macandreae* were identified with high confidence in similar habitat to *Nephrops*. Burrows constructed by the crab *Goneplax rhomboides* and snake blenny *Lumpenus lampretaeformis* have entrance characteristics similar to those of *Nephrops*, and both species were present in the survey area (and previously recorded in the Clyde sea area; Atkinson 1986). Depth and sediment preferences of these species vary slightly (*Goneplax* in shallower and sandier sediment than *Nephrops*; *Lumpenus* in deeper water) but overlap. However, characteristic semi-circular excavation traces of *Goneplax* were not observed and *Lumpenus* was rarely observed in this survey area. It is therefore considered probable that the majority of burrow systems identified as *Nephrops* are correct, and that density estimates are not significantly influenced by the presence of these other species.

Estimation of *Nephrops* population density (and by implication, stock size) on the basis of burrow counts is a standard method (e.g. Marrs et al. 1996; ICES 2007) but is subject to several assumptions. Significant factors include:

- **Identification of *Nephrops* burrows**: burrows of adult *Nephrops* are generally distinctive (including one or more shallow-angle “railway tunnel”

openings) and distinguishable from burrows of other species present in the area (primarily the thalassinid crustacean *Calocaris macandreae*). Other potential confusing species include the crab *Goneplax rhomboides* and various fish species; however, no burrows were observed which could be conclusively attributed to these (see above). The squat lobster *Munida rugosa* was observed in high densities around the edges of *Nephrops* ground, and in several cases was observed in burrow entrances. *Munida* is known to opportunistically use burrows of other species (mainly *Nephrops*), and in some cases to excavate shallow burrows, and it is possible that a proportion of burrows attributed to *Nephrops* may have belonged to *Munida*.

- **Number of entrances per burrow**: the small-scale distribution of observed *Nephrops* burrows was patchy, i.e. several burrows (2-10) tended to occur in close proximity and it was frequently not possible to distinguish individual burrow systems. Accordingly, all burrow entrances were counted. Marrs et al. (1996) examined an extensive collection of resin casts of *Nephrops* burrows (148 in total), most burrows had either two or three openings, but some had six or more (the average was three). Assuming an average of three entrances per burrow system, the maximum estimated burrow system density (1.19 /m^2) corresponds to a high density (>0.8 /m^2) using the classification adopted by ICES for *Nephrops* stock assessment (ICES, 2011). Most of the surveyed *Nephrops* ground from the present study would be classified as low-medium burrow density (<0.3 /m^2).

  Nephrops densities in the Clyde Sea area are reported by Atkinson (1986) as varying from 0.07 /m^2 (southeast of Arran) to 0.9-1.5 / m^2 (Kilbrannan Sound) and densities recorded in this survey area would therefore be typical of this range.

- **Abandoned burrows**: Marrs et al (1996) also considered the occupancy rate of *Nephrops* burrows, concluding that there were no reliable visual indications that a burrow was occupied, and that it may be necessary to derive estimates of the number of empty burrows from knowledge of the numbers of *Nephrops* removed by the fishery and by natural causes. This factor is therefore not taken into account by this study.

- **Field of view, visibility and edge effects** – these factors all influence the estimation of burrow density from camera systems, and have been considered in some detail in the context of stock assessment (e.g. ICES 2007). In this study, field of view was variable, due to changes in the height of the camera sledge above the seabed. However, the effects of increased field of view with height is offset by loss of visibility at heights more than 1m, and the overall estimate of an average field of view of 0.6m is considered reliable. Edge effect can lead to overestimates of between 20 and 35% (Addison & Bell 2000) in abundance when used to raise counts from a number of tows to larger areas, but is not considered to significantly influence the conclusions of this study.

References

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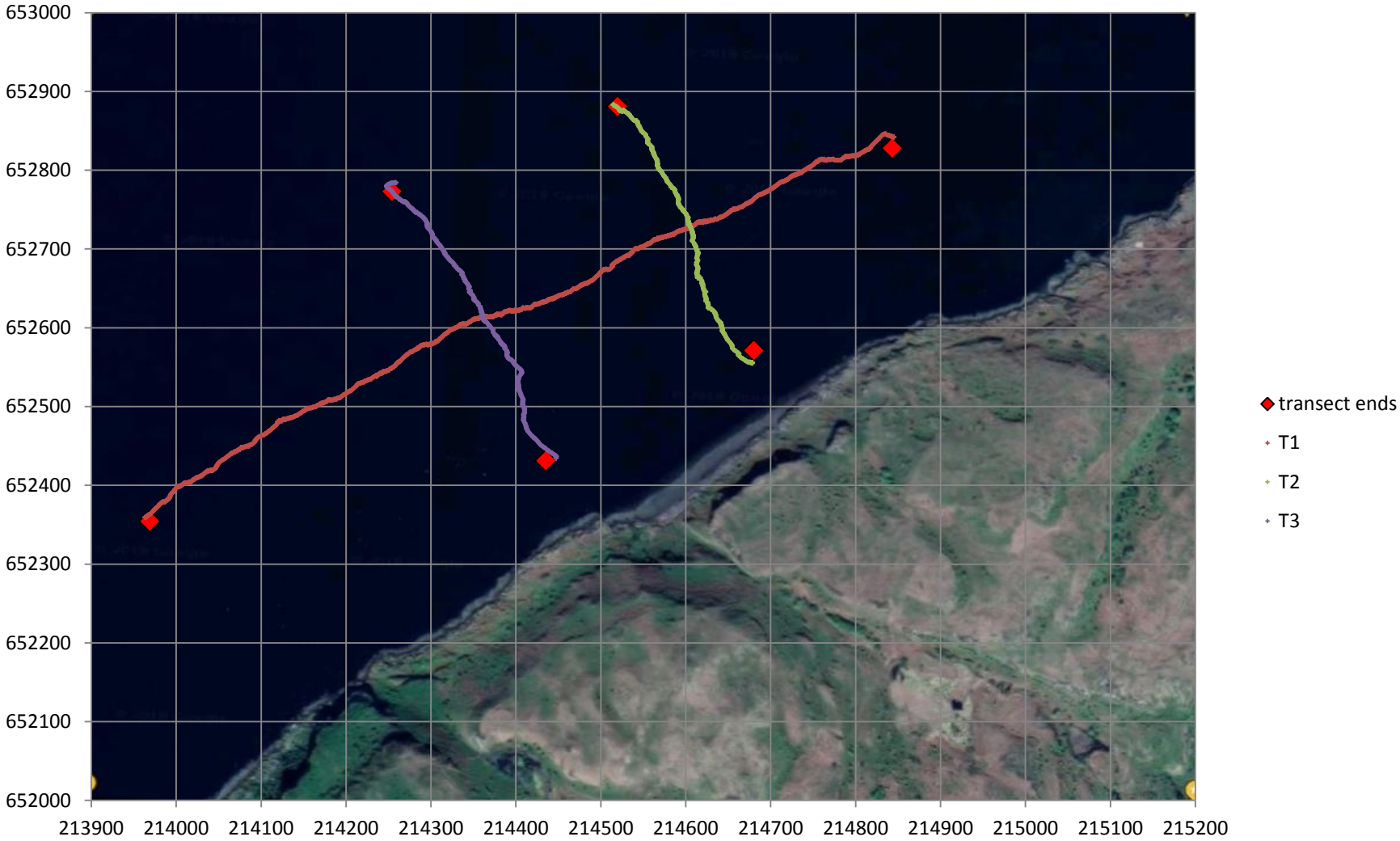

Figure 2. Proposed and actual transects, Little Cumbrae

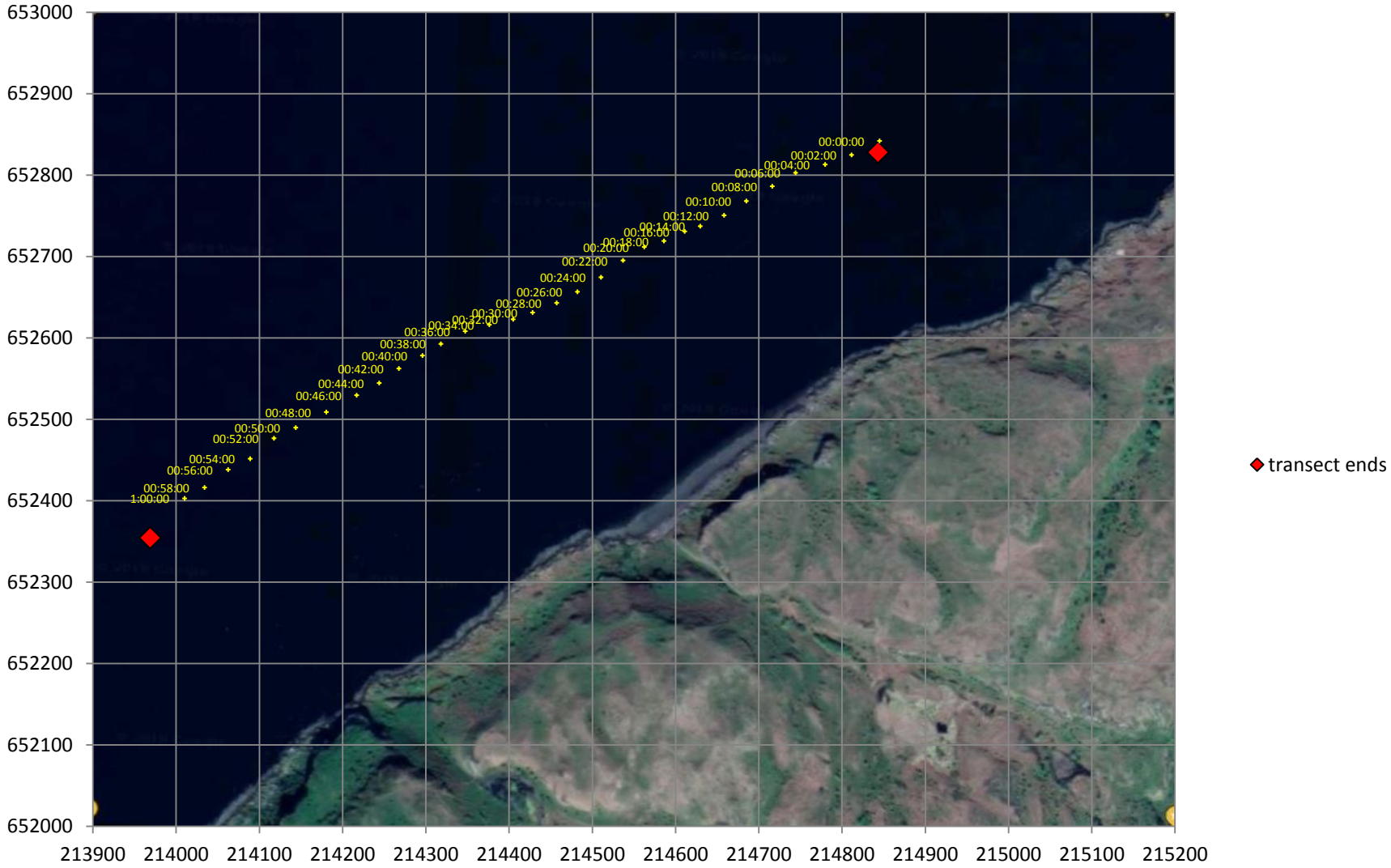

Figure 3. Transect 1, 2-minute interpretation segments

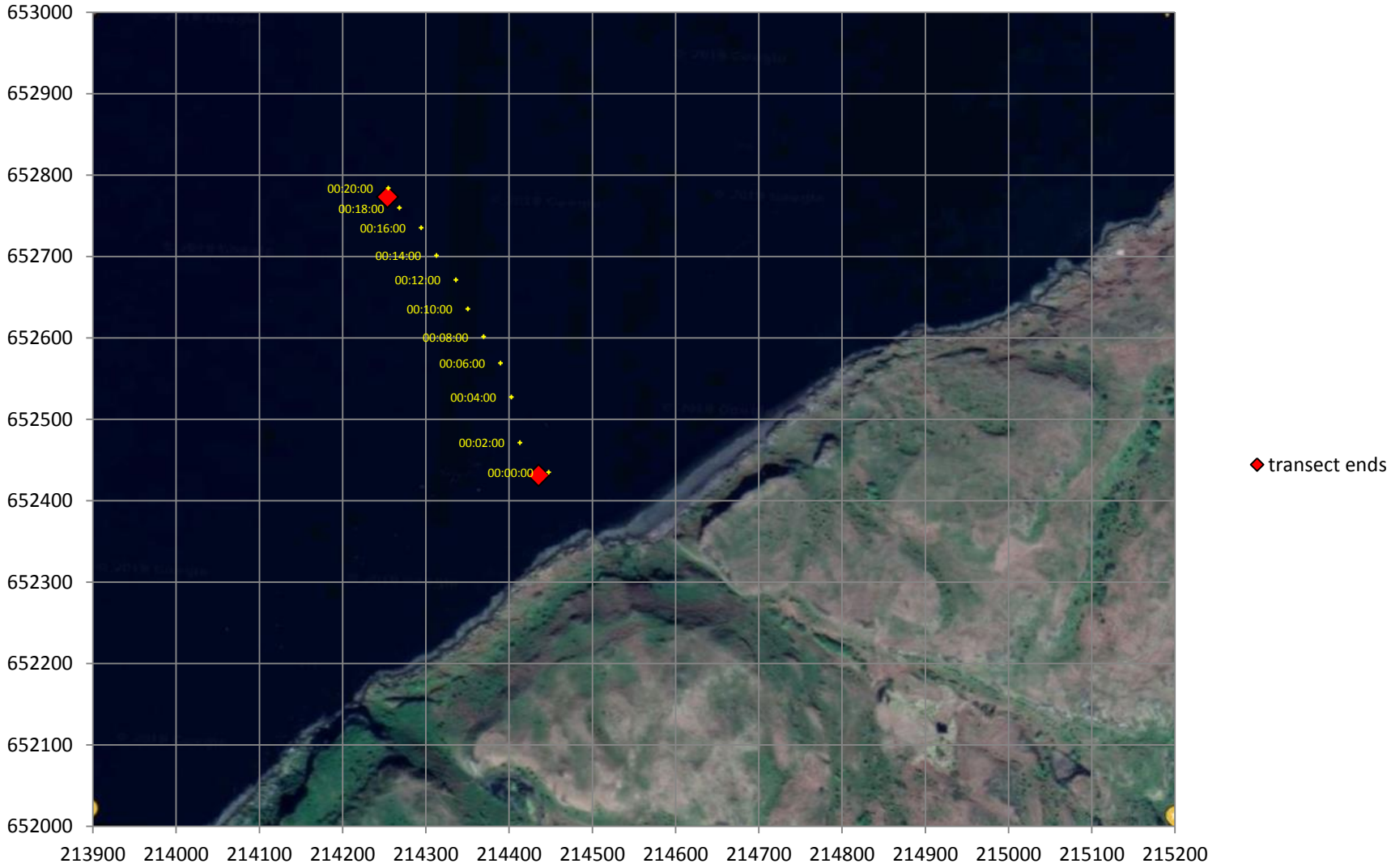

Figure 4. Transect 2, 2-minute interpretation segments

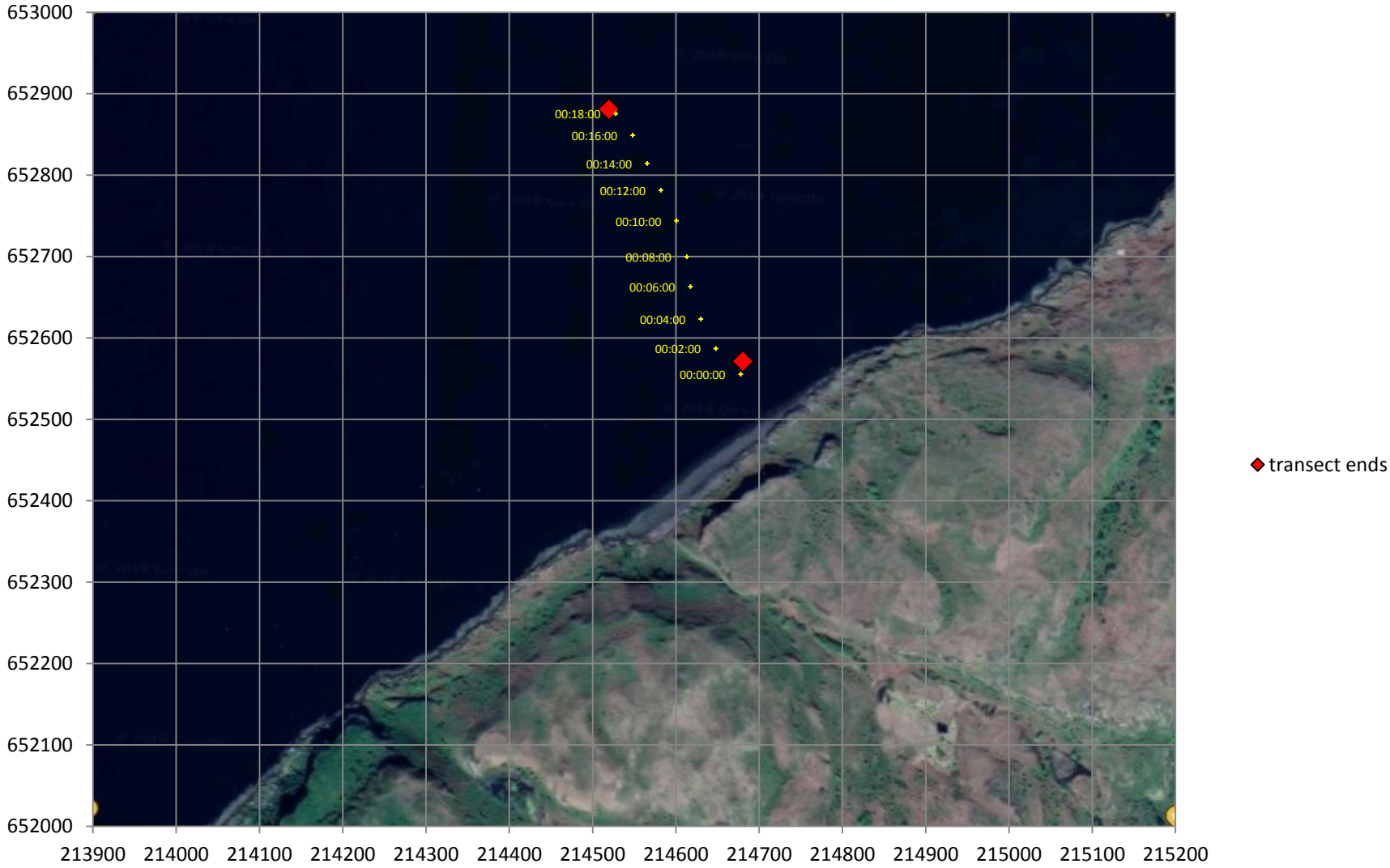

Figure 5. Transect 3, 2-minute interpretation segments

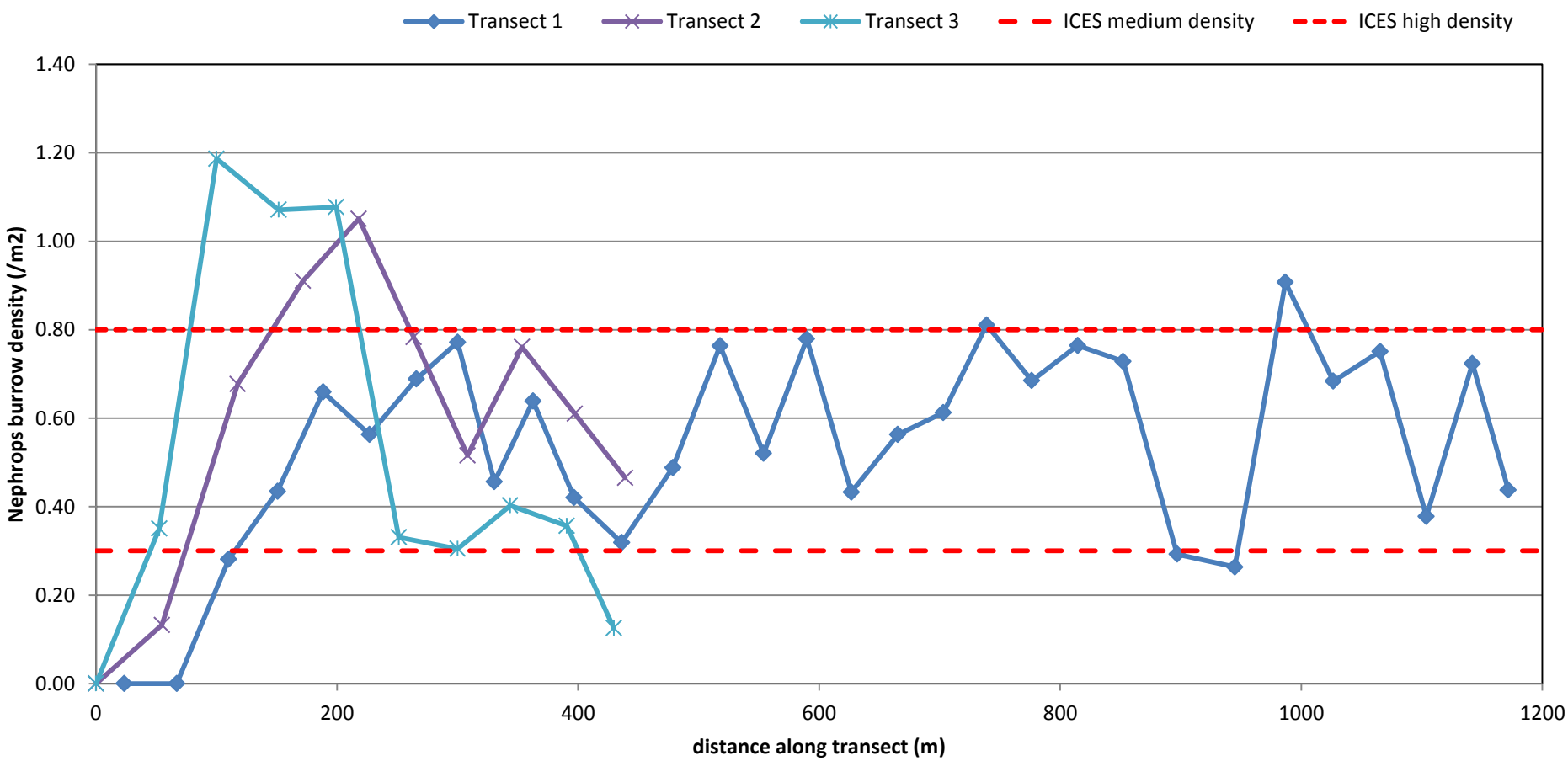

Figure 6. Nephrops burrow density along video transects, Little Cumbrae

Figure 7 (still 2). Silty sand habitat. *Alcyonium digitatum*, *Spirobranchus*, hydroids

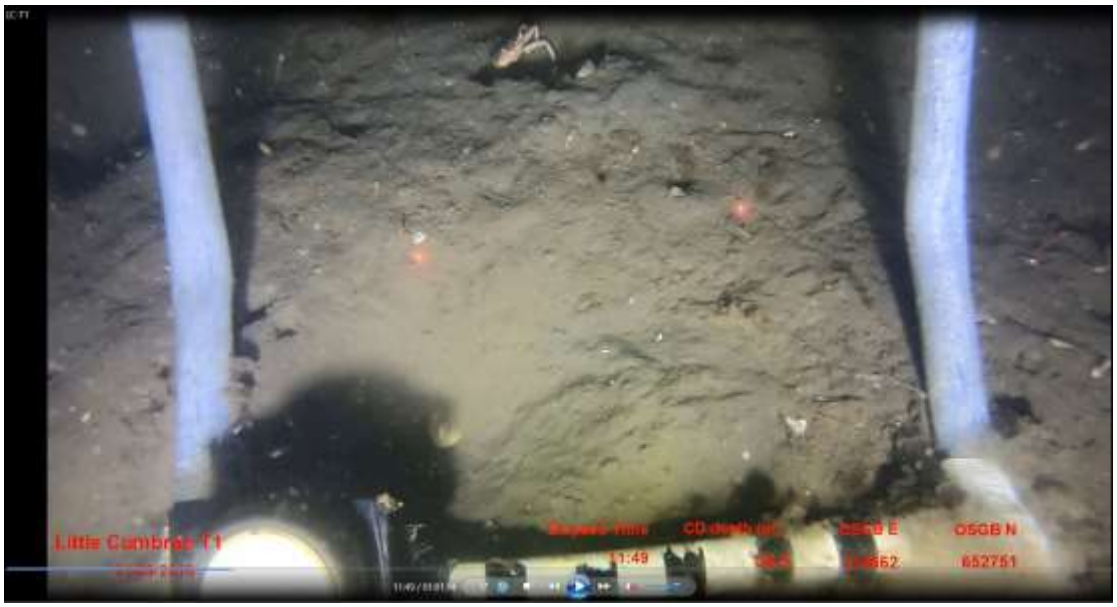

Figure 8 (still 4). Silty fine sand, *Goneplax rhomboides*

Figure 9 (still 5). Silty fine sand, *Eledone cirrhosa*

Figure 10 (still 6). Silty fine sand, *Nephrops norvegicus*

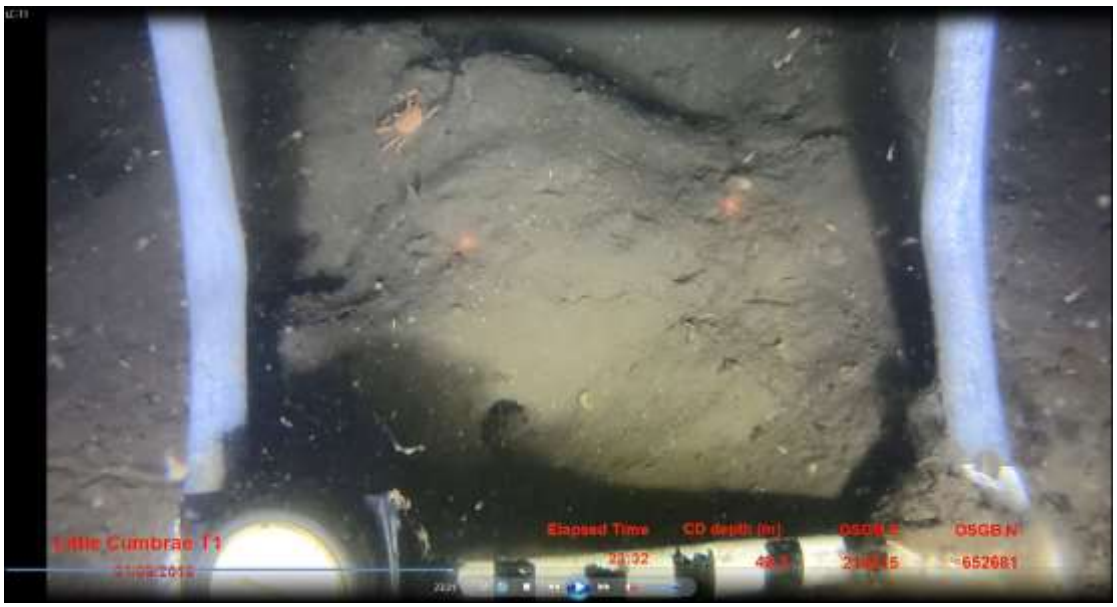

Figure 11 (still 9). Silty fine sand, *Goneplax rhomboides*

Figure 12 (still 10). Medium silt. *Sabella* tube, *Munida rugosa*

Figure 13 (still 11). Medium silt. *Calocaris macandreae*?.

Figure 14 (still 12). Medium silt, *Nephrops norvegicus*

Figure 15 (still 1). Silty sand and cobbles. *Cerianthus lloydi*, *Spirobranchus sp*.

Figure 16 (still 3). Medium silt. Dab *Limanda limanda*

Figure 17 (still 4). Medium silt. Little cuttle *Sepia atlantica*

Figure 18 (still 2). Gravel and cobbles. Blue sponge *Hymedesmia paupertas, Spirobranchus*

Figure 19 (still 3). Gravelly sand and pebbles. *Cerianthus lloydi*

Figure 20 (still 5). Coarse silt with trawl scars

Table 1. Little Cumbrae 01 September 2018 transect start and end positions

transect	start							end					
	deg-N	min-N	deg-W	min-W	OSGB E	OSGB N		deg-N	min-N	deg-W	min-W	OSGB E	OSGB N
1	55	43.723	4	57.846	213969	652354		55	43.998	4	57.031	214843	652828
2	55	43.775	4	57.404	214435	652431		55	43.955	4	57.591	214254	652773
3	55	43.856	4	57.176	214680	652571		55	44.019	4	57.342	214520	652881

Table 2. Little Cumbrae Nephrops burrow counts

transect	interpretation segment	area	entrance count	density	depth
		m2		burrows/m2	m
T1	00:00:00	28.1	0	0.00	28.9
T1	00:00:00	24.3	0	0.00	31.1
T1	00:04:00	27.3	23	0.28	31.8
T1	00:06:00	21.5	28	0.43	32.5
T1	00:08:00	23.8	47	0.66	33.8
T1	00:10:00	22.5	38	0.56	34.6
T1	00:12:00	24.2	50	0.69	35.6
T1	00:14:00	16.8	39	0.77	36.2
T1	00:16:00	19.7	27	0.46	36.5
T1	00:18:00	18.8	36	0.64	37.9
T1	00:20:00	22.2	28	0.42	39.1
T1	00:22:00	25.1	24	0.32	40.7
T1	00:24:00	25.9	38	0.49	42.5
T1	00:26:00	20.9	48	0.76	43.8
T1	00:28:00	22.4	35	0.52	44.9
T1	00:30:00	20.5	48	0.78	46.0
T1	00:32:00	23.9	31	0.43	46.6
T1	00:34:00	22.5	38	0.56	47.2
T1	00:36:00	22.8	42	0.61	47.9
T1	00:38:00	20.1	49	0.81	48.3
T1	00:40:00	24.8	51	0.69	48.6
T1	00:42:00	20.9	48	0.76	49.0
T1	00:44:00	24.2	53	0.73	48.8
T1	00:46:00	29.6	26	0.29	49.6
T1	00:48:00	27.8	22	0.26	52.4
T1	00:50:00	22.4	61	0.91	56.0
T1	00:52:00	25.4	52	0.68	57.0
T1	00:54:00	21.3	48	0.75	57.7
T1	00:56:00	24.7	28	0.38	59.0
T1	00:58:00	21.2	46	0.72	59.2
T1	01:00:00	14.5	19	0.44	59.1
T2	00:00:00	32.8	0	0.00	25.8
T2	00:02:00	37.7	15	0.13	34.7
T2	00:04:00	32.5	66	0.68	40.3
T2	00:06:00	27.8	76	0.91	44.6
T2	00:08:00	27.3	86	1.05	46.4
T2	00:10:00	26.8	63	0.78	47.8
T2	00:12:00	27.1	42	0.52	48.5
T2	00:14:00	26.3	60	0.76	49.2
T2	00:16:00	25.1	46	0.61	49.6
T2	00:18:00	25.1	35	0.47	50.7
T3	00:00:00	31.5	0	0.00	20.4
T3	00:02:00	28.5	30	0.35	29.7
T3	00:04:00	30.9	110	1.19	33.5
T3	00:06:00	28.6	92	1.07	34.8
T3	00:08:00	31.3	101	1.08	35.8

T3	00:10:00	29.2	29	0.33	37.3
T3	00:12:00	26.3	24	0.30	38.8
T3	00:14:00	28.1	34	0.40	38.9
T3	00:16:00	23.4	25	0.36	39.2
T3	00:18:00	13.3	5	0.13	39.6

LITTLE CUMBRAE APPENDIX A. VIDEO INTERPRETATION

	depth		
T1	28.9	00:00:00	silty sand. Unidentified tube - siphon or Chaetopterus? Hydroids on pebbles. Munida. Nemertesia. Spirobranchus. Alcyonium. Still LC T1 1. Several Pecten. Myxicola. Asterias. Ciona.
	31.1	00:00:00	silty sand with shell fragments. Munida. Alcyonium. Nemertesia. Pecten. Asterias. Sabella? tube.
	31.8	00:04:00	silty sand. Asterias. Tracks from Turritella shells probably Pagurus. Munida. Still 2. Liocarcinus. Alcyonium. Siphon/Chaetopterus. Scattered small nephrops burrows, then some adult burrows
	32.5	00:06:00	silty fine sand. Burrows. Asterias. Pecten. Liocarcinus. Dragonet. Still 3 burrow. Munida
	33.8	00:08:00	silty fine sand. Nephrops burrows, many with Munida.
	34.6	00:10:00	silt fine sand. Nephrops burrows, various sizes. Asterias. Liocarcinus. Goneplax? 11:49 still 4 - burrows may be this.
	35.6	00:12:00	silty fine sand, burrows. Siphon/tubes. Munida. Asterias.
	36.2	00:14:00	silty fine sand, burrows. Possible Nephrops chelae 14:40. Octopus 15:25 still 5.
	36.5	00:16:00	silty fine sand. Nephrops 16:25 still 6.
	37.9	00:18:00	silty fine sand. Nephrops burrows and several individuals
	39.1	00:20:00	silty fine sand. Asterias. Munida. Still 7. Dab. Octopus 21:10.
	40.7	00:22:00	silty fine sand. Scattered boulders with hydroids. Asterias. still 8. Goneplax 23:32 still 9.
	42.5	00:24:00	silty fine sand. Sabella tube? Dragonet
	43.8	00:26:00	silty fine sand. Lumpenus 26:21. Lanice?
	44.9	00:28:00	medium silt. Munida. Boulder with hydroids, Marthasterias. Sabella
	46.0	00:30:00	medium silt. Sabella. Haddock.
	46.6	00:32:00	medium silt. Haddock. Trisopterus.
	47.2	00:34:00	medium silt. Gurnard.
	47.9	00:36:00	medium silt. Dab. Gurnard.
	48.3	00:38:00	medium silt.
	48.6	00:40:00	medium silt. Lumpenus. Possible dead Virgularia stalks. Sabella tubes. Buccinum.
	49.0	00:42:00	medium silt. Haddock. Gurnard
	48.8	00:44:00	medium silt. Paired siphons (Chaetopterus?). Trisopterus.
	49.6	00:46:00	medium silt. Siphons. Munida. Dab?
	52.4	00:48:00	medium silt. Virgularia. Boulders with hydroids. Solenette. Dab. Sabella tube still 10.
	56.0	00:50:00	medium silt. Munida. Liocarcinus. Boulder. Sabella. Nephrops.
	57.0	00:52:00	medium silt. Sabella. Munida. Trisopterus. Calcaris? Out of burrow. 53:16 still 11. Nephrops. Cancer.
	57.7	00:54:00	medium silt. Nephrops. Still 12.
	59.0	00:56:00	mud. Nephrops.
	59.2	00:58:00	mud. Abundant Nephrops.
	59.1	01:00:00	mud. Nephrops.
T2	25.8	00:00:00	silty sand and cobbles. Spirobranchus. Cerianthus. Still LC T2 1. Echinus. Munida. Aequipecten.
	34.7	00:02:00	silty medium sand. Dragonet. Trisopterus. Still 2. Munida. Few small burrows, poss Nephrops or Munida
	40.3	00:04:00	silty fine sand. Munida. Sabella. Common Chaetopterus tube?
	44.6	00:06:00	coarse silt. Munida. Gurnard. Lumpenus.
	46.4	00:08:00	medium silt.
	47.8	00:10:00	medium silt. Trawl scars.
	48.5	00:12:00	medium silt. Sabella.
	49.2	00:14:00	medium silt. Haddock. Solenette. Munida. Sabella. Dab. Still 3.
	49.6	00:16:00	medium silt. Sabella. Dab.
	50.7	00:18:00	medium silt. Asterias. Trisopterus. Nephrops. Juv. Cuttlefish 19:22 still 4.
T3	20.4	00:00:00	gravel and cobbles. Cerianthus. Spirobranchus. Still LC T3 1. Luidia. Blue sponge Hymedesmia paupertas common. Still 2. Nudibranch egg masses. Ascidiella. Asterias. Ciona. Alcyonium. Munida. Deeper, gravelly sand and pebbles still 3. Patch of abundant Asterias. Hydroids.Pecten.
	29.7	00:02:00	gravelly medium sand, cobbles. Asterias abundant. Munida. Hydroids. Dragonet. Cerianthus. Deeper, fine sand with burrows. Possibly Goneplax?
	33.5	00:04:00	silty fine sand. Chaetopterus? Tubes. Numerous small burrows. Nephrops. Trawl scars.
	34.8	00:06:00	coarse silt. Numerous Nephrops burrows. Liocarcinus.
	35.8	00:08:00	medium silt. Munida. Numerous Nephrops burrows.
	37.3	00:10:00	medium silt. Munida. More cobbles and shell fragments. Lanice. Pagurus. Dab. Occasional burrows. Still 4. Nephrops.
	38.8	00:12:00	coarse silt, shell fragments. Trawl scars still 5. Munida. Siphons. Nephrops
	38.9	00:14:00	coarse silt. Sabella tube. Liocarcinus. Abundant Paguris in Turritella shells.
	39.2	00:16:00	coarse silt. Asterias. Munida. Gurnard.
	39.6	00:18:00	coarse silt. Munida. Asterias.

LITTLE CUMBRAE APPENDIX B. CAPTURED STILL IMAGES

Figure	transect	still		video file time
	T1	1	silty sand habitat. Alcyonium digitatum, Spirobranchus, hydroids	00:00:36
7	T1	2	silty sand habitat.	00:04:28
	T1	3	silty fine sand, Nephrops (or Goneplax?) burrow	00:07:12
8	T1	4	silty fine sand, Goneplax rhomboides	00:11:49
9	T1	5	silty fine sand, Eledone cirrhosa	00:15:24
10	T1	6	silty fine sand, Nephrops norvegicus	00:16:25
	T1	7	silty fine sand habitat, Nephrops burrows, Sabella tube	00:20:22
	T1	8	silty fine sand	00:22:25
11	T1	9	silty fine sand, Goneplax rhomboides	00:23:02
12	T1	10	medium silt. Sabella tube, Munida rugosa	00:50:00
13	T1	11	medium silt. Calocaris macandreae?	00:53:16
14	T1	12	medium silt, Nephrops norvegicus	00:54:22
15	T2	1	silty sand and cobbles. Cerianthus lloydi, Spirobranchus sp.	00:00:03
	T2	2	silty medium sand. Cerianthus tubes (anemones retracted)	00:02:42
16	T2	3	medium silt. Dab Limanda limanda	00:15:26
17	T2	4	medium silt. Little cuttle Sepia atlantica	00:19:22
	T3	1	gravel and cobbles. Spirobranchus	00:00:25
18	T3	2	gravel and cobbles. Blue sponge Hymedesmia paupertas, Spirobranchus	00:00:55
19	T3	3	gravelly sand and pebbles. Cerianthus lloydi	00:01:33
	T3	4	medium silt with faint trawl scars. Dab Limanda limanda	00:11:10
20	T3	5	coarse silt with trawl scars	00:12:07