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Methodological trials:
Recording subtidal epibiota *in situ* and in photographs, Portrush August 2013 and Sound of Mull August 2014

Moore, J., Bunker, F., van Rein, H. & Jones, J.

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY
www.jncc.defra.gov.uk

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Summary

The Inter-Agency Marine Monitoring Group (IAMMG) discusses, co-ordinates and develops benthic habitat monitoring approaches within, and outside of, Marine Protected Areas (MPAs). Monitoring programmes based on *in situ* recording of epibenthic communities by diver surveyors have been developed in a number of MPAs. Consistency of recording has long been an issue with such surveys, but the level of inconsistencies has been little studied. Photo-monitoring techniques are also being developed and will have a number of advantages over *in situ* recording, but also some disadvantages. Previous studies have compared some of the advantages and disadvantages of the two recording techniques, but with limited focus on the consistency of recording. When the JNCC dive team approached the IAMMG for project ideas for their 2013 work programme, it was suggested that a study of those techniques and issues would be useful. The DOE(NI) Marine Division invited the dive team to work on these monitoring issues with their team and Queens University, Belfast, based at Portrush, on the north coast of Northern Ireland. Fieldwork for the Portrush studies was carried out in August 2013. The results of those studies clarified a number of issues with recording consistency, but raised further questions and outlined limitations. JNCC therefore decided to carry out further studies in 2014 and to use the study as an opportunity to focus on the recording of sponges, sponge morphologies and anthozoa, as those groups had been targeted for study by Defra's Healthy and Biologically Diverse Seas Evidence Group (HBDSEG). Fieldwork for these studies was carried out in the Sound of Mull, on the west coast of Scotland, in August 2014.

The overall purpose of the studies was to provide data and recommendations that can inform and improve the design of marine benthic monitoring programmes. The study was based on a widely used transect/quadrat methodology. The main objectives were:

Portrush 2013
Assess consistency of *in situ* recording by divers:
Which taxa are most/least consistently recorded?
How important are the various sources of inconsistency, including surveyor knowledge and experience, bias in estimation of % cover, and the physical characteristics of the taxa.
Compare *in situ* recording and photography:

- Are some taxa or groups of taxa recorded more consistently *in situ* or from photographs?
- Does surveyor experience improve consistency of records from photographs?
- What are the differences in costs between the two methods?
- Can records taken from photographs provide sufficient meaningful estimates of community composition and abundance?

Sound of Mull 2014
To assess the consistency of *in situ* recording of selected groups of taxa (specifically sponges, sponge morphologies and anthozoa) in quadrats by survey divers:

- To assess the improvements in consistency with training and familiarisation.
- To compare this with the quality and consistency of recording from photographs.
- To assess the value of such data for the purposes of habitat quality monitoring.

Two sites were established in each survey area for the specific purposes of the studies: at Portrush – a shallow algal-dominated bedrock wall within a kelp forest and a deeper tide-swept horizontal bedrock dominated by ascidians; in the Sound of Mull – a shallow algal-dominated bedrock wall and a deeper bedrock wall with sponges and anthozoa. An additional site within a *Zostera* bed near Portrush was opportunistically studied when rough seas made the main sites inaccessible. Each site consisted of one or two rope transects, fixed in place with pitons, marked with gradations of 50cm or10 cm, within areas of relatively

homogenous habitat. Wire frame quadrats, 25cm x 25cm, were placed or fixed at a number of known positions along the transects and surveyed by the divers, who varied in levels of survey experience and knowledge of the fauna and flora. The divers recorded species composition and abundance (counts or % cover) of the selected taxonomic groups onto recording forms designed for each site and study. Recording protocols were defined, surveyors were trained, and the effects of training were studied. A large number of quadrat records were collected from each transect with many quadrat positions surveyed multiple times by multiple surveyors (the extent of which defines the degree of 'replication'). During the Sound of Mull studies each diver carried out repeat surveys of numerous quadrats over the survey period. A number of logistical and survey design lessons were learned after the Portrush studies and the Sound of Mull studies provided a more-balanced dataset for analysis. Photographs were also taken of each quadrat along each transect. These photographs were later analysed by the same surveyors, and two other surveyors, to record species composition and abundance in the same way as the *in situ* recording.

Data from *in situ* surveys and photo-quadrats were analysed using various multivariate (PRIMER and PERMANOVA) and univariate techniques to describe the inter- and intra-surveyor variability in records of species assemblages, individual taxa and individual sponge morphologies and test the effects of various factors.

Taking the two studies together, the main conclusions were:

- Consistency between surveyors was low for most of the taxa recorded from any site, both qualitatively (recorded presence/absence of a species) and quantitatively (abundance estimates). Much of the variability was due to the small size and inconspicuous nature of many taxa, but variability was also poor for many larger and easily recognised taxa. High levels of consistency were achieved only for a small number of taxa that are easily identified and stand out from the substrata they live upon and from the other epibiota that surrounds them. There was also a large amount of variability between surveyors in the number of taxa recorded.
- Within-surveyor variability accounted for a large proportion of the overall inconsistency, that is, there were apparently arbitrary differences in species and abundance estimates recorded from a quadrat by an individual surveyor
- There was also considerable bias in the recording of many species by many of the surveyors.
- Surveyor experience was a significant factor, particularly with identification of the less well-known taxa, but consistency of recording by experienced surveyors was still low.
- Fewer species were recorded from photo-quadrats compared to *in situ* surveys and estimates of abundance were also generally lower. Consistency between surveyors was low for most species, but slightly greater than *in situ* surveys for a few more-easily recognised taxa. Identification and abundance estimation of algae in photographs was particularly difficult.
- Notwithstanding the above, multivariate data (i.e. data for multiple taxa within a taxonomic group), from *in situ* surveys or photographs, did detect differences between quadrats, but that detection was largely dependent on the abundances of a relatively small number of dominant and conspicuous taxa.
- Training and familiarisation, over the course of the Sound of Mull studies, improved the consistency of recording for some taxa, by improving species recognition and reducing surveyor bias in abundance estimates, but only to a limited extent.

- There was almost as much, and sometimes more, variability in the counts of sponges morphologies as there was of the individual sponge taxa, some of which was due to the difficulty of assigning sponge colonies to the defined morphology categories.

The report provides a full description of the methods, results, analyses and conclusions from both studies. A number of recommendations are given.

A collection of sponges from one of the sites in the Sound of Mull (Auliston Point) was taken for laboratory analysis and the results are included in the report. General guidance on identification of algae and sponges is also included.

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Surveyors:
Francis Bunker, ASML, Bentlass, Pembrokeshire (JNCC Diving Officer & survey leader)
Jon Moore, ASML, Cosheston, Pembrokeshire

Dan Bayley, JNCC, Peterborough
Helen Ellwood, JNCC, Peterborough (JNCC Dive Team Leader)
Neil Golding, JNCC, Peterborough
Becky Hitchin, JNCC, Aberdeen
Nikki Taylor, JNCC, Peterborough
John Weinberg, JNCC, Aberdeen

Hugh Edwards, Marine Division, DOE NI
Tim Mackie, Marine Division, DOE NI
Ronnie Snidjer, Marine Division, DOE NI

Henk van Rein, Queens University Marine Laboratory, Portaferry

Mark Burton, NRW, Skomer Marine Nature Reserve [photo analysis only]

Other assistance and advice:
Joe Breen, DOE Marine Division (N. Ireland)
Gary Burrows and staff, Coastal Zone Centre, Portrush
Mark Burton, NRW, Skomer Marine Nature Reserve
Simon Exley, Lochaline Dive Centre
Jen Jones, NRW, Skomer Marine Nature Reserve
Mark and Annabel Lawrence and staff, Lochaline Dive Centre
Alan Livingstone – Skipper of Sound Diver, Lochaline Dive Centre

Report review:
Emma Verling, JNCC, Peterborough (Report Lead)
Helen Ellwood, JNCC, Peterborough
Hayley Hinchen, JNCC, Peterborough
Becky Hitchin, JNCC, Aberdeen
Nikki Taylor, JNCC, Peterborough
Megan Parry, JNCC, Peterborough
Joe Turner, JNCC, Peterborough
Becca Lowe, JNCC, Peterborough
John Weinberg, JNCC, Aberdeen

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1 Introduction

1.1 Background

JNCC plays an active role in providing evidence and advice to the UK Government on marine biodiversity conservation and is the leading partner in a UK Marine Biodiversity Monitoring Research and Development (R&D) programme. This programme develops monitoring options for UK Government and devolved administrations covering benthic habitats in all UK waters, including those that would best be monitored using divers. Through the Inter-agency Marine Monitoring Group (IAMMG), JNCC and the statutory nature conservation bodies (SNCBs: Department of Environment (DOENI) Marine Division Northern Ireland, Natural England, Natural Resources Wales, Scottish Natural Heritage) discuss, co-ordinate and develop benthic habitat monitoring approaches within - and outside of - marine protected areas (MPAs) in UK waters. The JNCC dive team approached the MMG for ideas of projects focusing on in tackling specific monitoring issues in order to improve monitoring protocols and answer key questions that would assist the SNCBs in carrying out monitoring work across the UK.

Among suggestions received were those examining the consistency of *in situ* hard substrata community recording as compared to records collected from photographs, and identification of indicator species versus comprehensive identification of all taxa. Of particular concern was the recording of seaweeds in quadrats. The decision was taken to examine this issue within the JNCC dive team's programme of work as consistency in recording has long been an issue with *in situ* monitoring of benthic communities. A number of site-condition monitoring programmes in the UK are based on *in situ* recording by divers of species composition within quadrats (fixed or otherwise), repeated at temporal intervals (see Murray 2001). Other monitoring programmes are developing methods based on analysis of photographs to produce similar community data (e.g. van Rein *et al* 2011a, 2011b and 2012). A primary objective of such monitoring programmes is to provide data that can be used to detect ecologically significant changes in those benthic communities. However, there are a number of sources of potential variability in the benthic data collected by these methods that could reduce their ability to reliably detect real change, which might otherwise be masked by artefacts of recording variability of the survey activity. These include:

- Spatial patchiness (which varies between species).
- Data collection method – i.e. there are inherent differences between *in situ* recording and recording from photographs.
- Detailed methodological protocols applied by different surveyors or on different occasions (e.g. how to place quadrat and whether to waft silt away to facilitate more comprehensive recording).
- Equipment issues, e.g. diving, survey and camera equipment faults or characteristics.
- Site and survey conditions, e.g. water clarity, swell and currents.
- Surveyor knowledge, experience and familiarity; this can create differences in species identification and numbers of species recorded (which varies greatly between different species and taxonomic groups according to surveyor 'bias').
- Surveyor condition, e.g. eyesight and health.
- Other surveyor biases, e.g. observational skills, mood, and alertness.

Some of these potential sources of variability are well known and are routinely considered during survey design (e.g. Murray 2001). The potential for surveyor error and biases is also known, particularly in intertidal surveys (e.g. Baker and Little 1989), but few diving-based monitoring programmes have studied the level of such errors and biases. Previous studies that have attempted to investigate these issues of consistency include Moore (2000), Stanwell-Smith *et al* (2010), and various other smaller-scale exercises at Skomer Marine

Nature Reserve (Mark Burton, pers. comm.). However, more evaluation of survey practice is needed to be able to better inform survey design to ensure that monitoring programmes are able to detect real change in the marine environment. This is particularly important in the context of the development of indicators for the Marine Strategy Framework Directive[1] and the need to ensure that indicators are measurable and realistic. In addition, while recent advances in digital photography have enabled its use in benthic monitoring, with the potential to save time and money, there is the risk that the data acquired from photographs may be of a different quality and level of detail to data collected *in situ*.

1.2 Overall objectives and programme of work

The issues of recording consistency in sublittoral epibenthic monitoring were taken as the basis for a programme of work by the JNCC dive team in 2013 and continued in 2014. The overall purpose of the study was to provide data and recommendations that can inform the design and content of marine benthic monitoring programmes.

In 2013, following discussions with the DOE Marine Division in Northern Ireland the dive team was invited to work with their team based at Portrush. Links were made with Dr Henk van Rein of Queens University, Belfast who was keen to explore further the usefulness of photographing quadrats in monitoring studies.

Fieldwork for the Portrush studies was carried out in August 2013. A full description of the objectives, methods, results, analyses, conclusions and recommendations are given in Section 2.

The results of the 2013 studies clarified a number of issues with recording consistency but raised further questions – particularly regarding the potential for improving consistency through training and familiarisation with taxa being recorded. JNCC therefore decided to carry out further studies in 2014. It was also decided to use the study as an opportunity to focus on the recording of sponges, sponge morphologies and anthozoa. Those groups had been targeted for study by Defra’s Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) because their diversity and composition may be related to site condition. The chosen study area was the Sound of Mull.

Fieldwork for the Sound of Mull studies was carried out in August 2014. A full description of the objectives, methods, results, analyses, conclusions and recommendations are given in Section 3.

[1] http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

2 Portrush 2013

2.1 Aims and objectives

The outline for the study is based on a widely used transect/quadrat methodology (see, for example, Murray 2001) and the methodological trials described in Moore (2000). The work plan was developed in detail during the fieldwork and during the preliminary analysis of data gathered during the survey. The primary aim of the survey was to test issues of consistency in marine biological recording by divers. A secondary aim, using the opportunity to include the photo-quadrat survey techniques of Dr Henk van Rein, was to make comparisons between *in situ* recording and photography.

The key objectives were to:

Assess consistency of *in situ* recording by divers:

- Which taxa are most/least consistently recorded?
- How important are the following causes of inconsistency:
    - Surveyor experience – in general and for particular taxa/taxonomic groups.
    - Surveyor eyesight/observational skills (use of magnification was not assessed).
    - Surveyor bias in estimation of % cover.
    - Size, colour, form and cryptic nature of taxa (i.e. how distinctive they are against the substrata and from the other species surrounding them).

Compare *in situ* recording and photography:

- Are some taxa or groups of taxa recorded more consistently *in situ* or from photographs?
- Does surveyor experience make any difference to the consistency of records created from photographic study?
- What are the differences in costs between the two methods?
- Can records taken from photographs provide sufficient meaningful estimates of community composition and abundance?
- What other advantages and disadvantages are associated with the two methods?

2.2 Methods

Fieldwork was carried out between 1-10 August 2013. The team was based at the Coastal Zone Centre, Portrush, and established a field laboratory in the training room. A field log is given in Appendix A1.1.

2.2.1 Site locations and layout

Three sites were established for the methodological studies within the Skerries and Causeway Special Area of Conservation (SAC). The locations are shown in Figure 2.1 and described below.

At each site, one or two 10 metre (m) transect lines were laid, and fixed, within a relatively homogenous area of the chosen habitat and at the same depth. The transect lines, with gradations marked at 0.5m intervals, provided a simple practical structure for the surveyors to relocate the quadrat positions. The layout of each transect is shown in Figure 2.2 and illustrative images are given in Photographs 1 to 6.

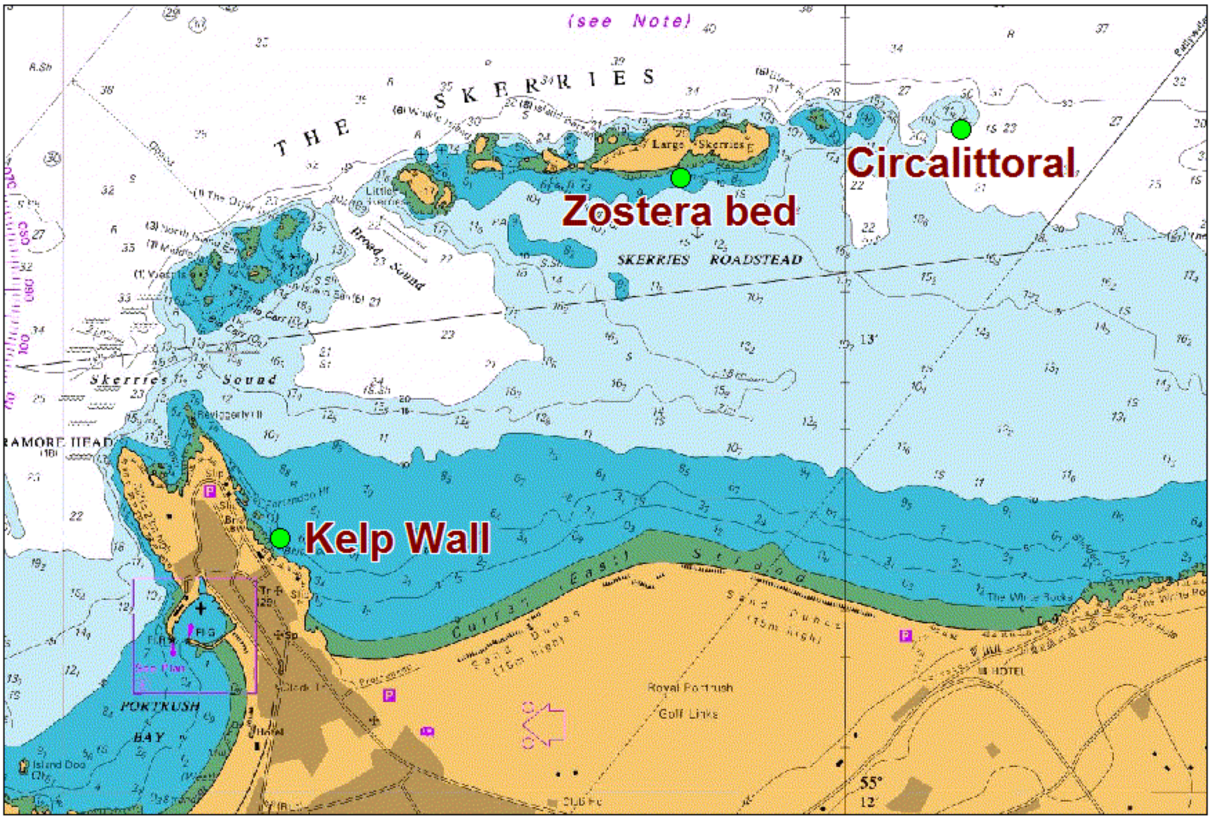

Figure 2.1 Location of survey sites, Portrush, August 2013.

Kelp Wall, Portrush [55.20919oN 6.65288oW WGS84]

This site was situated approximately 40m north of the Blue Pool, close to the Coastal Zone Centre, and was normally accessed by shore dives from the Blue Pool. Water depth was approximately 4m and the site consisted of a small vertical cliff up to 1.5m high running along the edge of horizontal kelp dominated bedrock. The communities on the wall were rich in red algae and a variety of sponges, anthozoa, bryozoa, ascidians and other typical shallow infralittoral cliff fauna. Two 10m transects, marked by gradations on a rope labelled every 50cm, were fixed, end to end, half way up this wall. The transects were fixed in position with eye-bolts, which were hammered into crevices in the rock face. Theoretically this provided 40 x 4 (top left, top right, bottom left, bottom right at each mark) potential positions for quadrats. However, many positions provided unsuitable habitat for recording (due to the route of the transect line and the topography), so another pre-survey dive was carried out to identify suitable quadrat positions. Quadrat surveys were then carried out *in situ* by seven surveyors over six days. A series of quadrat photographs were taken for later analysis.

Circalittoral ascidian turf on bedrock, East of the Skerries [55.22525oN 6.60915oW WGS84]

Situated approximately 1km east of the Skerries and accessed by two DOE Marine Division RIBs (*Capitella* and *Modiolus*), this was a tide-swept bedrock site in approximately 20m of water and dominated by an ascidian turf. Two roughly parallel transects were laid approximately 3m apart and quadrat surveys carried out *in situ* by nine surveyors over two days. A series of quadrat photographs were taken for later analysis.

Zostera ***bed, South of the Skerries [55.2235oN 6. 62741oW WGS84]***

On the final day of fieldwork the sea conditions were found to be too rough to revisit the circalittoral site, so the boats detoured to the known location of a *Zostera* bed on the south coast of the Skerries. A single 10m transect was laid within the bed and quadrat surveys carried out *in situ* by six surveyors on one day. A series of quadrat photographs were taken for later analysis.

Marked transects made from leaded line were attached to the seabed via temporary fixing (expandable rawl bolts and hooks). The sites were then buoyed via shot markers for ready re-location.

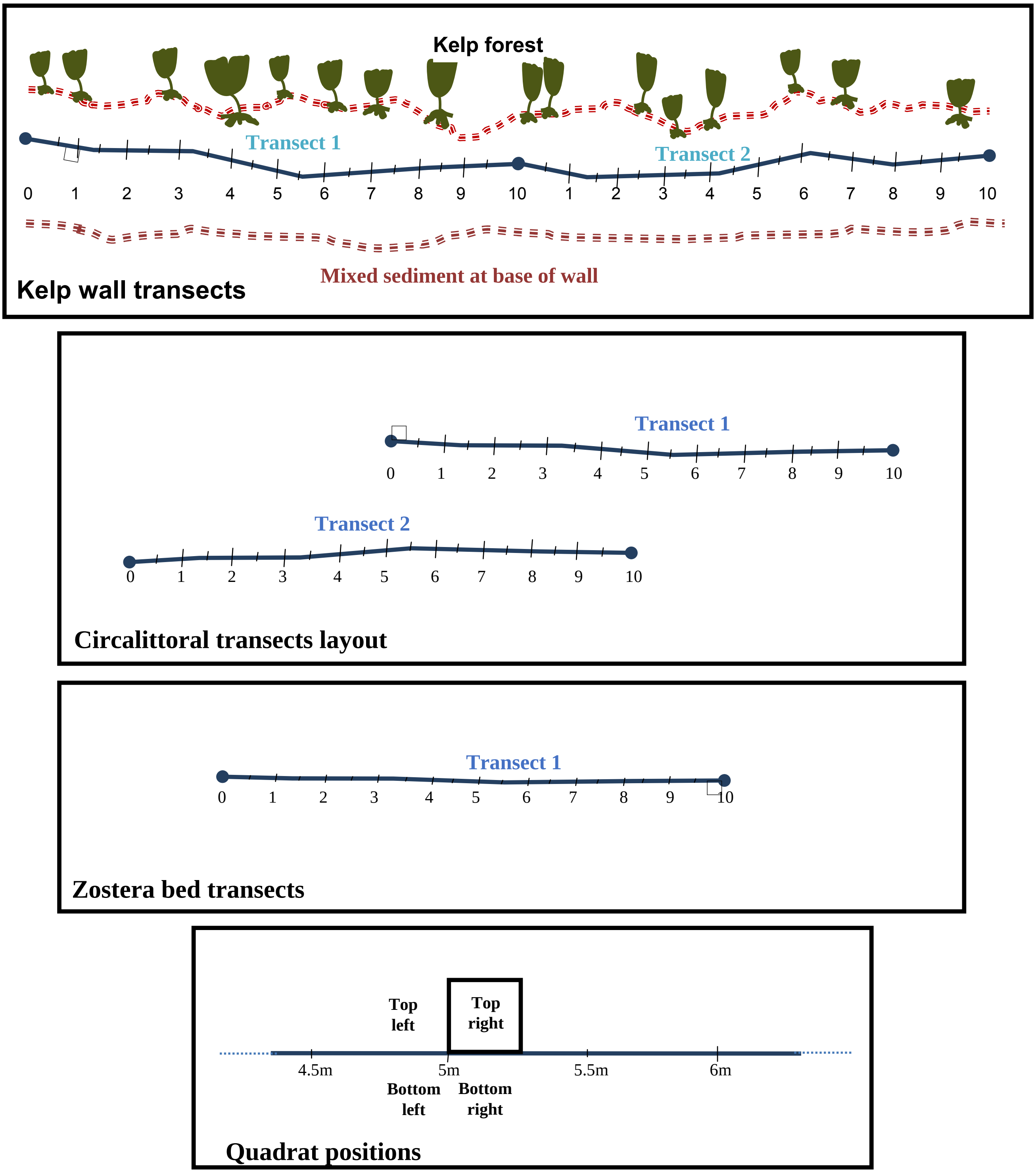

Figure 2.2 Schematic layout of transects and arrangement of quadrat positions. The blue line indicates transect, with numbered distances (metres). The dashed red lines in the Kelp Wall diagram indicate the top edge and the base of the vertical wall.

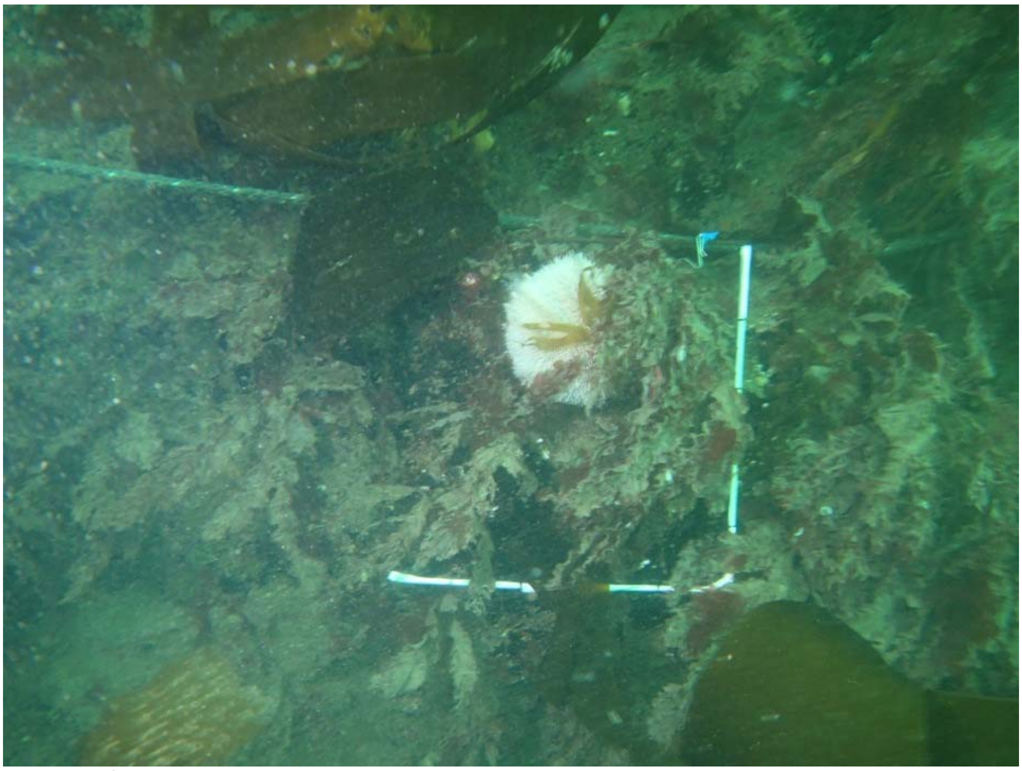
Photo 1. Quadrat suspended on vertical rock at the Kelp Wall site.

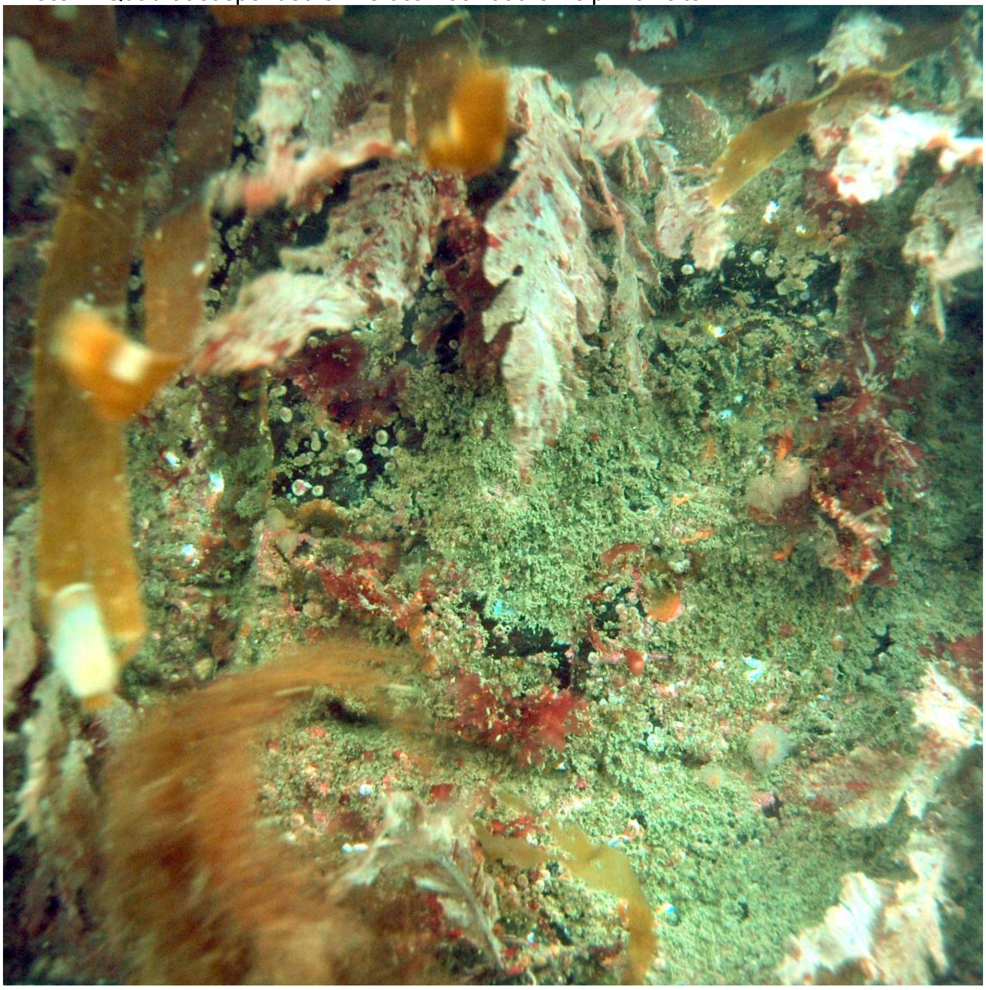
Photo 2. Example photo quadrat from the Kelp Wall site.

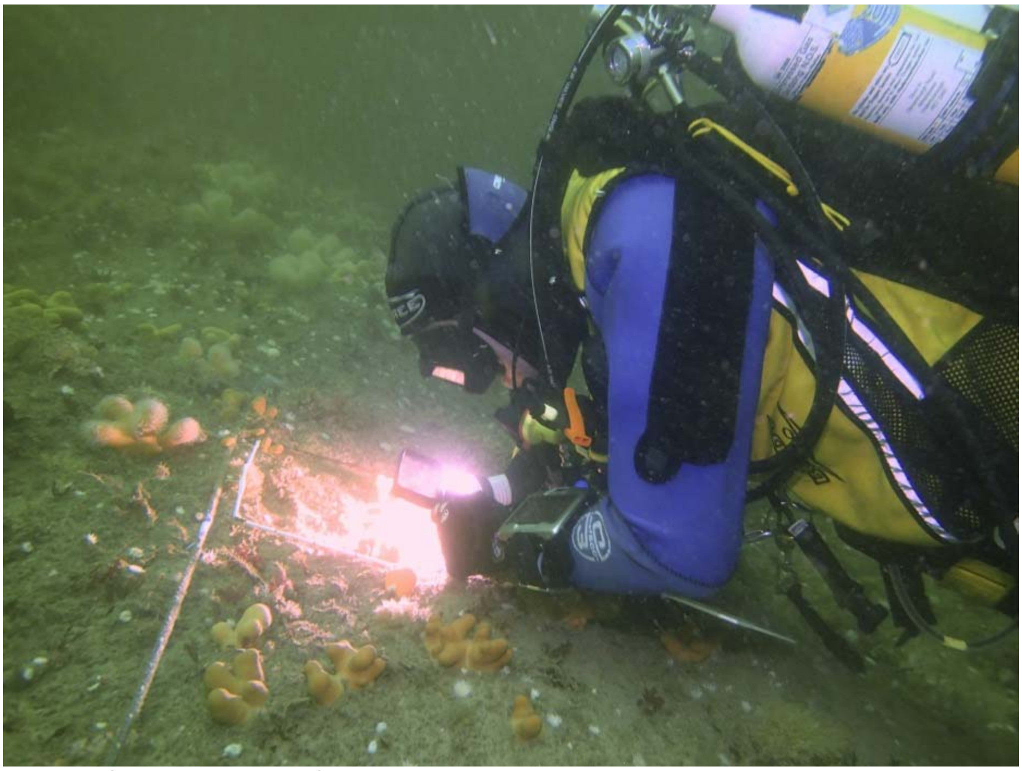

Photo 3. Surveyor recording from a quadrat on the circalittoral transect.

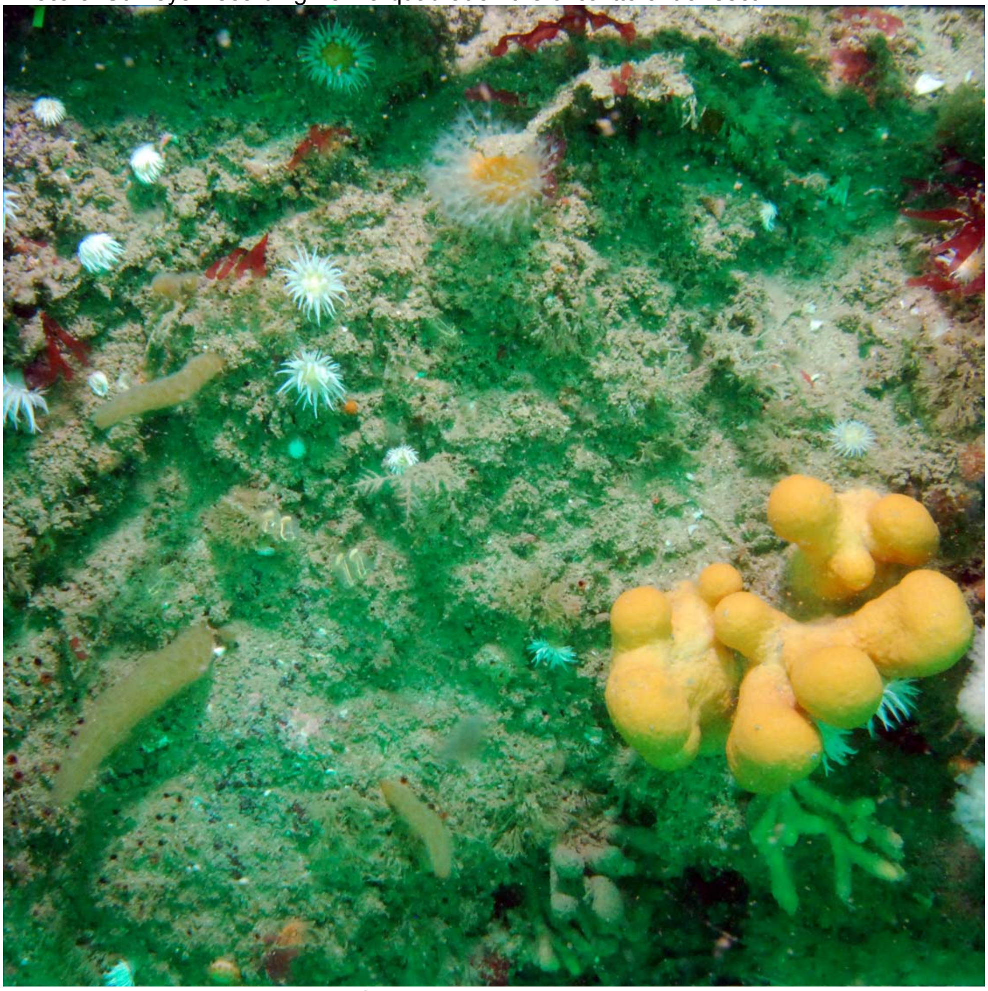

Photo 4. Example photo quadrat from the circalittoral transect.

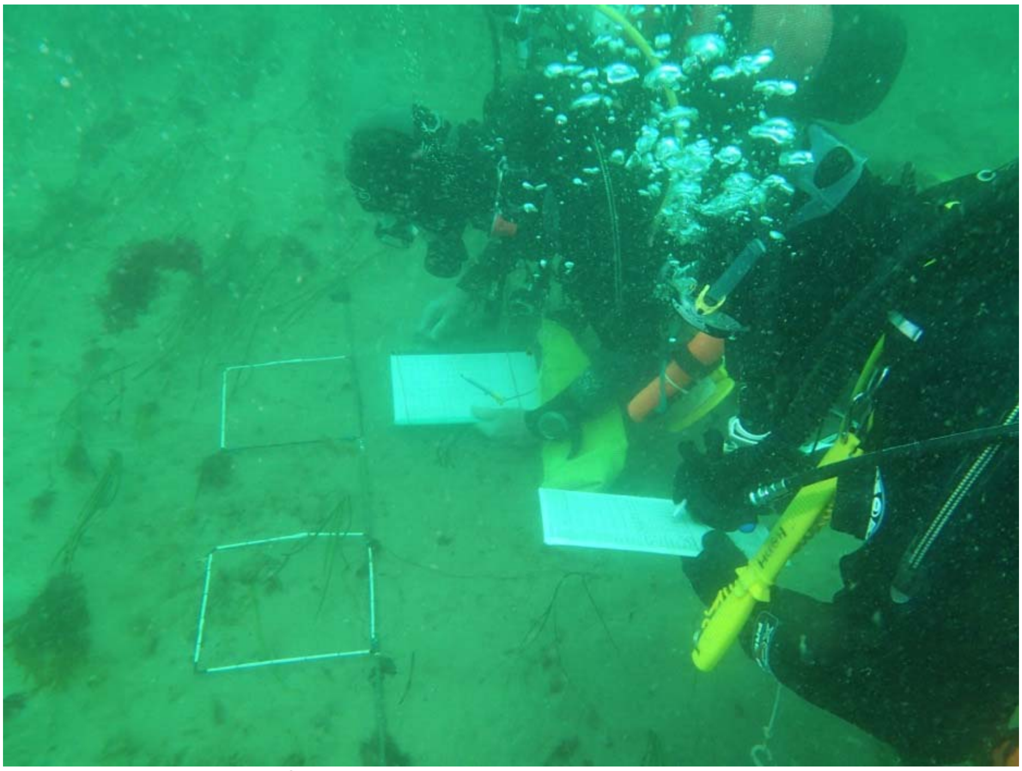

Photo 5. Divers recording from quadrats on the *Zostera* bed transect.

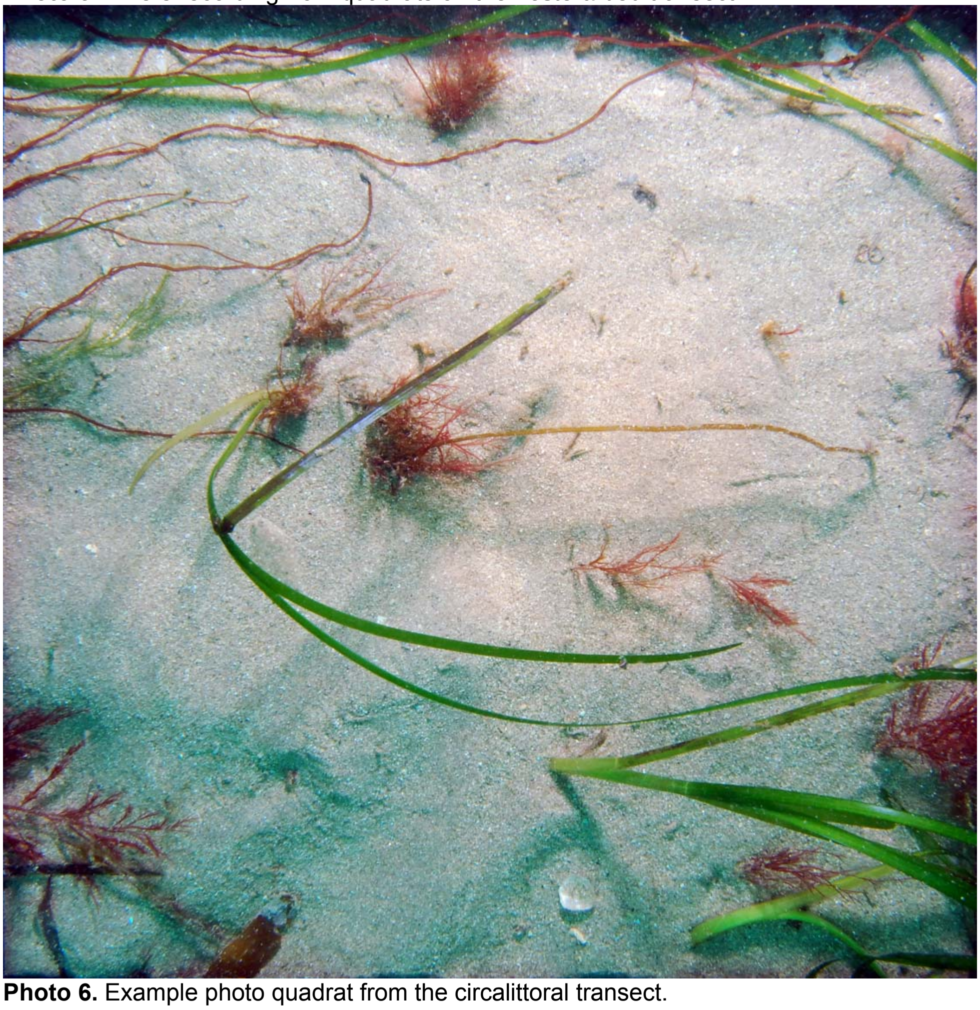

Photo 6. Example photo quadrat from the circalittoral transect.

2.2.2 Survey design

The primary objective was for the surveyors to record the epibiota present in as many of the quadrat positions as possible at each site. The number of potential quadrat positions on each transect was much greater than required to have enough data (see Section 2.2.1). Therefore, a subset was chosen (based on one of the four positions around the mark on the transect (e.g. top right, bottom left, etc., see Figure 2.2) and each surveyor was assigned a list of quadrats to survey, using a simple coding system to identify the transect (i.e. 1 or 2), the distance along the transect (0.5 to 9.0, at 0.5m intervals) and the position in relation to the mark (e.g. BR = bottom right). Initially the assignment of quadrat positions was random, but as it became clear that it was still taking too long to complete all the quadrats, it was necessary to assign a smaller number of specific quadrats to surveyors.

Ideally all the surveyors would have recorded from a large number of randomly selected quadrats, with enough sampling undertaken from the same quadrat positions (‘replication’) to allow direct comparisons. This would provide a description of each community as recorded by each individual surveyor and by particular groupings of the surveyors (i.e. more experienced and less experienced). Logistical limitations made it impractical to complete the desired number of quadrats for a fully balanced dataset. However, a large number of quadrats were surveyed by many of the surveyors on each transect with many quadrat positions being visited by multiple surveyors, allowing many comparisons to be made.

The surveyors were categorised by their survey experience as either experienced (the two ASML surveyors) or less experienced (the five JNCC and three DOE NI surveyors).

The photo-quadrat survey design was simply to take one photograph of each quadrat position along each transect. These could then be matched to the quadrat positions surveyed *in situ* and analysed by the same surveyors after the survey period, to provide a dataset for comparison with the *in situ* observations.

Site specific features of the survey design were as follows:

Kelp Wall transects

As the JNCC surveyors had been receiving focused training on identification of algae earlier in 2013, it had already been decided that red algae would be a focus of the survey work in this habitat. Anthozoans (a number of conspicuous species) and encrusting bryozoa (as an aggregate taxon) were also chosen for focused recording. Together, these taxa are referred to as the ‘selected’ taxa from this site, throughout this report. The dominant species of red algae and anthozoans are listed on the relevant part survey recording form (0). It was decided to estimate percentage cover of the algae and all colonial invertebrates, with counts used for certain taxa that are mobile or clearly individual.

The less-experienced surveyors carried out part surveys of the selected taxa only, while the more-experienced surveyors carried out surveys of all conspicuous taxa (comprehensive surveys) on a different recording form. In the data analysis, direct comparisons between the experienced and less experienced surveyors could then be carried out with a subset of the dataset (i.e. only the selected taxa). Direct comparisons between the two experienced surveyors could also be carried out on the full list of taxa.

Circalittoral transects

Ascidians dominated the epibiota at this site and their high diversity was known to be an important feature of the SAC. It was therefore decided to focus the recording on that group, but it was considered likely that estimates of abundance (% cover or counts) would be difficult and time consuming. An alternative approach of recording presence / absence of each taxa in each quadrat, which would take less time to complete and therefore result in a larger number of quadrat records, was decided upon. As with the Kelp Wall site, the ascidians are referred to as the ‘selected’ taxa from this site, throughout this report. The dominant ascidian species are listed on the relevant part survey recording form (Appendix 3).

As with the Kelp Wall site, the less-experienced surveyors carried out part surveys of the selected taxa only, while the more experienced surveyors carried out surveys of all conspicuous taxa (comprehensive surveys) on a different recording form.

Explanation of terms used

A large number of analyses have been carried out on the data and it is important to understand which dataset is used in each analysis. The following terms are used throughout the report:

Selected taxa data – refers to data collected on a subset of taxa that were chosen for focused survey work at a site, by all surveyors. It is not limited to the data from the part surveys (by the less-experienced surveyors).

Full taxa data – refers to data collected on all taxa, by the more-experienced surveyors only.

2.2.3 Pre-survey preparation

The team undertook pre-survey familiarisation dives, followed by laboratory inspection of collected specimens and close-up photographs were undertaken at the Kelp Wall and Circalittoral sites. The survey team then worked as a group in the laboratory examining specimens and viewing photographs in order to prepare for recording in the field. Lack of preparation time, due to rough sea conditions, meant that familiarisation dives were not undertaken on the *Zostera* bed, but numbers of species present were low and recording was much more straightforward.

Survey recording forms with checklists of species were prepared using the most frequently occurring taxa encountered during the familiarisation dives. Two forms were prepared for each site (except in the case of the *Zostera* bed): one for comprehensive surveys (all conspicuous epibiota) and one for part surveys (selected taxa only, see Section 2.2.2). The species in the checklist were labelled with the appropriate abundance measure (% cover or counts). Copies of the blank forms are given in Appendix 3.

The quadrat size was set at 0.0625m^2 (25cm x 25cm). Small wire hooks were attached to the top of the quadrats for hanging on the transect line at the Kelp Wall site. Note that the choice of quadrat size for community recording is always a compromise. If a quadrat is too small it does not suit the recording of larger organisms (e.g. *Laminaria*). If it is too big, then it is difficult to obtain accurate count data on small organisms (e.g. *Caryophyllia smithii*). The selection of a square 25cm x 25cm was considered to provide a good compromise for the biota being studied at each site. It was also the same size as the photo-quadrat frame being used for the photographic data collection for the project, and therefore appropriate for the overall comparison objectives of the study.

2.2.4 *In situ* quadrat recording protocols

Quadrat recording protocols were defined for each site, to minimise some of the potential variability due to habitat patchiness and some of the potential biases in recording between surveyors.

Kelp Wall transect protocol:

- Waft away sediment.
- Make sure that the quadrat does not drag the line down out of position.
- Record epibiota attached to the base substrata (don’t record epibiota on stipe and blades of foliose algae).
- Large flapping blades of algae – visualise how they might lie if there was no swell and estimate % cover.
- Species checklist – check for all those species on the list. Preferably use a small horizontal dash to indicate absence. Record other species that are not on the list.
- Estimating % cover – do not include the gaps within a patch of a species (e.g. the gaps between barnacles or the gaps between algae branches. Total % of all species may be more than 100%, due to layering.
- Recording % cover – do not spend long trying to estimate the % precisely. The following categories are certainly adequate: P (‘present’, meaning<1), 1, 2, 4, 5, 8, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95, 98, 99, 100. Do not use ticks (sometimes they could be mistaken for a dash).
- Sporelings and other juveniles – try to match to adults nearby, if you cannot and it covers >1 % then take a specimen from outside of the quadrat, put in a labelled bag for identification in the laboratory and record abundance with a description, e.g. Sp A (small flat blades).

Circalittoral transect protocol:

- Survey the top left quadrat every 0.5m.
- Substrata in the quadrat must consist of at least 80 % upward-facing bedrock.
- If the top left quadrat is not suitable habitat then move the quadrat over clockwise to next position and if this is also not suitable, move the quadrat round again (i.e. top right, bottom right, bottom left).
- Do not waft sediment first.
- Record epibiota attached to the base substrata (do not record epibiota on stipe and blades of foliose algae).
- Only record a species when its base is in a quadrat (not when fronds are wafted across from outside).
- If the base of a specimen is half way in the quadrat or more then count it (if less, then do not count it).
- If an ascidian is not listed and you cannot identify it to species level, include descriptive notes (e.g. *Polycarpa* – orange), then photograph it and/or collect a specimen (from outside of transect area).
- Species checklist – check for all those species on the list. Preferably use a small horizontal dash to indicate absence. Add other species that are not on the list.
- Sporelings and other juveniles – try to match to adults nearby, if you cannot and it covers >1 % then take a specimen from outside of the quadrat, put in a labelled bag for identification in the laboratory and record abundance with a description, e.g. Sp A (small unidentified ascidian).

2.2.5 Photography

A digital single-lens reflex (DSLR) camera, the Nikon D40X, was used to collect the images from the sampled quadrats for purposes of comparison. The camera was housed in an Ikelite underwater housing with an 8-inch dome port and a single strobe light. A photo-quadrat frame was fixed to the camera housing to facilitate the collection of quadrats measuring 25 x

25cm (internal measurements). This sampling apparatus was originally developed for monitoring work by van Rein *et al* (2012; Figure 2.3).

The images were collected by aligning the photo-quadrat frame and the sampling quadrat located *in situ* and simply taking the photograph. Sample images were taken at every possible location of a sampling quadrat along the transect lines and their positions noted so that later the sample images could be associated with data collected *in situ* by the surveyors.

The Nikon D40X has an image sensor that produces 10 megapixel images, from which taxa measuring 2 x 2mm across have been accurately identified (van Rein *et al* 2011a). However, collecting images of this quality depends heavily on the turbidity of the water column and other diving conditions, such as tide and swell. Unfortunately, the weather during the sampling week produced considerable swell on some of the infralittoral Kelp Wall sampling days, which led to difficulties of image collection and poor images as a result. Further technical issues linked to strobe function led to the collection of additional poor quality imagery. These issues highlight some of the potential disadvantages of using photography in underwater survey work. However, the consistency of image quality can be improved with training, equipment familiarisation and sampling on days with better weather.

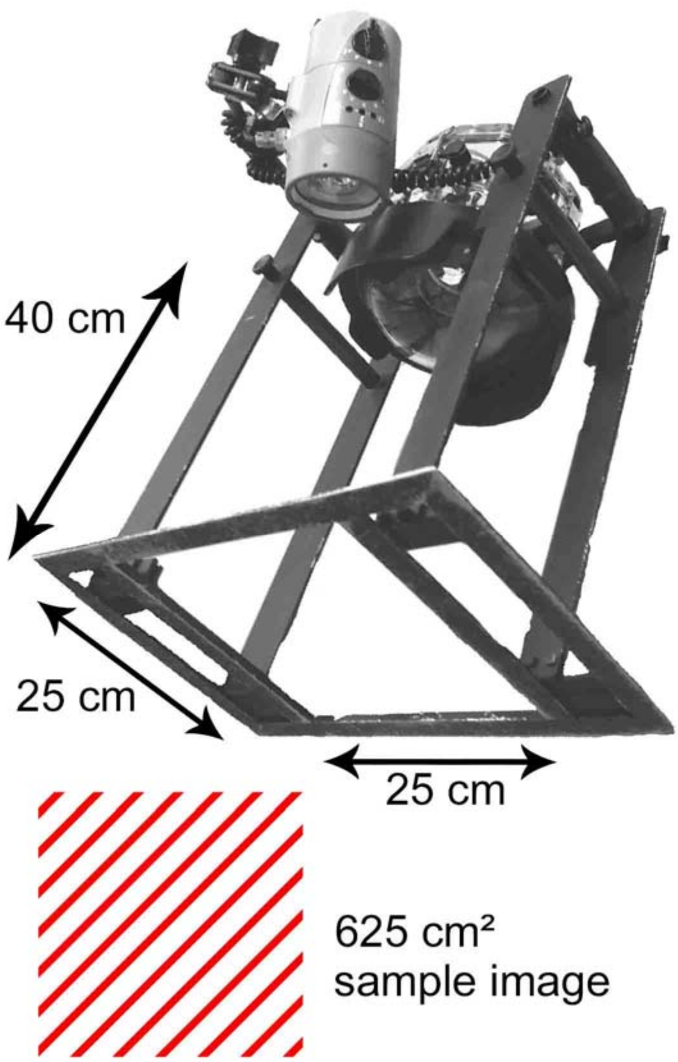

Figure 2.3 Photo quadrat sampling apparatus showing key dimensions and impression of a collected sample image.

2.2.6 Post-survey analysis of photo-quadrats

Only those photographs corresponding to quadrats surveyed *in situ* were processed for analysis. Images were cropped at their recorded resolution (300 dpi) using *Adobe Photoshop CS5* so that only the 25cm x 25cm sampling quadrat was visible. Basic image enhancement (using the auto-levels tool) was applied to images that would have benefited from it. This would not have compromised the identification of any taxa but rather made it easier for the surveyor.

Photo-quadrat recording protocols were essentially the same as for the *in situ* surveys, but with the addition of the following:

- Use available ID guides and carry out the recording to the best of your ability without reference to the *in situ* results.
- There are no strict time limits, but a reasonable maximum average time to analyse a photograph should be about 20 minutes. The images may well take longer at first until familiarity with the photo-quadrats and species increases.
- If the transect line is in the image (i.e. the photoframe was placed too high), only record from the area that should be in the quadrat, and add a note, including an estimate of the % area of the quadrat that it was possible to record from (i.e. indicate how much of the quadrat was not present in the image). Where this occurs then abundances may be lower than were recorded *in situ*. Record % cover of the area that is visible – e.g. if 80% of the original quadrat and half is covered in *Ulva*, then % cover is to be recorded as 50%.
- Add extra rows for taxa that you cannot identify but which appear to be distinct, with a short description of the characteristics seen; e.g. Green algae (dark filamentous) or *Polycarpa* (black marks around siphon).
- *Polycarpa* – it is certainly possible that the variety of solitary (particularly the *Polycarpa*, *Pyura* and *Molgula*-like) ascidians that were seen may not be such a large variety of species. Use the descriptions in the available ID guides (e.g. http://www.habitas.org.uk/marinelife/) and if the specimens observed do not fit the descriptions, then add another row.
- Make a note, for each photograph, about its quality and adequacy for this recording.

Each surveyor then studied the photo-quadrats and recorded the amount of time it took them to complete the sample image. Data were then entered into the spreadsheets.

2.2.7 Data preparation and analysis

2.2.7.1 Data entry, quality assurance (QA), collation and preparation for analysis

The data from the *in situ* recording were copied from the recording forms / divers' slates and entered into a computer spreadsheet (Micosoft Excel), usually by the individual surveyors that recorded the data. During the fieldwork, Quality Assurance (QA) checks were carried out by two members of the team at intervals to minimise the risk of transcription errors.

For the photo analysis, new Excel spreadsheets were prepared for each surveyor, with the same the checklist as on the field survey recording forms and a surveyor-specific list of quadrats that he/she surveyed *in situ*.

After the survey and the analysis of the photo-quadrats, all the data were collated and put through a series of formatting procedures and QA checks to make them ready for analysis, including:

- Correcting spelling of taxon names and revising nomenclature to that of the World Register of Marine Species (www.marinespecies.org).
- Checking and correcting format of abundance data.
- Merging data for a few entities that were poorly described and/or likely to be the same taxon but described differently by different surveyors (based on the experience of the author).
- Formatting for importing into PRIMER (with all potentially useful Factors and Indicators).

2.2.7.2 Data inspection and univariate analyses

Data for individual taxa and other univariate parameters were sorted, summed, averaged and inspected and presented graphically using various tools in Microsoft Excel.

2.2.7.3 Multivariate analyses

All multivariate analyses of the community data collected from the three habitats was carried out using PRIMER-E with the PERMANOVA add-on (Anderson *et al* 2008). Due to the imbalanced design and multifactoral nature of the data the PERMANOVA routine was selected to test for differences between four ‘Factors’ (PRIMER terminology):

- Data collection methods;
- surveyor experience;
- transect; and
- quadrat.

The taxa are the variables, which can also be grouped by Indicators. For the analyses that included multivariate data from both experienced and less-experienced surveyors, only data for the relevant selected taxa were included, not the full taxa. Data from each habitat were analysed slightly differently, as described below.

Kelp Wall

Data were not transformed as the differences between the proportions of dominant taxa (e.g. *Delesseria sanguinea*) and rare taxa (e.g. *Schottera nicaeensis)* were small. This also retained greater data integrity. PERMANOVA tests were conducted to describe variability in the data and measure the statistical significance between groups of records separated by the four factors. Two datasets were analysed: one on selected taxa data (recorded by every surveyor) and one on the full taxa list (recorded by only Francis Bunker and Jon Moore). Two PERMANOVA designs were constructed accordingly. The first had four fixed factors: data collection method (*in situ* vs. Photo-quadrat), experience level of surveyor (High or Low), transect (1 or 2) and quadrat (which was nested within its respective transect). The second design had only three factors: data collection method (*in situ* or Photo-quadrat), transect (1 or 2) and quadrat, nested within transect. In both cases, Bray-Curtis similarity matrices were constructed before running the main PERMANOVA analyses at 9999 permutations. The components of variation tables generated gave an indication of where the majority of variability was contained with the data. As Bray-Curtis similarity matrices were used the components of variation figures represent the percentage dissimilarity between different conditions within the same factor (Anderson *et al* 2008). Post-hoc tests (PERMANOVA pairwise analysis with 9999 permutations) explored factorial interactions (e.g. Method X Quadrat or Experience X Method) and other interesting factorial combinations. To further explore the data the SIMPER routine was utilised, and set at 95%, to show the taxa that contributed most to the similarities and dissimilarities among the data. Finally, non-parametric Multi-Dimensional Scaling (MDS) plots were used to visualise the data in

2-dimensional space to highlight any similarities or dissimilarities in the community composition between the different groups of records.

Circalittoral site

The data collected from this site were analysed in the same way as the Kelp Wall data, with the same factors and the same two PERMANOVA models as those from the Kelp Wall. The key difference was that the data were in a presence/absence format rather than percentage cover. Therefore, similarly no statistical transformations were made.

Zostera *bed*

As these data were recorded from two formats, abundance (in the form of counts) and percentage cover, they were analysed separately, but using the same approach. No transformations were made to the data for the same reasons stated above for the Kelp Wall data. Only one PERMANOVA model was constructed as every surveyor recorded against a full taxa list in this habitat. There were only three fixed factors selected for this analysis as there was only one transect sampled at the site. The factors were data collection method (*in situ* compared to Photo-quadrat), experience level of surveyor (High or Low) and quadrat. Bray-Curtis matrices were constructed and a main PERMANOVA test was run with 9999 permutations. A ‘components of variation’ table was generated. Post–hoc tests were conducted for a more-detailed analysis of the percentage cover data between all three factors. SIMPER analysis was used to explore the similarities and dissimilarities in the data and MDS plots were used to visualise those similarities and dissimilarities in 2 or 3 dimensions.

2.3 Results and discussion

The results are based on data from large numbers of quadrat records from each transect, which together provide a good description of the transect communities. However, as described in the methodology sections above, the divers did not survey all the same quadrats, i.e. it was not a balanced design. For many of the comparisons described below there were therefore insufficient quadrat positions surveyed by all the surveyors to analyse statistically; so all the quadrats were analysed. Some of the differences may therefore be due to spatial variability in the communities. Direct comparisons between individual quadrats that were surveyed by multiple surveyors are also discussed below.

Note: Individual surveyors are identified by letter codes (A to F), which remain the same throughout the Portrush results.

2.3.1 Summary description of data

2.3.1.1 Kelp Wall transects

The most frequently recorded taxa from the Kelp Wall transect quadrats and the main differences in taxa recorded by the four methods are summarised in Table 2.1. The last four rows of the table give additional statistics.

Table 2.1 Percentage occurrence* of taxa in Kelp Wall quadrat survey records. See text for description of survey methods. Dash marks (-) indicate taxa not surveyed in part surveys.

Taxon	*In situ* Full	*In situ* Selected	Photo Full	Photo Selected
Leuconia	11	-	25	-
Actinothoe sphyrodeta	33	20	8	11
Caryophyllia smithii	44	25	0	0
Sabellidae	17	-	0	-

Taxon	*In situ* Full	*In situ* Selected	Photo Full	Photo Selected
Spirobranchus	100	-	92	-
Balanus crenatus	94	-	100	-
Jassa (tubes)	39	-	0	-
Calliostoma zizyphinum	17	-	0	-
Bryozoa (orange enc)	100	87	75	15
Crisiidae	94	-	50	-
Electra pilosa	17	-	0	-
Scrupocellaria	89	-	42	-
Clavelina lepadiformis	61	-	17	-
Morchellium argus	17	-	17	-
Aplidium (2 spot)	17	-	0	-
Aplidium punctum	72	-	33	-
Didemnum maculosum	28	-	0	-
Polycarpa	11	-	8	-
Corallinaceae (enc)	100	18	83	16
Schottera nicaeensis	17	11	0	5
Plocamium lyngbyanum	11	11	0	0
Acrosorium ciliolatum	6	9	17	11
Cryptopleura ramosa	56	51	0	23
Delesseria sanguinea	94	97	100	98
Hypoglossum hypoglossoides	89	55	17	16
Erythroglossum laciniatum	33	24	17	20
Pterosiphonia parasitica	56	43	0	2
Pseudolithoderma	39	-	0	-
Dictyota dichotoma	67	-	42	-
Laminaria (sporelings)	22	-	8	-
Laminaria hyperborea	17	-	33	-
Quadrats surveyed (Total=23)	11	22	8	18
Records (Total=160)	18	81	12	49
Total taxa (Total=62)	55	17	21	13
Average taxa / record	16.3	4.3	8.0	2.1

*Percentage occurrence of taxa – e.g. *Actinothoe sphyrodeta* was present in 33% of the 18 quadrat records collected *in situ* during surveys of the full taxa list (i.e. only by the more-experienced surveyors), and in 20% of the 81 quadrat records collected *in situ* during all surveys of selected taxa (all surveyors).

2.3.1.2 Circalittoral transects

The most frequently recorded taxa from the Circalittoral transect quadrats and the main differences in taxa recorded by the four methods are summarised in Table 2.2. The last four rows of the table give additional statistics.

Table 2.2 Percentage occurrence of taxa in Circalittoral quadrat survey records. See text for description of survey methods. Dash marks (-) indicate taxa not surveyed in part surveys.

Taxon	*In situ* Full	*In situ* Selected	Photo Full	Photo Selected
Alcyonium digitatum	55	-	44	-
Sagartia elegans	45	-	0	-
Actinothoe sphyrodeta	91	-	78	-
Caryophyllia smithii	55	-	33	-
Balanus crenatus	91	-	0	-
Calliostoma zizyphinum	18	-	33	-
Crisia	64	-	0	-
Alcyonidium diaphanum	73	-	56	-
Flustra foliacea	55	-	67	-
Securiflustra securifrons	27	-	11	-
Cellaria (fine)	27	-	11	-
Scrupocellaria	82	-	78	-

Taxon	*In situ* Full	*In situ* Selected	Photo Full	Photo Selected
Bugula	0	-	33	-
Bugula flabellata	45	-	22	-
Bugula plumosa	18	-	22	-
Ophiura	27	-	0	-
Clavelina lepadiformis	36	76	33	61
Pycnoclavella aurilucens	55	21	22	10
Synoicum incrustatum	45	14	0	0
Aplidium turbinatum	36	12	0	0
Didemnidae (dark blue)	27	0	0	0
Didemnidae (white spiky)	27	0	0	0
Polycarpa (orange)	45	15	0	32
Polycarpa fibrosa (mat)	64	74	100	94
Polycarpa scuba	82	70	44	65
Molgula manhattensis	36	14	0	0
Rhodophyta (forked)	0	-	33	-
Corallinaceae	18	-	11	-
Hypoglossum hypoglossoides	73	-	11	-
Erythroglossum laciniatum	36	-	11	-
Quadrats surveyed (Total=39)	7	37	6	24
Records (Total=117)	11	66	9	31
Total taxa (Total=67)	43	20	33	6
Average taxa / record	15.4	3.5	9.3	2.7

2.3.1.3 *Zostera* bed transect

The most frequently recorded taxa from the *Zostera* bed transect quadrats and the main differences in taxa recorded by the two methods are summarised in Table 2.3. The last four rows of the table give additional statistics.

Table 2.3 Percentage occurrence of taxa in *Zostera* bed quadrat survey records. See text for description of survey methods.

Taxon	*In situ*	Photo
Ericthonius (on *Zostera* leaves)	0	24
Tricolia pullus (on *Zostera* leaves)	0	8
Rhodophyta (fil mat)	23	12
Rhodophyta (fil. branching)	97	96
Rhodophyta (flat)	10	0
Gracilaria gracilis	10	8
Polysiphonia elongata	13	32
Phaeophyceae (fil on *Zostera*)	0	8
Chorda filum	5	4
Chlorophyta (branching)	3	12
Chlorophyta (fil)	15	28
Ceramium	13	0
Ulva (flat)	3	8
Ulva (tubular)	36	40
Bacillariophyceae (fil brown diatoms)	72	68
Zostera marina	69	72
Quadrats surveyed (Total=18)	18	10
Records (Total=64)	39	25
Total taxa (Total=21)	16	16
Average taxa / record	3.8	4.3

2.3.2 Consistency of *in situ* recording and comparisons between surveyors

2.3.2.1 Kelp Wall transects

Multivariate community data

PERMANOVA analysis of quantitative selected taxa data (percentage covers, all surveyors) found that there was a significant difference between the more experienced and less experienced surveyors (Pseudo F = 11.0, P = 0.0001, df = 1). This difference, which can been seen in the MDS plot (Figure 2.4), was partly a result of greater numbers of taxa identified in the quadrats by the more experienced surveyors, but SIMPER analysis showed that differences in the estimated abundance of *Delesseria sanguinea* contributed to over 70% of the overall dissimilarity.

Multivariate analysis of the full community data (Figure 2.5) found a significant difference between the two experienced surveyors (ANOSIM analysis: Global R = 0.585, P = 0.1%), which was due to differences in the recorded abundances (percentage cover) of a number of species, particularly *Pseudolithoderma*, *Balanus crenatus*, and *Jassa* (tubes). Other species identified by the SIMPER analysis (see Appendix 2) included *Delesseria sanguinea*, *Dictyota dichotoma* and encrusting coralline algae, but comparison of their average abundances finds very little difference between the surveyors (for example, average abundance of *Delesseria sanguinea* recorded by both surveyors on Transect 1 was 36%). Dissimilarity between records of these species by the two surveyors is due to a far greater range in recorded abundances by one surveyor, often because that surveyor happened (by chance) to survey a quadrat with an unusually low or high abundance. More quadrat records by the two experienced surveyors would have evened out the dissimilarities in the species records and improved the multivariate analysis.

Although the number of records was small, the percentage similarity suggests that there was greater consistency of data among records collected by the more experienced surveyors. A more-detailed tabulation of the multivariate analysis results is given in Appendix 2. The following sections provide more details on the individual taxa.

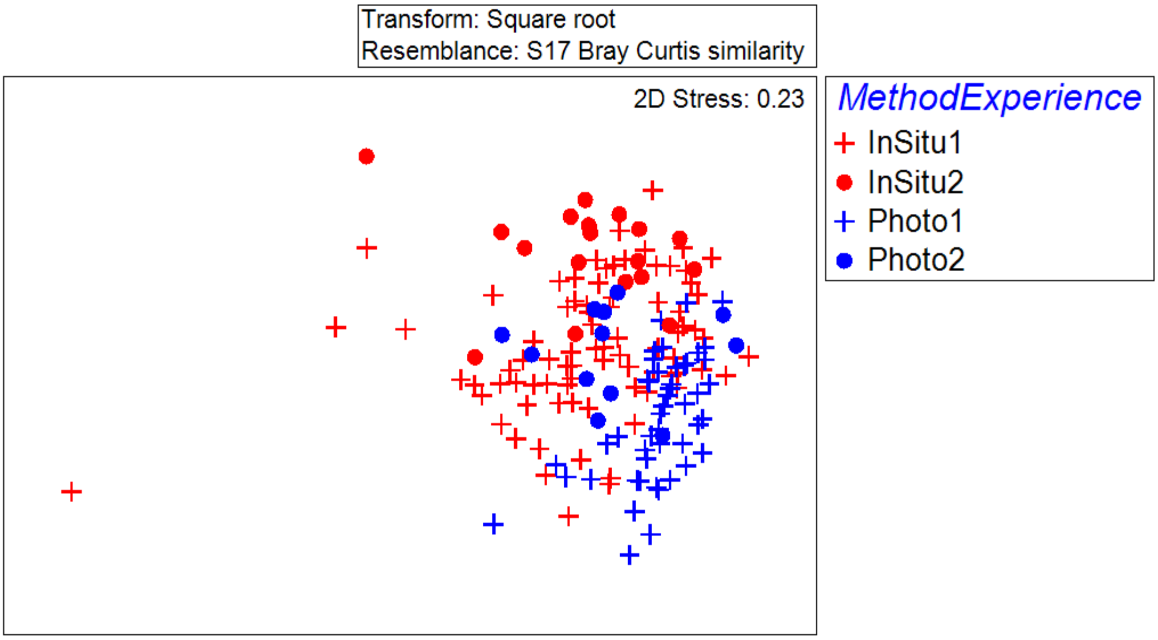

Figure 2.4 MDS plot of selected community data (red algae, anthozoans and bryozoan crusts only) from Kelp Wall transect quadrats, by survey method (*in situ* and Photo) and experience level (1=low, 2=high).

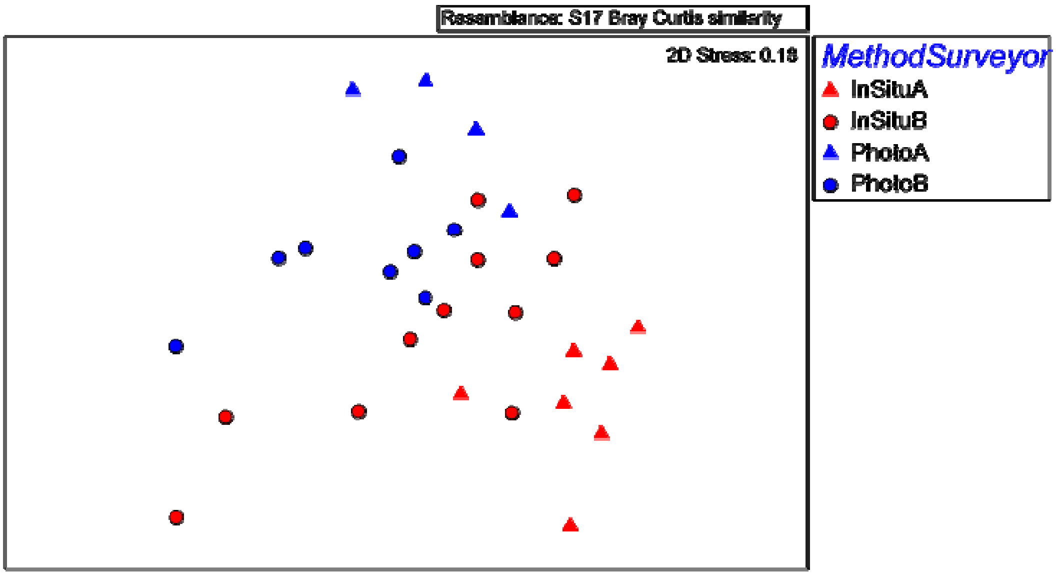

Figure 2.5 MDS plot of full community data (all taxa, experienced surveyors only) from Kelp Wall transect quadrats, by survey method (*in situ* and Photo) and surveyor (A and B).

Presence/absence data for individual taxa

Of the selected taxa (red algae, anthozoans and bryozoan crusts), none were recorded consistently as present/absent by all surveyors in all quadrats. The red algae *Delesseria sanguinea* was by far the most consistently recorded, being noted in every quadrat by almost every surveyor; but even this species was recorded by one surveyor as absent in a quadrat where all the other surveyors recorded it having at least 10% cover. Bryozoan crusts were fairly consistently recorded as present/absent by most surveyors, but one of the less experienced surveyors recorded them much less frequently than others. The cup coral *Caryophyllia smithii* was also fairly consistently recorded as present/absent, but not always, presumably where small or hidden individuals were not noticed by all surveyors. Consistency was much poorer for the other selected taxa, particularly among the less experienced surveyors. The more-experienced surveyors were fairly consistent in their recording of some of the other red algae species (including *Cryptopleura ramosa* and *Hypoglossum hypoglossoides*).

Of the other taxa (i.e. those only recorded by the two experienced surveyors), one (*Pyura microcosmus*) was recorded completely consistently, because a large conspicuous individual was present in a single quadrat. However, the presence/absence of a number of other species were also recorded fairly consistently, including *Spirobranchus*, *Balanus crenatus*, Crisiidae spp., *Scrupocellaria*, *Clavelina lepadiformis*, *Aplidium punctum*, Corallinaceae (encrusting (enc)), and *Dictyota dichotoma*.

The number of species recorded by each surveyor in each quadrat also varied considerably, with some surveyors recording twice the number of species of other surveyors in the same quadrat. The average number of species recorded per quadrat varied less between surveyors (see Table 2.4), but there was a bias towards higher or lower species numbers by some surveyors. One of the more experienced surveyors always recorded more of the selected taxa than any other surveyor. For example, *Pseudolithoderma* and *Jassa* (tubes) were recorded from every quadrat surveyed by that surveyor, but were overlooked completely by all of the other surveyors.

Percentage cover and counts data for individual taxa

Of the taxa that were relatively consistently recorded as present/absent, few showed much consistency in recordings of abundance. Counts of *Caryophyllia smithii* were the most consistent, but estimates of percentage cover for algae, barnacles or colonial animals typically varied by a factor of at least two and for most of the less abundant species variation by a factor of ten or more was not unusual. There was greater consistency of abundance estimates by the more experienced surveyors, but variations by large factors still occurred for many species.

The average abundance of each species recorded per quadrat also varied greatly between surveyors (see Table 2.4 and Table 2.5), indicating surveyor biases that routinely over or underestimate abundance (by a factor of at least two between some surveyors).

Table 2.4 Average abundance of selected taxa in Kelp Wall transect quadrats recorded by each surveyor. Averages only taken for quadrats that were surveyed by at least four different surveyors.

	Less experienced surveyors					More experienced	
Taxon	**C**	**E**	**D**	**G**	**F**	**A**	**B**
Actinothoe sphyrodeta (counts)	0.1	0.2	0.2	0.2	0.4	0.4	0.4
Caryophyllia smithii (counts)	0.4	0.5	0.3	0.3	0.4	0.7	0.3
Bryozoa (orange enc) (%)	2.5	1.7	3.8	1.0	2.2	4.2	6.6
Schottera nicaeensis (%)	0.1	0.9	0.0	0.0	0.0	0.0	0.0
Plocamium lyngbyanum (%)	1.6	0.0	0.0	0.0	0.3	0.0	0.6
Rhodymenia pseudopalmata (%)	0.4	0.3	0.2	0.0	0.0	0.0	0.0
Rhodymenia ardissonei (%)	1.3	0.7	0.0	0.0	0.0	0.0	0.0
Pterothamnion plumula (%)	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Acrosorium ciliolatum (%)	0.0	0.0	0.1	0.0	0.2	0.3	0.0
Cryptopleura ramosa (%)	2.8	3.5	1.3	1.0	1.9	2.9	2.4
Delesseria sanguinea (%)	36.3	19.6	20.1	21.1	15.9	40.7	30.0
Hypoglossum hypoglossoides (%)	0.9	0.1	1.2	0.3	1.0	3.0	2.1
Erythroglossum laciniatum (%)	0.0	0.6	1.0	0.0	0.0	0.7	0.2
Pterosiphonia parasitica (%)	1.0	0.6	1.0	0.5	1.6	2.0	1.3
Average No. of selected taxa/quadrat	**4.6**	**4.5**	**4.8**	**3.4**	**4.5**	**6.7**	**5.1**

Table 2.5 Average abundance of other taxa in Kelp Wall transect quadrats. Averages only taken for quadrats that were surveyed by both of the experienced surveyors.

Taxon (abundance measure used)	**A**	**B**
Sycon ciliatum (%)	0.3	0.0
Sabellidae (%)	0.6	0.0
Spirobranchus (counts)	8.7	7.7
Balanus crenatus (%)	25.3	8.7
Jassa (tubes) (%)	9.1	0.0
Anomiidae (counts)	0.3	0.0
Crisiidae (%)	3.9	0.9
Scrupocellaria	6.3	1.2
Clavelina lepadiformis (%)	0.6	2.3
Morchellium argus (counts)	0.3	0.1
Aplidium (2 spot) (counts)	0.7	0.0
Aplidium punctum (counts)	2.4	2.7
Didemnum maculosum (%)	0.2	0.0
Molgula (sandy) (counts)	0.4	0.0
Rhodophyta (dk red enc) (%)	1.0	0.0
Corallinaceae (enc) (%)	5.7	7.3
Pseudolithoderma (%)	32.1	0.0
Dictyota dichotoma (%)	4.9	4.4
Laminaria (sporelings) (%)	1.4	2.9
Average No. of other taxa/quadrat	**13.7**	**8.3**

2.3.2.2 Circalittoral transects

Multivariate community data

PERMANOVA analysis of quantitative selected taxa data (percentage covers, all surveyors) found that there was no significant difference between the more-experienced and less-experienced surveyors in this habitat (Pseudo F = 0.683, P = 0.584, df = 1). See MDS plot (Figure 2.6). Similar communities were recorded by both groups, although the more-experienced surveyors recorded relatively more taxa. The lack of a significant difference is at least partly due to the limited number of replicate quadrats surveyed by the more experienced surveyors. As they were recording all species from their quadrats they took much longer than the less-experienced surveyors, and bottom time at 20m water depth limited the number of quadrats they could survey (on average two to three per dive).

There was greater consistency of data, measured by the percentage similarity, among records collected by the more experienced surveyors (Figure 2.7). A more detailed tabulation of the multivariate analysis results is given in Appendix 2. The following sections provide more details on the individual taxa.

The highest proportion of variability in the entire data set is attributed to differences between the quadrats and that recorded by the different surveyors. Differences between the quadrats were significant (Pseudo F = 1.957, P = 0.001, df = 37).

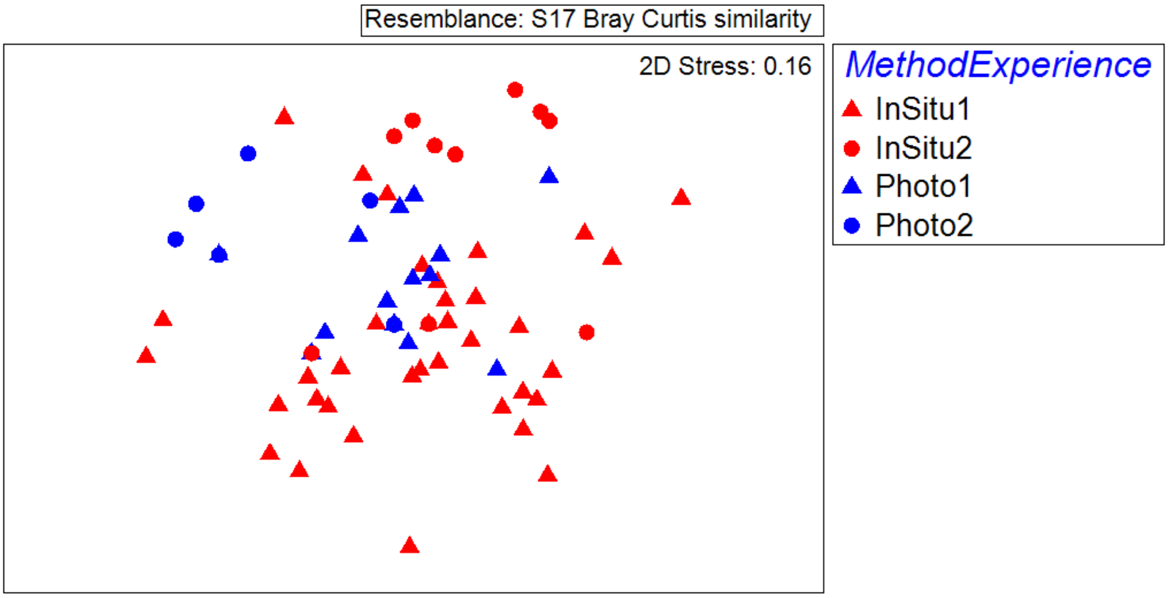

Figure 2.6 MDS plot of selected community data (ascidians only) from Circalittoral transect quadrats, by survey method (*in situ* and Photo) and experience level (1=low, 2=high).

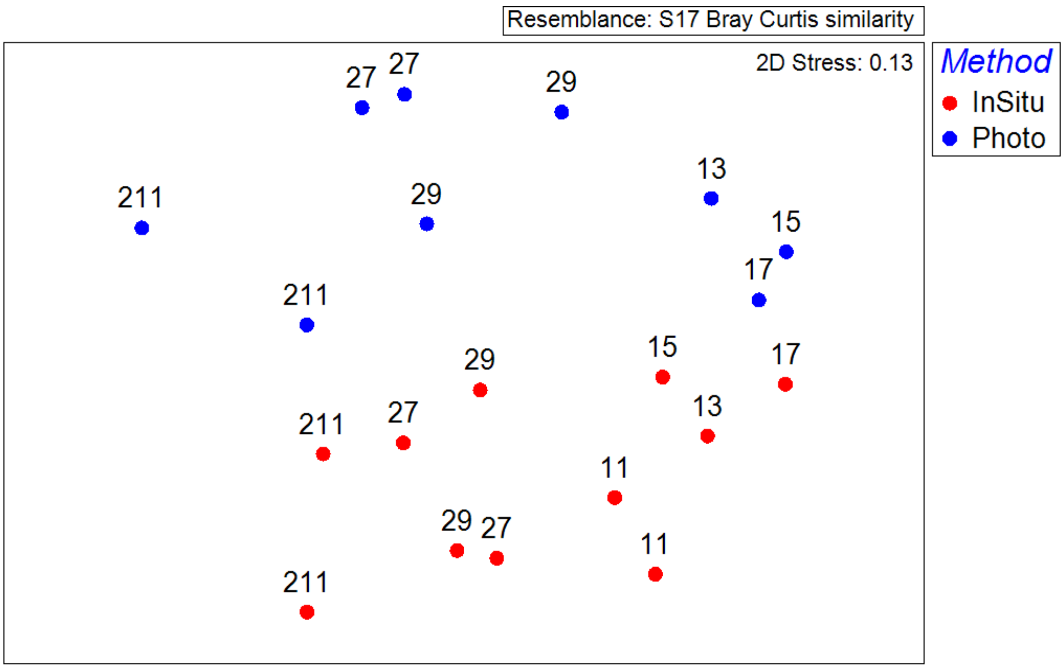

Figure 2.7 MDS plot of full community data (all taxa, experienced surveyors only) from Circalittoral transect quadrats, by survey method (*in situ* and Photo) and Transect_Quadrat number (first digit is transect number, second is distance along the transect).

Presence/absence data for individual taxa

Of the selected taxa (ascidians), none were recorded consistently as present/absent by all surveyors in all quadrats. *Clavelina lepadiformis* was the most consistently recorded, mainly because it was found in almost every quadrat and is easily recognised; but even all surveyors did not record it completely consistently, possibly where small or hidden individuals were not noticed by all surveyors or simply because it was accidentally overlooked. Similarly, *Polycarpa fibrosa* and *Polycarpa scuba* were almost ubiquitous and consistency was high but not perfect (see Table 2.6). These species, like most of the ascidians present in the low turf at this site are cryptic and not easy to identify, even by experienced surveyors. Consistency was much poorer for the other ascidians. The more experienced surveyors appeared slightly more consistent in their recording, but the limited number of records makes this inconclusive.

Of the other taxa (i.e. those only recorded by the two experienced surveyors), a number were recorded completely consistently, including *Alcyonium digitatum*, *Flustra foliacea*, *Securiflustra securifrons*, *Scrupocellaria* and *Hypoglossum hypoglossoides*. Surprisingly there was relatively poor consistency in records of the anthozoan *Sagartia elegans*, *Actinothoe sphyrodeta* and *Caryophyllia smithii*. The bright white *A. sphyrodeta* were usually very conspicuous, but it is likely that one of the quadrats happened to have a single small inconspicuous individual (possibly with retracted tentacles) that was overlooked by one of the surveyors.

As with the Kelp Wall transects, the number of species recorded by each surveyor in each quadrat also varied considerably, with some surveyors recording more than twice the number of species of other surveyors in the same quadrat. The average number of species recorded per quadrat varied less between surveyors (see Table 2.6 and Table 2.7), but there was a bias towards higher or lower species numbers by some surveyors. Usually, but not always, the bias to higher or lower numbers was with the same surveyors as at the Kelp Wall site. For example, one of the more-experienced surveyors usually, but not always, recorded more species than any other surveyor.

Table 2.6 Sum of records of selected taxa (ascidians) in Circalittoral transect quadrats. Only includes quadrats that were surveyed by at least three different surveyors.

	Less experienced surveyors						More experienced	
Taxon	**D**	**G**	**E**	**H**	**I**	**F**	**A**	**B**
Ascidiacea	4	1	0	0	0	1	1	0
Clavelina lepadiformis	5	3	3	3	4	3	1	3
Pycnoclavella aurilucens	1	4	1	0	0	3	2	2
Synoicum incrustatum	0	0	2	0	3	1	2	3
Morchellium argus	0	0	0	1	0	0	0	0
Aplidium turbinatum	0	0	1	2	0	0	2	1
Aplidium punctum	0	2	0	1	0	0	0	0
Didemnidae	0	0	0	0	0	1	1	2
Polycarpa	4	0	4	1	0	0	4	1
Polycarpa fibrosa (mat)	5	6	3	3	4	3	0	6
Polycarpa scuba (white teeth)	0	1	0	1	0	0	0	0
Polycarpa scuba	5	3	3	0	3	2	3	4
Pyura	1	0	0	0	0	0	0	0
Molgula manhattensis	0	2	2	0	1	2	1	3
Average No. of selected taxa/quadrat	**5.0**	**3.7**	**4.8**	**4.0**	**3.8**	**5.3**	**5.7**	**4.3**

Table 2.7 Sum of records of other taxa in Circalittoral transect quadrats. Only includes four quadrats that were surveyed by both of the experienced surveyors.

Taxon	**A**	**B**
Scypha ciliata	1	1
Obelia dichotoma	1	0
Rhizocaulus	0	1
Alcyonium digitatum	2	2
Urticina felina	1	0
Sagartia elegans	3	2
Actinothoe sphyrodeta	3	4
Caryophyllia smithii	1	2
Spirobranchus	1	0
Balanus crenatus	4	3
Bryozoa (enc orange)	0	1
Crisia	4	1
Alcyonidium diaphanum	4	1
Flustra foliacea	3	3

Securiflustra securifrons	1	1
Cellaria (fine)	1	1
Scrupocellaria	4	4
Bicellariella ciliata	1	0
Bugula flabellata	3	2
Bugula plumosa	1	1
Corallinaceae	1	0
Hypoglossum hypoglossoides	3	3
Erythroglossum laciniatum	2	0
Average No. of other taxa/quadrat	**12.3**	**9.8**

2.3.2.3 *Zostera* bed transects

Multivariate community data

Community data recorded from this transect had the greatest variability between records, as measured by multivariate dissimilarity, of all the data sets collected in this study. However, most of that variability appears to be attributable to differences between surveyors and data collection methods rather than within the community itself. This may have been because this site was a last-minute improvised study, with no pre-survey familiarisation or discussion of methods.

Pairwise t-tests of quantitative community data (percentage covers, all surveyors) found that there was a significant difference between the more-experienced and less-experienced surveyors ($t = 1.879$, $P = 0.016$, $df = 13$). This difference, which can been seen in the MDS plot (Figure 2.8) was partly a result of greater numbers of taxa identified in the quadrats by the more experienced surveyors, but SIMPER analysis showed that differences in the estimated abundance (percentage cover) of *Bacillariophyceae* (brown diatoms) contributed a lot to this result.

There was greater consistency of data, measured by the percentage similarity, among records collected by the more experienced surveyors. A more-detailed tabulation of the multivariate analysis results is given in Appendix 2. The following sections provide more details on the individual taxa.

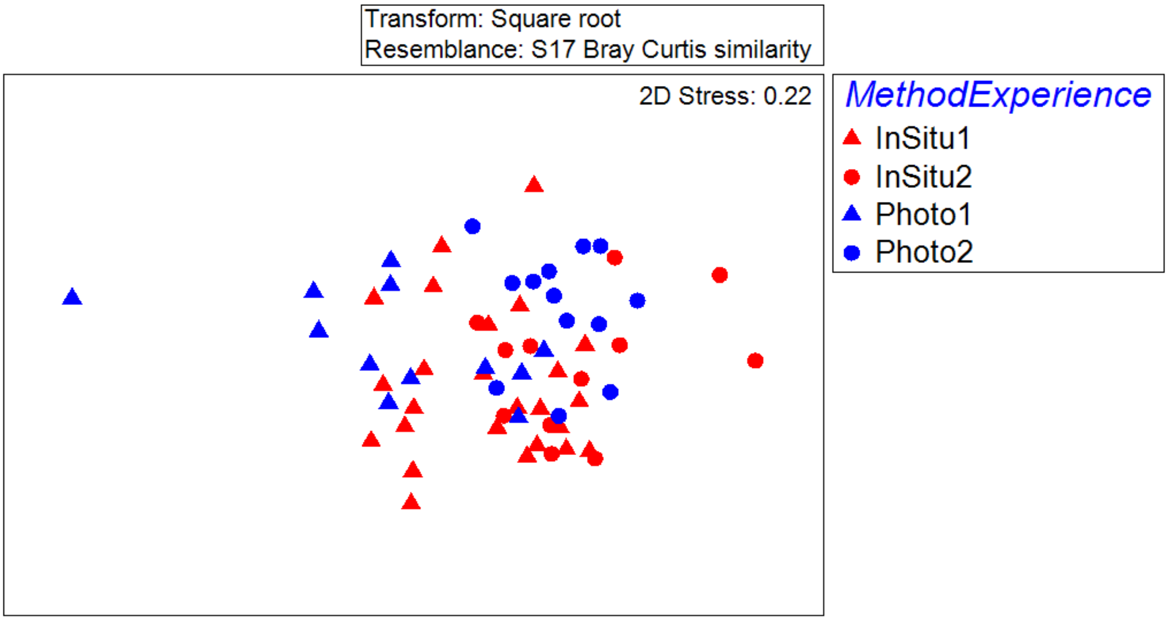

Figure 2.8 MDS plot of community data (all taxa, experienced surveyors only) from *Zostera* bed transect quadrats, by survey method (*in situ* and Photo) and experience level (1=low, 2=high)

Percentage cover and counts data for individual taxa

Compared to the other two habitats, the *Zostera* bed quadrats were characterised by relatively few species and low percentage covers. Consistency of recording for easily identified species was therefore high. In particular, counts of *Zostera* plants were highly consistent (Table 2.8). Any differences between records were likely due to differences in how recorders counted multiple shoots arising close together from the same rhizome. Records of filamentous branching red algae were also fairly consistent, with estimates of percentage cover that rarely differed by more than a factor of 3. Cover of *Bacillariophyceae* (filamentous brown diatoms) and *Ulva* (tubular) were also fairly consistently recorded by some surveyors, and would likely have been much more consistent between all of the surveyors if there had been any opportunity for pre-survey familiarisation in this habitat and a prepared checklist of species. Consistency of other taxa was generally poor, but would also likely have been improved by familiarisation and a checklist.

Table 2.8 Average abundance of selected taxa in *Zostera* bed transect quadrats. Averages only taken for quadrats that were surveyed by at least three different surveyors.

	Less experienced surveyors			More experienced	
Taxon (abundance measure used)	**E**	**G**	**F**	**A**	**B**
Rhodophyta (fil mat) (%)	0.0	0.0	0.5	0.0	0.0
Rhodophyta (fil. branching) (%)	5.0	10.4	4.5	7.2	6.3
Rhodophyta (flat) (%)	0.0	0.0	0.7	0.0	0.0
Gracilaria gracilis (%)	0.0	0.0	0.2	0.0	0.0
Polysiphonia elongata (%)	0.0	0.0	0.0	0.1	0.0
Chorda filum (counts)	0.0	0.0	0.2	0.0	0.1
Chlorophyta (branching) (%)	0.0	0.0	0.0	0.0	0.4
Chlorophyta (fil) (%)	0.8	0.0	0.0	0.0	0.0
Ceramium (%)	0.00	0.0	0.0	0.1	0.0
Ulva (tubular) (%)	0.00	0.6	0.8	0.8	0.3
Bacillariophyceae (fil brown diatoms) (%)	6.5	2.0	1.5	5.8	7.7
Zostera marina (counts)	1.3	2.0	2.2	1.8	1.9

2.3.3 Comparison between *in situ* data collection and photos

Multivariate analyses of community data found statistically significant differences between the *in situ* recording and the photo-quadrat recording methods in three of the five data-sets (Table 2.9).

Table 2.9 Summary of PERMANOVA results comparing *in situ* and photo data (ns=Not significant). See 0 for more details.

Site and dataset	Pseudo F	Probability	Sig.diff.
Kelp Wall, Selected taxa	10.665	0.0001	***
Kelp Wall, Full taxa	4.08	0.013	*
Circalittoral, Selected taxa	2.105	0.117	ns
Circalittoral, Full taxa	7.539	0.003	**
Zostera bed	2.723	0.103	ns

The MDS plots in Figure 2.4 to Figure 2.8 illustrate some of these differences (*in situ* method in red symbols, photo method in blue symbols), although the large differences between individual quadrats means that there is also a large overlap in some plots. The lack of a significant difference between the two methods in the selected taxa community data from the Circalittoral site was investigated in more detail and a significant difference between the methods was evident in the Transect 2 data, but not in the Transect 1 data. Relatively more taxa were recorded from the Transect 1 photo-quadrats, so there were fewer differences with the *in situ* data.

The differences between *in situ* records and photographic records from the Kelp Wall is partly due to lower numbers of taxa recorded in the photo quadrats, a number of which are consistently unrecorded in the photo quadrats. Further, where quantitative data are analysed there are significant differences in the recorded abundance of some conspicuous dominant taxa that contributes greatly to the overall dissimilarity between the methods. Detailed inspection of the data for individual taxa and groups of taxa highlights these differences and also highlights a few taxa that are relatively consistently recorded between the two methods. Table 2.11 to Table 2.15 show the differences between the methods and the following paragraphs summarize the key findings with respect to comparing the data collection methods for some of the characterising taxa.

- Distinctive anemones and cup corals, e.g. *Caryophyllia smithii* and *Actinothoe sphyrodeta*, are typically conspicuous, easy to identify and count. There is a relatively high level of consistency between *in situ* and photo records, particularly where numerous individuals were present and not obscured by overlying algae. However, in a number of quadrats, small inconspicuous individuals were unrecorded in photo-quadrats, probably due to overlying algae or the quality of the photographs (due to limited resolution, inadequate illumination and/or blur).

- Large and distinctive algal fronds, e.g. *Delesseria sanguinea* are typically conspicuous and easy to identify in photographs, but it is often difficult to distinguish boundaries with other red algae, so percentage estimates from photographs can vary as widely between individual surveyors as *in situ* estimates [in a worst case the % cover estimates ranged from 3% to 25%]. The average % cover was generally higher in *in situ* records than photo records, which contributed greatly to the significant difference described in the PERMANOVA analysis; however, this trend was not consistent in all quadrats.

- Other, less distinctive, algae – most algae are difficult to identify in the photographs and it is even more difficult to estimate their abundance with any consistency.

- Large and distinctive fauna, e.g. *Alcyonium digitatum*, *Calliostoma zizyphinum* and *Flustra foliacea*, as with the anemones and cup corals, these species were recorded with high consistency between the *in situ* and photo methods.

- Encrusting species with fine textural detail, e.g. encrusting bryozoa, coralline algae, many sponges and *didemnid ascidians*; the crusts vary greatly in how conspicuous they are and some of the less experienced surveyors consistently recorded them as absent in *in situ* surveys and even the more experienced surveyors sometimes recorded a range of % cover estimates (e.g. 2% to 10%) from the same quadrat *in situ*. These species were particularly difficult to distinguish in the photo quadrats and were rarely recorded at all by the less experienced surveyors. Where the more experienced surveyors did record them in the photo quadrats, the estimates of % cover were usually much lower than in the *in situ* records from the same quadrats.

- Barnacles – like the encrusting species, estimating percentage cover of barnacles often requires fine textural detail that cannot be seen in the quadrat photographs. Where the more-experienced surveyors did record them in the photo quadrats, the estimates of % cover were usually much lower than in the *in situ* records from the same quadrats.

- Ascidian turf species – distinguishing and identifying ascidians also requires more detail than could be seen in the photographs.

While the above differences show that the photo-quadrats provide significantly less information on the community composition than *in situ* records, SIMPER analyses and detailed inspection of the data show that consistency of recording between surveyors (experienced or less experienced) was significantly greater (by approximately 10%) in the photo-quadrat records from seven of the eight datasets (see Table 2.10).

Table 2.10 Average similarity (%) from SIMPER analysis, comparing *in situ* and photo data. See 0 for more details.

Site and dataset (Taxa and Experience)	*In situ*	Photo
Kelp Wall, Selected taxa, Experienced	52	61
Kelp Wall, Selected taxa, Less-experienced	48	56
Kelp Wall, Full taxa, Experienced	42	50
Circalittoral, Selected taxa, Experienced	41	56
Circalittoral, Selected taxa, Less-experienced	49	63
Circalittoral, Full taxa	48	41
Zostera bed, Experienced	44	44
Zostera bed, Less-experienced	39	49

Table 2.11 Average percentage cover of selected taxa in Kelp Wall transect quadrats. Averages taken from records by all surveyors but only includes the 18 quadrats that were surveyed with both methods.

Taxon	*In situ*	Photo
Actinothoe sphyrodeta	0.2	0.2
Caryophyllia smithii	0.4	0.3
Bryozoa (orange enc)	3.1	0.5
Schottera nicaeensis	0.2	0.1
Plocamium lyngbyanum	0.7	0.0
Rhodymenia pseudopalmata	0.2	0.1
Rhodymenia ardissonei	0.1	0.1
Pterothamnion plumula	0.2	0.0
Acrosorium ciliolatum	0.1	0.0
Cryptopleura ramosa	1.2	0.8
Delesseria sanguinea	19.4	17.8
Hypoglossum hypoglossoides	0.8	0.4
Erythroglossum laciniatum	0.3	0.5
Pterosiphonia parasitica	0.5	0.1

Table 2.12 Average percentage cover of other taxa in Kelp Wall transect quadrats. Averages taken from records by experienced surveyors, but only includes the 8 quadrats that were surveyed with both methods.

Taxon	*In situ*	Photo
Sycon ciliatum	0.2	0.1
Sabellidae	2.5	0.0
Sabellaria spinulosa	0.0	0.0
Spirobranchus	18.8	17.7
Balanus crenatus	16.5	5.6
Jassa (tubes)	4.1	0.0
Gibbula cineraria	0.1	0.0
Calliostoma zizyphinum	0.1	0.0
Bryozoan turf	0.0	2.6
Crisiidae	2.5	0.2
Scrupocellaria	4.1	0.0
Aslia lefevrii	0.3	0.0
Clavelina lepadiformis	1.2	0.5
Morchellium argus	0.3	0.3
Aplidium turbinatum	0.0	0.0
Aplidium (2 spot)	0.2	0.0
Aplidium punctum	3.2	0.6

Polycarpa	0.0	0.3
Pyura microcosmus	0.2	0.0
Rhodophyta (dk red enc)	0.4	0.0
Corallinaceae (enc)	9.0	3.1
Pseudolithoderma	7.5	0.0
Dictyota dichotoma	3.6	0.9
Laminaria (sporelings)	0.0	0.4

Table 2.13 Sum of all recorded occurrences, by all surveyors, of selected taxa (ascidians) in Circalittoral transect quadrats. Only includes the 23 quadrats that were surveyed with both methods.

Taxon	*In situ*	Photo
Ascidiacea	6	3
Clavelina lepadiformis	42	21
Pycnoclavella aurilucens	14	5
Synoicum incrustatum	12	0
Morchellium argus	1	0
Aplidium turbinatum	10	0
Aplidium punctum	2	0
Didemnum maculosum	0	2
Didemnidae (dark blue)	6	0
Polycarpa	20	10
Polycarpa fibrosa (mat)	42	37
Polycarpa scuba	45	24
Dendrodoa grossularia	0	1
Botrylloides leachii	1	0
Pyura	4	0
Molgula manhattensis	9	0

Table 2.14 Sum of all recorded occurrences, by all surveyors, of other taxa in Circalittoral transect quadrats. Only includes the six quadrats that were surveyed with both methods.

Taxon	*In situ*	Photo
Scypha ciliata	2	0
Alcyonium digitatum	4	4
Sagartia elegans	3	0
Actinothoe sphyrodeta	8	7
Caryophyllia smithii	5	3
Spirobranchus	1	0
Balanus crenatus	8	0
Calliostoma zizyphinum	2	3
Crisia	6	0
Alcyonidium diaphanum	7	5
Flustra foliacea	6	6
Securiflustra securifrons	1	1
Scrupocellaria	7	7
Bicellariella ciliata	1	0
Bugula	0	3
Bugula flabellata	5	2
Bugula plumosa	2	2
Ophiura	3	0
Holothurian	1	1
Corallinaceae	2	1
Hypoglossum hypoglossoides	6	1
Erythroglossum laciniatum	3	1

Table 2.15 Average abundance of taxa in *Zostera* bed transect quadrats. Averages only taken for quadrats that were surveyed with both methods.

Taxon (abundance measure used)	***In situ***	**Photo**
Rhodophyta (fil mat) (%)	0.23	0.20
Rhodophyta (fil. branching) (%)	6.65	4.48
Rhodophyta (flat) (%)	0.14	0.00
Gracilaria gracilis (%)	0.04	0.12
Polysiphonia elongata (%)	0.02	0.76
Phaeophyceae (branching) (%)	0.03	0.00
Phaeophyceae (fil on Zostera) (%)	0.00	0.08
Phaeophyceae (flat fleshy) (%)	0.00	0.12
Chorda filum (counts)	0.06	0.04
Chlorophyta (branching) (%)	0.10	0.12
Chlorophyta (fil) (%)	0.14	0.52
Ceramium (%)	0.02	0.00
Ulva (flat) (%)	0.10	0.08
Ulva (tubular) (%)	0.49	0.44
Bacillariophyceae (fil brown diatoms) (%)	4.23	1.76
Zostera marina (counts)	2.23	1.96

2.3.4 Analysis of recording time

The times taken to extract data from each quadrat, whether collected *in situ* or from a photo-quadrat, varied from 15.3 minutes (± 0.9mins Standard Error-SE) on the Kelp Wall to 2.1 minutes (± 0.9 SE) in the *Zostera* bed (see Figure 2.9). On average, it took a fraction more time to collect data *in situ* (7.0 minutes ± 0.7 SE) than it did from a photo-quadrat (6.2 minutes ± 0.8 SE), but this is biased by the time taken for the comprehensive surveys at the Kelp Wall. However, these relatively small differences in recording time are irrelevant when the amount of time required for the full diving operations is taken into account.

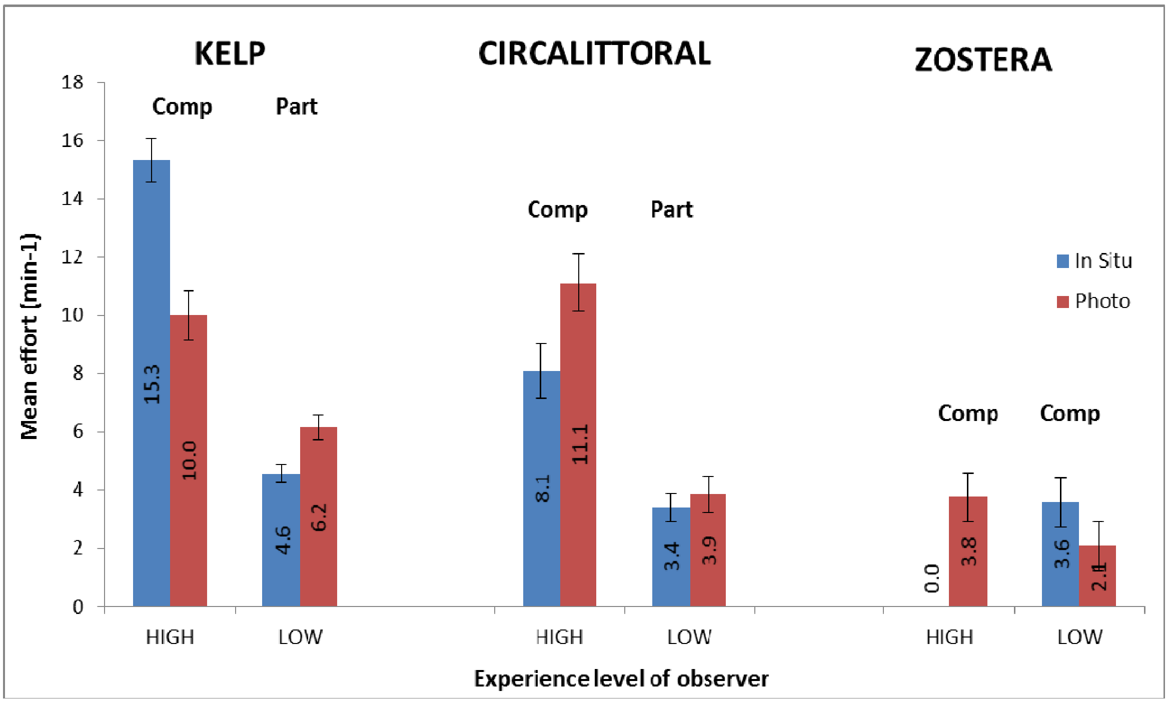

Figure 2.9 Mean data collection/extraction effort across sites and between taxa data lists, data collection methods and observer experience levels. Error bars indicate Standard Errors. 'Comp' refers to the comprehensive surveys of all taxa within a quadrat by the more experienced surveyors; 'Part' refers to the part surveys of selected taxa by the less experienced surveyors. Data is limited for the *in situ* surveys in the *Zostera* bed as time was only recorded by two of the surveyors.

Of greater relevance to *in situ* recording is the number of quadrat records that can be completed per dive by one surveyor. This varies between habitats and the level of detail being surveyed (see Table 2.16), but is many times fewer than it is possible to photograph in one dive. While a detailed comparison of cost-effectiveness of the two methods would need to take account of all the time-consuming elements of survey planning, data and photo-processing etc., the most important cost factor will be the number of *in situ* survey dives required to collect sufficient quadrat records for monitoring purposes. For comprehensive surveys on the Kelp Wall and Circalittoral transects, it is apparent that numerous dives would be required, particularly given the patchiness of the epibiota communities at these particular sites.

Table 2.16 Average number of quadrats surveyed per dive (and number of dives, in parentheses) by one surveyor for comprehensive (experienced surveyors) and part surveys (less-experienced surveyors).

	Comprehensive	Part
Kelp Wall	3 (6)	5.8 (14)
Circalittoral	2.8 (4)	6.6 (10)
***Zostera* bed**	6.5 (2)	6.5 (4)

2.4 Conclusions

2.4.1 Consistency of *in situ* recording across divers

Which taxa are most/least consistently recorded and what are the causes of inconsistency?

The study showed that consistency between surveyors was low for most of the taxa recorded from the three sites, both qualitatively (i.e. in terms of the simple presence/absence of taxa in surveyors records) and quantitatively (i.e. in estimates of abundance). High levels of consistency were achieved only for a small number of taxa that are easily identified and stand-out from the substrata they live upon, and from the other epibiota that surrounds them (i.e. due to their size, colour, form and micro-habitat preference) (see Section 2.3.2).

Surveyor experience was a significant factor in consistency of recording, primarily with recognition of the less well-known taxa. Red algae at the Kelp Wall site and ascidians at the Circalittoral site are both difficult groups to identify to species level. It is apparent that the identification training provided to the less-experienced surveyors was insufficient to prepare them for such detailed recording. However, for many of the red algae and ascidians it is apparent that consistency of identification was poor even between the experienced surveyors.

Surveyor experience was less of a factor in the consistency of abundance estimates. For species that were identified consistently, estimates of percentage cover by experienced surveyors appeared to range as widely as estimates by less-experienced surveyors. For the algae it is likely that some of the inconsistency was due to movement of the fronds, but that does not account for inconsistency in records of short turf and encrusting species. Counts of anthozoan species were relatively consistently recorded by all surveyors, but they were all in low numbers.

There was inadequate data to statistically test whether surveyor eyesight and use of magnifying glasses (by some of the surveyors on some days) had any significant effect on consistency. However, it is apparent from records and comments made by some surveyors that poor eyesight and no magnifying glass resulted in frustrating difficulties with seeing and identifying the smaller epibiota (e.g. the ascidians on the circalittoral site). It is also likely that the use of a magnifying glass to search for epibiota in a quadrat (rather than just using it to identify and estimate abundance of epibiota that has been seen with the naked eye or standard moderately-magnifying reading glasses) will result in longer species lists. The issue of how to reduce variability between inexperienced surveyors with keen eyesight and experienced surveyors with deteriorating eyesight will not be discussed further here.

While high levels of consistency are valuable in monitoring, some level of inconsistency will be acceptable if the survey design includes numerous replicates and if there is no notable bias in identification or abundance estimation by the surveyors. The tables in Section 2.3.2 show that there was considerable bias in the recording of many species by many of the surveyors. Some surveyors also recorded significantly more species than other surveyors. The more-experienced surveyors tended to show less bias for more species, but further improvements through defined recording protocols, species familiarisation, training and calibration would be necessary before the data were adequate for detecting notable community changes.

In a 1998/99 study of subtidal *in situ* quadrat methodologies, Moore (2000) concluded that the surveyors were largely unbiased in their recording, that the majority of the variability in the data was between individual records and that adequate community data for monitoring can be achieved with relatively few replicated surveys. The Portrush study, and other on-going studies familiar to the authors (currently unpublished), suggest that conclusion may have been optimistic unless considerable efforts to develop recording protocols are invested in, surveyors are suitably trained and it is accepted that it may not be possible to detect even some moderately large changes in the benthic community.

2.4.2 Comparison of *in situ* recording and photography

Due to a number of technical issues, the quality of the photo quadrats taken for this study was relatively poor compared to that which can now be achieved. This will have had a notable effect on the data that could be collected from the photo quadrats and the comparative analyses described in Section 2.3.3. However, a number of conclusions have been made in the following paragraphs.

Are some taxa or groups of taxa recorded more consistently *in situ* or from photographs?

Fewer species were identified in the photo quadrats compared to *in situ* and estimates of abundance were also generally lower, presumably because the algae obstructed the camera's view of the underlying substrata. However, consistency between surveyors was greater in the photo-quadrat records, in both multivariate data and data for individual taxa that were recorded by both methods. This is presumably due to the static nature and limited resolution of the photographs, which the surveyor can study at ease for as long as necessary; that is, there are fewer confusing/stressful factors arising from the site and survey conditions. Consistency in the multivariate *in situ* record data will have been influenced by some inconsistently recorded species that were not recorded from the photo-quadrats.

There was no obvious overall difference in consistency between the two main sites for either method, mainly because both sites were dominated by a taxonomic group that was difficult to identify *in situ* without considerable training and difficult to identify in the photographs for other reasons. However, it is apparent that identification of algae is particularly difficult in photographs, while it is expected that identification of ascidians may be greatly improved by better-quality images. For ascidians and many other benthic invertebrates, it will also be easier to train surveyors in consistent identification and abundance estimation from photographs compared to *in situ* recording.

Does surveyor experience make any difference to the consistency of records from photographs?

The more experienced surveyors did identify more species from the photo quadrats, with some greater consistency than the less experienced surveyors, but the differences in abundance of individual species were less than with the *in situ* recording. With good-quality photographs it should also be possible to improve the level of consistency with training.

What are the differences in costs between the two methods?

It is clear from Section 2.3.4 that to collect detailed whole-community data with *in situ* recording takes considerable time and that the amount of time that a diver can spend recording per day is limited. Most hard substrata epibenthic communities are very patchy, so to provide sufficient data to represent a site and detect notable change will require numerous replicates. For each of the two main sites described in this report (Kelp Wall and Circalittoral), it should be possible for two pairs of experienced surveyors to survey a total of at least 15 replicate quadrats (along a single transect) in one day (approx. 6 man-dives). Based on the studies described in Moore (2000), that is likely to be the minimum number of replicates required to provide a reasonable description of the community and its patchiness for monitoring purposes. That also assumes that methodological protocols and training are further developed to increase the consistency of *in situ* recording. Data entry, collation and QA procedures should be completed by the surveyors on the same day whilst the work is still foremost in their minds.

Applying a photo-monitoring methodology to either of the same sites would also require a team of four divers (UK Health and Safety Executive[2] regulations) but would take considerably less time to complete (one dive) and only one experienced surveyor/photographer. This could generate a large number of high-resolution photographs,

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[2] www.hse.gov.uk

which could be processed by the photographer on the same day to make them ready for data collection. Collecting data from at least 30 photographs could be achieved by one experienced surveyor in one day.

A detailed comparison of the costs of the above would need to take account of day rates of the various surveyors and assistants, and the type of the dive equipment and the photographic equipment deployed. However, based on the typical relative costs for such staff and equipment, the *in situ* method is likely to cost around twice that of the photographic method, but provide around half the number of records. This assumes similar time and costs to prepare the sites and train the surveyors, although it is likely that would also be greater for the *in situ* method. The per-quadrat cost for additional quadrat records would be an order of magnitude less for photo-monitoring.

Can records taken from photographs provide sufficiently meaningful estimates of community composition and abundance?

Photographs cannot provide all the taxonomic details and clues that are routinely used to identify epibiota *in situ*, but for some habitat and species indicators of condition, they could provide consistent data as part of a monitoring programme. For example, it is suggested that close-up photography (e.g. using a 10cm x 10cm frame on a high-resolution camera) could be used as part of an effective non-destructive monitoring design for the ascidian turf at the Circalittoral site.

As noted above, photography is unlikely to provide adequate data for describing or monitoring community composition in algal dominated habitats like the Kelp Wall site. In such habitats experienced *in situ* observations are the preferred method of collecting monitoring data.

What other advantages and disadvantages are associated with the two methods?

Photography will normally provide useful contextual information for any survey or monitoring programme (except where water clarity is very poor).

Digital photographs provide a permanent resource that can be referred to or re-analysed as much as necessary.

Photography works best when the data extraction is kept simple and objective, such as when functional groups are recorded rather than species and percentage cover is estimated using point counts rather than by visual estimation (van Rein *et al* 2011b).

In situ studies and specimen collection by expert taxonomists are essential to describe the true diversity of a habitat.

2.4.3 Methodological trials

This study was subject to a series of difficulties with weather, equipment and limited knowledge of the sites. All diving surveys are logistically complex operations; and the methodological trials, that were novel to most of the surveyors, required careful control of all operations. So, the additional difficulties greatly limited the amount of quality survey time and resulted in a dataset that was not as large or as balanced as intended and statistical analysis has been limited. Many of these difficulties might have been overcome if it had been possible to carry out a pre-survey site reconnaissance and establish fixed transects.

2.5 Lessons carried forward

The following lessons and ideas were carried forward from Portrush to the Sound of Mull trials:

Study design

- Consistency of recording is generally poor, except for species that are easily identified and distinct from the substrata. Consistency also increases with surveyor experience. Thus: a key objective carried forward to the Sound of Mull study is to test whether consistency can be increased by training and familiarisation.
- Training should include both species identification and abundance estimation.
- Training of surveyors should make good use of photography and specimens taken from the study site.
- Greater emphasis should be given to getting a balanced dataset with more replication of quadrats by different surveyors.
- Fewer quadrat positions should be established, but not so few that surveyors remember the species composition from one visit to the next.

Logistics

- More detailed planning and preparation is needed before large logistically complex methodological trials like these, including site reconnaissance, habitat selection and establishment of fixed transects etc.
- Surveyors should have good torches and, if necessary, good magnifying glasses.
- A suitable underwater camera system is needed for taking good quality photo-quadrat images.

3 Sound of Mull 2014

3.1 Aims and objectives

The overall aim of the survey, following on from and building upon the Portrush survey was to test issues of consistency in marine biological recording by divers of populations *in situ* and using photography.

The key objectives of the survey were:

- To assess the consistency of *in situ* recording of selected groups of taxa (specifically sponges, sponge morphologies and anthozoa) in quadrats by survey divers.
- To assess the improvements in consistency with training and familiarisation.
- To compare this with the quality and consistency of recording from photographs.
- To assess the value of such data for the purposes of habitat quality monitoring.
- To make recommendations for future monitoring and assessment.
- To collect specimens of sponges for laboratory identification.

3.2 Methods

3.2.1 Initial planning and reconnaissance

The Sound of Mull was chosen as an area with designated marine conservation importance (Sunart SAC), high diversity of sponges and anthozoa, reliable good visibility, areas that are sufficiently sheltered from wave action to limit risk of down time and easy access from the Lochaline Dive Centre. Potential sites within reasonable distance of Lochaline were researched by reviewing existing data in the Marine Recorder database, SNH research reports and discussions with people who had contemporary familiarity with the area. A reconnaissance survey, from 7-10 July 2014, was then carried out with the aim of locating suitable sites and habitats – ideally with the following site selection criteria:

- Communities containing fairly rich and abundant sponge and anthozoan fauna.
- Areas of homogenous habitat - i.e. relatively flat, without notable heterogeneity in substratum, slope or current exposure along its length.
- No logistical limitations on access for surveyors – i.e. reasonably wave sheltered, sufficiently long periods of slack water, quick and easy access.

Two sites were chosen, at Lochaline and Auliston (Figure 3.1). Pitons were fixed in place, ready for establishing fixed transect lines.

Survey work on these transects was then carried out between 13-23 August 2014. The survey team was based at the Lochaline Dive Centre, Lochaline. A field log is given in Appendix 1.

3.2.2 Site locations and layout

Site locations are shown in Figure 3.1 and Figure 3.2 and described below.

Both sites, particularly the Lochaline site, are popular with recreational divers, so the pitons were labelled with ‘research study site, please leave’ on yellow tape and the staff at the Lochaline Dive Centre were asked to inform divers not to tamper with them.

At each site, a single transect line of approximately 12m was fixed, approximately horizontally, within a relatively homogenous area of the chosen habitat. Pitons were hammered into crevices and the transect line was strung through, tightened and cable-tied to the end piton. The transect lines, made of Dyneema non-stretch line, were labelled at 1m intervals and marked at 10cm intervals so that divers could easily identify quadrat positions. A number of wire quadrats, made of 3mm galvanised fencing wire, 25cm x 25cm with integral hooks, were hung on the transect, spaced out (as best possible) to represent the whole line and then cable-tied on so that they were fixed in place. Sections of transect where the quadrats would not lie well against the rock were avoided. The layout of the transects is shown in Figure 3.3 and illustrative photographs are given in Photos 7 to 12.

Lochaline Hotel Beach Wall [56.53215^{o}N 5.78141^{o}W WGS84]

This site is on the north side of the Sound of Mull, just outside Lochaline and less than 800m drive from the Lochaline Dive Centre. It is approximately 140m from a parking area at the top of the beach and was accessed from this shore, entailing a swim of up to 100m each way, depending on tide level. A 4.5m inflatable boat was moored above the site during diving operations, from which the dive supervisor and diver communications operated. The transect was established near the top of the wall, at a water depth of approximately 13.5m below chart datum. The community along the transect was dominated by foliose red algae (lower infralittoral zone), barnacles and encrusting coralline algae, with a range of other animals and algae in low abundance. Twenty quadrats were fixed along this transect.

Auliston Point [56.649617oN 5.990204oW WGS84]

This site is a wall dive situated on the south side of the entrance to Loch Sunart, approximately 25km boat ride from Lochaline (approx. 1 hour journey time by hard boat). The transect was established at a water depth of approximately 14m below chart datum. The community along the transect was dominated by ascidians, feather stars, sponges, encrusting coralline algae, soft corals, anemones and cup corals, with a range of other animals and algae in low abundance. Thirteen quadrats were fixed along this transect, though the last two were added on after the start of the recording trials and not often surveyed.

Figure 3.1 Location of survey sites, Sound of Mull, August 2014.

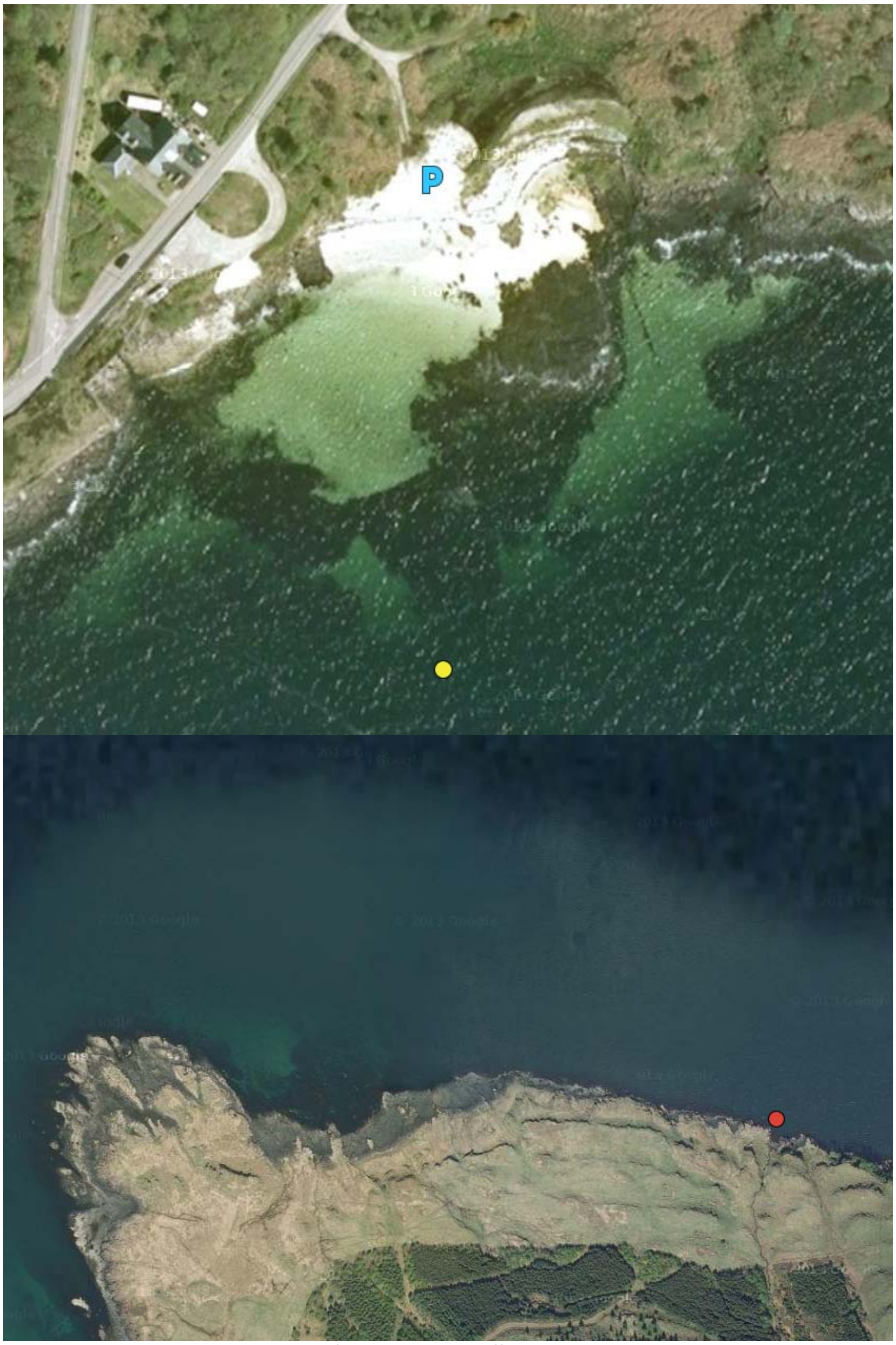


Figure 3.2 Approximate location of transect sites off Lochaline Hotel beach (top) and at Auliston Point (bottom).

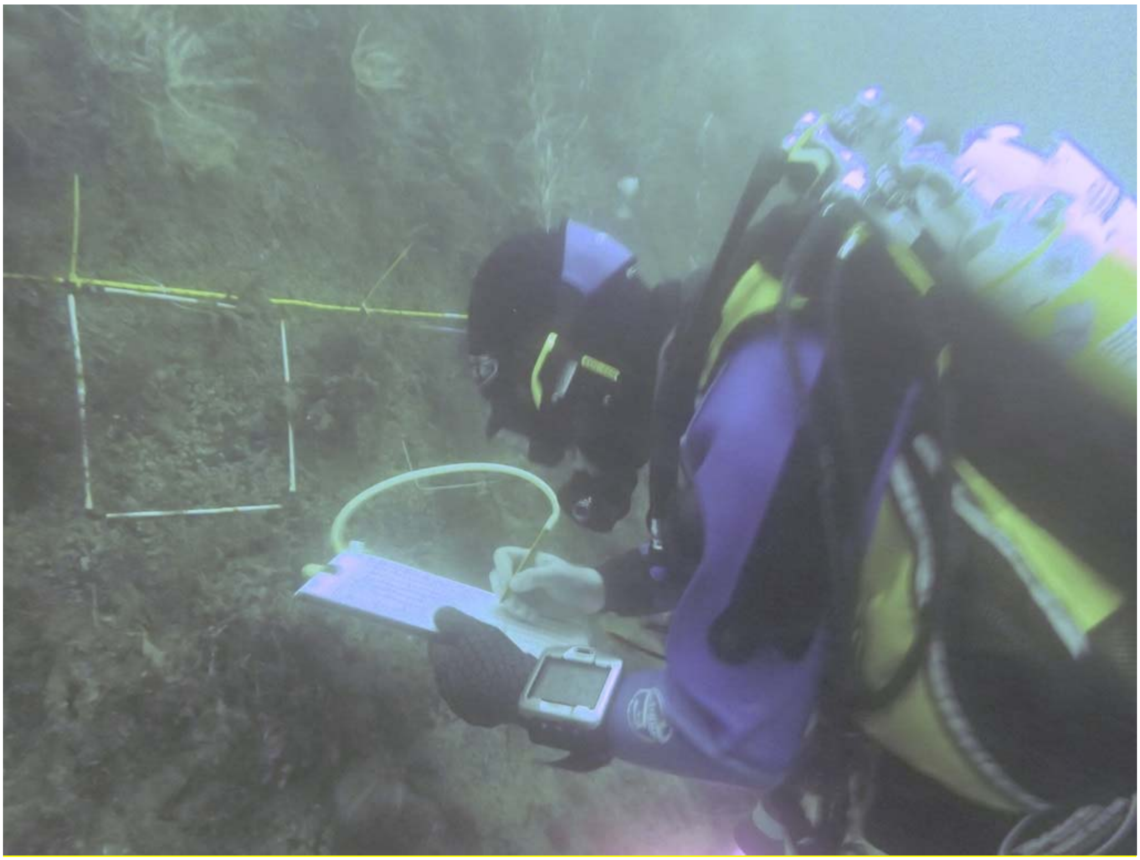


Photo 7. Surveyor recording from quadrat on Lochaline wall transect.

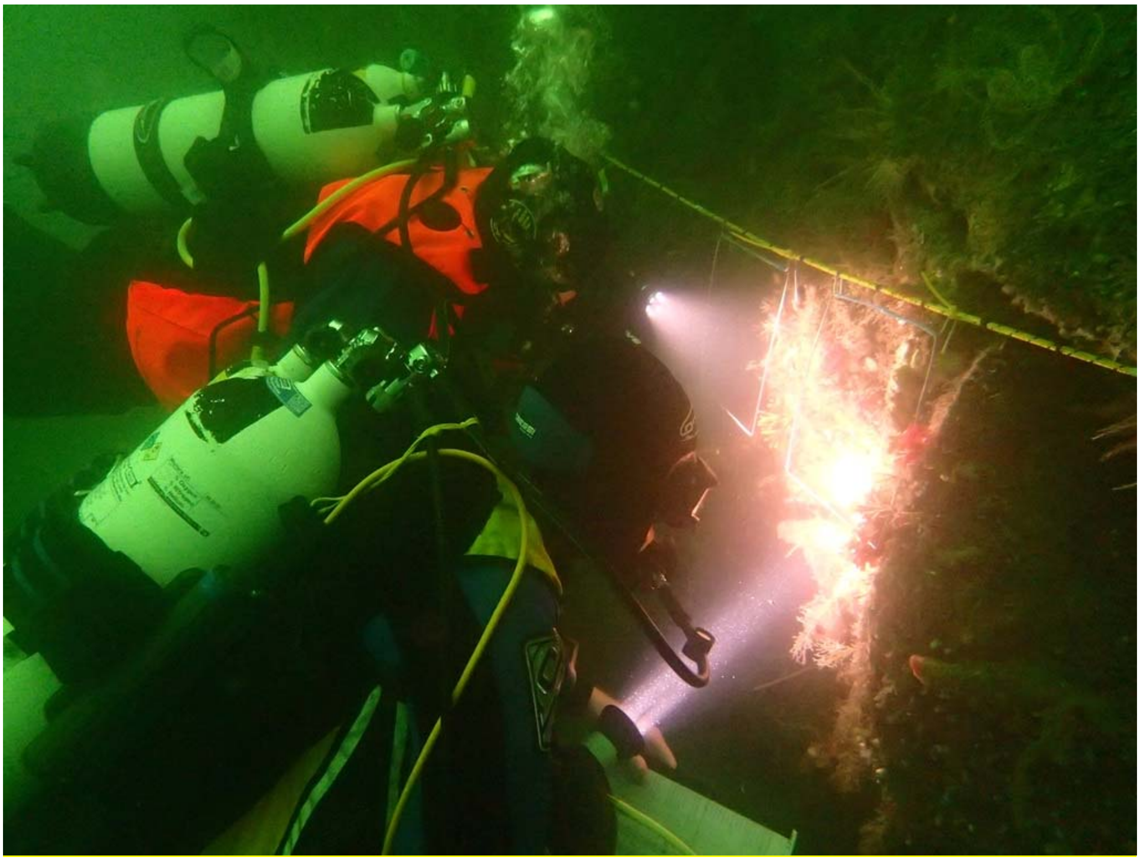


Photo 8. Surveyors recording from quadrats on Auliston Point transect.

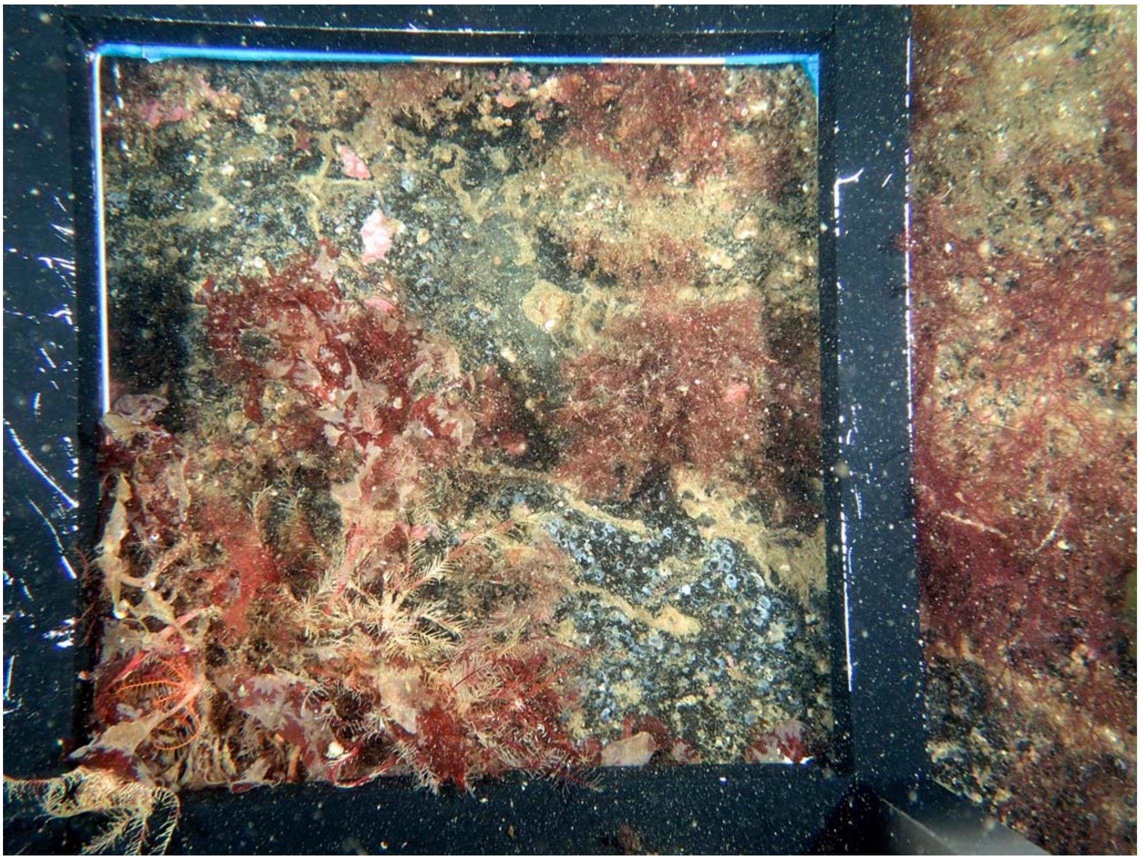


Photo 9. Quadrat 10 on Lochaline wall transect.

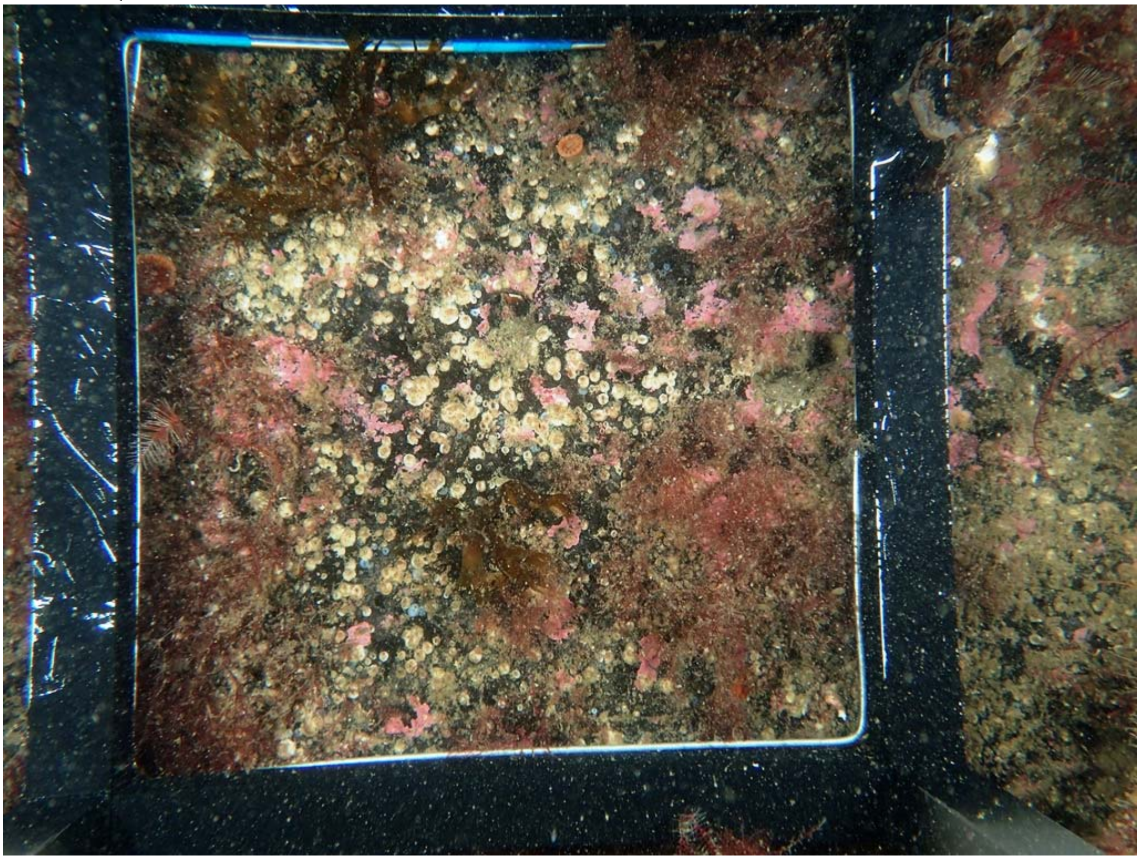


Photo 10. Quadrat 19 on Lochaline wall transect.

Photo 11. Quadrat 3 on Auliston Point transect.

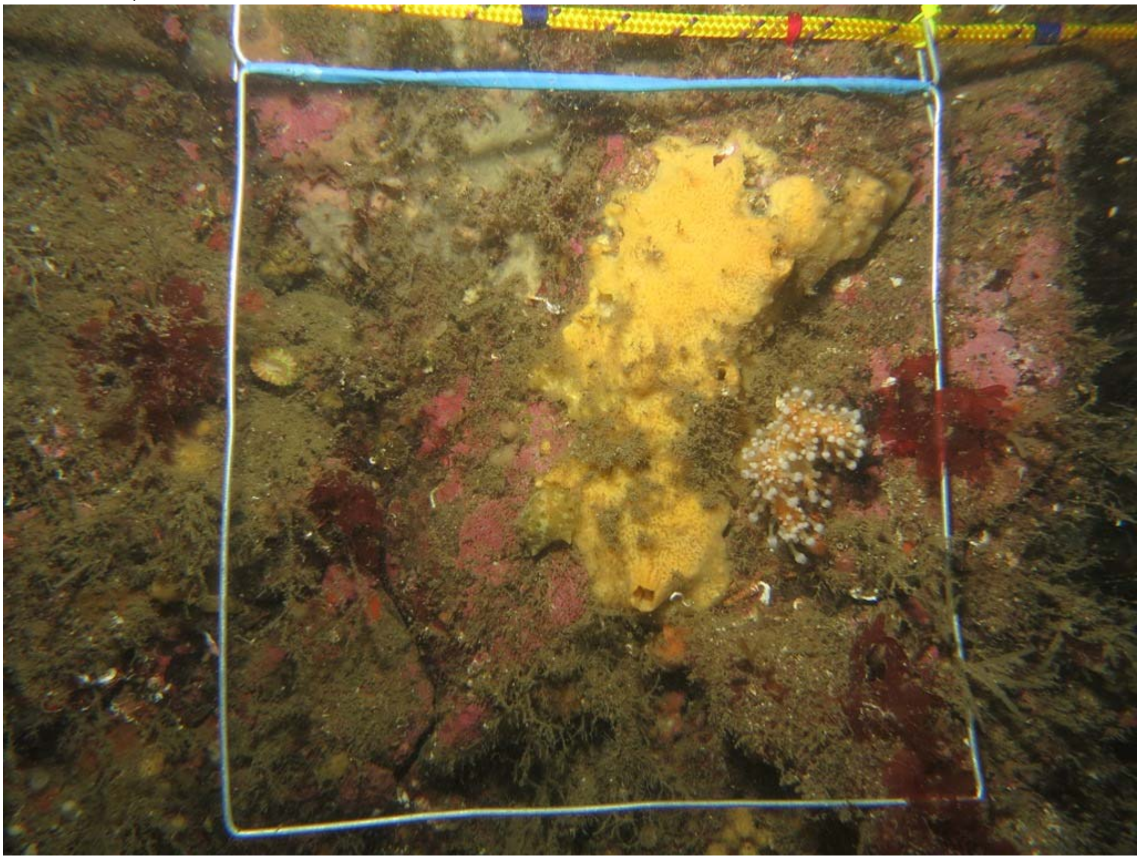


Photo 12. Quadrat 9 on Auliston Point transect.

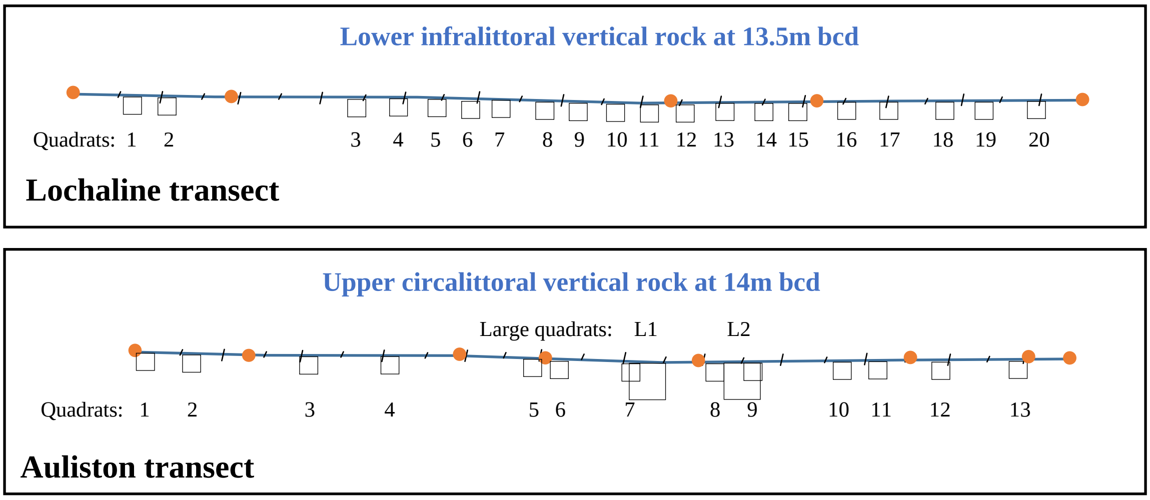


Figure 3.3 Layout of transect lines (marked at 1m and 0.5m intervals), pitons (orange) and fixed quadrats. Twenty standard (25cm x 25cm) quadrats at Lochaline, 13 standard quadrats and two large (50cm x 50cm) quadrats at Auliston.

3.2.3 Survey design

The same basic design used for the Portrush studies was also used for the Sound of Mull studies – that is, multiple surveyors recording the abundance of selected taxa and morphologies from multiple fixed quadrats within a relatively homogenous habitat. However, there were significant improvements in the layout of the transects and quadrats (see Section 3.2.9).

The photo-quadrat survey design was simply to take one photograph of each fixed quadrat along each transect. These could then be matched to the quadrat data from the *in situ* surveys analysed by the same surveyors after the survey period, to provide a dataset for comparison with the *in situ* observations.

During the fieldwork the fixed quadrats were identified (and recorded on the forms) by their distance along the transect lines (e.g. 4.7m), using the marks on the lines. This was simplified during the analysis and for easier representation in this report, to the Quadrat ID numbers (1 to 20 for the Lochaline quadrats and 1 to 13 for the Auliston quadrats). The same ID numbers are used for both the *in situ* and photo-quadrats.

Site specific features of the survey design were as follows:

Lochaline transect

Reconnaissance dives on the Lochaline Hotel beach wall did not manage to find a suitable area with sufficient diversity and abundance of sponges to carry out the planned studies. However, a suitable area of lower infralittoral algal dominated rock was located and algae, including encrusting species, were therefore chosen as the focus of the survey work at that site. Other commonly occurring taxa included barnacles, a variety of anemones and some encrusting sponges and bryozoa. The chosen abundance method for the algae, barnacles and encrusting species was percentage cover. Counts were recorded for anemones. Counts of barnacles were also trialled on one day.

Auliston transect

Reconnaissance dives on the wall at Auliston Point found an area that was almost ideal for the planned studies, with a variety of sponges, sponge morphologies and anthozoa. These groups were therefore chosen as the focus of the survey work at that site. Counts of sponge colonies and anthozoa were chosen as the primary abundance measure, as that is the measure used in other studies of sponge morphologies. Percentage cover of individual sponge taxa and anthozoa was also recorded in most of the recording phases as this was perceived as a better measure of abundance for most space covering species and to test whether consistency was better or worse than counts.

Recording forms

Survey recording forms with checklists of species were prepared at the beginning of the survey on each site using brief lists of the dominant taxa encountered during the reconnaissance dives and observed in the photographs. The species in the checklist were labelled with the appropriate abundance measure (% cover or counts). As the surveys and training progressed, more species and taxa were recognised as frequently occurring in the community and were added to the forms to remind surveyors to look for them. Other improvements to the forms were also made to make them easier to use. The revised forms were given version numbers, which were recorded with the data when it was entered into a spreadsheet. Copies of the blank forms are given in Appendix 3.

3.2.4 Survey phases – progressive training, familiarisation and guidance

As a primary aim of the study was to test for improvements in recording with progressive training and familiarisation, there was no formal programme of pre-survey training. Many of the survey team had seen the sites during the reconnaissance dives, one month before the main survey, so had some familiarity with the communities present, but no detailed knowledge. The first opportunity for the surveyors to prepare for the recording work was therefore when they received the recording forms on the morning of the survey and could spend some time familiarising themselves with the species and morphologies by referring to identification guides. This is similar to a common situation on diving surveys where the survey schedule allows limited or no time for formal pre-survey training and the divers have a short time to familiarise themselves with the checklist species.

After the first or second wave of survey dives there was then a formal training session where specimens and photographs collected by one or more divers were identified and studied by the team. The more experienced surveyors also assisted the less experienced surveyors and there were discussions on the identification of difficult species. Specimens and photographs remained available to the surveyors for the rest of the survey and surveyors would repeatedly refer to them and to identification guides and discuss uncertainties.

In addition to the training sessions on identification for each site there was also a session on abundance estimation half way through the survey. This highlighted the large variability in percentage cover estimates and biases by certain surveyors. The team were tested with images of known percentage cover and provided with a simple guide showing the areas represented by increasing % cover of a 25cm x 25cm quadrat (Figure 3.4).

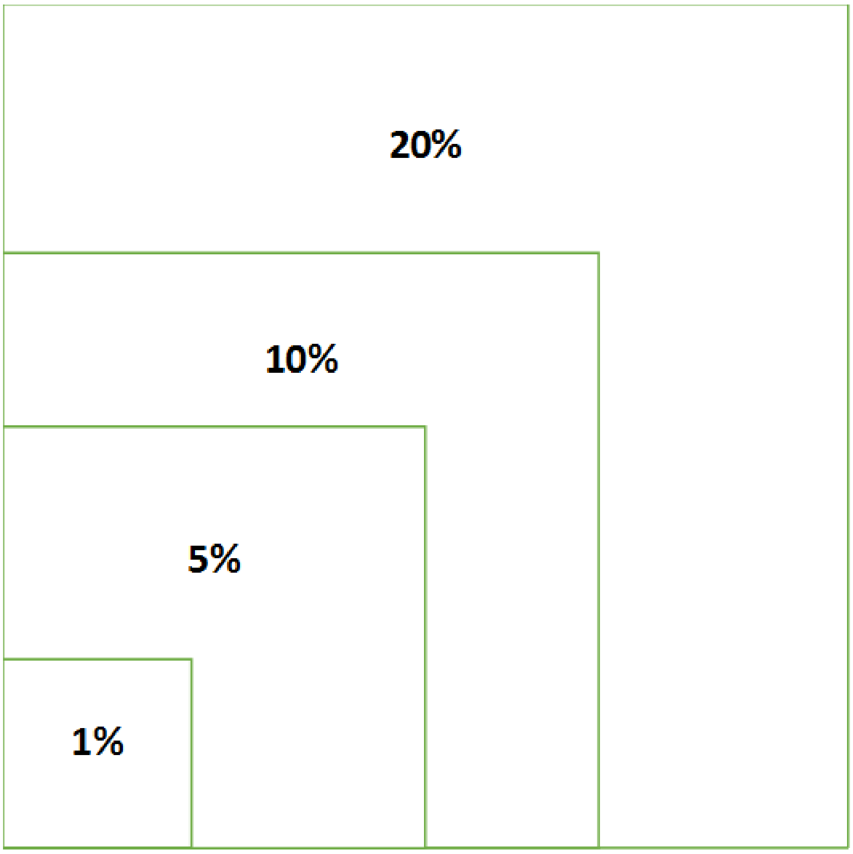


Figure 3.4 Percentage cover guide - each square represents the % area of a 25cm x 25cm quadrat. Provided to the surveyors on waterproof paper to stick to their recording slates. [When printed, the 20% square should be 11.2cm x 11.2cm].

The fieldwork at each site was thus organised according to this programme of progressive training on identification and abundance estimation. With each dive, the surveyors also became increasingly familiar with the communities.

The data from each period of diving (day or half day) was labelled with a letter denoting its *Dataset*. After the survey the datasets were grouped to make three *Phases* for each transect. Table 3.1 and Table 3.2 summarise the characteristics of each Phase and the data from each.

Table 3.1 Lochaline datasets and survey phases. A form gives the version of the recording used (see Appendix 3). Number of records (Recs) is the number of completed quadrat records. Dive Numbers are listed in the field log (Appendix A1.2).

Data set	Phase	Form	Taxa surveyed	Pre-survey training & guidance	Recs	Divers	Dive No's
A	**1**	V1	Barnacles and coralline crusts	None	39	B, D	5
B	**1**	V2	Foliose algae, barnacles and coralline crusts	Self-training on checklist algae with ID guides	29	Full team	6 - 8
C	**1**	V3	Foliose algae, anthozoa, barnacles and various crusts	Self-training on checklist algae with ID guides	27	Full team	9 - 11
D	**2**	V4	Foliose algae, anthozoa, barnacles and various crusts	Checklist algae ID training with Francis Bunker and specimens	27	Full team	12 - 14
E	**2**	V4	Foliose algae, anthozoa, barnacles and various crusts	Self-training on checklist algae with ID guides and specimens. Training exercise and tests on percentage cover estimation. Percentage cover guide provided to divers.	55	Full team	15 - 20
F	**3**	V4	Foliose algae, anthozoa, barnacles and various crusts	Self-training on checklist algae with ID guides and specimens. Percentage cover guide provided to divers.	47	Full team	39 - 43

Table 3.2 Auliston datasets and survey phases.

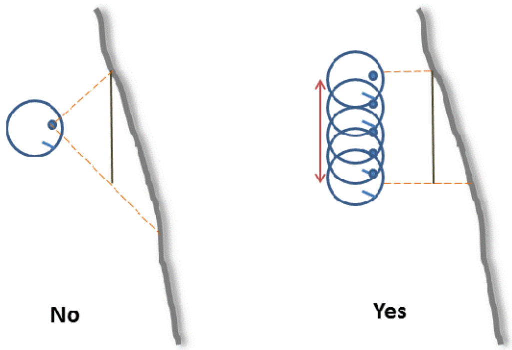
Data set	Phase	Form	Taxa surveyed & quadrat size	Pre-survey training & guidance	Recs	Divers	Dive No's
A	**1**	V1	Sponge morphologies (counts), Sponge taxa (indicator spp) (counts), and anthozoa (% cover and counts) [25 cm x 25cm]	Self-training on checklist sponge morphologies and species (sponges & anthozoa) with ID guides. Sponge morphologies and percentage cover guide provided to divers.	61	Full team	21 - 26
B	**2**	V2	Sponge morphologies (counts), Sponge taxa (indicator spp) (% cover and counts), and anthozoa (% cover and counts) [25 cm x 25cm]	Team training session on identification of checklist sponge morphologies and species (sponges & anthozoa) with ID guides and close-up photos from July survey. Sponge morphologies and percentage cover guide provided to divers.	61	Full team	27 - 32
C	**3**	V2	Sponge morphologies (counts), Sponge taxa (indicator spp) (% cover and counts), and anthozoa (% cover and counts) [25cm x 25cm]	Self-training on checklist sponge morphologies and species (sponges & anthozoa) with ID guides. Brief team training on selected taxa. Sponge morphologies and percentage cover guide provided to divers.	39	Full team	33 - 38
D	**3**	V2	Sponge morphologies (counts) and anthozoa (% cover and counts) [50 cm x 50cm]	Nothing additional to above	6	B, C, E, A	37 - 38

3.2.5 *In situ* quadrat recording protocols

Quadrat recording protocols were defined for each site, to minimise some of the potential variability due to habitat patchiness and some of the potential biases in recording between surveyors. Some of these were defined at the start (e.g. 1 and 2 in the list below), while others were defined as issues arose (e.g. 3 and 14) or as they were discussed (e.g. 4 and 12). It was intended that this would have added to the improvements in consistency as the survey phases progressed.

General recording protocol:

1. Waft away significant amounts of sediment (mainly silt) that covers or obscure surface features of fauna and flora, before surveying. [This was initially carried out by the first divers on each transect, which removed most of the silt and sand, and was then maintained daily by surveyors as they worked along the quadrats].
2. Species checklist – check for all those species on the list. Preferably use a small horizontal dash to indicate absence. Add other species that are not on the list.
3. Move large fauna (e.g. urchins and starfish) out of the quadrat.
4. Where there is space between wire quadrat and substrata, avoid parallax errors by imagining that quadrat has perpendicular sides, as illustrated below:



5. Record what can be seen from a view straight down onto the quadrat - i.e. don't record from sides of rock faces that can't be seen without looking sideways.
6. Estimating % cover – do not include the gaps within a patch of a species (e.g. the gaps between barnacles or the gaps between algae branches).
7. Recording % cover – do not spend long trying to estimate the % precisely. The following categories are certainly adequate: P (meaning<1), 1, 2, 4, 5, 8, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95, 98, 99, 100. Do not use ticks (sometimes they get mistaken for a dash).

Lochaline protocol:

8. Record all algae, barnacles and epibiota attached to the base substrata (do not record epibiota on stipe and blades of foliose algae).
9. Push back or ignore large flapping blades of algae from outside the quadrat.
10. Total % of all species may be more than 100%, due to layering.

Auliston protocol:

11. Record all sponges and anthozoa, including those living as epibiota on ascidians etc.
12. Record an anemone if it is >= half in the quadrat.
13. Count all patches of encrusting sponge that you can see - i.e. no minimum size limit.
14. Difference between encrusting and massive sponge - massive sponge has 3-D shape across most of its area.

3.2.6 Photography and photo analysis

3.2.6.1 Photography

Two different underwater camera systems were used to collect images of the fixed quadrats. On the Lochaline transect, an Olympus TG3 fixed to a bespoke quadrat frame of 25cm x 25cm (internal measurements) was used and lighting was provided by two Inon S2000 strobes (see Figure 3.5). The Auliston Point quadrats were photographed using a Canon Powershot S100 camera in a housing with a single Inon S2000 strobe, with no camera-fixed quadrat frame.

Figure 3.5 Camera and photo quadrat.

Additional photographs and videos were taken along the transects and surrounding habitat for sponge identification (i.e. to use in training sessions) and for illustration.

3.2.6.2 Post-survey analysis of photo-quadrats

Photo-quadrat recording protocols were essentially the same as for the *in situ* surveys. The photographs were of good quality, with even lighting and high resolution.

Lochaline wall transect

Analysis of the quadrat photographs from this transect was carried out by the same six surveyors who carried out the *in situ* surveys. Most of the surveyors did this during a break in the diving half way through Phase 2, so they were already fairly familiar with the assemblage of species, but had not yet used the % cover guide (Figure 3.4). Surveyor D carried out the analysis a few weeks after the fieldwork.

Auliston Point transect

The surveyors carried out the photograph analysis a few weeks after the *in situ* survey work so had been very familiar with the assemblage of species, but may have forgotten some of them in the interim. Photograph analysis was carried out by the same six surveyors who carried out the *in situ* surveys and two additional surveyors (G and H) with sponge and anthozoan survey experience.

3.2.7 Data preparation and analysis

Data entry, management and analysis was similar to that used for Portush data, except that it was also imported into Microsoft Access to allow easier management and extraction for specific analyses. All multivariate analyses of the community data was carried out using PRIMER-E, but without the PERMANOVA tools. Analyses of percentage cover and count data were carried out separately, after first applying the commonly used square root and log(x+1) transformations respectively.

3.2.8 Collection and analysis of sponges

Specimens of sponges from the Auliston site (off transect) were collected by Francis Bunker during the second day of the Auliston transect survey and were then sent for laboratory analysis by Jen Jones. Analysis was by examination of the sponge spicules.

3.2.9 Methodological differences compared to Portrush study

The following summarises the differences in methods used for the 2014 Sound of Mull studies compared to the 2013 Portrush study:

Logistics

- Reconnaissance survey to Sound of Mull, one month before the main survey, to locate suitable study sites (taking account of tides, visibility and wave exposure) and habitats, establish fixed transects and take photographs and video to use in survey planning and training surveyors.
- Improved transect line material (non-stretch) and transect fittings (pitons and line clamps), to reduce risk of transect-line movement during surveys.
- Improved method of marking transect line and attaching quadrats, to reduce potential for errors in quadrat placement. At Portrush, with only a small number of quadrats available, the surveyors had to carry the quadrats and place them at marked places on the fixed transect. In Sound of Mull, numerous wire quadrats were prepared in advance and then fixed in place with cable ties, so that they could not move. The transect line was also marked with a simpler system of distance notation.
- Surveyors carried good torches and magnifying glasses on all survey dives. At Portrush there were occasions when surveyors reported that available lighting was limited and that a magnifying glass would have improved their ability to discern key identification features on some species.
- A different camera system was used for taking photo-quadrat images
- A percentage cover guide (Figure 3.4) was used by surveyors for the second half of the Sound of Mull study.
- All quadrats were wafted free of silt at the start of the survey and were kept free of silt by further wafting when necessary.

Study design

- Some different taxonomic groups and species studied in the Sound of Mull survey compared to the Portrush survey.
- Observations of sponge morphology was included in the Sound of Mull study.
- All surveyors recorded the same selected taxonomic groups, using the same survey forms – i.e. there were no comprehensive surveys (all taxa) and there was less emphasis on the experience of the surveyors, both in the field recording and the analysis.
- There was a multiple-phased approach to survey at each site, with progressive training (formal and informal) between phases; rather than a series of one-off surveys.
- There was no formal training on species identification before the first recording dives (Phase 1).
- More formal and informal training on both taxonomic identification and abundance estimation was provided during the Sound of Mull survey.
- There were fewer quadrat positions on each transect and more repeat surveys of each by all or most surveyors, to provide a more balanced dataset with more replication of quadrats by different surveyors.
- Improvements were made to survey protocols and forms to ease recording and reduce risk of records being biased or thrown out due to simple errors.
- All recording was quantitative – i.e. there was no attempt to repeat the presence/absence recording used on one of the Portrush sites.

3.3 Lochaline results and discussion

Note: Individual surveyors are identified by letter codes (A to F), which remain the same throughout the Sound of Mull results.

3.3.1 Summary description of data

The most frequently recorded taxa from the Lochaline wall transect quadrats and the main differences in taxa recorded *in situ* are summarised in Table 3.3. The last three rows of the table give additional statistics.

Table 3.3 Number of records (Recs) and average abundance of selected taxa (Phase 1 to 3) in Lochaline wall quadrat survey records. See text for description of survey methods. Qs = numbers of fixed quadrats within which the taxa was recorded (out of 20). Surv. = number of surveyors who recorded that species (out of 6). MaxC / Max% = maximum count / percentage recorded from any quadrat.

Taxa (counts)	**Recs**	**Phase1**	**Phase2**	**Phase3**	**Qs**	**Surv.**	**MaxC**
Sagartia elegans	27	0.05	0.11	0.05	14	5	3
Sagartia troglodytes	20	0.01	0.12	0.03	9	5	2
Hormathia coronata	40	0.03	0.16	0.08	14	6	2
Caryophyllia smithii	53	0.05	0.28	0.25	10	6	2
Cirripedia	64	143			20	5	700
Taxa (% cover)	**Recs**	**Phase1**	**Phase2**	**Phase3**	**Qs**	**Surv.**	**Max%**
Porifera (enc)	19	0.00	0.04	0.00	10	5	3
Cirripedia	223	4.90	8.41	4.71	20	6	75
Bryozoa (enc)	34	0.12	0.06	0.00	15	6	5
Bonnemaisonia asparagoides	105	0.38	1.08	0.31	17	6	20
Trailliella intricata	68	0.31	0.23	0.07	18	6	10
Corallinaceae (enc)	220	3.53	2.72	2.14	20	6	40
Schottera nicaeensis	15	0.01	0.02	0.01	11	6	3
Plocamium lyngbyanum	45	0.51	0.96	0.21	13	6	35
Rhodophyllis irvineorum	14	0.00	0.04	0.05	6	5	5
Rhodophyllis divaricata	36	0.03	0.25	0.13	10	6	10
Compsothamnion thuyoides	48	0.02	0.28	0.13	16	6	8
Delesseria sanguinea	147	2.72	3.68	2.40	20	6	35
Phycodrys rubens	120	0.50	1.73	1.02	20	6	30
Heterosiphonia japonica	105	0.66	0.89	0.57	18	6	20
Heterosiphonia plumosa	91	0.10	2.63	1.33	15	6	35
Aglaozonia parvula (brown enc)	26	0.29	0.14	0.04	10	6	10
Dictyota dichotoma	41	0.41	0.17	0.25	9	6	20
Quadrats surveyed (Total=20)		20	15	10			
Records (Total=1646)		481	720	445			
Total taxa (Total=44)		35	38	29			

3.3.2 Multivariate analysis of algal data

Multivariate analysis of all *in situ* records of algal community data (% cover) by the six surveyors (Figure 3.6) again shows that there is considerable variation between the records from within each quadrat, and while the records from each quadrat are generally grouped together there is overlap between many quadrats. Accepting that a level of inconsistency between surveyors recording % cover of algae is inevitable, then the fairly clear grouping of each quadrat is encouraging but is marred by a few outliers. Further analysis and inspection of the data shows that many of those outliers are by three of the surveyors and from Dataset B (pre-training).

Again this is encouraging, but it does not explain a large part of the variability and detailed inspection shows that a large proportion of the similarities within quadrats is due to only a few species, particularly those that are relatively larger, most abundant and relatively distinctive. This was analysed further using the *SIMPER* routine in *Primer* to identify algae that contributed the most to the quadrat groupings. To limit the effect from small numbers of replicates, only those eight quadrats for which there were at least ten replicates were included. It showed that seven taxa contributed by far the majority with only three others contributing a notable proportion (at least 10% each) of the dissimilarity between any pair of quadrats. Most taxa contributed no more than 2%. The effect of removing the seven taxa that contributed the most is then illustrated by the MDS plot in Figure 3.6b which is from analysis of the same records as Figure 3.6a but excludes data for those seven taxa. Thus, with the majority of species still present in the analysis, the quadrat records are either widely scattered around the plot or are all so similar that they form a tight cluster. Within the cluster only a few still show some grouping by quadrat. This shows that without those seven taxa, the consistency between the surveyors was very poor and multivariate analysis could not reliably distinguish the quadrats.

It is also notable, in Figure 3.6a, that the two halves of the transect are easily distinguished, but that this pattern disappears in Figure 3.6b. There were notable differences in the dominant species between two halves of the transect, though this was not appreciated when the transect was established. Thus, the right side (Quadrats 10 to 20) was characterised by much higher abundances of both *Phycodrys rubens* and *Heterosiphonia plumosa* than the left side (Quadrats 3 to 9).

The results of the multivariate analysis of algal community data have also been used to identify whether progressive familiarisation and training in algal identification has improved the overall consistency of surveyors records. This is done in two ways – using the Multivariate Dispersion (*MVDISP*) routine in *PRIMER* and by visual inspection of the MDS plots. The MVDISP routine calculates an index of the average dispersion of dissimilarities between the samples. Table 3.4 gives the results, calculated across all samples (i.e. taking no notice of quadrat identity) and also averaged across quadrats (i.e. calculated for each combination of phase and quadrat, then averaged by phase). Both calculations show reduced dispersion of the samples as one moves through the phases, suggesting increasing consistency.

Table 3.4 Index of dispersion (from MVDISP)

	Phase 1	Phase 2	Phase 3
All samples	1.52	1.02	0.62
Averaged across quadrats	1.47	1.01	0.68

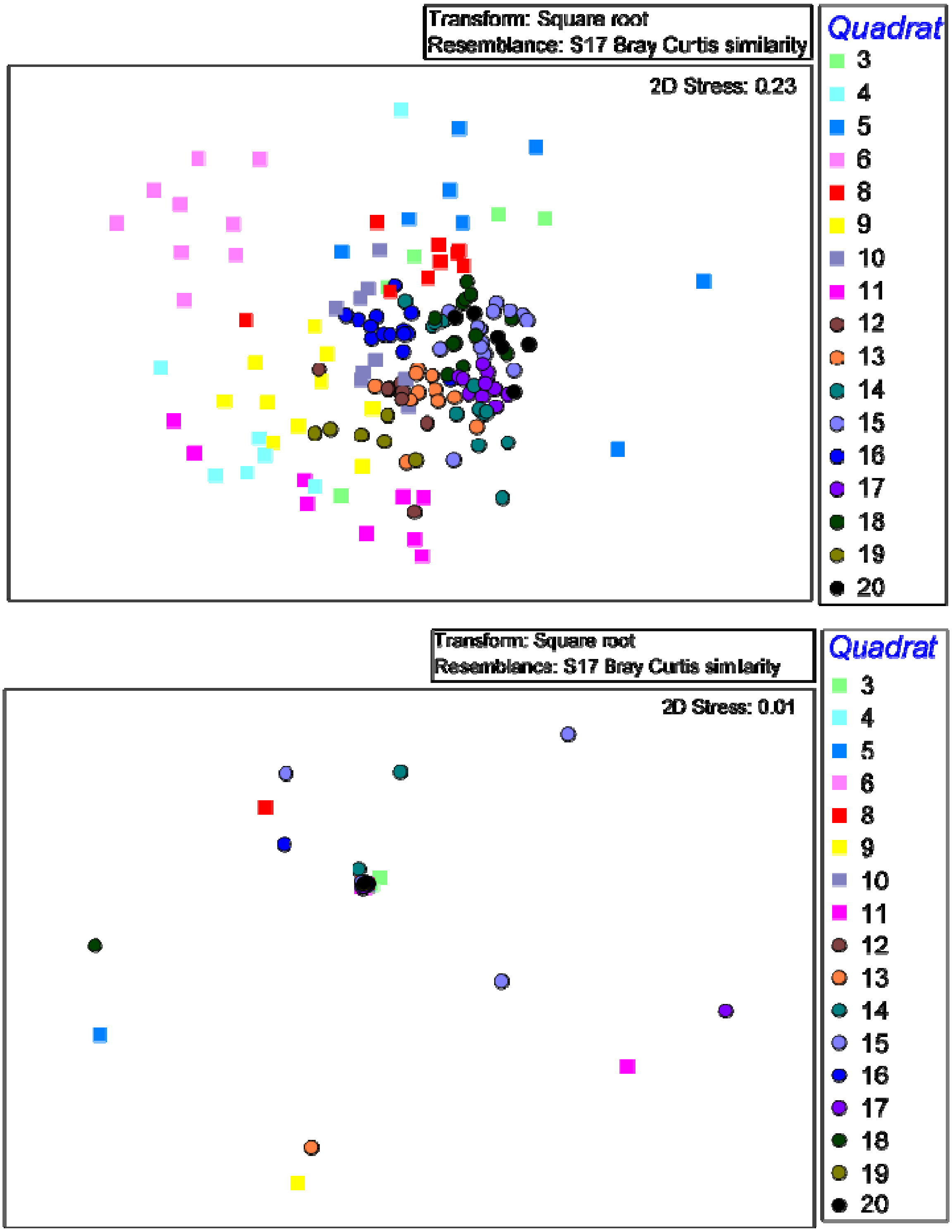


Figure 3.6 MDS plots of algal community data (% cover, all surveyors, *in situ* records only) from Lochaline transect quadrats, by quadrat. Square and round symbols aid identity of the quadrats, but also distinguish the two halves of the transect. a) Top plot: All algal taxa. b) Bottom plot: As top, but excl. *Delesseria sanguinea*, *Phycodrys rubens*, *Heterosiphonia plumosa*, *Heterosiphonia japonica, Bonnemaisonia asparagoides, Rhodophyllis divaricata* and encrusting coralline algae.

Visual illustration of changes in consistency are shown in the examples from four quadrats in Figure 3.7. If, for each quadrat, the spread of records between Phases 1 and 2 is compared in Figure 3.7a and between Phases 2 and 3 is compared in Figure 3.7b they suggest notable improvements only for Q7 and Q16. The examples shown are typical for the rest of the quadrats, with a few suggesting notable improvements, but more showing little or no difference. The species specific differences are described in the sub-sections below.

Data from the analysis of the photo-quadrats has also been included in the MDS plots in Figure 3.7. They mostly show that the photo data groups well with the *in situ* data although there is still considerable variability between surveyors. Again, these examples are typical of the other quadrats. The data for Q7 is an exception. Species specific results are described in the sub-sections below.

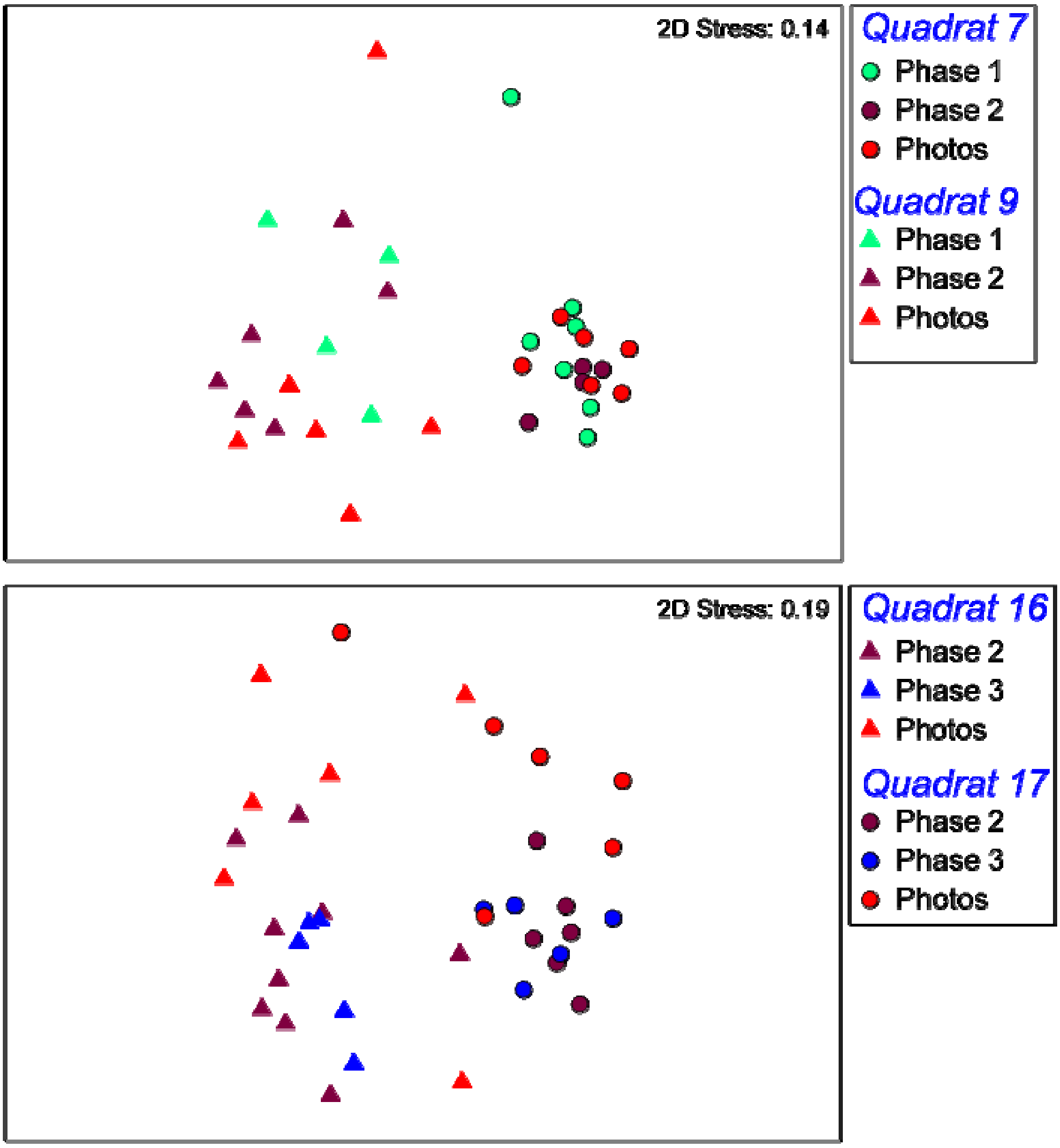


Figure 3.7 MDS plots of algal community data (% cover, square root transformation, all surveyors) from Lochaline transect quadrats, by survey phase. Examples from two quadrats in each plot. a) Top plot: Comparison of Phases 1, 2 and photo records for Q7 and Q9. b) Bottom plot: Comparison of Phases 2, 3 and photo records for Q16 and Q17.

3.3.3 Species richness

In situ *records*

Figure 3.8a shows that the number of taxa recorded *in situ* by the surveyors varied considerably within each quadrat. The worst case being for Q6 in Phase 1, where the number of recorded taxa ranged from three to 10. The number of taxa recorded generally increased as the level of training and familiarity increased. Consistency between surveyors also improved slightly with training and familiarity, but was still poor in Phase 3. It might be expected that at least some of this inconsistency would be caused by biases in the recording of particular surveyors, but Figure 3.8b shows that there was very little such bias. Surveyors E and F tended, on average, to have recorded fewer taxa than the other surveyors in Phase 1, but in Phases 2 and 3 there was very little difference between any of the surveyors. Despite the variability, Figure 3.8 also shows a notable pattern of change as one moves along the transect, with peaks in the middle and right hand end of the transect and particularly low numbers at the left hand end of the transect. This is due to the natural community changes along the transect.

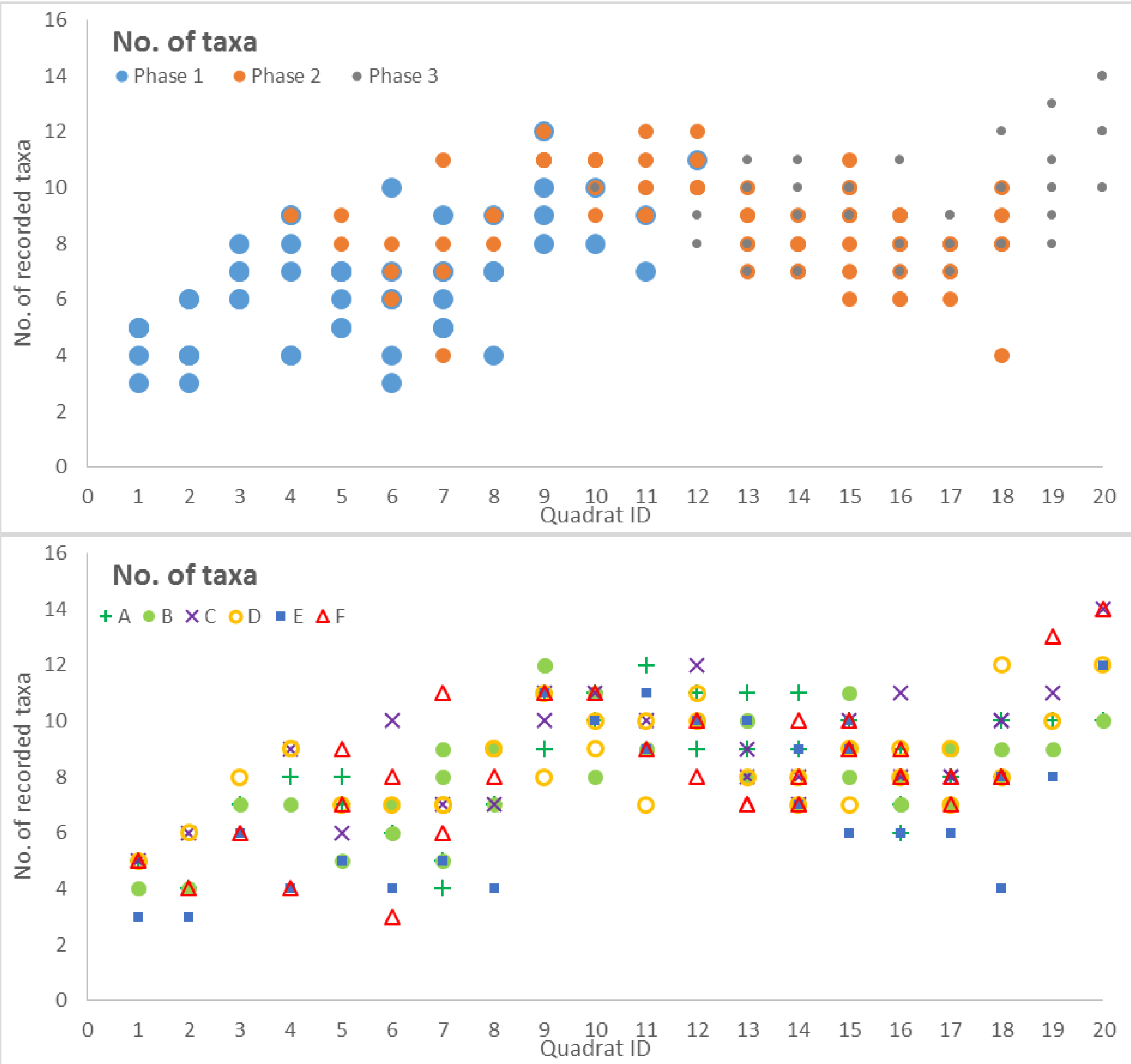


Figure 3.8 Number of taxa recorded *in situ* per quadrat in 20 fixed quadrats on the Lochaline transect; a) Top: by survey Phase (1 to 3); and b) Bottom: by surveyors (A to F).

Other potential causes of variability include the diving conditions (tidal currents, visibility and swell) and the condition of the divers. Diving conditions were recorded as “OK” throughout and there were no notable issues with divers’ health, but ‘recording fatigue’ was mentioned as a possible source of error. Figure 3.9 shows that the average number of taxa recorded reduced slightly over the course of survey dives in Phases 2 and 3, though not in Phase 1. These trends were not correlated with position on the transect (i.e. the left to right trend in species richness shown in Figure 3.8) as the direction taken by divers’ along the transects varied with other logistical factors. However, the reductions are small compared to the overall variability and it is concluded that most of the variability is effectively random.

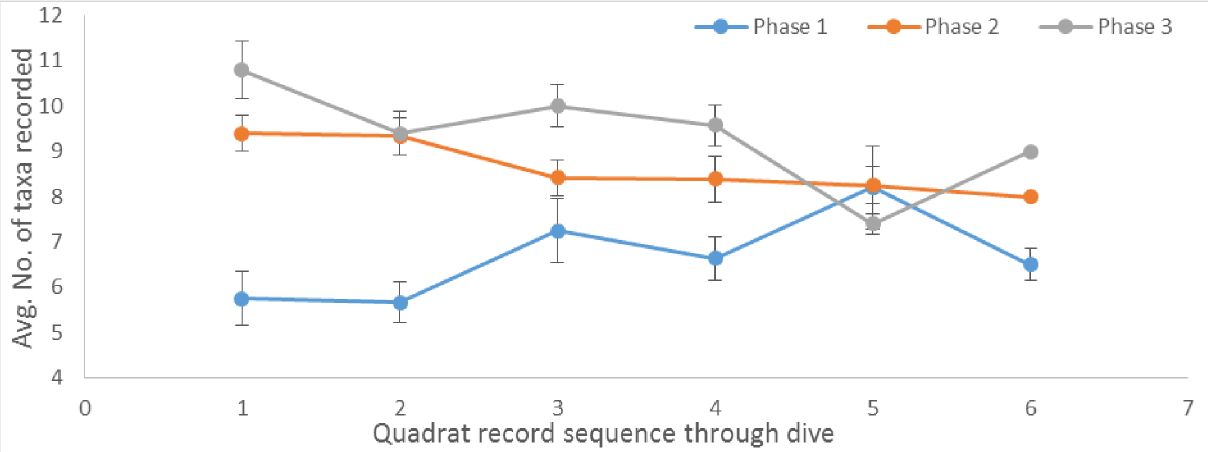


Figure 3.9 Average number of taxa recorded per quadrat against the sequential order in which they were recorded by each surveyor during a dive, by survey phase. Includes data from 184 records (20 fixed quadrats, six surveyors). Standard error bars are given for each average.

Photo records

Figure 3.10 shows that the variability in the photo data is even greater than that from the *in situ* survey records (cf.Figure 3.8). The well-defined pattern of change along the transect that was shown by the *in situ* records (summarised by the dashed line) is also not shown in the photo data. Generally, fewer taxa were recorded per quadrat from the photographs than *in situ*, but this was not the case for all quadrats (e.g. Q3). Like the later phases of the *in situ* data there is little evidence of surveyor bias, with the exception of surveyor D who carried out the photo analysis many weeks later and then generally recorded more taxa.

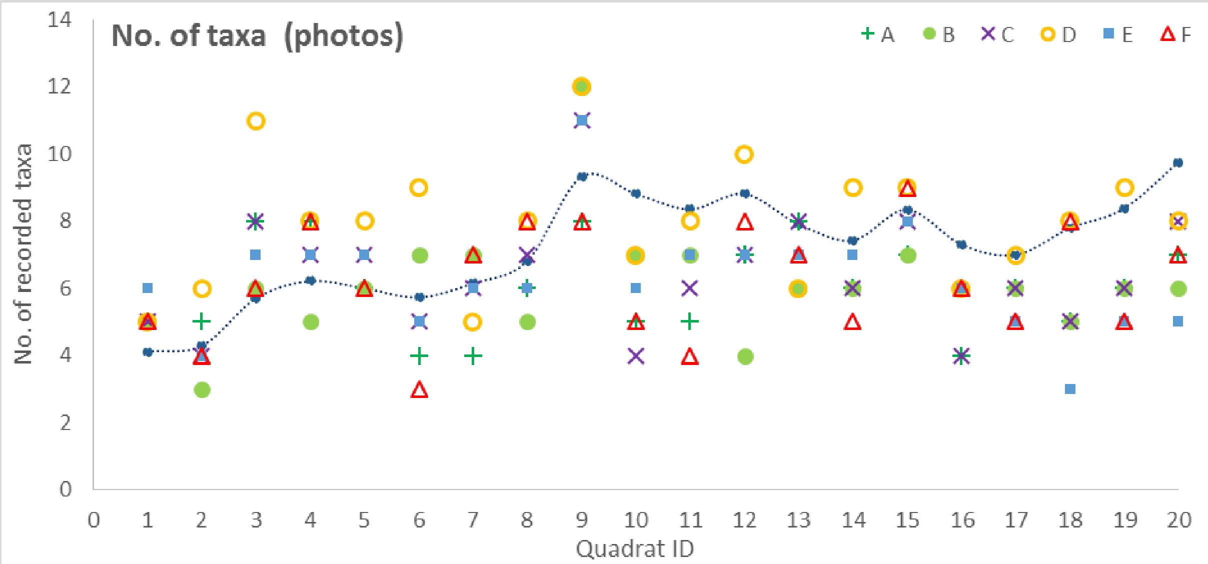


Figure 3.10 Number of taxa per quadrat recorded from photographs of 20 fixed quadrats on the Lochaline transect by six surveyors (A to F). Dashed line = average abundance of all *in situ* survey records.

3.3.4 Individual taxa

Table 3.5 and Table 3.6 and Figure 3.11 to Figure 3.21 show the variability in recorded abundances for selected individual taxa on the Lochaline transect, both *in situ* and from photographs of the quadrats. Table 3.5 also includes subjective scales (1 to 5) of the ease of identification and conspicuousness for each taxa. The scales are based on the authors' experience (not from the present survey data) and are intended as a guide that may help to explain variability. The following sections describe some of the most notable features.

Table 3.5 Range of average recorded abundance (minimum to maximum averages by surveyor) and recording characteristics (ID and Con.) of taxa (Phase 1 to 3) in Lochaline wall *in situ* quadrat survey records. Abundances are % cover, except for those taxa labelled 'counts'. See Table 3.3 for numbers of quadrats and records. ID = ease of identification scale; Con. = conspicuousness scale. Both scales range from 1 to 5, where 1 = very difficult to identify/very inconspicuous.

	Phase 1	Phase 2	Phase 3	ID	Con.
Porifera (enc)	0.03 - 0.08	0 - 0.2	0 - 0.05	4	3
Sagartia (counts)	0 - 1	0 - 0.7	0 - 0.7	4	3
Hormathia coronata (counts)	0 - 0.4	0.1 - 0.7	0.1 - 0.3	3	3
Edwardsiella (counts)	0 - 0	0 - 0.07	0 - 0.2	3	2
Caryophyllia smithii (counts)	0 - 0.6	0.2 - 0.8	0.6 - 1.2	5	4
Cirripedia %	5.9 - 15.6	15.3 - 38.2	12.9 - 29.4	5	4
Bryozoa (enc)	0 - 2.2	0 - 0.4	0 - 0.04	4	3
Rhodophyta (enc)	0 - 0	0 - 0.1	0 - 0.03	3	3
Bonnemaisonia asparagoides	0 - 2.9	1.0 - 3.8	0.5 - 1.9	3	4
Trailliella intricata	0 - 2.6	0.2 - 0.9	0 - 1.0	3	3
Corallinaceae (enc)	3.6 - 16	5.6 - 12.1	3.8 - 16.9	5	5
Schottera nicaeensis	0 - 0.08	0 - 0.2	0 - 0.1	2	3
Plocamium (agg.)	1.4 - 5.4	1.1 - 5	0.3 - 2.5	5	4
Rhodophyllis irvineorum	0 - 0.01	0 - 0.5	0 - 0.5	2	3
Rhodophyllis divaricata	0 - 0.3	0.1 - 1.9	0.2 - 1.0	2	3
Lomentaria clavellosa	0 - 0	0 - 0.01	0 - 0	3	3
Lomentaria orcadensis	0 - 0.01	0 - 0	0 - 0.2	3	3
Compsothamnion thuyoides	0 - 0.2	0.01 - 1.8	0 - 1.6	1	1
Delesseria sanguinea	5 - 13.4	5.6 - 9.6	6.8 - 14.3	4	4
Phycodrys rubens	0 - 7.5	1.9 - 8.5	2.6 - 5.4	3	4
Erythroglossum laciniatum	0 - 0.4	0 - 0.01	0 - 0	2	2
Heterosiphonia japonica	0 - 5.6	0.9 - 3.1	0.7 - 4.4	2	2
Heterosiphonia plumosa	0 - 1.1	1.9 - 9.4	1.7 - 9.2	3	3
Aglaozonia parvula (enc)	0 - 5	0 - 0.6	0 - 0.6	3	3
Dictyota dichotoma	0.3 - 2.5	0 - 1	0.4 - 1.4	4	4

Table 3.6 Average abundance (across all *in situ* and photo records) and frequency of photo records by surveyor for selected taxa (most frequently recorded) on Lochaline wall transect. Abundances are % cover except for the first three rows (labelled with C) which are counts.

	Average abundance		Frequency of photo records by surveyor					
Entity	***In situ***	**Photo**	**A**	**B**	**C**	**D**	**E**	**F**
Sagartia (agg) C	0.4	0.2	1	2	0	5	5	7
Hormathia coronata C	0.3	0.1	3	2	3	2		2
Caryophyllia smithii C	0.5	0.4	5	6	6	6	5	7
Cirripedia	16.4	13.7	20	20	20	19	20	20
Bryozoa (enc)	0.4	0.1	1	3	4	1	4	3
Rhodophyta (fil)	0.9	1.4				5	16	
Rhodophyta (flat)		0.1				7	7	
Bonnemaisonia asparagoides	1.7	1.1	8	9	6	11	5	5
Trailliella intricata	0.7	0.2	4	1	6	2	2	1
Corallinaceae (enc)	8.7	7.0	20	20	20	20	20	20
Plocamium (agg)	3.1	1.7	3	5	6	6	5	5
Rhodophyllis irvineorum	0.1	0.1	4		1	2		2
Rhodophyllis divaricata	0.3	0.4	4	4	3	4	1	2
Delesseria sanguinea	8.8	9.3	15	16	15	17	15	13
Phycodrys rubens	3.0	1.0	4	10	8		4	6
Erythroglossum laciniatum	0.00	0.3			3	10		
Heterosiphonia japonica	2.2	2.2	11	11	9	11		1
Heterosiphonia plumosa	3.8	2.6	8	5	5	10	2	12
Aglaozonia parvula (brown enc)	0.8	0.3		3	4	4	4	1
Dictyota dichotoma	0.9	1.1	3	2	4	3	4	8

Animals recorded as counts

Porifera – small patches of encrusting sponge (more than one species) were present in very low abundance along the whole transect. Although listed on the proformas in Phase 2 and 3, recording was very erratic by all surveyors, due to the small size and inconspicuous nature of the patches. Some surveyors became increasingly familiar with the appearance of Porifera and subsequently recorded them from most quadrats. There were even fewer records from the photographs and only by three of the surveyors.

Sagartia – includes records of *Sagartia*, *S. elegans* and *S. troglodytes* – a fairly easily recognised genus of anemone (particularly as other similar species were not found on the site), but individuals can be difficult to distinguish on complex backgrounds. Small numbers were scattered along most of the transect. The genus was listed on the pro forma, except at the start of Phase 1, and most surveyors quickly became familiar with what to look for. However, surveyor C did not record it in any quadrat, and most surveyors overlooked it in at least one quadrat where other surveyors did record it. Consistency of recording appeared to decrease from Phase 2 to 3, but abundances were low so data is limited. It was more difficult to see *Sagartia* in the photographs and only three of the surveyors developed a good search image for them, so consistency was poor.

Hormathia coronata – slightly smaller and usually less conspicuous than *Sagartia*, but recorded in small numbers along the whole transect by all surveyors. Consistency was not high in any Phase, presumably because it is not conspicuous, and most surveyors did not record it in at least one quadrat where other surveyors did note it. In the photographs, there were a couple of individuals that were fairly conspicuous and were recorded by five of the surveyors, but not by surveyor E. Overall, the average abundance from the photographs was less than half that of the *in situ* survey.

Caryophyllia smithii – cup corals – these are very distinctive, but sometimes hidden by algae. Recorded in as one or two specimens in half of the quadrats. Consistency of recording was high in Phases 2 and 3 (the highest of all taxa recorded on the Lochaline transect), but most surveyors overlooked individuals in at least one quadrat. In the photographs, some specimens were conspicuous and were consistently recorded by all of the surveyors. Average abundance records were lower than the *in situ* survey data, but consistency between the surveyors was high.

Barnacles - large numbers of barnacles (not recorded by species) were present in all quadrats, but were more abundant in some. In Phase 1 of the *in situ* survey there was an initial attempt to assess the consistency of barnacle counts in each quadrat. Most of the records were by two of the surveyors. Figure 3.11 shows that at low abundance the consistency of the counts was fairly high, but that it declined as the abundance increased. Recording could have been continued, but it was fairly time consuming and was therefore discontinued.

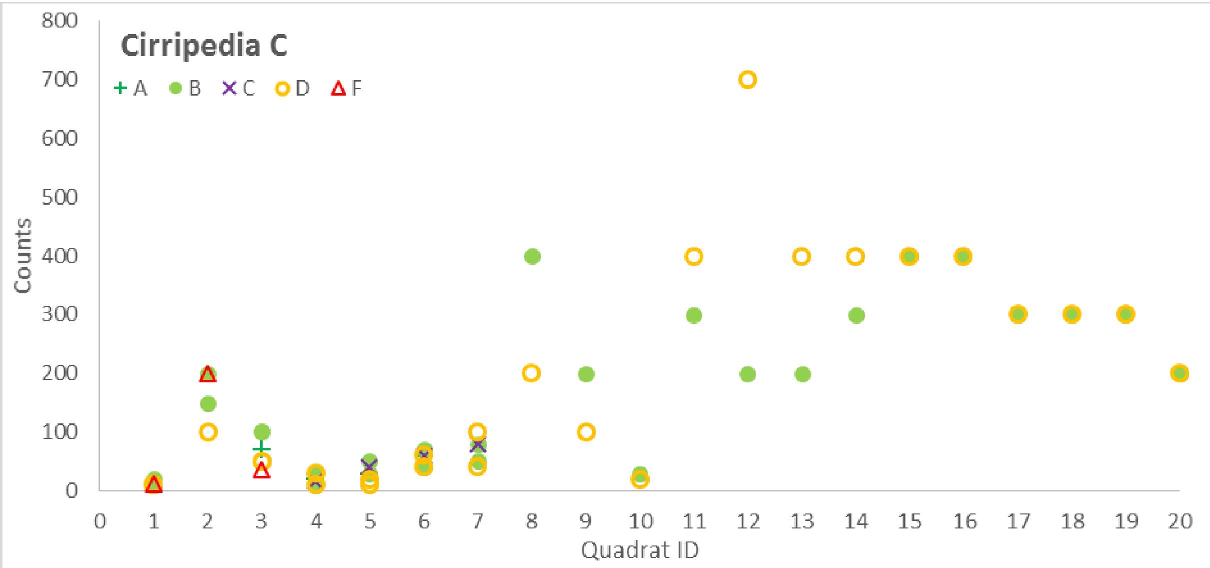


Figure 3.11 Records of barnacle counts in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors.

Barnacles **(% cover)**

Large numbers of barnacles (not recorded by species) were present in all quadrats but more abundant in some (see Figure 3.12a). Estimates of % cover were particularly difficult with large numbers of small individuals scattered around the quadrat and consistency of *in situ* recording was very poor in Phase 1 and not much better in Phase 2. Consistency did improve with training and the use of the % cover guide, but Figure 3.12a shows that even in Phase 3 there was considerable variation between surveyor's estimates (e.g. Q18: estimates ranged from 5% to 30%). Some of the variability was due to surveyor bias and this was evident through all Phases.

Records from the photographs (Figure 3.12b) shows similarly high levels of variability in % cover estimates and much of that variability was due to surveyor bias. Estimates from the photographs were, on average, slightly less than from *in situ* records.

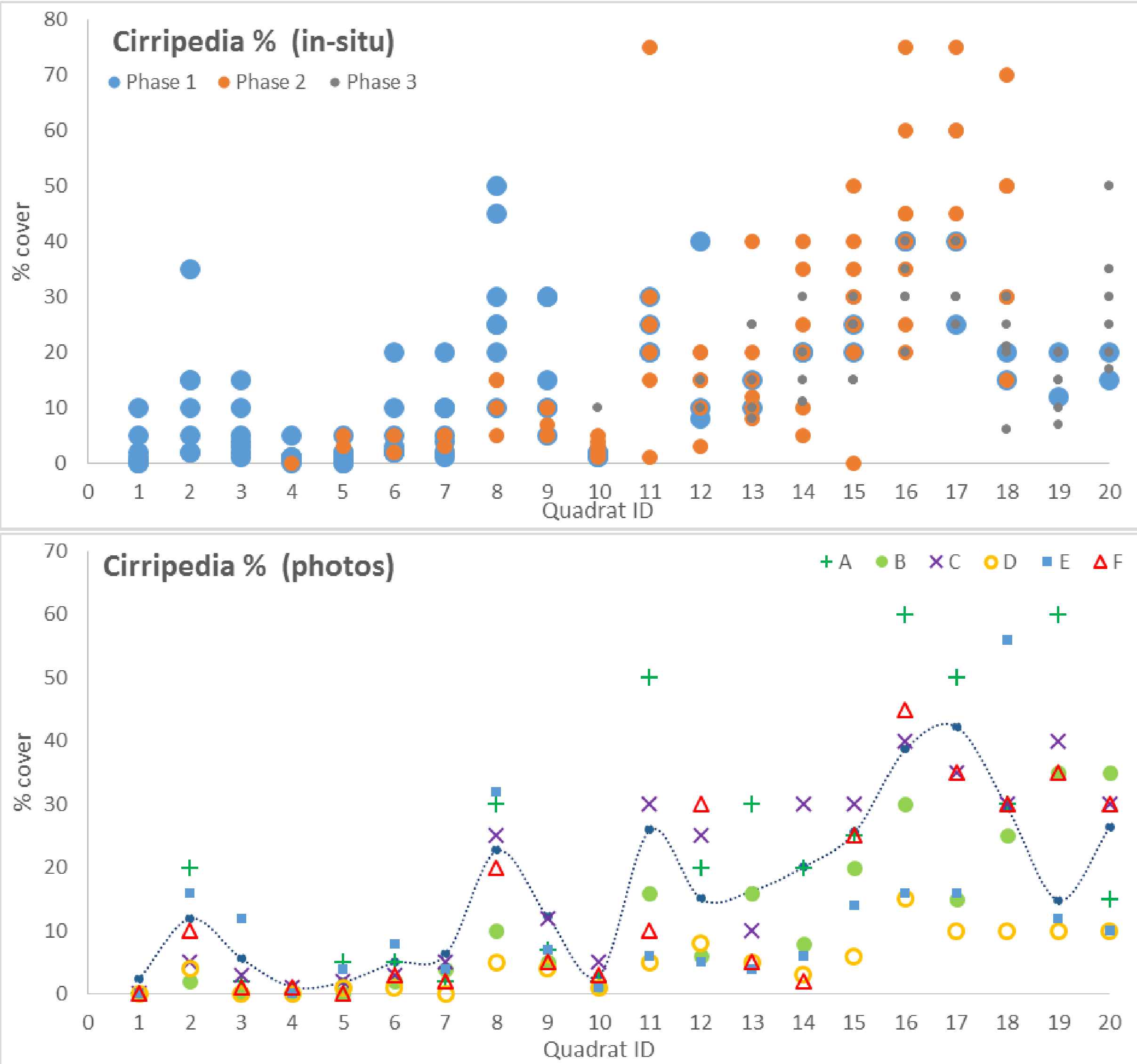


Figure 3.12 Records of abundance of barnacles in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. a)Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Bryozoa (enc.)

These were recorded in low abundance from a number of quadrats (Figure 3.13), but more often overlooked than recorded, particularly in Phase 3, suggesting that % cover was over-estimated in Phase 1. Some encrusting species are very conspicuous on clean rock surfaces, but others less so.

There were fewer records and lower % cover estimates from the photographs than there were from *in situ* surveys, even compared to *in situ* Phase 3, suggesting under estimation.

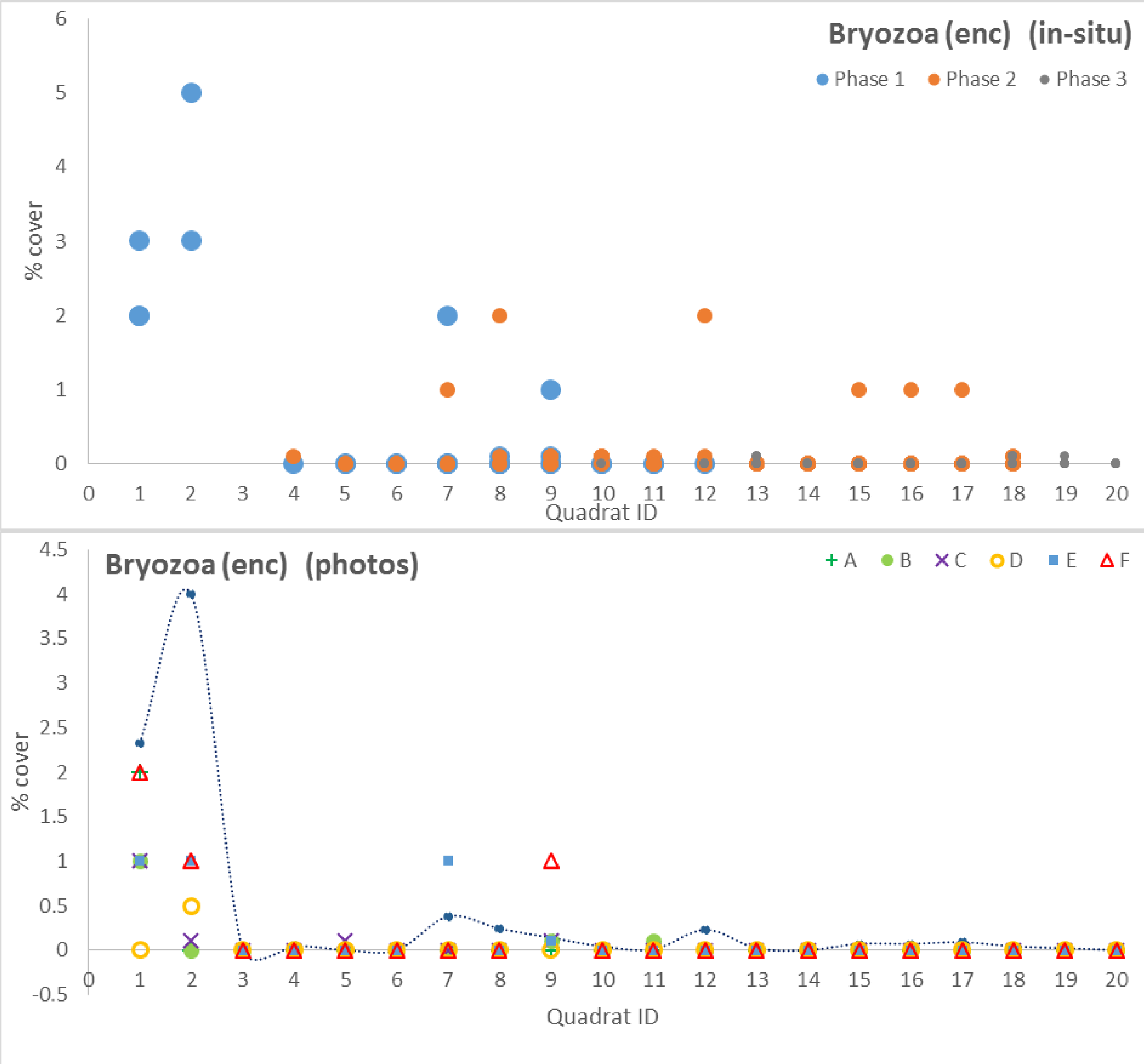


Figure 3.13 Records of abundance of bryozoan crusts in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. Top: *in situ* records by three survey Phases. Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Bonnemaisonia asparagoides

This is a distinctively coloured, finely branched, red algae, present in over half of the quadrats, but usually in low abundance. All of the surveyors increased their familiarity with the species by Phase 3, but small plants were still overlooked occasionally and abundances were not easy to estimate consistently (Figure 3.14). However, there was very little surveyor bias.

The records from the photo analysis showed much the same pattern of distribution along the transect, but with occasional records in quadrats where the species was not recorded by anyone *in situ*, suggesting mis-identification. Percentage cover estimates were on average lower than *in situ* and again there was very little surveyor bias.

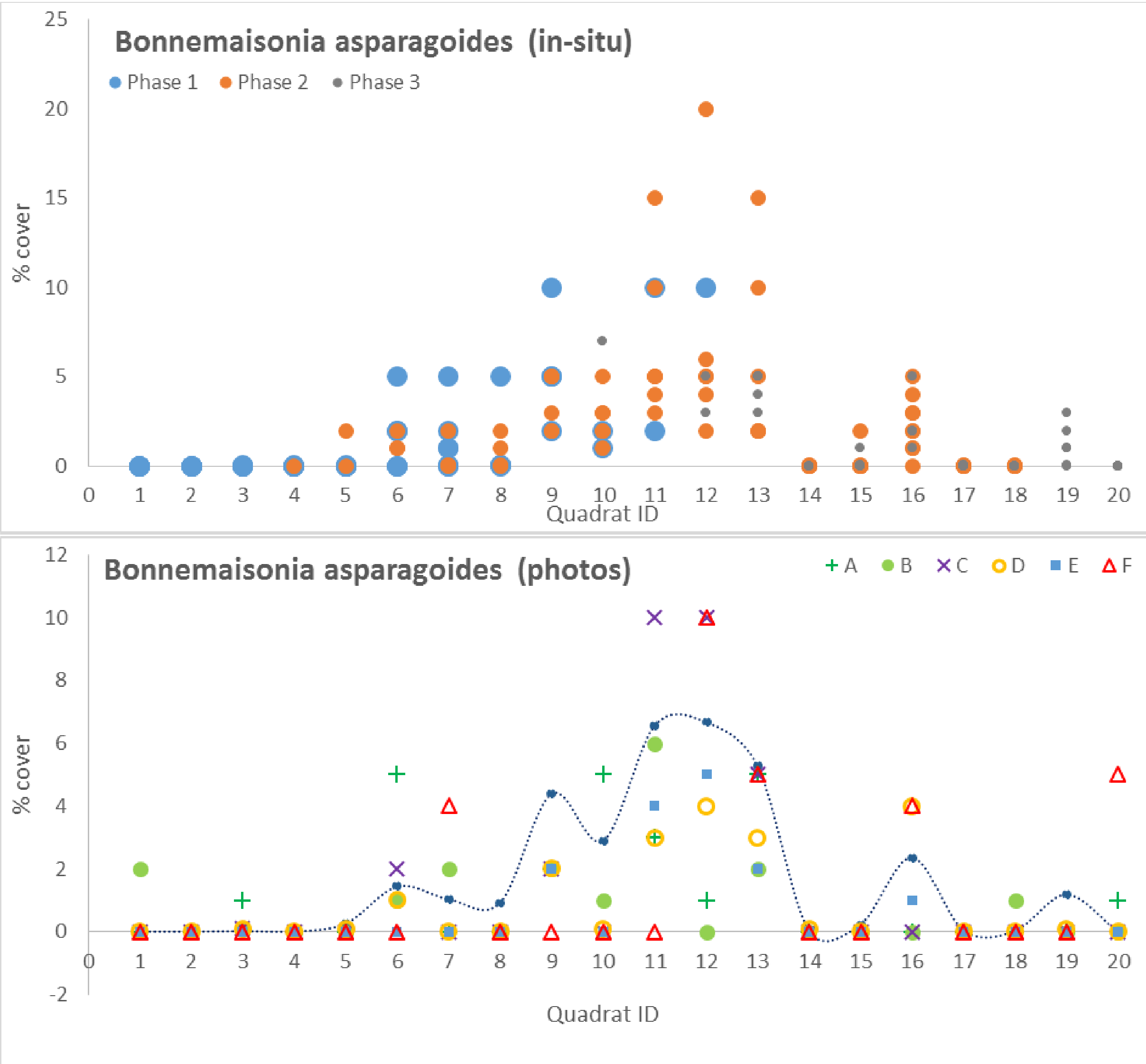


Figure 3.14 Records of abundance of *Bonnemaisonia asparagoides* in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. Top: *in situ* records by three survey Phases. Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Corallinaceae (enc)

Pink crusts of coralline algae were very distinctive set against the black rock, easy to identify and present in every quadrat. It was rare for any surveyor not to record it *in situ*, although a couple of surveyors did miss it in the three quadrats with the lowest abundances. Estimates of % cover varied considerably within each quadrat, but consistency improved with training and the use of the % cover guide, though not in every quadrat. Figure 3.15, however, shows that even in Phase 3 there was considerable variation between surveyor's estimates (e.g. Q20: estimates ranged from 10% to 40%). Further inspection shows that a notable proportion of this variation was due to surveyor bias, but also that this bias changed between Phases. The most striking example of this is for surveyors A and F - in Phase 1 the average cover of coralline crusts recorded by surveyor A was 16% while for surveyor F it was 4%, but in Phase 3 their biases switched round to 4% by surveyor A and 17% by surveyor F.

The photo data shows a similar pattern of distribution along the transect with slightly less variability compared to the *in situ* data overall Phases. On average the % cover estimates were also lower and there was less surveyor bias.

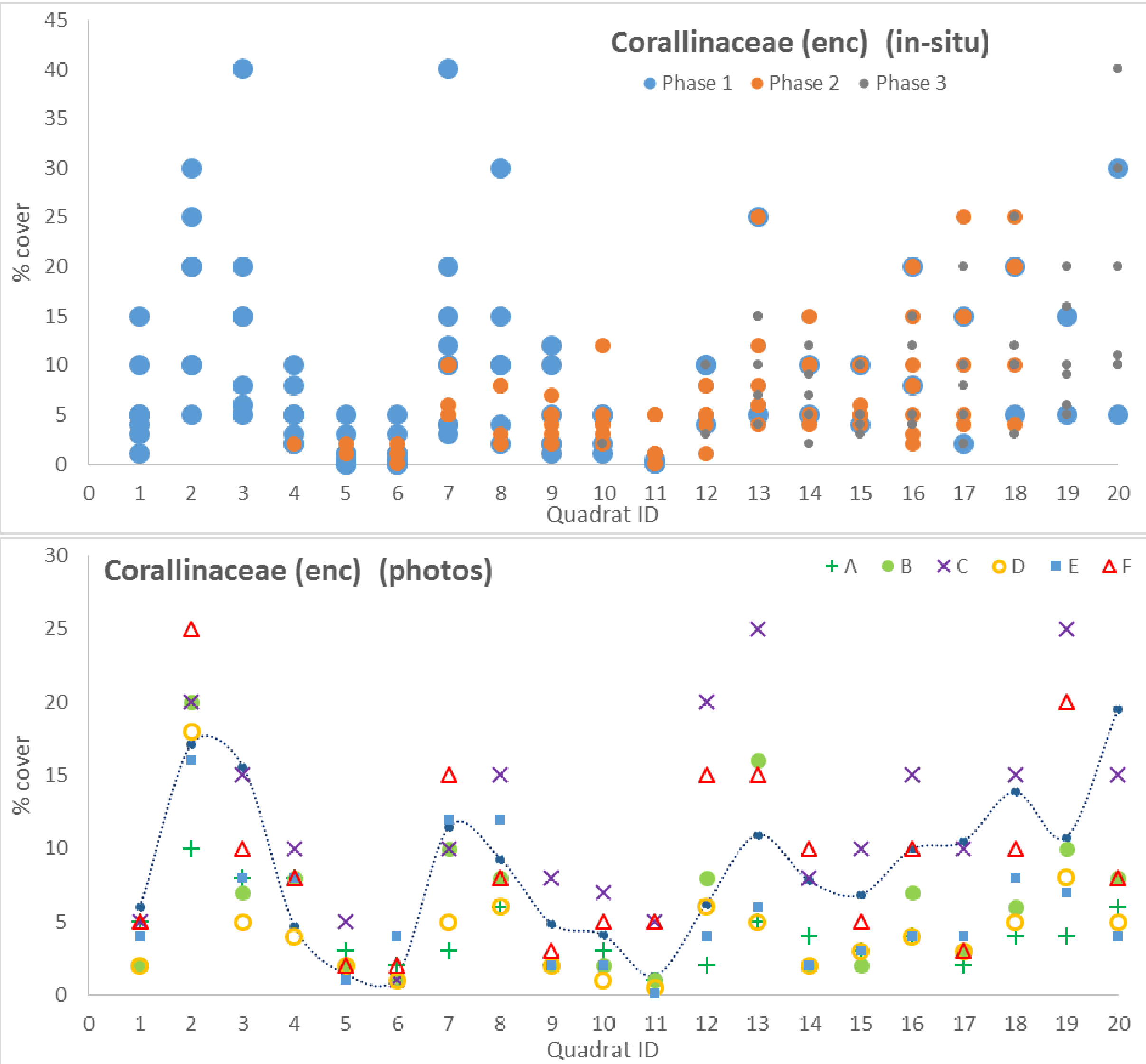


Figure 3.15 Records of abundance of coralline crusts in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. Top: *in situ* records by three survey phases. Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Delesseria sanguinea *and* Phycodrys rubens

These are relatively large and conspicuous red algae with midribbed blades, both present in many quadrats on the transect, which can be distinguished easily from each other in good specimens, but not so easily in tattered form later in the season. *D. sanguinea* was recorded most often and in higher abundances than *P. rubens*, but surveyors sometimes confused the two, particularly in Phase 1. By Phase 2, however, surveyors had good consistency in recording the presence of *D. sanguinea* and fairly good for *P. rubens*, but estimates of % cover were variable.

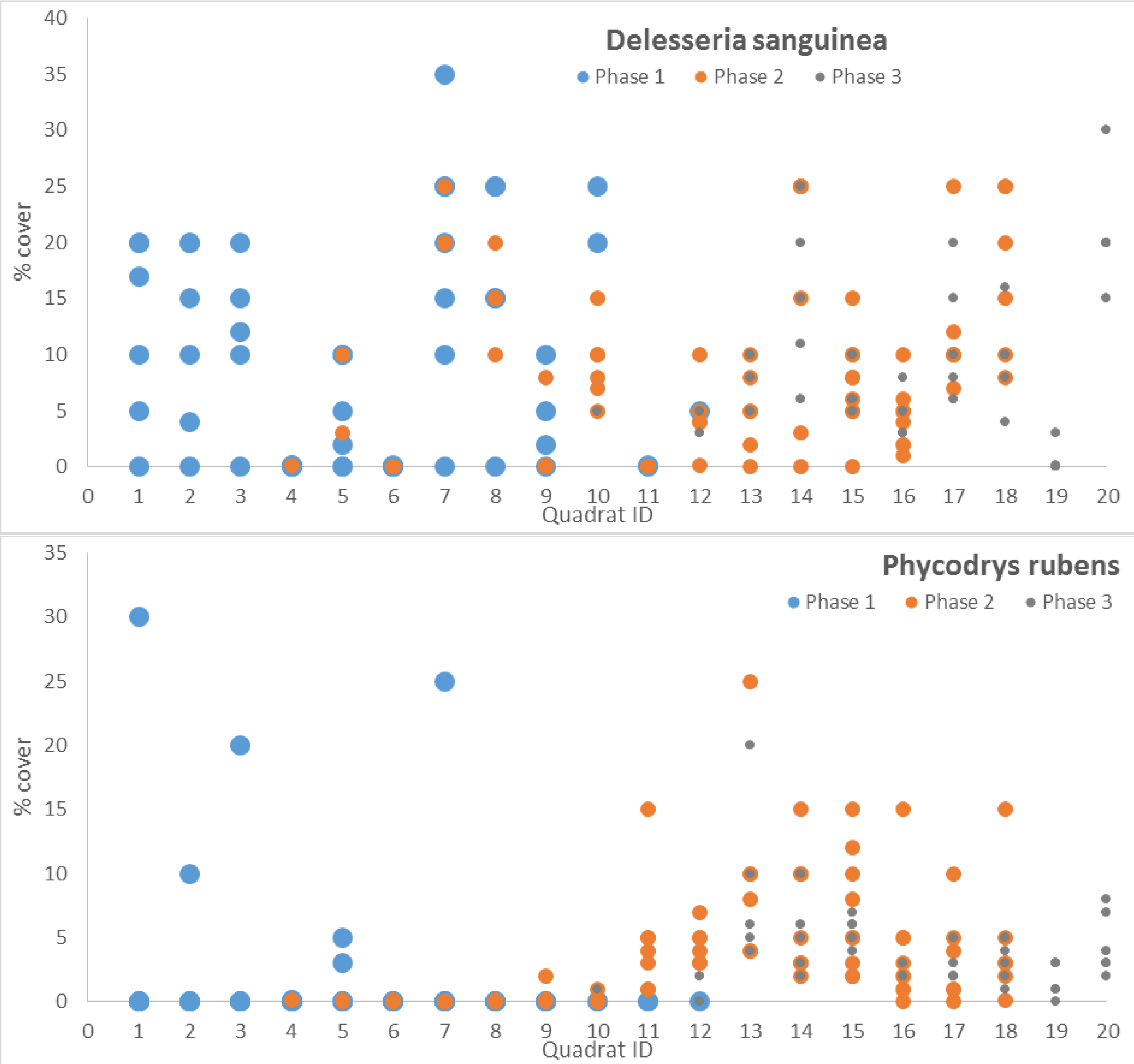


Figure 3.16 *In situ* records of abundance of *Delesseria sanguinea* (top) and *Phycodrys rubens* (bottom) by three survey Phases in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors.

Photo records for these two species highlight the difficulty of distinguishing the two species unless the surveyor is able to examine the frond edges closely and there were very few records of *P. rubens*. Surveyor D did not record it from any quadrat. *D. sanguinea* was much more obvious in the photographs and there was considerable variability within each quadrat but not much surveyor bias. When compared with the *in situ* records it is notable that the photo records along the first half of the transect are mostly above the dashed line, but are mostly below the dashed line along the second half. One interpretation of this is that the surveyors tend to make lower % cover estimates as they work through the quadrats (which may be the result of recording fatigue) and that this shows in the photo data because they progressively work through them all in sequence.

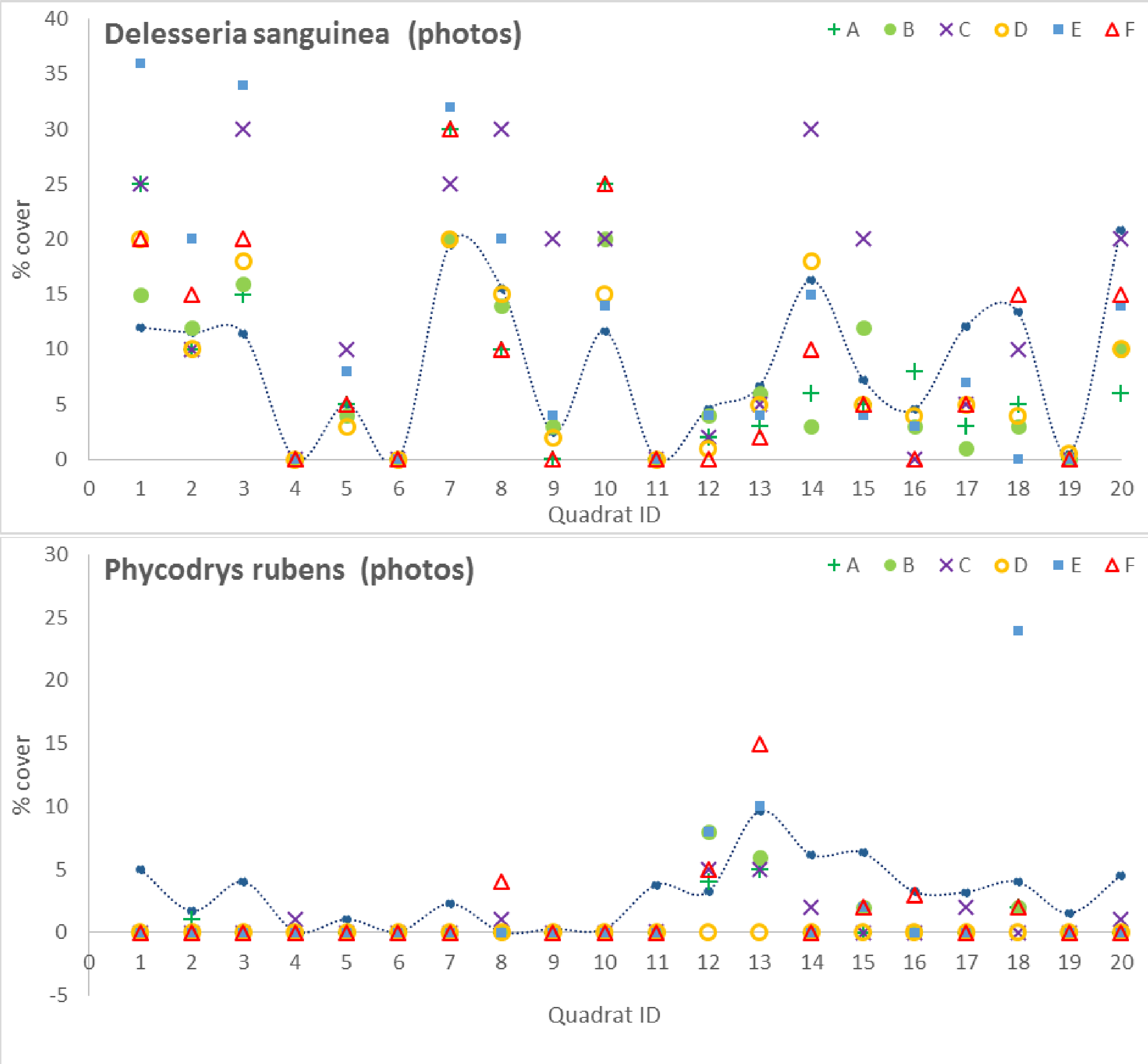


Figure 3.17 Records of abundance of *Delesseria sanguinea* (top) and *Phycodrys rubens* (bottom) in photos of 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors.

Heterosiphonia plumosa

This is a bushy red algae that grows to moderate size and is fairly easy to identify *in situ* once a surveyor has become familiar with securely identifying the species, but it may be confused with various other branching species. It was present in over half of the quadrats, mainly along the right hand half of the transect. Layering with other bushy species made cover estimates difficult and this is very evident in Figure 3.18a. Consistency of recording improved slightly by Phase 3, but there were still occasions when a surveyor recorded it as absent when other surveyors recorded it in moderate abundance. Some of the variability in abundance estimates was due to surveyor bias, with surveyors C and F tending to record the higher cover estimates and surveyors B and E the lower cover estimates.

Figure 3.18Figure 3.18b shows that identifying and estimating abundances of this algae are more difficult in photographs as there are significant differences compared to the *in situ* data. Nevertheless, the overall pattern is similar. Surveyor bias is still evident, particularly surveyors B and F.

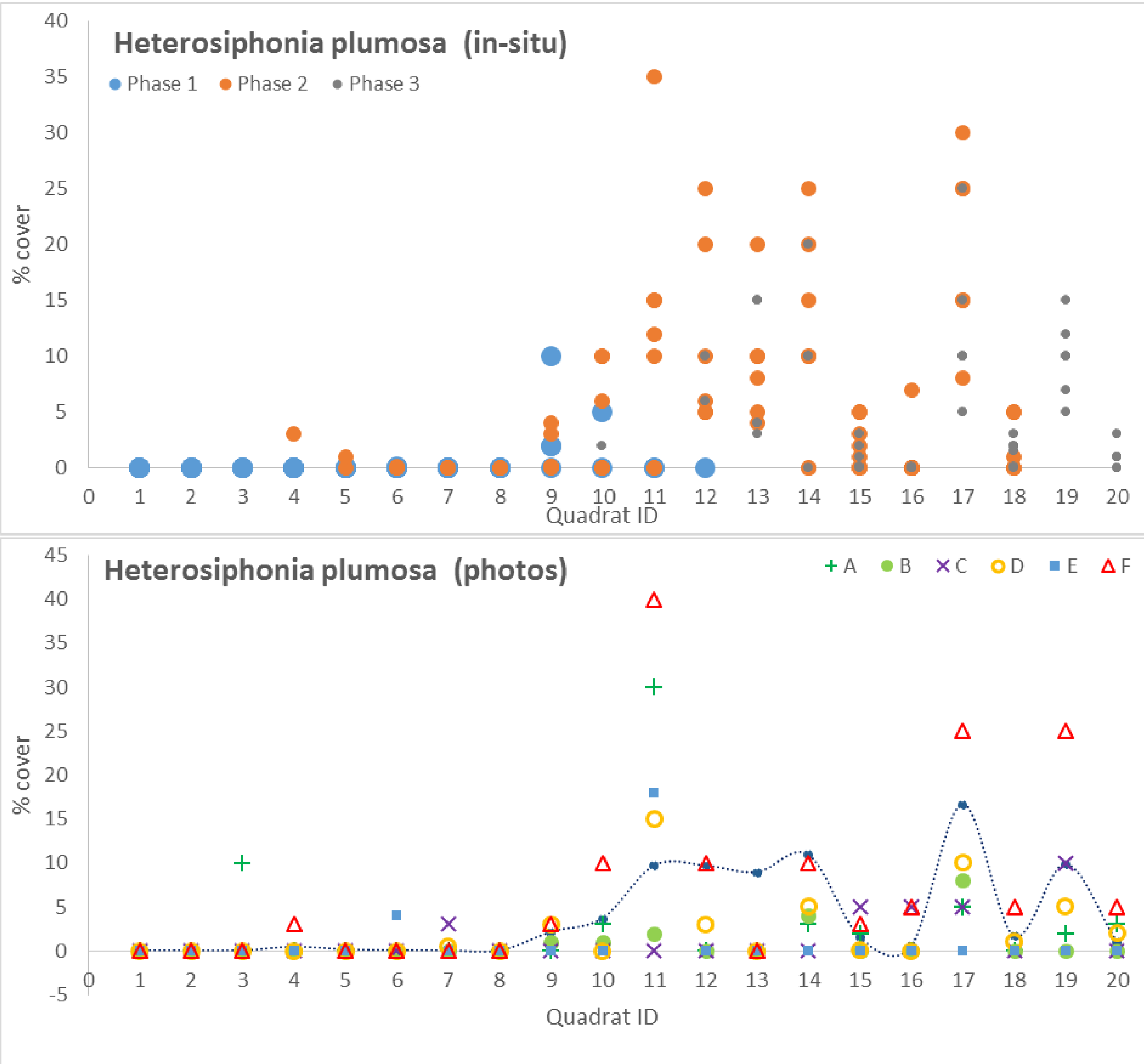


Figure 3.18 Records of abundance of *Heterosiphonia plumosa* in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Heterosiphonia japonica

This is a non-native species, similar to *H. plumosa* but more finely branching, so more difficult to distinguish from other finely branching species. It was recorded *in situ* from many quadrats, but in many of those quadrats it was not recorded by the experienced phycologist, suggesting numerous misidentifications. For at least some of those records the order of abundances suggests misidentifications with *H.plumosa*. Consistency of recording improved slightly by Phase 3, in that surveyors more consistently recorded its presence or absence, but variability of % cover estimates were still high.

At least three of the surveyors struggled to identify this species in the photographs, but the other three made a reasonable attempt and the distribution pattern of their records along the transect was similar to the *in situ* data. Overall, however, consistency was poor.

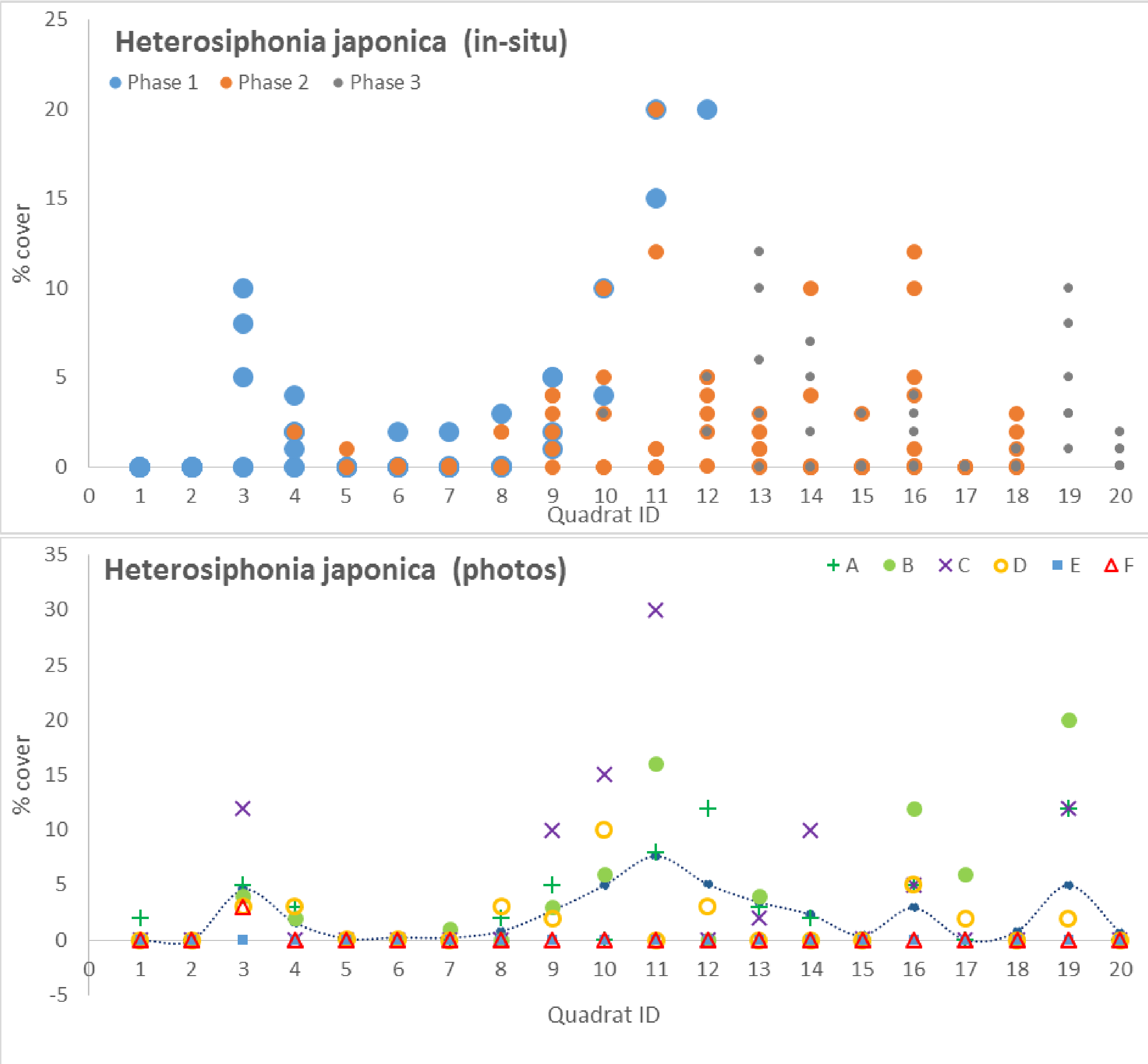
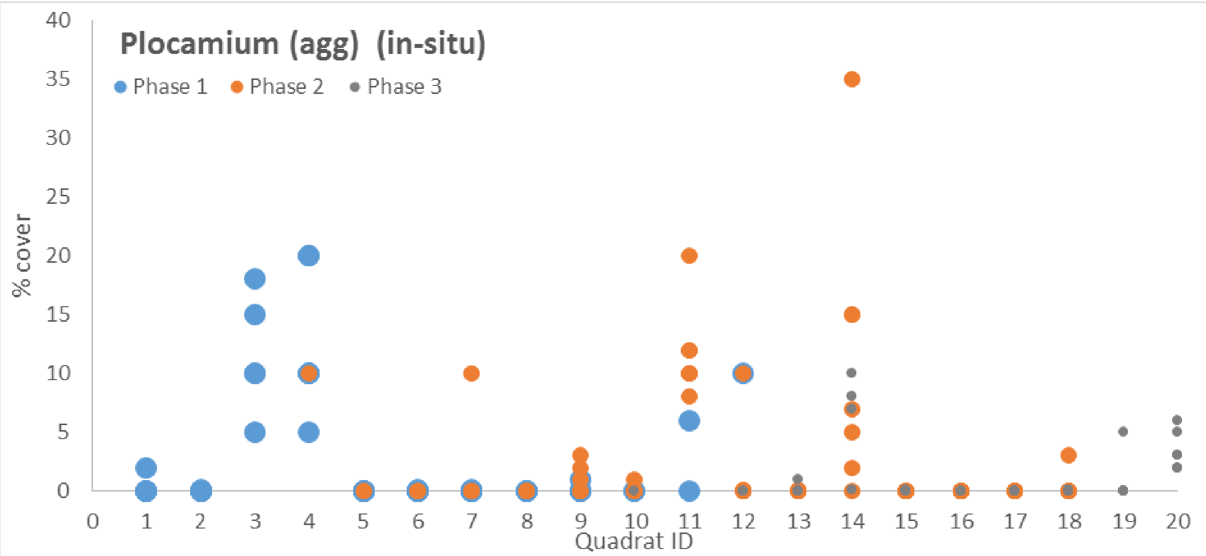


Figure 3.19 Records of abundance of *Heterosiphonia japonica* in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. Top: *in situ* records by three survey Phases. Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Plocamium

This category includes records of *Plocamium*, *P. lyngbyanum* and *P. cartilagineum* – a distinctive and fairly conspicuous genus of branching red algae, present in over half of the quadrats with large plants in five of them. Some surveyors attempted to distinguish between the two species, which were both present on the transect, but the results show that this was very unsatisfactory *in situ*, so the data were aggregated for Table 3.5 and Figure 3.20. Surveyors consistently recorded their presence, but estimating their abundance was complicated by the multi-species layering that often occurred, with various epiphytes and other branching species. This variability shows in Figure 3.20. Estimates were more consistent in Phase 3, but were still fairly variable between surveyors (e.g. Q14: estimates ranged from <1% to 10%). There was some bias by particular surveyors, with surveyor F usually recording the highest estimates in all Phases.

It was clearly more difficult for the surveyors to discern the smaller *Plocamium* plants in the photographs, and surveyor A overlooked a number of the larger plants, but most of the surveyors consistently recorded the larger plants with no obvious bias in % cover estimation.



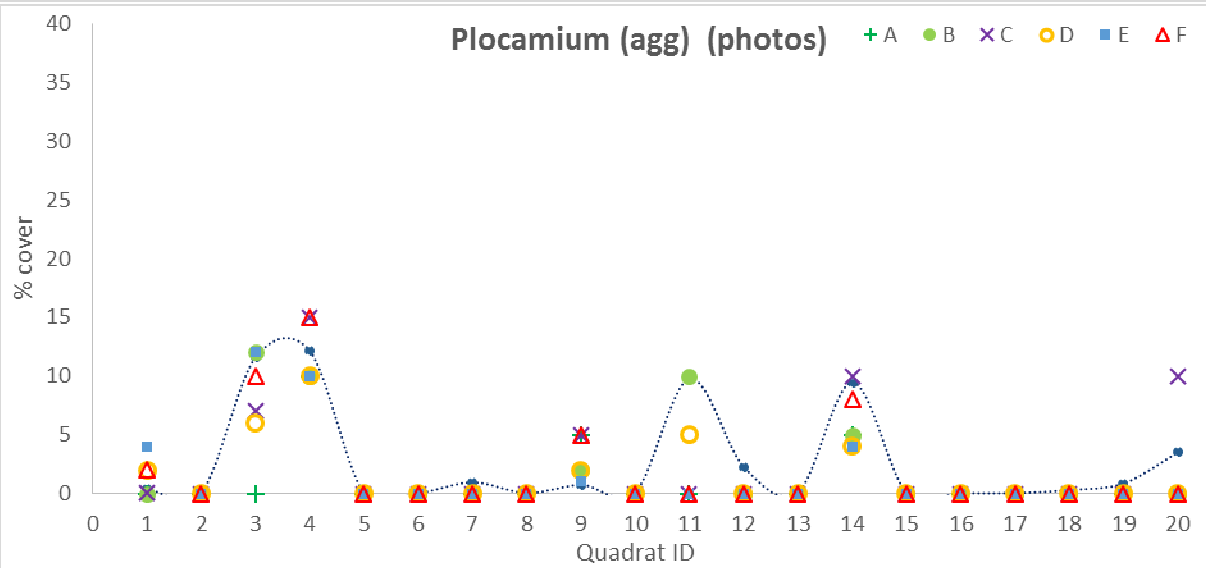


Figure 3.20 Records of abundance of *Plocamium* in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. Top: *in situ* records by three survey Phases. Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Dictyota dichotoma

A bifurcated strap-like brown algae, both conspicuous and easy to identify, but only recorded from six quadrats. Consistency of identification was high and the consistency of abundance estimates appears to have improved with training, though with some surveyor bias, but the number of records was too small to be conclusive (Figure 3.21).

Records from the photo analysis show that *D. dichotoma* was fairly consistently identified by the surveyors (although surveyor E appears to have entered a record for Q6 in the wrong column of the spreadsheet). Consistency of abundance estimates was no worse than *in situ*.

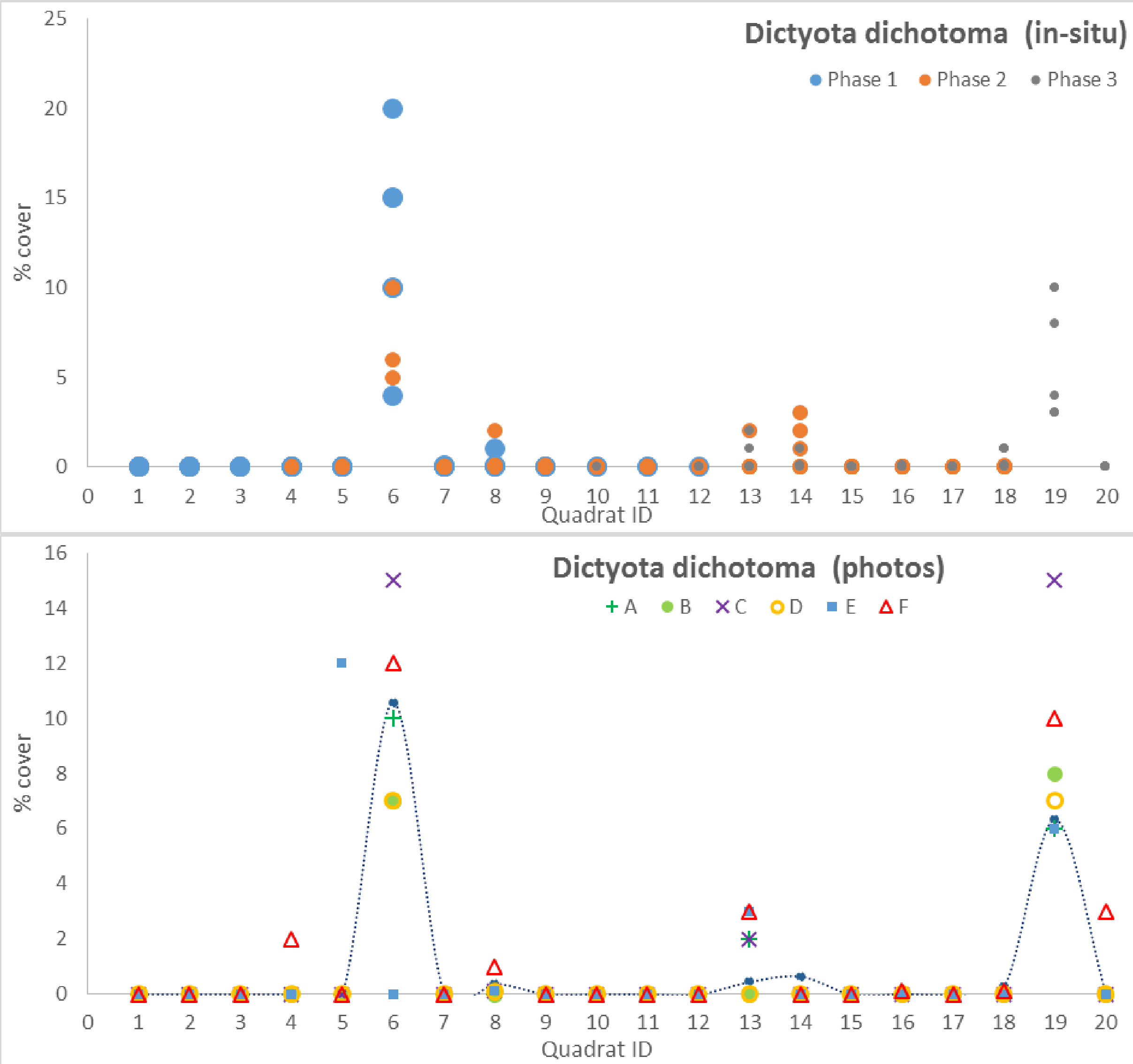


Figure 3.21 Records of abundance of *Dictyota dichotoma* in 20 fixed quadrats on the Lochaline transect. Multiple records by six surveyors. Top: *in situ* records by three survey Phases. Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

3.3.5 Recording time

Surveyors recorded the time (to the nearest minute) at the start and end of each quadrat survey, for both *in situ* surveys and photo quadrat analysis. The duration has been calculated for each quadrat, and while there are a number of potential errors and complications, the large number of records provides some useful statistics.

The average time taken by the survey divers to survey a single quadrat *in situ* (averaged across datasets B to F) was 6 minutes 27 seconds (range: 2–15 minutes). Surveyor bias accounts for a small amount of the variability (lowest average = 5 minutes 23 seconds (surveyor A); highest average = 7 minutes 47 seconds) (surveyor D). A larger effect was that surveyors took much longer on the first quadrat of the dive and less time on subsequent quadrats (average recording time for 1st to 6th quadrat: 7.4, 6.5, 6.5, 6.4, 5.8, 4.6 minutes).

As noted in Section 2.4.2, the number of quadrats that were surveyed per dive is more useful for logistical calculations. There were a total of 26 dives on the Lochaline transect, not including the reconnaissance and site establishment dives in July 2014. Full survey data (datasets B to F) were collected from 20 of those dives, producing 185 quadrat records = 9.25 quadrats per dive (from a pair of survey divers) or 4.6 quadrats per surveyor. The rate did change over the period of the survey: averaging 4.6 quadrats in the first third, 4.5 in the middle and 5.3 in the last third. There was also some surveyor bias, with averages ranging from 3.6 quadrats per dive (surveyor C) to 5.5 (surveyor F).

The equivalent average time for the photo quadrat analysis was 7 minutes 51 seconds (range: 2–26 minutes) per quadrat, and surveyor bias was greater (lowest average = 5 minutes 19 seconds (surveyor A); highest average = 10 minutes 30 seconds) (surveyor D). The surveyors usually took most time over the quadrats they analysed first and less time for subsequent quadrats, but this was complicated by occasional breaks and by their occasional use of identification guides (which some surveyors used more than others).

3.4 Auliston results and discussion

3.4.1 Summary description of data

The most frequently recorded taxa from the Auliston Point transect quadrats and the main differences in taxa recorded are summarised in Table 3.7. The last three rows of the table give additional statistics.

Table 3.7. Number of records (Recs) and average abundance of selected taxa (Phase 1 to 3) in Auliston wall quadrat survey records. See text for description of survey methods. Qs = numbers of fixed quadrats within which the taxa was recorded (out of 20). Surv. = number of surveyors who recorded that species (out of 6). MaxC / Max% = maximum count / percentage recorded from any quadrat. Mean% = average percentage cover (over all quadrats and surveyors). Blank cells indicate no records, while zero values indicate an abundance <0.1.

		Mean counts / quadrat							
Morphology	**Recs**	**Phase 1**	**Phase 2**	**Phase 3**	**Qs**	**Surv.**	**MaxC**		
Porifera: Encrusting	164	1.7	3	2.6	13	6	29		
Porifera: Massive	79	0.1	0.3	0.4	10	6	8		
Porifera: Globular	16	0.1	0	0	7	5	2		
Porifera: Pedunculate	19	0	0	0.1	4	5	5		
Porifera: Tubular	9	0	0.1	0	5	5	14		
Porifera: Repent	6	0	0		3	4	1		
Porifera: Arborescent	20	0	0.1	0.1	3	6	3		
Porifera: Papillate	19		0	0.4	6	6	10		
Taxa	**Recs**	**Phase 1**	**Phase 2**	**Phase 3**	**Qs**	**Surv.**	**MaxC**	**Max%**	**Mean%**
Porifera (orange enc)	100	0.3	1.6	1.5	12	6	10	10	0.94
Porifera (yellow enc)	81	0.1	1.2	1.5	13	6	21	11	0.63
Porifera (other enc)	40		0.5	0.2	12	6	5	15	0.44
Porifera (orange cushion)	31	0	0.3	0.3	9	4	6	4	0.18
Suberites carnosus	27	0.1	0.1	0.1	3	6	2	10	0.27
Polymastia	13			1.5	6	6	10	3	0.35
Stelligera stuposa	14	0	0.1	0.1	2	6	3	10	0.27
Myxilla incrustans	49	0.2	0.4	0.1	12	6	12	40	1.88
Hymedesmia paupertas	45	0.1	0.2	0.3	8	6	7	10	0.24
Aplysilla sulfurea	15			0.8	7	5	7	2	0.21
Alcyonium digitatum	41	0.1	0.1	0	11	6	2	8	0
Alcyonium glomeratum	35	0.1	0.2	0.1	10	6	8	15	0.38
Parazoanthus anguicomus	30	2.9	2.6	2.8	3	6	150	25	0.27
Protanthea simplex	19	0.1	0.1	0	3	6	3	8	0.06
Hormathia coronata	23	0	0	0.1	4	6	2	2	0.02
Caryophyllia smithii	124	0.5	0.5	0.3	11	6	5	3	0.15
Quadrats surveyed (Total=13)		13	13	7					
Records (Total=1749)		351	742	656					
Total taxa (Total=36)		25	26	28					

3.4.2 Multivariate analysis of sponge and anthozoan data

Multivariate analysis of *in situ* records of sponge and anthozoan community data was carried out on both photo and *in situ* counts (with log(x+1) transformation) and % cover (with square root transformation) data and the resulting MDS plots are shown in Figure 3.22. [Note that only Phase 2 and 3 data was analysed as a number of species were not included in the Phase 1 surveys]. Both plots show considerable variation between records within each quadrat by different surveyors. The count data (Figure 3.22a) is generally worst, with very little grouping of records by quadrat. Quadrats with large numbers of a species that is otherwise present rarely (e.g. *Parazoanthus* in Q3) do group fairly well in the count data, but the variation in surveyor's counts of other species is too great to separate the other quadrats. The % cover data (Figure 3.22b) groups the records by quadrat to a much greater extent, but further analysis shows that the separation is primarily due to a small number of taxa that were recorded relatively consistently. More taxa were important to the quadrat grouping than in the multivariate analysis of the Lochaline algae (Section 3.3.2), but some taxa were recorded so inconsistently that they reduce the quadrat groupings.

The results of the multivariate analysis of sponge / anthozoan community data have also been used to identify whether progressive familiarisation and training in algal identification has improved the overall consistency of surveyors records. Table 3.8 gives MVDISP results, calculated across all samples (i.e. taking no notice of quadrat identity) and also averaged across quadrats (i.e. calculated for each combination of phase and quadrat, then averaged by phase). Both calculations, for both % cover and counts, show reduced dispersion of the samples as one moves through the phases, suggesting increasing consistency (Note: the results from phase 1 will be affected by the lack of data for some species).

Table 3.8 Index of dispersion (from MVDISP)

	Phase 1	Phase 2	Phase 3
Auliston % cover - all samples	1.18	0.91	0.77
Auliston % cover - averaged across quadrats	1.09	0.92	0.94
Auliston counts - all samples	1.22	0.91	0.67
Auliston counts- averaged across quadrats	1.19	0.95	0.81

While overall improvements in recording with training and familiarisation may be present, a more detailed inspection shows that they are often subtle and not universal. They are difficult to distinguish in 2 dimensional plots of the whole data, so the MDS plots in Figure 3.23 show records from just four selected quadrats. The count data (Figure 3.23a) shows some improved consistency (tighter grouping) for Q8 and Q9 from Phase 2 to Phase 3 records, but little or no improvements for other quadrats or within the % cover data (Figure 3.23b).

The multivariate analyses also show that, as with the Lochaline algal data, that the photo-quadrat records group fairly well with the *in situ* data although there is still considerable variability between surveyors.

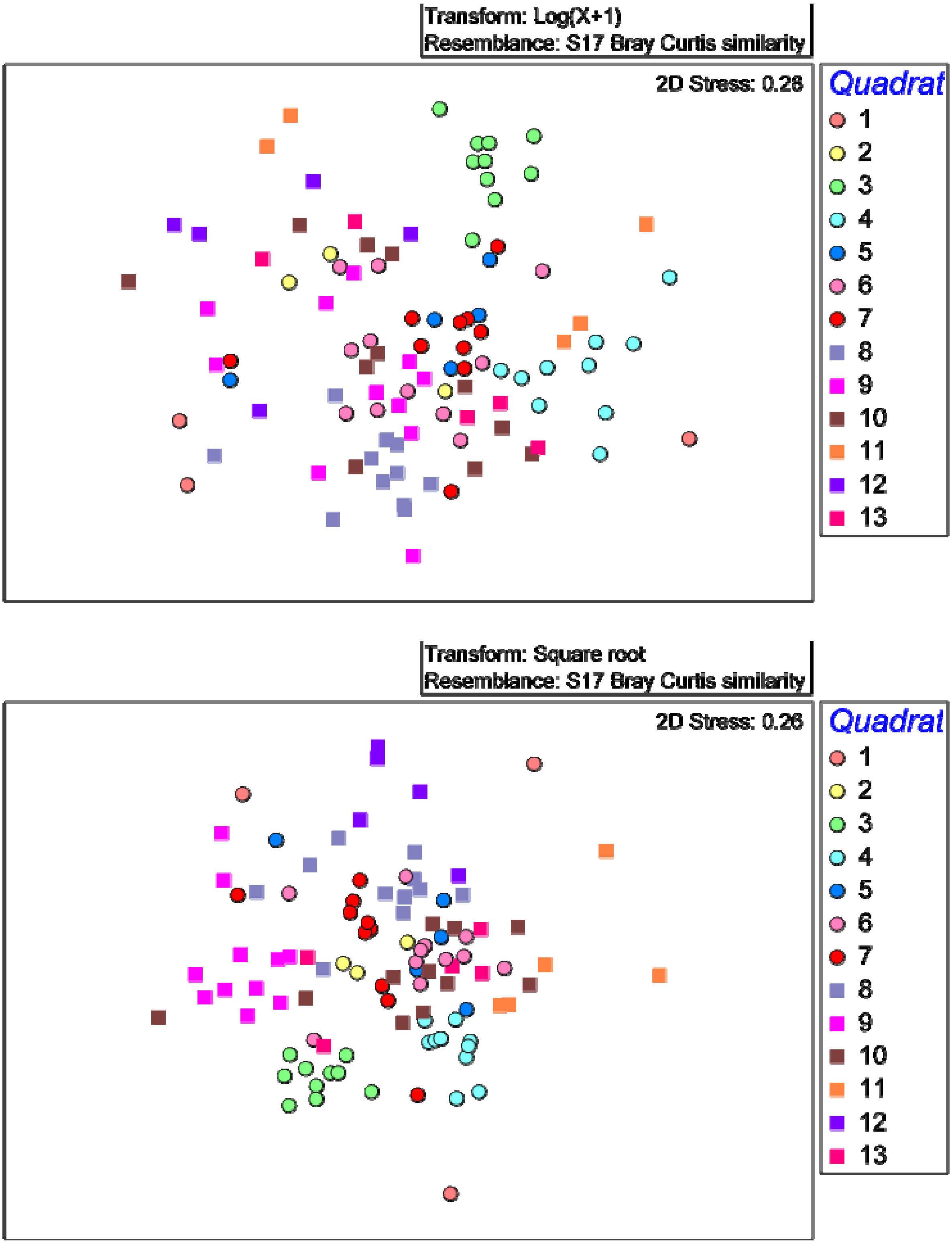


Figure 3.22 MDS plots of sponge and anthozoan community data (all surveyors, *in situ* records only, Phases 2 and 3 only) from Auliston transect quadrats, by quadrat. Square and round symbols aid identity of the quadrats, but also distinguish the two halves of the transect. a) Top plot: Counts data. b) Bottom plot: % cover data.

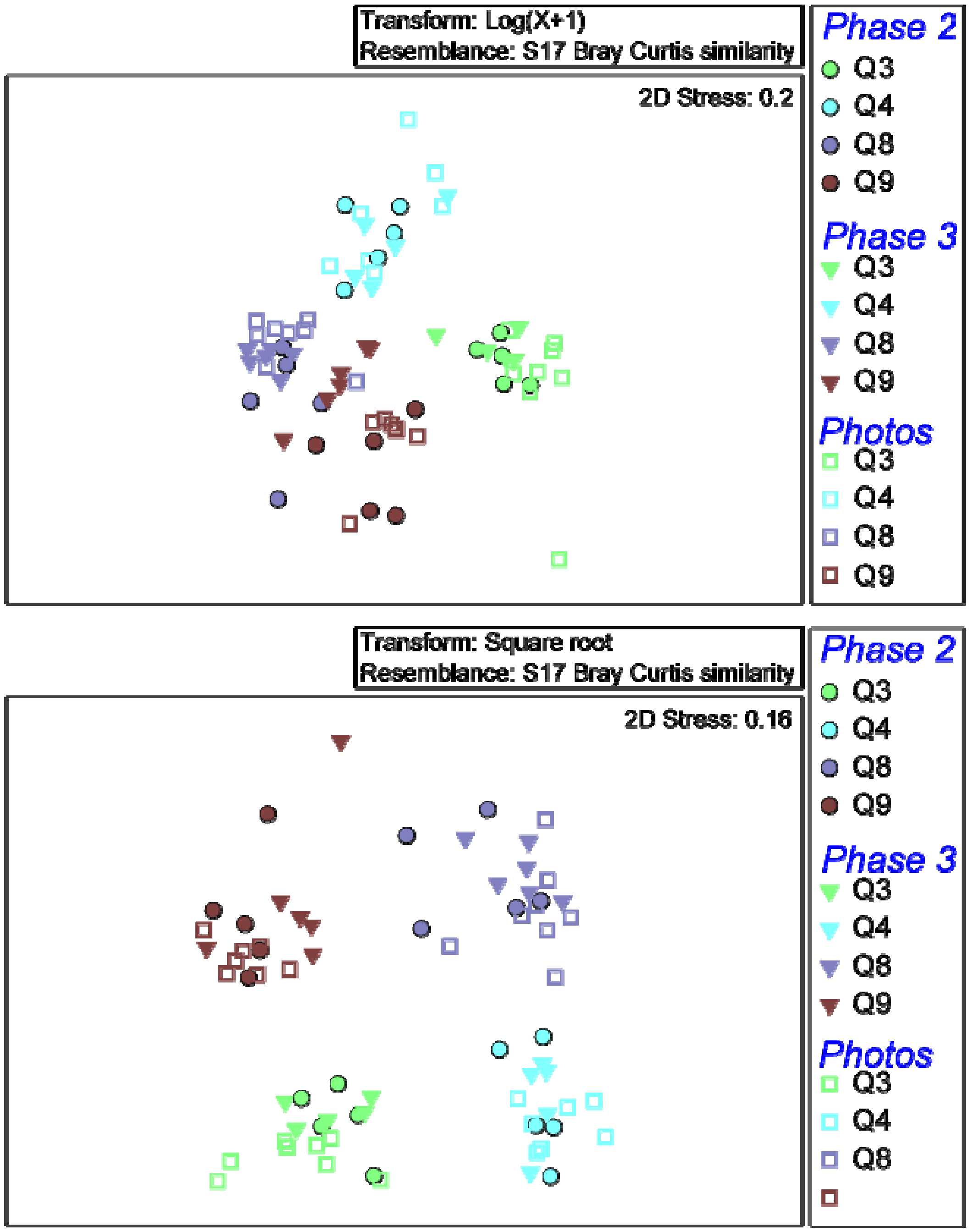


Figure 3.23 MDS plots of sponge and anthozoan community data from Auliston transect quadrats, by survey phase. Examples from four quadrats. a) Top plot: count data. b) Bottom plot: % cover data.

3.4.3 Species richness

In situ *records*

Figure 3.24a shows that the number of taxa recorded *in situ* by the surveyors varied considerably within each quadrat. [Note that Phase 1 data was excluded here as a number of species were not included in the phase 1 surveys]. The worst case is for Q10, where the number of recorded taxa ranged from two to ten, and it is clear that there was a notable difference in recording from this quadrat between Phases 2 and 3. As with the Lochaline algae, the number of taxa recorded generally increased as the level of training and familiarity increased. Consistency between surveyors also improved slightly, but was often still poor in Phase 3.

The same data is categorised by individual surveyors in Figure 3.24b and shows that there was little surveyor bias in the number of species recorded. However, this was not the case in Phase 1 (not shown in Figure 3.24), when the average number of taxa varied considerably between surveyors and surveyor F recorded on average more than twice as many taxa as surveyor B. It is therefore very likely that training reduced surveyor bias in this case.

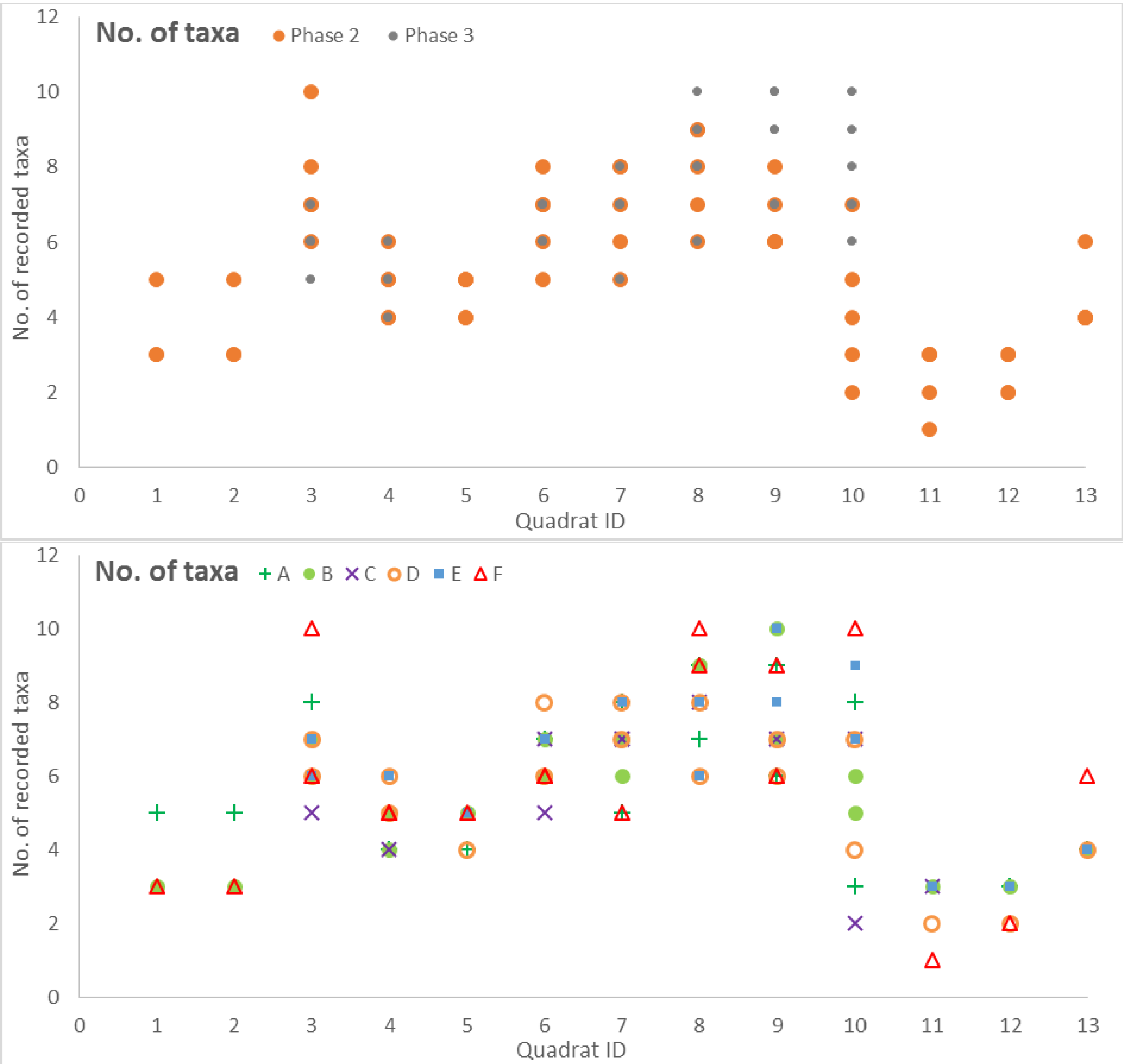


Figure 3.24 Number of taxa recorded *in situ* per quadrat in 13 fixed quadrats on the Auliston transect; Top: by survey Phase (2 and 3 only); and Bottom: by surveyors (A to F).

Figure 3.25 shows that the average number of taxa recorded increased slightly over the course of survey dives in Phase 1, fluctuated up and down in Phase 2 and reduced slightly in Phase 3. A similar pattern was shown at Lochaline (Section 3.3.3) and suggests some effect of recording fatigue.

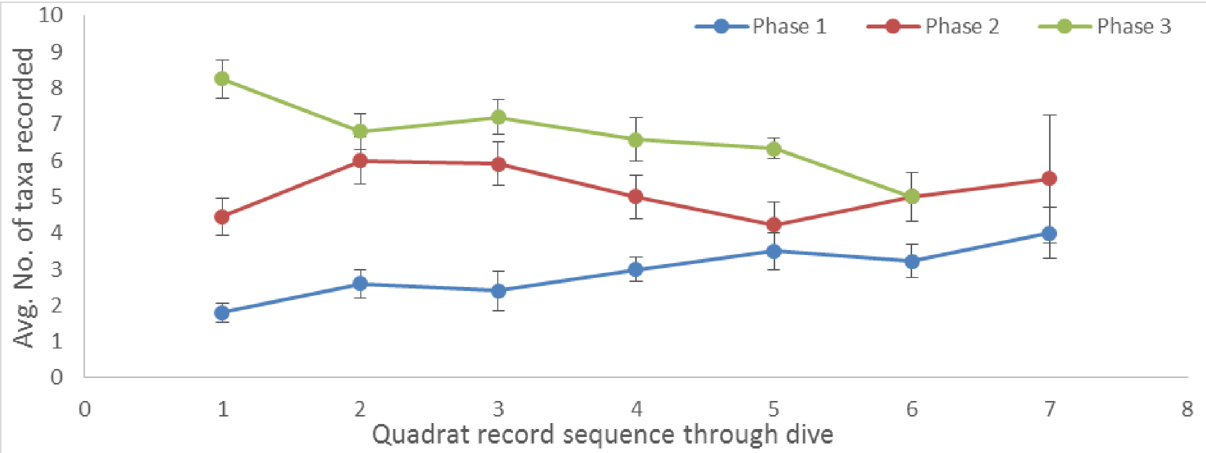


Figure 3.25 Average number of taxa recorded per quadrat against the sequential order in which they were recorded by each surveyor during a dive, by survey phase. Includes data from 161 records (13 fixed quadrats, six surveyors). Standard error bars are given for each average.

Photographic records

Figure 3.26 shows that the variability in the photo data is greater than that from the *in situ* survey records, as also shown by the Lochaline data, and that the average number of species recorded was generally slightly lower. Surveyor bias is more evident in the Auliston data, but this is primarily due to the records of Surveyor H, who recorded the fewest taxa in almost every quadrat and was not present on the fieldwork. Surveyor G, who was also not present on the fieldwork, recorded numbers of taxa from photographic quadrats that were within the same range as the other surveyors that had been in the field.

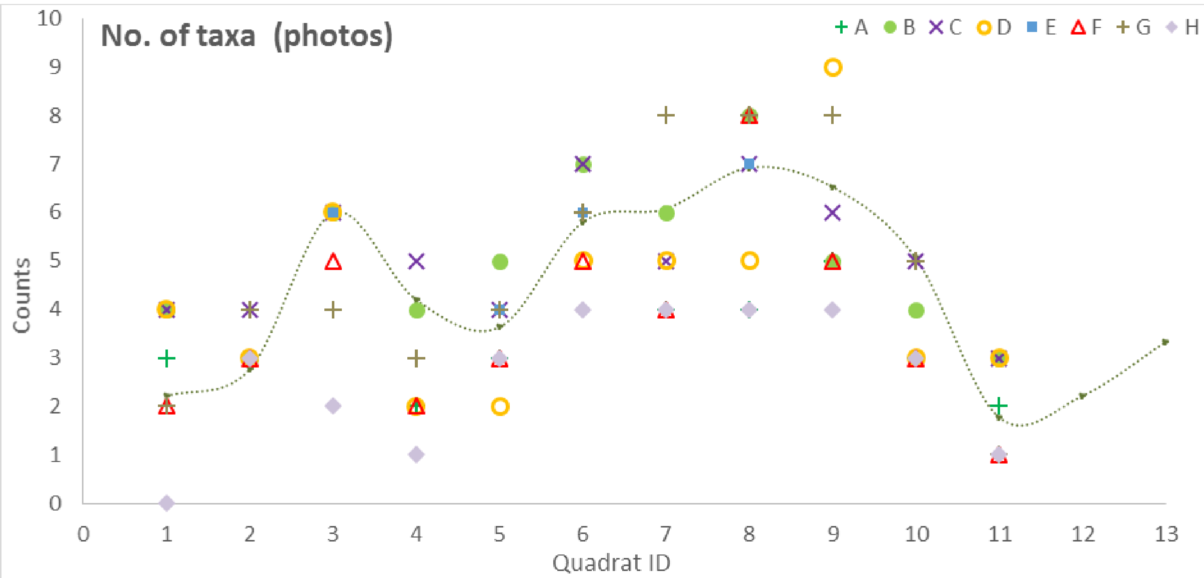


Figure 3.26 Number of taxa per quadrat recorded from photographs of 13 fixed quadrats on the Auliston transect by eight surveyors (A to H). Dashed line = average abundance of all *in situ* survey records.

3.4.4 Individual taxa

Table 3.9 and Table 3.10, and Figure 3.27 to Figure 3.36 show the variability in recorded abundances for selected individual taxa on the Auliston Point transect. Table 3.9 also includes subjective scales (1 to 5) of the ease of identification and conspicuousness for each taxa. The following paragraphs highlight some of the most notable features.

Table 3.9 Range of average recorded abundance (minimum to maximum averages by surveyor) and recording characteristics (ID and Con.) of taxa (Phases 1 to 3) in Auliston *in situ* quadrat survey records. ID = ease of identification scale; Con. = conspicuousness scale. Both scales range from 1 to 5, where 1 = very difficult to identify / very inconspicuous.

	Counts			**% cover**				
Entity	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 1**	**Phase 2**	**Phase 3**	**ID**	**Con.**
Porifera: Encrusting	2.8 - 8.8	5.5 - 10.6	8.4 – 14.0				4	3
Porifera: Massive	0 - 0.7	0.2 - 1.7	1.14 - 2.8				3	4
Porifera: Globular	0 - 0.3	0 - 0.3	0 - 0.1				4	4
Porifera: Pedunculate	0 - 0.5	0 - 0.3	0 - 1				4	4
Porifera: Tubular	0 - 0.08	0 - 1.6	0 - 0.3				5	3
Porifera: Repent	0 - 0.2	0 - 0.2	0 - 0				4	4
Porifera: Arborescent	0 - 0.2	0 - 0.2	0.3 - 0.4				5	5
Porifera: Papillate	0 - 0	0 - 1.3	0.6 - 2.8				4	4
Porifera (orange enc)	1.8 - 4	0.5 - 4.4	2.2 - 6.6		0.9 - 3.5	0.9 - 6.1	3	3
Porifera (yellow enc)	0.8 - 1	0.7 - 5.6	2.3 - 9.3		0.3 - 2.6	0.71 - 2.8	3	3
Porifera (other enc)	0 - 0	0.09 - 2	0 - 1		0.08 - 1.7	0 - 3	3	2
Porifera (orange cushion)	1.5 - 1.5	0 - 1.3	0 - 2.7		0 - 0.8	0 - 2.1	3	2
Clathrina lacunosa	0 - 0	2 - 2	0 - 0.8		0.1 - 0.1	0 - 0.04	5	1
Sycon ciliatum	0 - 0	1 - 1.7	0 - 0.6		0.1 - 0.1	0 - 0.06	5	2
Suberites carnosus	0 - 0.3	0.09 - 0.3	0 - 0.3		0.09 - 1.3	0 - 1.9	5	5
Polymastia	0 - 0	0 - 0	0.4 - 2.8		0 - 0	0.01 - 0.6	3	3
Stelligera stuposa	0 - 0.08	0 - 0.3	0.3 - 0.4		0 - 0.5	0.29 - 1.4	5	5
Myxilla incrustans	0.08 - 0.6	0.2 - 3.2	0.3 - 1.3		0.03 - 6.5	0.72 - 6.7	3	4
Iophon	0 - 1.6	0 - 0.6	0 - 1		0 - 2.5	0 - 4.4	2	2
Hymedesmia paupertas	0 - 0.4	0.09 - 1.3	0.7 - 1.7		0.02 - 1.7	0.3 - 1.3	5	3
Aplysilla sulfurea	0 - 0	0 - 0	0 - 1.7		0 - 0	0 - 0.4	3	4
Alcyonium digitatum	0 - 0.7	0 - 0.6	0 - 0.6	0 - 1.3	0 - 0.7	0 - 0.06	4	4
Alcyonium glomeratum	0 - 0.4	0 - 0.9	0.1 - 1.3	0 - 1.2	0 - 3.8	0.01 - 3.3	5	5
Parazoanthus anguicomus	3.9 - 17	0 - 9.3	0 - 21.6	0.5 - 2.1	0 - 2.3	0 - 2.9	5	4
Protanthea simplex	0.08 - 0.6	0 - 0.5	0 - 0.4	0.01 - 0.8	0 - 0.7	0 - 1.1	5	5
Sagartia (agg)	0 - 0.4	0 - 0.6	0 - 2.2	0 - 0.04	0 - 0.1	0 - 0.3	4	3
Hormathia coronata	0 - 0.2	0 - 0.2	0 - 0.6	0 - 0.2	0 - 0.09	0 - 0.3	3	3
Caryophyllia smithii	1.17 - 1.46	0.5 - 1.64	1 - 1.67	0.07 - 0.78	0.25 - 0.84	0.04 - 1.3	5	4

Note: Sagartia (agg): *S. elegans*, *S. troglodytes* and *S.* spp. were very inconsistently recorded, so have been aggregated to assess consistency at the genus level.

Table 3.10 Average abundance (counts and % cover from *in situ* and photo records) and frequency of photo records by surveyor for selected taxa (most frequently recorded) on Lochaline wall transect.

	Average count		**Average %**		**Frequency of records by surveyor - from photos**								
Entity	***In situ***	**Photos**	***In situ***	**Photos**	**Freq**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Encrusting sponge	6.85	6.78			78	11	10	10	11	4	11	11	10
Massive sponge	0.77	0.81			36	5	8	1	7	1	5	6	3
Globular sponge	0.08	0.05			3		1	1				1	
Pedunculate sponge	0.14	0.06			5				1	2			2
Tubular sponge	0.12	0.04			3							2	1
Repent sponge	0.03	0.04			3		1	2					
Arborescent sponge	0.14	0.11			7		1	1	1	1	1	1	1
Papillate sponge	0.38	0.12			4		1	1		1	1		
Porifera (orange enc)	2.95	4.05	2.14	1.9	73	11	11	10	10	3	11	8	9
Porifera (yellow enc)	2.44	2.31	1.04	0.73	47	10	8	6	6	3		10	4
Porifera (other enc)	0.67	0.49	0.87	0.7	20	2	1	7	3	1	2	2	2
Porifera (orange cushion)	0.47	1.64	0.29	0.6	11		7					4	
Suberites carnosus	0.14	0.12	0.43	0.24	10	1	1	1	1	2	1	1	2
Stelligera stuposa	0.14	0.14	0.3	0.32	8	1	1	1	1	1	1	1	1
Myxilla incrustans	0.56	0.31	2.86	2.24	20	1	2	2	2	1	7	3	2
Hymedesmia paupertas	0.49	0.33	0.42	0.19	18		4	2	4	2	3	3	
Haliclona		0.92		0.19	10			5	3			2	
Aplysilla sulfurea	0.8	1	0.2	0.49	7				1	2	2	2	
Alcyonium digitatum	0.3	0.19	0.2	0.05	12	3	1	3	1	2		2	
Alcyonium glomeratum	0.43	0.4	0.91	0.59	18	1	5	2	3		3	2	2
Parazoanthus anguicomus	6.71	12.16	0.91	1.19	7	1	1	1	1	1	1	1	
Protanthea simplex	0.17	0.28	0.23	0.42	8	1	1	1	1	1	1	1	1
Caryophyllia smithii	1.37	1.23	0.6	0.54	50	7	8	6	6	3	7	7	6

Encrusting sponge

Encrusting sponges were separated into three colour categories: *orange*, *yellow* and *other*. Orange encrusting sponges commonly occur on tide-swept sublittoral rock, and include a number of species that cannot be reliably identified *in situ* to species or even genus. Patches were frequent in most of the fixed quadrats on the Auliston transect. However, many of the patches were small and there was considerable variability in the counts made by different surveyors and on different occasions (Figure 3.27). As the colour was also variable, there may also have been some confusion between these and the yellow crusts. Training and familiarisation did not improve the consistency of the counts, and possibly it slightly increased the number of patches recorded as the surveyors saw more small patches. Estimates of % cover were also very variable, with much of the variability due to surveyor bias (highest estimates by surveyor F, lowest by surveyor A), and again there was no notable improvement in consistency.

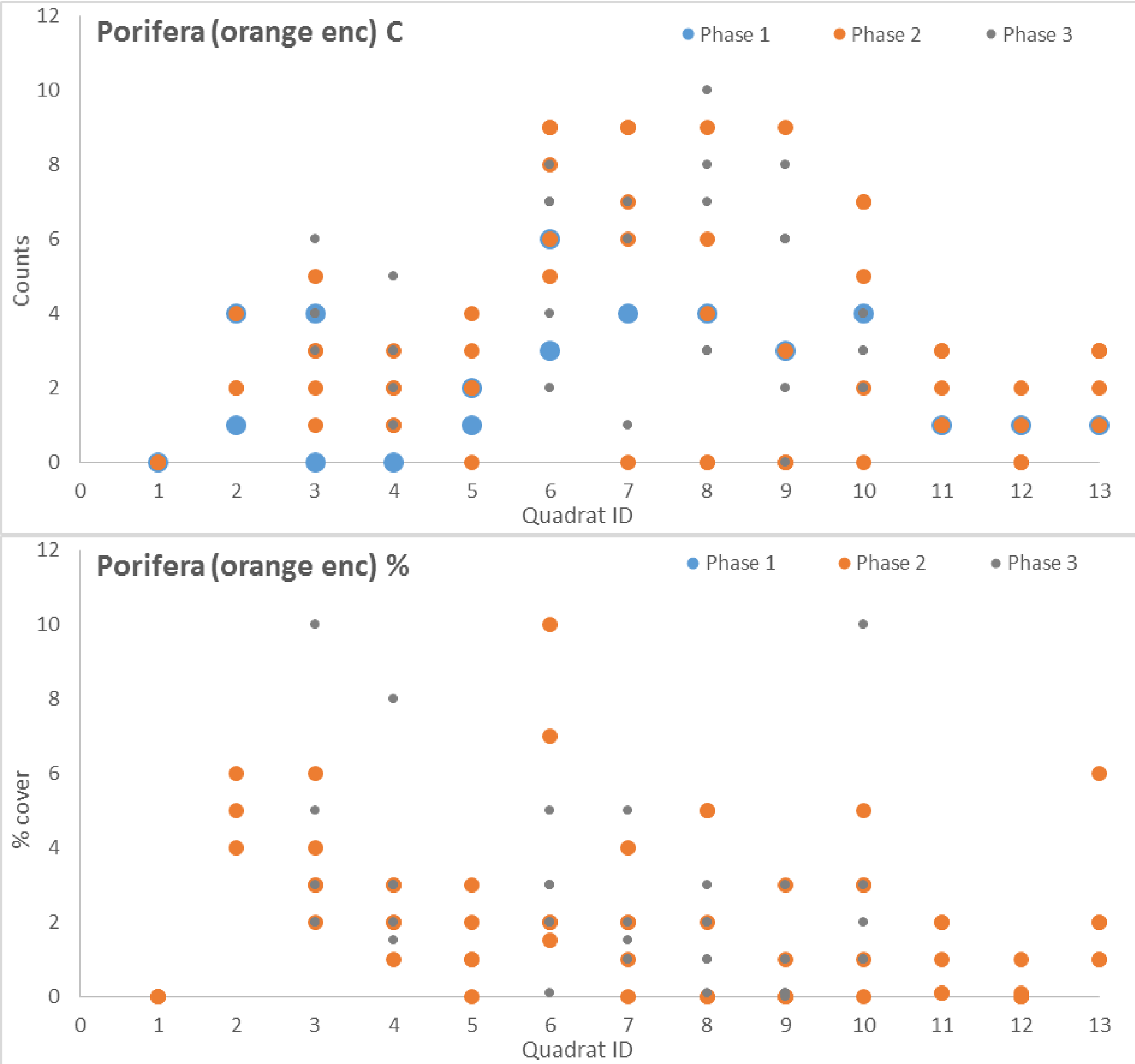


Figure 3.27 Records of abundance of encrusting orange sponge by three *in situ* survey phases in 13 fixed quadrats on the Auliston transect. Six surveyors. a) Top: counts, b) Bottom: % cover.

Surprisingly, given the small size of many of the patches, the counts of orange crusts from the photographs were generally higher than from *in situ* recording, possibly because photo analysis allowed more time for searching. However, variability was still very high. Estimates of % cover were more consistent, but still greatly affected by surveyor bias.

Yellow sponge crusts are also common on sublittoral rock, though less than orange crusts. They were recorded from all of the fixed quadrats, but where numerous small patches were present (e.g. Q8), the variability in counts was very large. Again, there were generally higher counts in Phase 3, as surveyors increasingly observed more in each quadrat, but consistency of counts did not improve with training. However, consistency of % cover estimates did improve slightly and surveyor bias was much less apparent than for the orange crusts, possibly because % cover values were dominated by the large, conspicuous, yellow patches.

Records from photos showed a similar distribution pattern to the *in situ* records, with slightly higher consistency of both counts and % cover. The latter estimates were mostly lower than the *in situ* records.

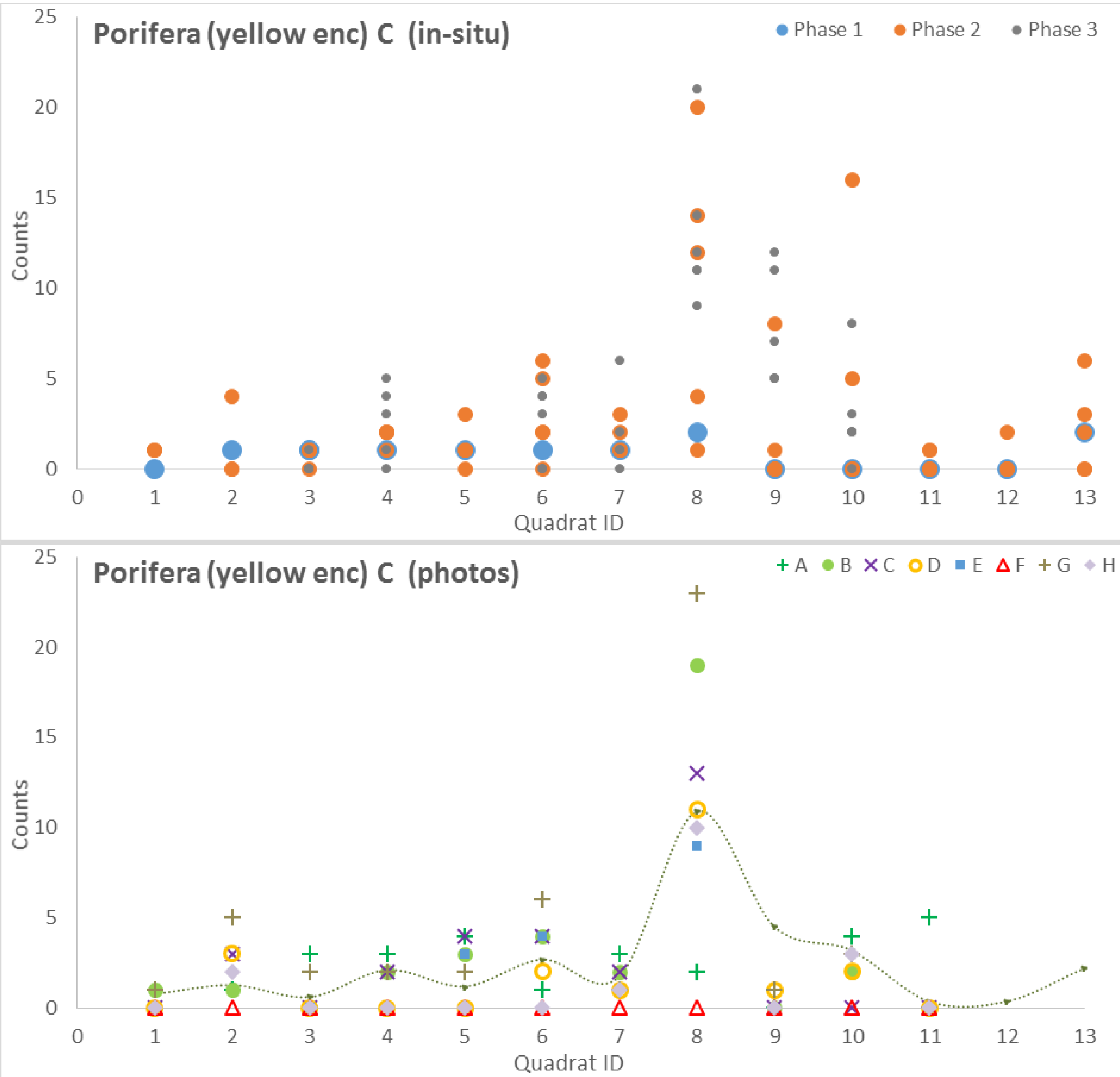


Figure 3.28 Records of abundance of encrusting yellow sponge in 13 fixed quadrats on the Auliston transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Recorded abundances (both counts and % cover) of *other* encrusting sponges were very variable, with consistency becoming clearly worse in Phase 3. Some surveyors recorded more in Phase 3, while others recorded far fewer, possibly because they were assigning them to other species (e.g. *Hymedesmia*). Records from photographs were similarly very variable and were in much the same range as the *in situ* abundances.

To assess whether the separation into colour categories was causing unnecessary confusion and reducing consistency, the encrusting sponge data (excluding the sponge morphology counts) were aggregated (summed) across all of the colour categories. This still showed considerable variability and no improvement in % cover estimates (Figure 3.29b) with familiarity and training, though there was greater consistency in counts (Figure 3.29a). Considerable surveyor bias was also still apparent.

Records from photos showed a similar distribution pattern to the *in situ* records, with slightly higher consistency of both counts and % cover. There was also less surveyor bias, though experienced surveyor F still tended to record the highest abundances.

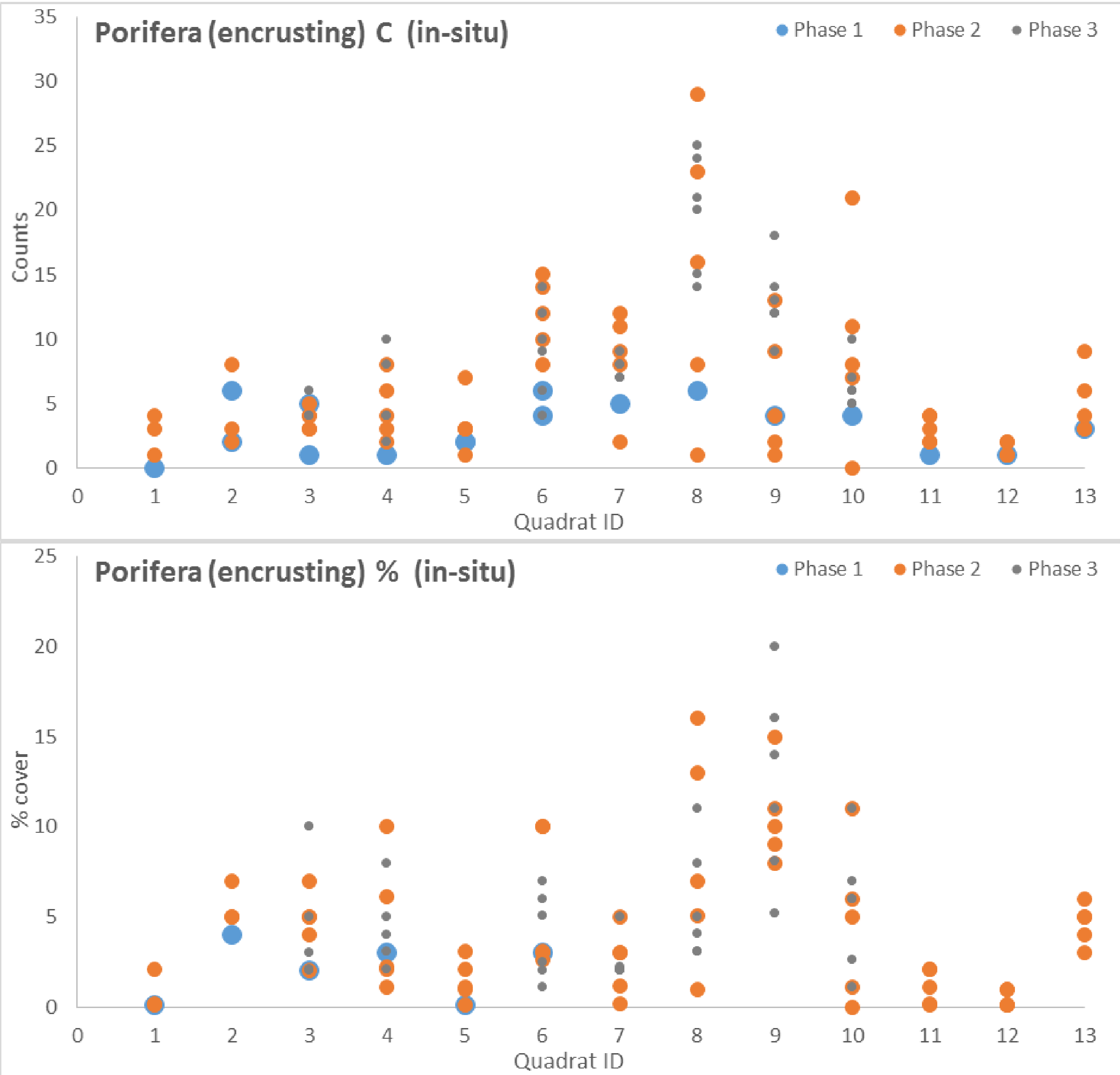


Figure 3.29 Records of abundance of encrusting sponge by three *in situ* survey phases in 13 fixed quadrats on the Auliston transect. Six surveyors. a) Top: counts; b) Bottom: % cover.

Myxilla incrustans

This is a commonly occurring sponge with a fairly distinctive texture but variable in colour that forms colonies with a massive or encrusting morphology. Two large colonies (>5% of the quadrat) were recorded consistently by all the surveyors from two quadrats, but estimates of % cover varied moderately (Figure 3.30). Estimates generally decreased with training, but were still variable. Small colonies were recorded *in situ* from a number of quadrats, but identification is more difficult in small colonies and most of these records were by just two surveyors (A and F). Whether those surveyors had become sufficiently familiar with occurrence of the species, or if their records were misidentifications is unclear.

The two large colonies in Q3 and Q9 were also consistently identified from the photographs by most surveyors (uncharactersitically not by surveyor A); and estimates of their % cover varied less than the *in situ* estimates. There were some, but fewer, records of small colonies from the photographs but only by surveyor F.

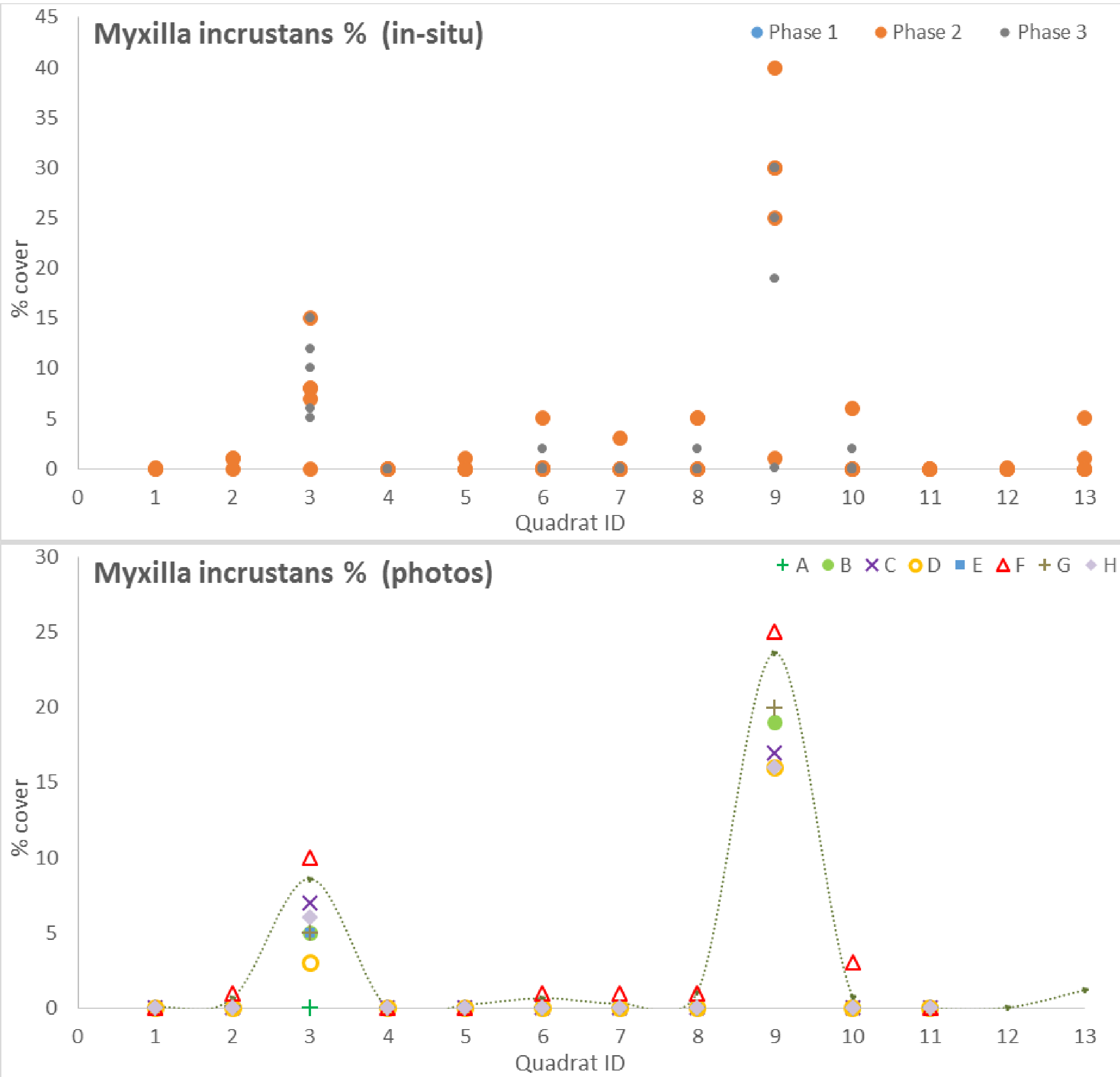


Figure 3.30 Records of abundance of *Myxilla incrustans* in 13 fixed quadrats on the Auliston transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Hymedesmia paupertas

This is a distinctive, blue, sponge with circular marks that forms colonies with a massive or encrusting morphology. Numerous small colonies were recorded, particularly from Q3 and Q4, but counts varied considerably. Recognition of the sponge improved with training, so that all of the surveyors were recording it by Phase 2, but counts still varied considerably in Phase 3. As all of the colonies were small, the estimated % cover was also fairly small. Estimates in Phase 2 still varied greatly, but improved with training. Surveyor bias also improved with training and was not evident in Phase 3.

Records from the photographs showed a very similar pattern to the *in situ* records, but counts and % cover estimates were slightly lower as fewer colonies were discernible, and there was a notable surveyor bias. Some surveyors recorded many colonies, while others recorded very few or none at all.

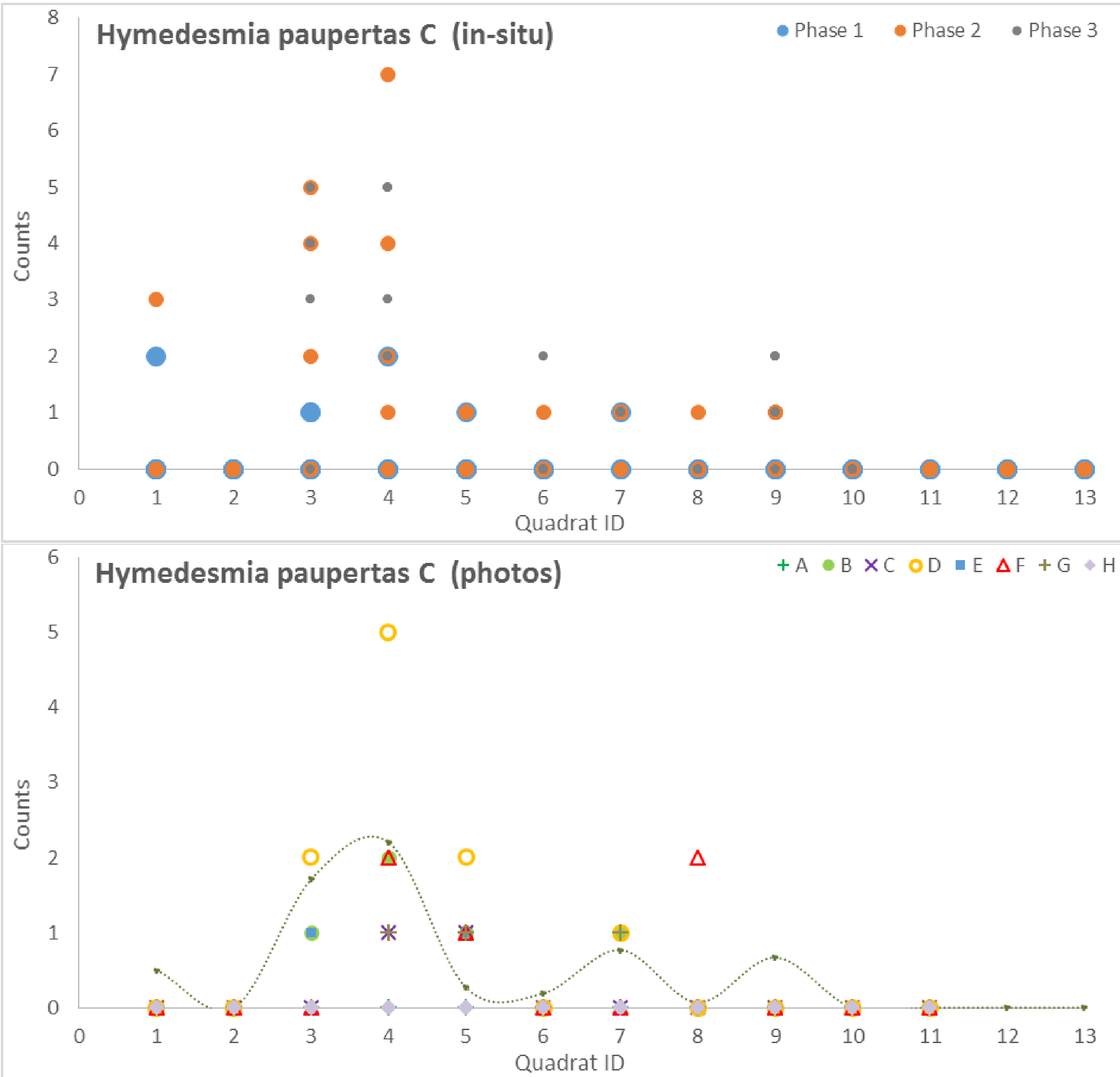


Figure 3.31 Records of abundance of *Hymedesmia paupertas* in 13 fixed quadrats on the Auliston transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Suberites carnosus

This is a conspicuous and distinctive pedunculate sponge with a velvety texture. Two individuals (one conspicuous, one less so) were recorded consistently, in Q6 and Q8, by most, but not all, surveyors. The missing records are presumed to be oversights rather than misidentifications. Additional records of other individuals were made by one of the surveyors, but not in Phase 3, so may have been misidentifications. Estimates of % cover of the individuals in Q6 and Q8 varied considerably and did not improve noticeably with training (Figure 3.32a).

The conspicuous *S. carnosus* individual in Q6 was recorded consistently from the photograph by all surveyors, though estimates of % cover still varied by more than might have been expected (Figure 3.32b). The smaller individual in Q8, however, was recorded by one of the surveyors (surveyor E) but not by the other seven.

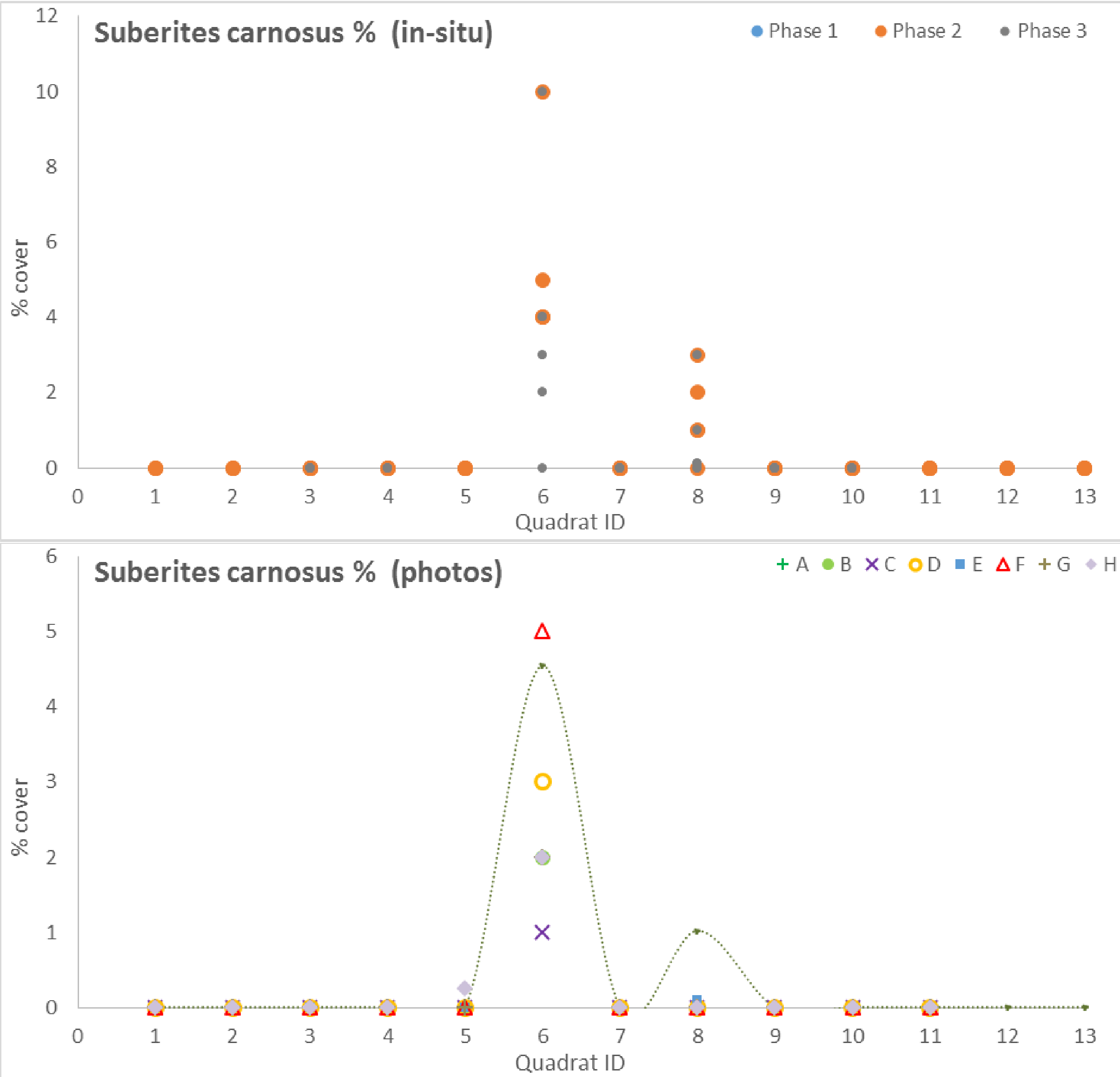


Figure 3.32 Records of abundance of *Suberites carnosus* in 13 fixed quadrats on the Auliston transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Stelligera stuposa

A conspicuous and distinctive branching sponge (arborescent morphology) that is similar to some other branching sponges, but none that were present on this transect. A conspicuous colony in Q8 was recorded by all surveyors (eight), and one or two inconspicuous colonies were noticed by some surveyors (Figure 3.33). Two surveyors did not record any in Phase 1, which may have been an oversight or because of lack of familiarity with the species. There was also a single record by surveyor F from Q3. Estimates of % cover for this erect species varied between 1% and 10% and did not improve with training.

All of the surveyors recorded *S.stuposa* from the Q8 photograph, as either one or two individuals and the estimates of % cover varied between 2% and 8%.

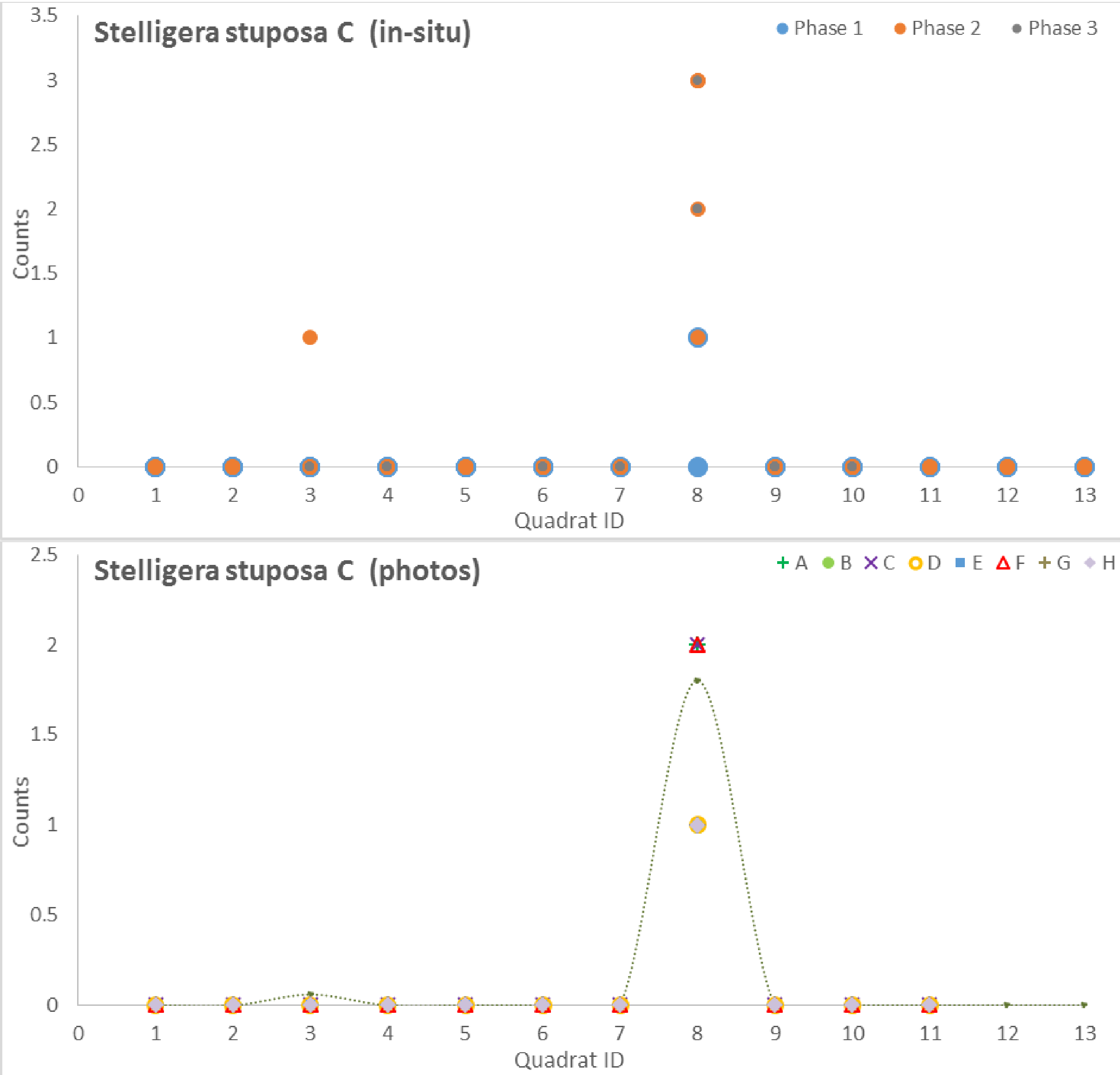


Figure 3.33 Records of abundance of *Stelligera stuposa* in 13 fixed quadrats on the Auliston transect. a) Top: *in situ* counts in three survey phases by six surveyors. b) Bottom: counts from photographs by eight surveyors. Dashed line = average abundance of all *in situ* survey records.

Alcyonium

This recording category includes two species of soft coral: the northern *A. glomeratum*, that can form large conspicuous red/orange colonies, and the more southern yellowish *A. digitatum*. However, colouration can vary and small colonies of *A. glomeratum* can be mistaken for reddish specimens of *A. digitatum*. Identification is easier when the colony is expanded. Another similar species, *A. hibernicum*, was also found on the transect in low numbers. The majority of records were recorded as *A. glomeratum*. The larger specimens, particularly in Q7 and Q9, were fairly consistently recorded as *A. glomeratum* (errors still occurred, but improved with training), but misidentifications between the three species probably occurred in some of the smaller specimens. Some of the smaller individuals were also not so conspicuous, so counts varied considerably (Figure 3.34) and did not notably improve with training. Estimates of % cover were typically variable for an erect species (e.g. Q7: ranging from 5 to 15%), but improved slightly with training.

Records from the photographs show a similar pattern to the *in situ* data, with fewer records of the smaller less-conspicuous colonies, but there was greater confusion between the two main species, even for larger specimens. Estimates of % cover were slightly better than *in situ*.

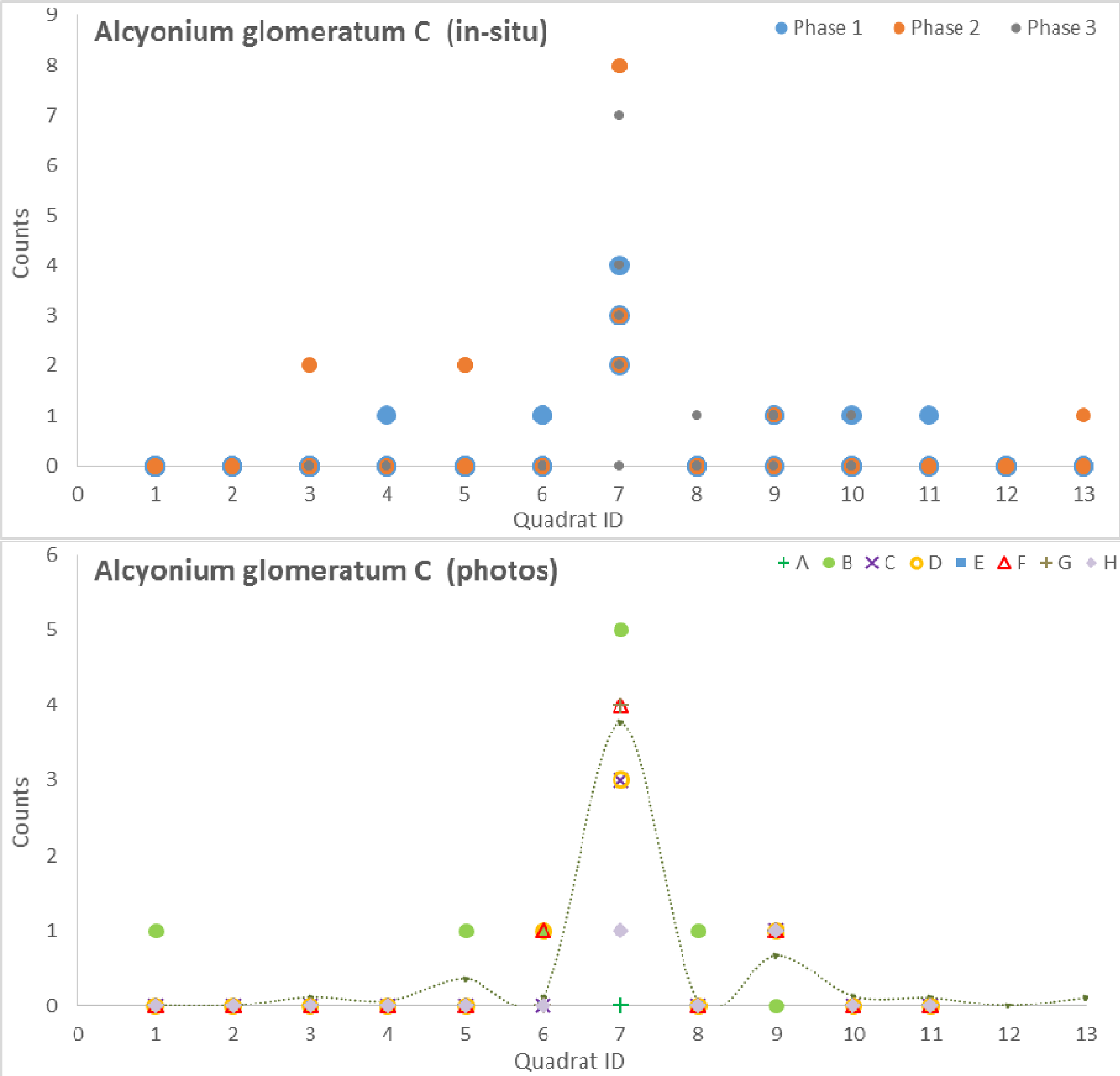


Figure 3.34 Records of abundance of *Alcyonium glomeratum* in 13 fixed quadrats on the Auliston transect. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by eight surveyors. Dashed line = average abundance of all *in situ* survey records.

Caryophyllia smithii

C. smithii was present in low numbers in almost every quadrat and, as for the Lochaline transect data (3.3.4), it was one of the most consistently identified species. Counts and % cover estimates varied because some individuals were small, and/or hidden (Figure 3.35a). There was no discernible improvement with training.

Records from the photos showed a very similar distribution to the *in situ* data, with some greater consistency in counts and % cover estimates, but there was still an unexpectedly large amount of variability in the counts for Q8 (Figure 3.35b).

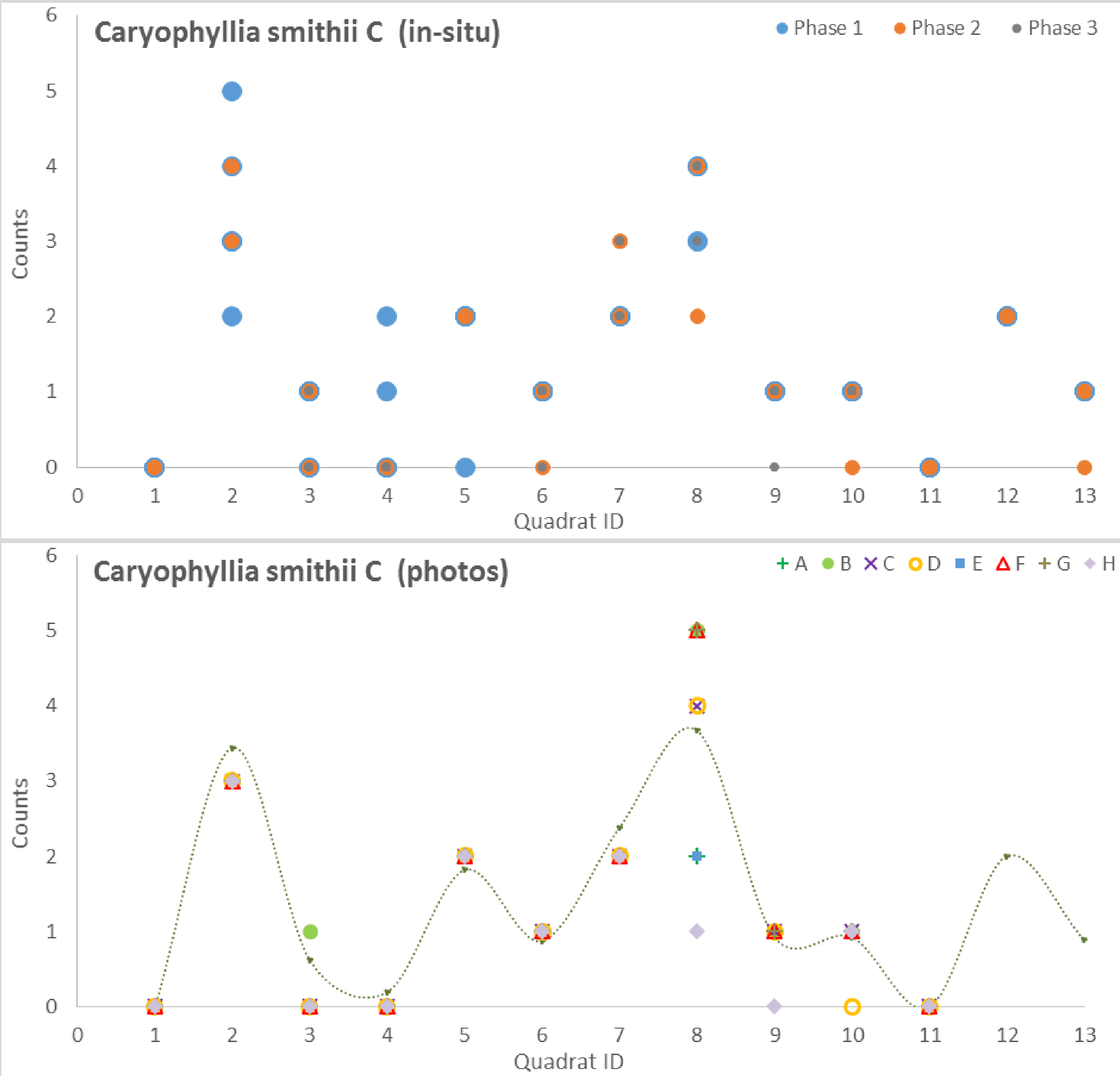


Figure 3.35 Records of abundance of *Caryophyllia smithii* in 13 fixed quadrats on the Auliston transect. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by eight surveyors. Dashed line = average abundance of all *in situ* survey records.

Parazoanthus anguicomus

This is a small, bright white, colonial anemone that is very conspicuous and easy to identify when the polyps are open, but less so when contracted. Large numbers were present and consistently recorded from Q3, though counts varied considerably (Figure 3.36a) and were surveyor biased (lowest counts by surveyors A and D, highest by surveyor F). Estimates of % cover varied enormously (ranging from 3% to 25%) and were similarly biased by surveyor. Consistency of counts and % cover estimates improved with training, but the % cover estimates were still poor. It is assumed that the missing record by surveyor D in Phase 3 was an oversight (last quadrat of the dive). Small numbers (1 or 2 individuals) were inconsistently recorded in Q8 and Q10, possibly depending on whether the anemones were contracted or expanded.

Consistency of counts and % cover from photos were very similar to Phase 3 of the *in situ* recording (Figure 3.36b). Counts from photographs were also higher than those from *in situ* records, presumably because the surveyors had time to carry out a thorough count.

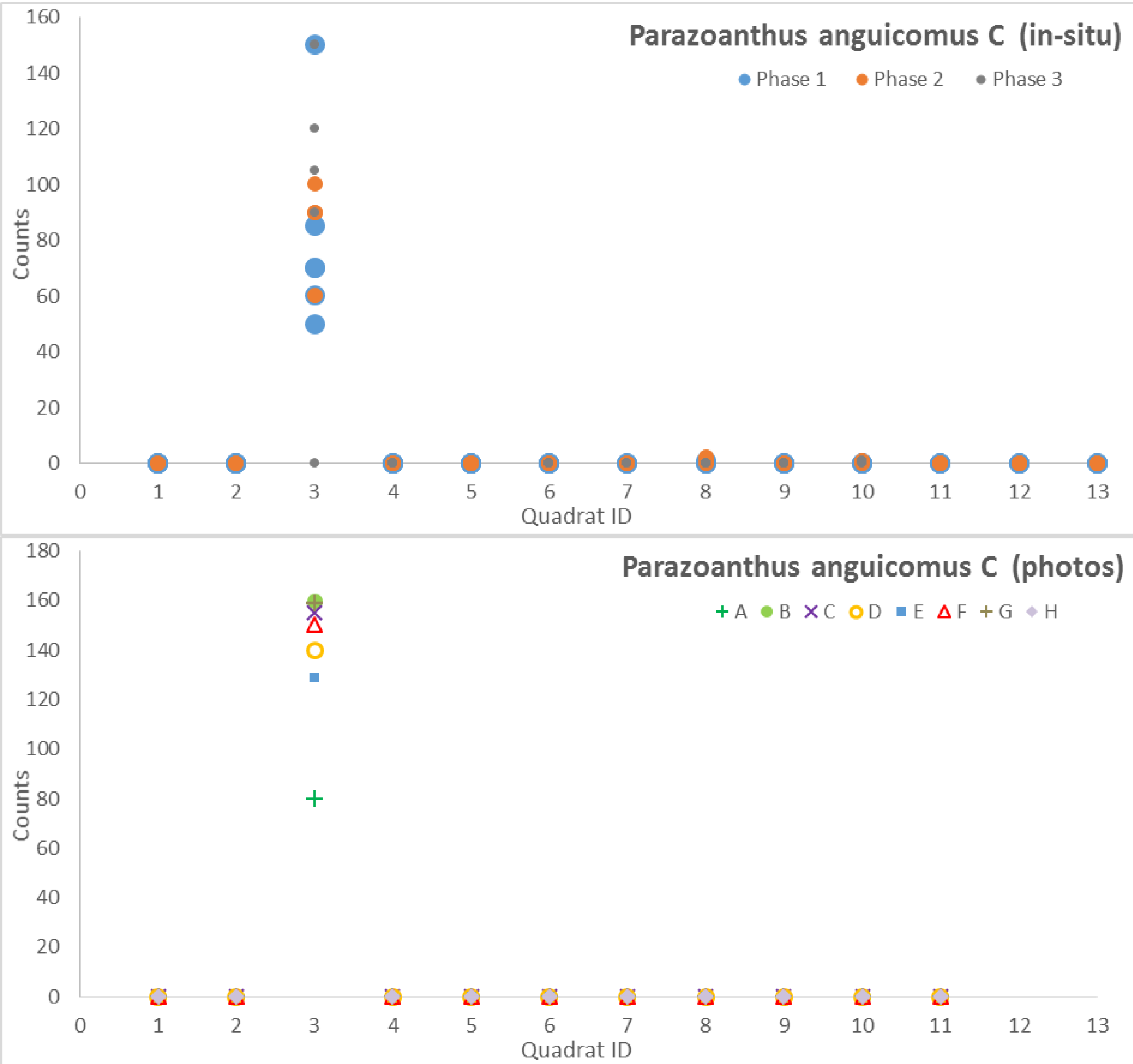


Figure 3.36 Records of abundance of *Parazoanthus anguicomus* in 13 fixed quadrats on the Auliston transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

3.4.5 Sponge morphologies

The ten standard morphologies (*sensu* Bell and Barnes 2001) that were used to categorise the sponges in this survey are illustrated in Figure 3.37. Two of them (flabellate and burrowing) were not represented on the Auliston transect, and some of them were only represented in one or two of the fixed quadrats.

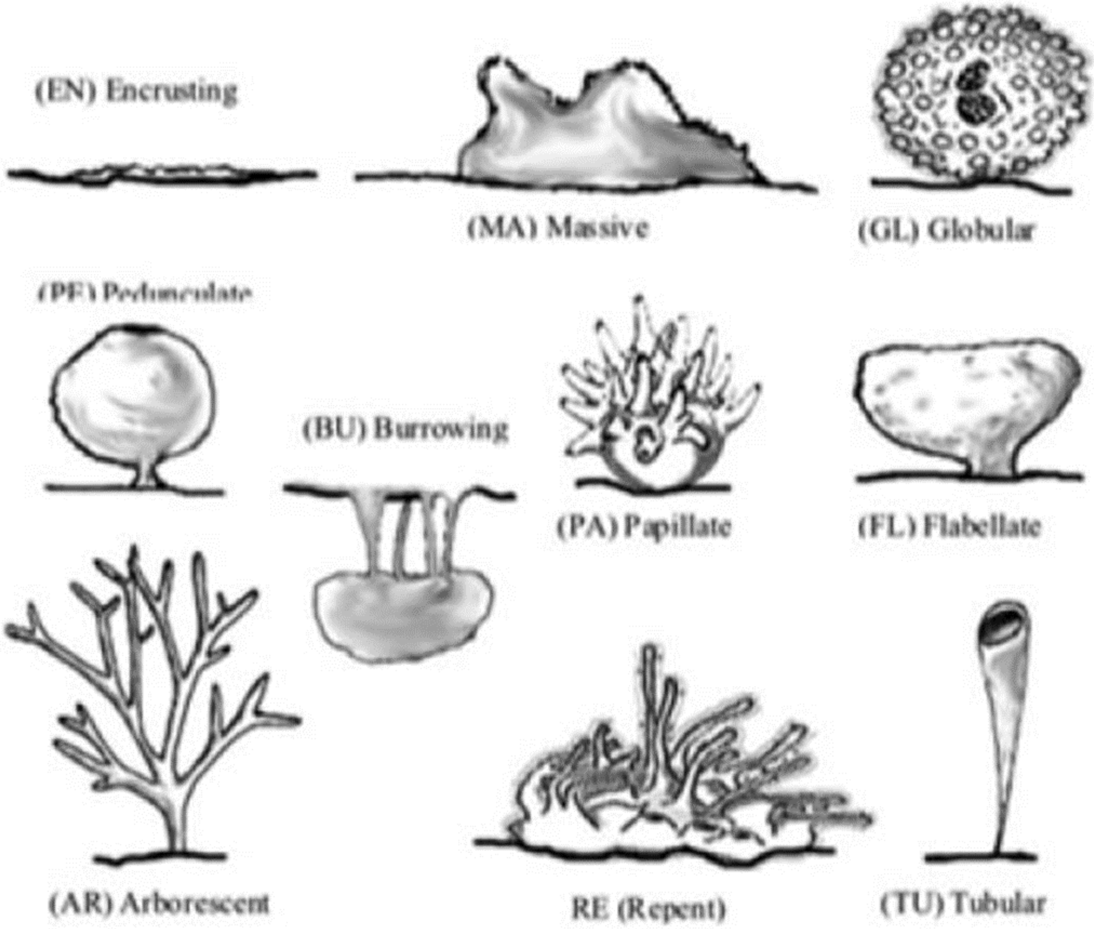


Figure 3.37 Morphological categories used to classify sponges (Bell & Barnes 2001)

Encrusting sponges

Encrusting sponges include a number of different species that cannot be reliably identified *in situ*, but are typically separated into broad colour categories in many sublittoral surveys (see Section 3.4.4). Aggregating them to all encrusting forms has resulted in an initially much greater variability in counts, but then a much greater improvement in consistency with training (Figure 3.38). Also, while there was some surveyor bias, it was not as obvious as it was in the counts of encrusting orange sponge, particularly after training.

There were, on average, slightly fewer counts of crusts from photographs compared to *in situ* records. Counts of crusts in the photographs were also slightly less variable than the overall *in situ* records, but more variable than the Phase 3 *in situ* records, suggesting that the improvements gained from training did not last the month between the fieldwork and the photo analysis.

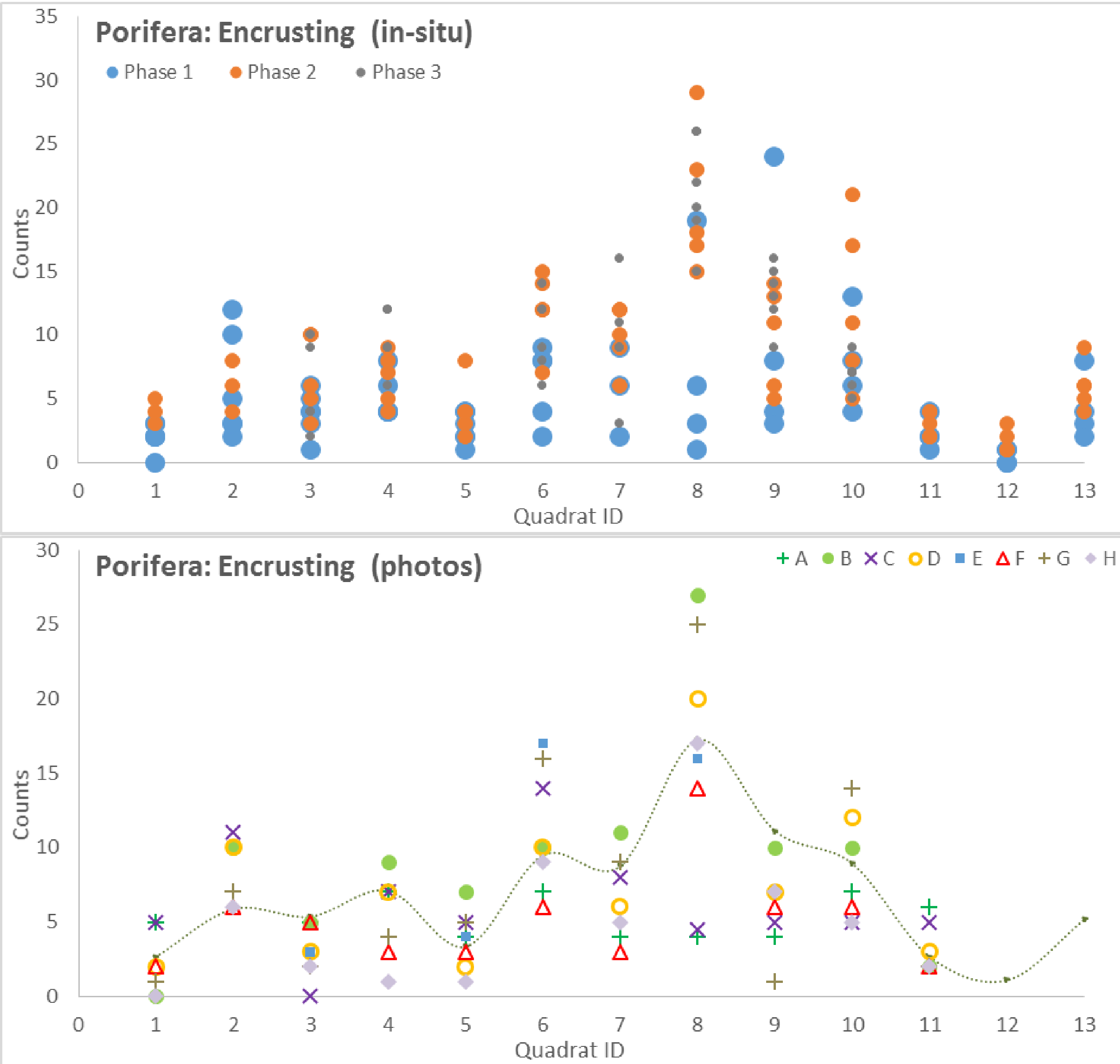


Figure 3.38 Counts of encrusting sponges in 13 fixed quadrats on the Lochaline transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Massive sponges

Given the small size of many of the sponge colonies it was sometimes difficult to distinguish between encrusting and massive morphologies and a protocol was devised to make this easier (see Section 3.2.5). This may have improved consistency between some surveyors, but not notably (Figure 3.39), and there was a significant amount of bias.

This bias, and the overall variability, is also seen in the records derived from the photographs.

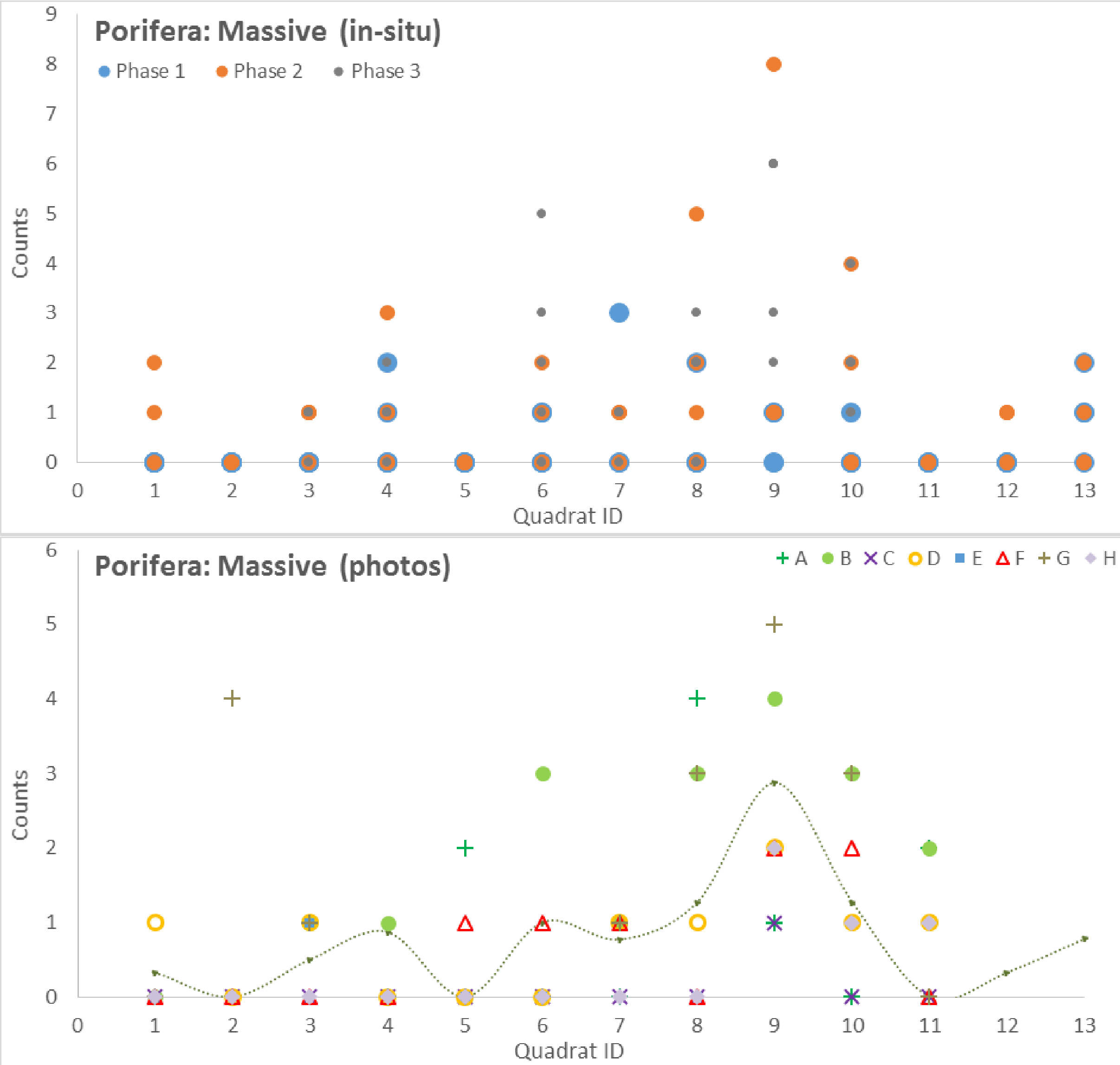


Figure 3.39 Counts of massive sponges in 13 fixed quadrats on the Lochaline transect. Multiple records by eight surveyors. a) Top: *in situ* records by three survey phases. b) Bottom: photo records by surveyor. Dashed line = average abundance of all *in situ* survey records.

Globular sponges

Records of globular sponges equated to *Suberites carnosus*, particularly in Phase 1 (Figure 3.40), but by Phase 3 many surveyors had recognised that *S. carnosus* has a short stalk and should therefore be considered pedunculate. However, the stalk is not conspicuous and could easily be overlooked.

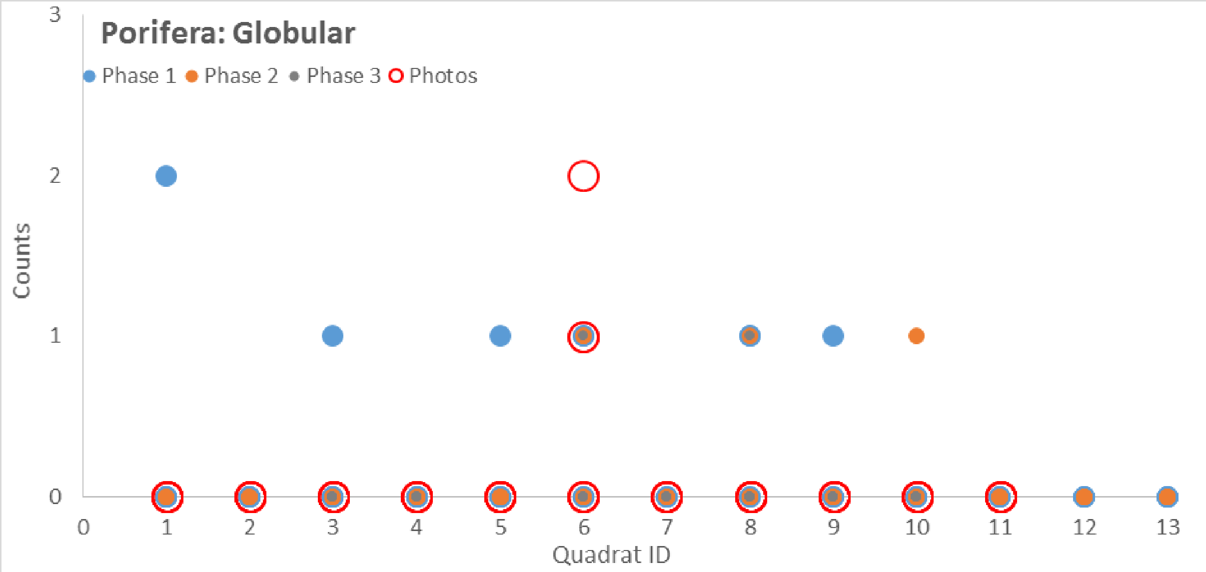


Figure 3.40 Counts of globular sponges in 13 fixed quadrats on the Lochaline transect by survey phase, including photo records. Multiple records by eight surveyors.

Pedunculate sponges

Records of pedunculate sponges equated to *Clathrina lacunosa* and *Suberites carnosus*, but some surveyors recorded *S. carnosus* as globular and continued to do so even after training. *C. lacunosa* is very small and was often not noticed by surveyors, which adds to the variability evident in Figure 3.41.

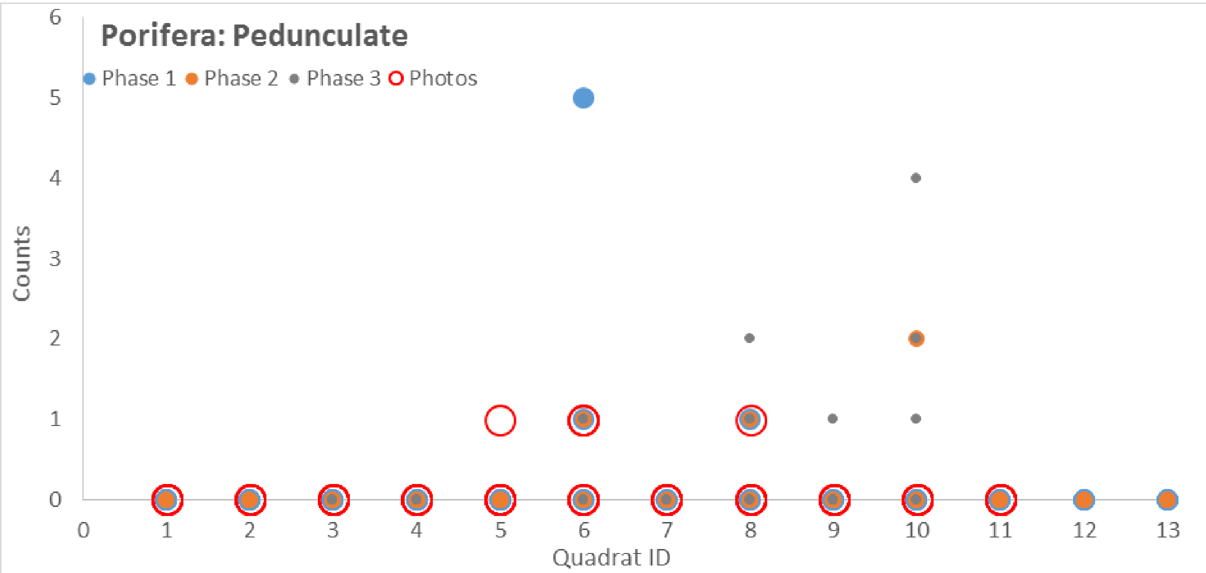


Figure 3.41 Counts of pedunculate sponges in 13 fixed quadrats on the Lochaline transect by survey phase, including photo records. Multiple records by eight surveyors.

Tubular sponges

Records of tubular sponges equated mainly to *Sycon ciliatum* and a few *Haliclona urceolus*, but sometimes there was no obvious match between a tubular morphology record and a species record. *S. ciliatum* and *H. urceolus* are small, so were not always noticed by surveyors.

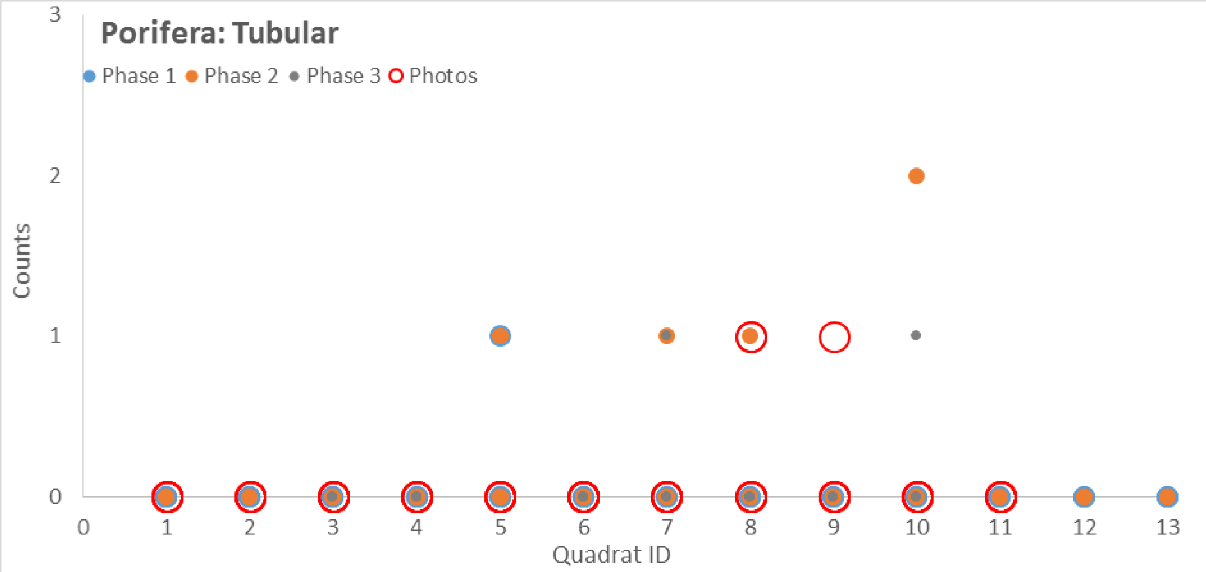


Figure 3.42 Counts of tubular sponges in 13 fixed quadrats on the Lochaline transect, including photo records. Multiple records by eight surveyors.

Repent sponges

Records of repent sponges equated mainly to *Leucosolenia*, but often there was no obvious match between a repent morphology record and a specific sponge record. *Leucosolenia* is often inconspicuous, so was often overlooked by surveyors.

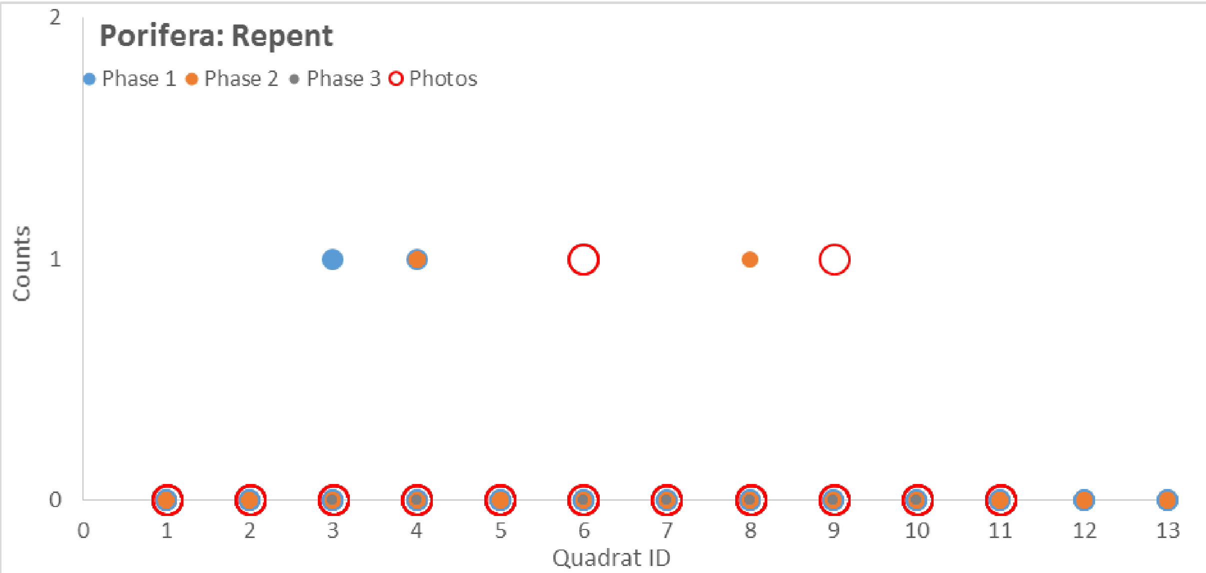


Figure 3.43 Counts of repent sponges in 13 fixed quadrats on the Lochaline transect, including photo records. Multiple records by eight surveyors.

Arborescent sponges

Records of arborescent sponges equated mainly to *Stelligera stuposa* and, as described in Section 3.4.4, the number of colonies in Q8 depended on whether the surveyor noticed the one or two inconspicuous ones as well as the large conspicuous one Figure 3.44. One surveyor recorded *S.stuposa* in Q8, but did not record arborescent morphology.

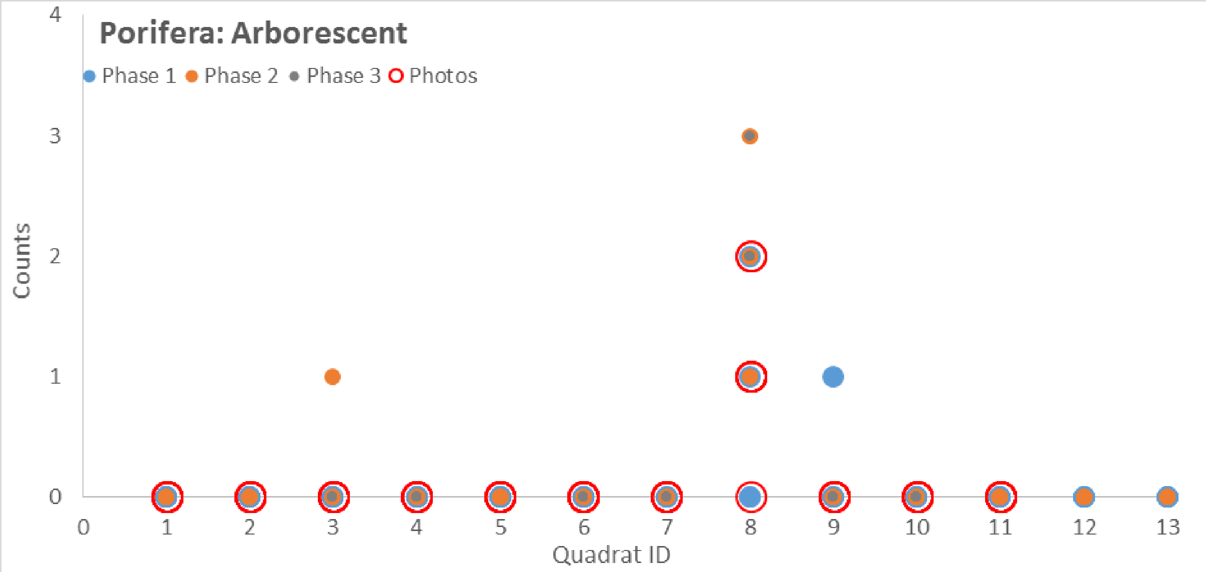


Figure 3.44 Counts of arborescent sponges in 13 fixed quadrats on the Lochaline transect, including photo records. Multiple records by eight surveyors.

Papillate sponges

Records of papillate sponges equated mainly to *Polymastia*, which was limited to a few small colonies that were not recognised by many surveyors until Phase 3 and were not strongly papillate. Counts therefore varied considerably (Figure 3.45) and indicated surveyor bias.

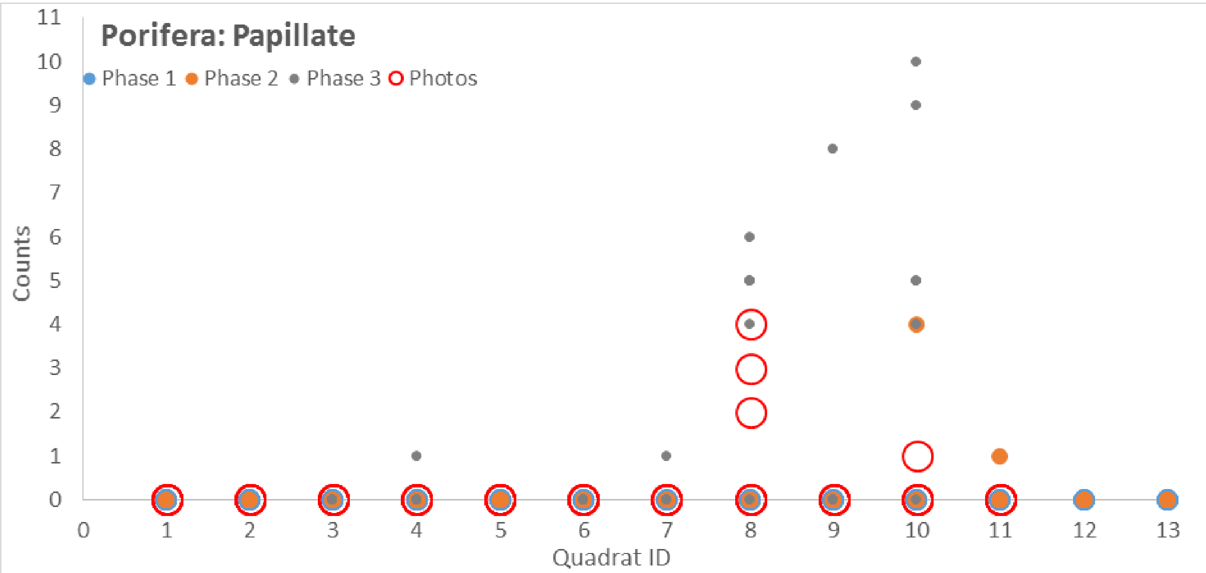


Figure 3.45 Counts of papillate sponges in 13 fixed quadrats on the Lochaline transect, including photo records. Multiple records by eight surveyors.

3.4.6 Recording time

The average time taken by a survey diver to survey a single quadrat *in situ* was 6 minutes 5 seconds (range: 2–15 minutes). Surveyor bias accounts for some of the variability (lowest average = 5 minutes 2 seconds (surveyor C); highest average = 7 minutes 47 seconds) (surveyor D). Another factor was that surveyors took longer on the first quadrats of the dive and less time on subsequent quadrats (the average recording time for 1st to 6th quadrat, was, respectively: 7.8, 7.2, 6.8, 6.0, 5.2 and 4.5 minutes).

There were a total of 18 dives on the Auliston transect, not including the reconnaissance and site establishment dives in July 2014. Full survey data (datasets A to C) were collected from 17 of those dives, producing 161 quadrat records = 9.47 quadrats per dive (from a pair of survey divers) or 4.7 quadrats per surveyor. The rate declined over the period of the survey: averaging 6.1 quadrats in the first third, 5.2 in the middle and 4.5 in the last third. There was also some surveyor bias, with averages ranging from 4.2 quadrats per dive (surveyor E) to 5.5 (surveyor B).

The equivalent average time for the photo-quadrat analysis was 6 minutes 56 seconds (range: 2–20 minutes) per quadrat, and surveyor bias was considerable (lowest average = 3 minutes 12 seconds (surveyor H); highest average = 11 minutes 32 seconds) (surveyor G). As with the Lochaline photoquadrats, the surveyors usually took most time over the quadrats they analysed first and less time for subsequent quadrats, but this was complicated by occasional breaks in identification effort and by the occasional use of identification guides.

3.5 General surveyor bias

A notable portion of the variability in abundance records described in the results for each taxon has been due to surveyor bias. While the pattern of bias is sometimes taxon specific, some surveyors appear to have more general biases. This has not been analysed in detail, but the average values in Table 3.11 and Table 3.12 show some strong biases in estimates of % cover and counts respectively, within each taxonomic group studied. There is a greater than twice the difference between the highest and lowest averages within most of the columns of both tables, except for counts of anthozoa. Some of the most notable biases include: high estimates of % cover for all groups and methods by surveyor F, high estimates of algae cover by surveyor C, low counts for most groups and methods by surveyor A, low counts for sponges from photos by surveyor H.

Table 3.11 Average % cover (and rank order), by surveyor, taxonomic group and survey method. Porifera and anthozoa records from Auliston transect. Algae records from Lochaline transect. Every value is the average of > 95 records (except * which are > 35 records).

	Porifera		**Anthozoa**		**Algae**	
Surveyor	***In situ***	**Photo**	***In situ***	**Photo**	***In situ***	**Photo**
A	0.75 (4)	0.54 (5)	0.33 (2)	0.31 (4)	1.17 (5)	0.92 (4)
B	0.84 (3)	0.55 (4)	0.29 (3)	0.16 (8)	0.96 (6)	0.91 (5)
C	0.54 (6)	0.58 (3)	0.26 (5)	0.43 (2)	1.67 (1)	1.56 (1)
D	0.64 (5)	0.62 (2)	0.21 (6)	0.20 (7)	1.44 (3)	0.90 (6)
E	0.91 (2)	0.40 (7)*	0.28 (4)	0.24 (5)*	1.28 (4)	1.22 (3)
F	1.32 (1)	0.92 (1)	0.47 (1)	0.52 (1)	1.46 (2)	1.28 (2)
G		0.39 (8)		0.21 (6)		
H		0.48 (6)		0.38 (3)		

Table 3.12 Average count (and rank order), by surveyor, taxonomic group and survey method. All records from Auliston transect. Every value is the average of > 95 records (except * which are > 35 records). [Excludes counts of *Parazoanthus anguicomus* which would have dominated the averages].

	Morphologies		**Porifera**		**Anthozoa**	
Surveyor	***In situ***	**Photo**	***In situ***	**Photo**	***In situ***	**Photo**
A	0.89 (4)	0.64 (6)	0.6 (5)	0.61 (6)	0.27 (3)	0.23 (7)
B	0.87 (5)	1.15 (2)	0.74 (2)	0.99 (2)	0.28 (2)	0.34 (2)
C	1.11 (2)	0.70 (5)	0.56 (6)	0.81 (4)	0.20 (6)	0.36 (1)
D	0.99 (3)	0.84 (4)	0.72 (3)	0.72 (5)	0.22 (5)	0.28 (6)
E	1.28 (1)	1.18 (1)*	1.08 (1)	1.00 (1)*	0.34 (1)	0.31 (3)
F	0.71 (6)	0.61 (7)	0.62 (4)	0.54 (7)	0.27 (3)	0.30 (4)
G		0.98 (3)		0.89 (3)		0.30 (4)
H		0.57 (8)		0.47 (8)		0.16 (8)

Calculating averages for each *in situ* survey phase was then used to assess the effect of training and familiarisation on surveyor bias. The results in Table 3.13 and Table 3.14 show that, within each column, the ratio between the highest and lowest averages reduced for sponges, morphologies and algae, suggesting reduced bias and therefore greater consistency. However, the ratio increased for anthozoa suggesting increased bias. Additionally, for some taxonomic groups and methods, the rank order of the surveyors does not change much with training, but it does for others.

Table 3.13 Average % cover (and rank order), by surveyor, taxonomic group and survey phase. Porifera and anthozoa records from Auliston transect. Algae records from Lochaline transect. Every value is the average of > 50 records.

	Porifera		**Anthozoa**		**Algae**	
Surveyor	**2**	**3**	**1**	**3**	**1**	**3**
A	0.72 (4)	0.79 (4)	0.34 (2)	0.22 (4)	1.53 (3)	1.04 (5)
B	0.77 (3)	0.94 (3)	0.29 (4)	0.37 (3)	1.00 (5)	1.15 (3)
C	0.21 (6)	0.69 (5)	0.13 (6)	0.42 (2)	1.78 (2)	1.60 (2)
D	0.69 (5)	0.51 (6)	0.16 (5)	0.20 (6)	2.26 (1)	0.89 (6)
E	0.83 (2)	1.06 (2)	0.30 (3)	0.22 (4)	1.36 (4)	1.15 (3)
F	1.29 (1)	1.35 (1)	0.35 (1)	0.85 (1)	0.98 (6)	1.63 (1)
Ratio (min/max)	6.1	2.7	2.6	4.2	2.3	1.8

Table 3.14 Average count (and rank order), by surveyor, taxonomic group and survey phase. All records from Auliston transect. Every value is the average of > 50 records. [Excludes counts of *Parazoanthus anguicomus*].

	Morphologies		**Porifera**		**Anthozoa**	
Surveyor	**1**	**3**	**1**	**3**	**1**	**3**
A	0.53 (3)	2.07 (1)	0.04 (5)	1.17 (2)	0.27 (2)	0.27 (4)
B	0.35 (5)	1.60 (3)	0.41 (2)	1.01 (3)	0.24 (3)	0.31 (3)
C	0.94 (1)	1.36 (5)	0.04 (5)	0.88 (4)	0.22 (5)	0.21 (6)
D	0.43 (4)	1.47 (4)	0.07 (4)	0.83 (6)	0.23 (4)	0.22 (5)
E	0.66 (2)	1.84 (2)	0.79 (1)	1.29 (1)	0.28 (1)	0.33 (2)
F	0.33 (6)	1.19 (6)	0.24 (3)	0.84 (5)	0.21 (6)	0.39 (1)
Ratio (min/max)	2.8	1.7	19	1.5	1.3	1.8

3.6 Laboratory identification of sponges from Auliston Point

3.6.1 Specimens identified

Of the sixteen sponge samples collected, 12 were identified to species level, three to genus level, and one only to family due to the very small size of the sample. There was duplication of two species and therefore thirteen entities were identified, as listed below.

Photo 13. *Stelligera rigida* (Montagu, 1918)

Photo 14. *Eurypon sp.*

Photo 15. *Iophonopsis nigricans* (Bowerbank, 1858)

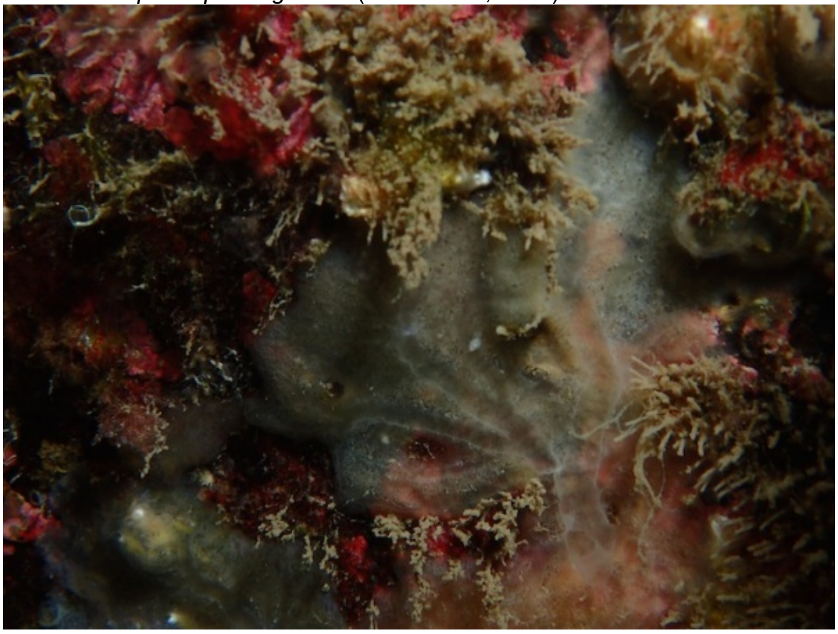


Photo 16. Microcionidae

Photo 17. *Microciona* cf. *armata*

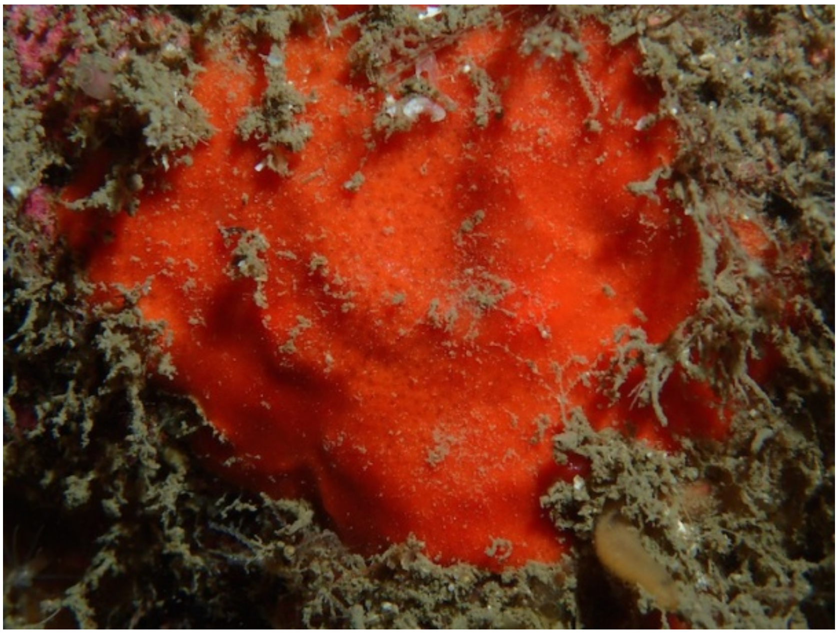


Photo 18. *Microciona atrasanguinea* (Bowerbank, 1862)

Photo 19. *Hymedesmia* sp.

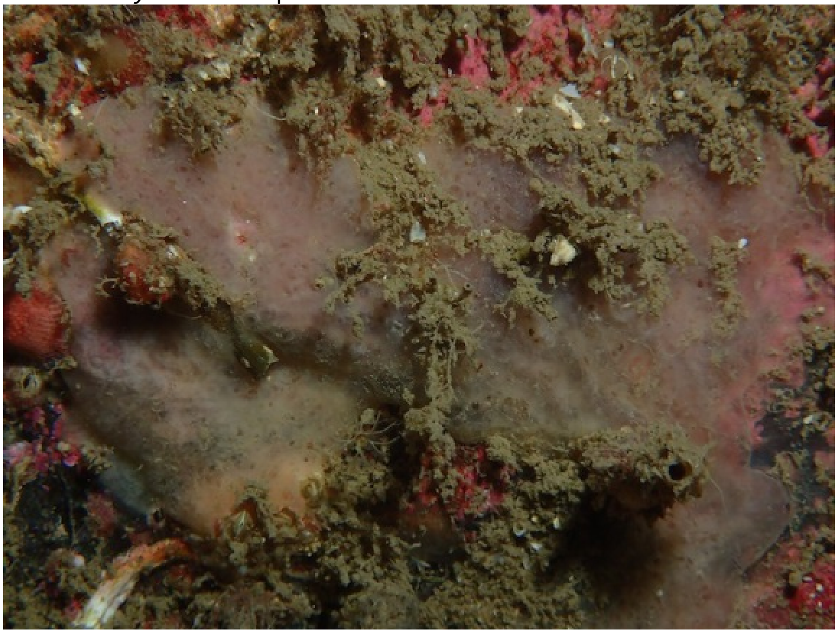


Photo 20. *Hymedesmia hibernica* (Stephens, 1916)

Photo 21. *Hymedesmia jecusculum (*Bowerbank, 1866)

Photo 22. *Hymedesmia primitiva* (Lundbeck, 1910)

Photo 23. *Plocamionida ambigua* (Bowerbank, 1866)

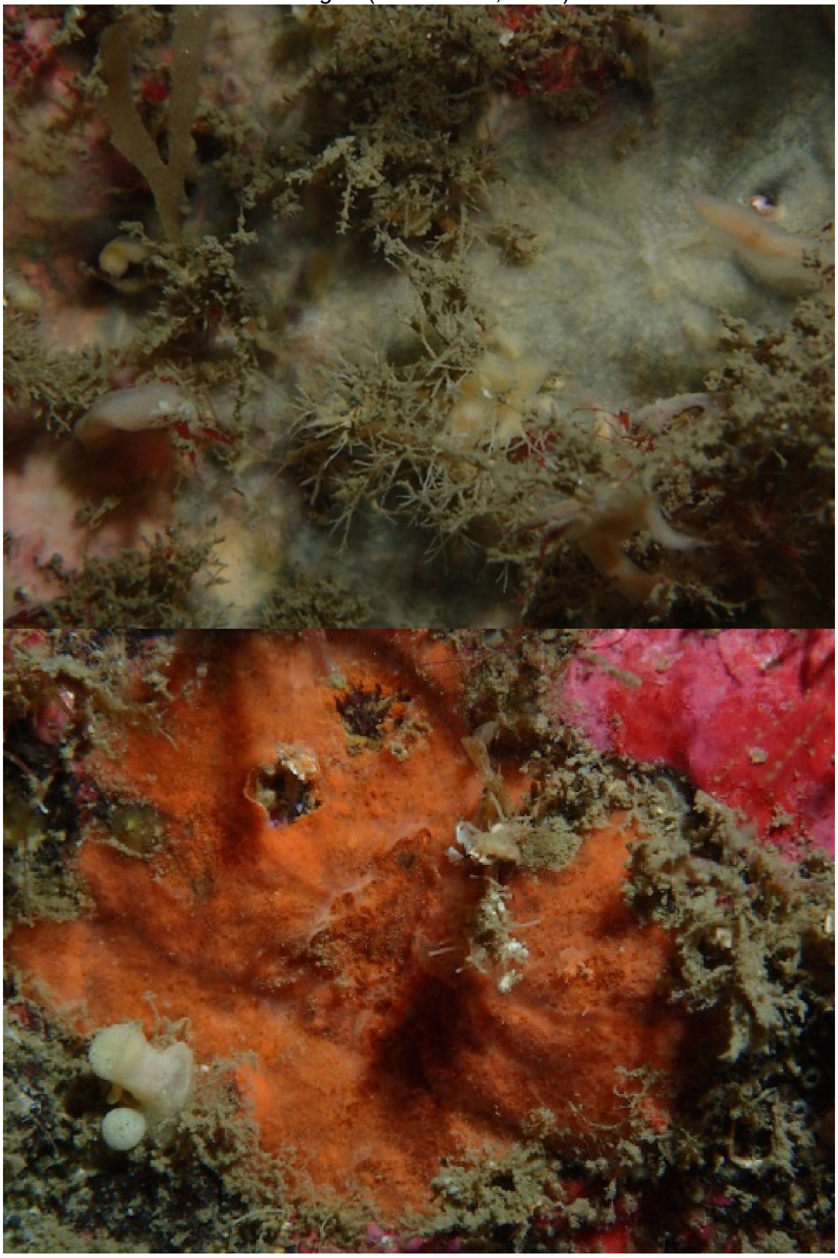


Photo 24. *Plocamionida ambigua* (Bowerbank, 1866)

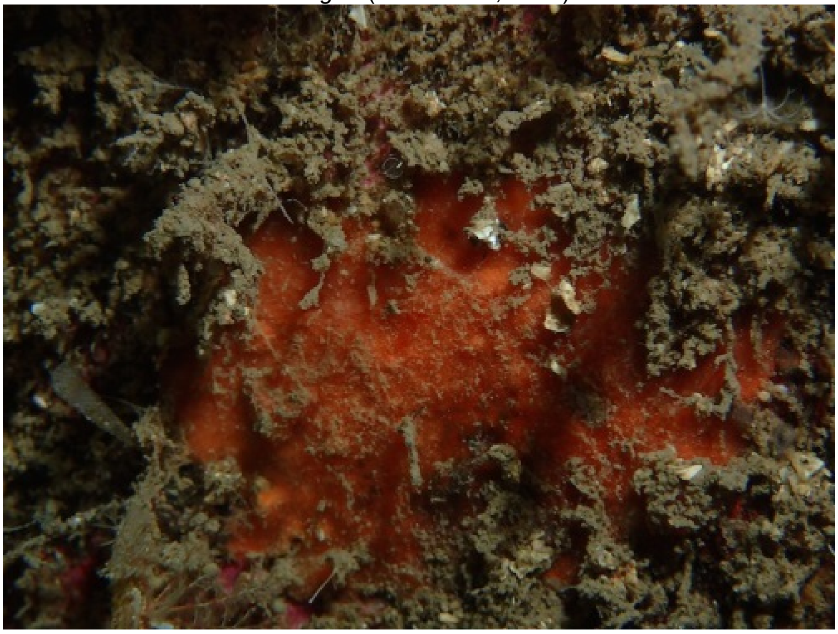


Photo 25. *Myxilla fimbriata* (Bowerbank, 1864)

Photo 26. *Myxilla fimbriata* (Bowerbank, 1864)

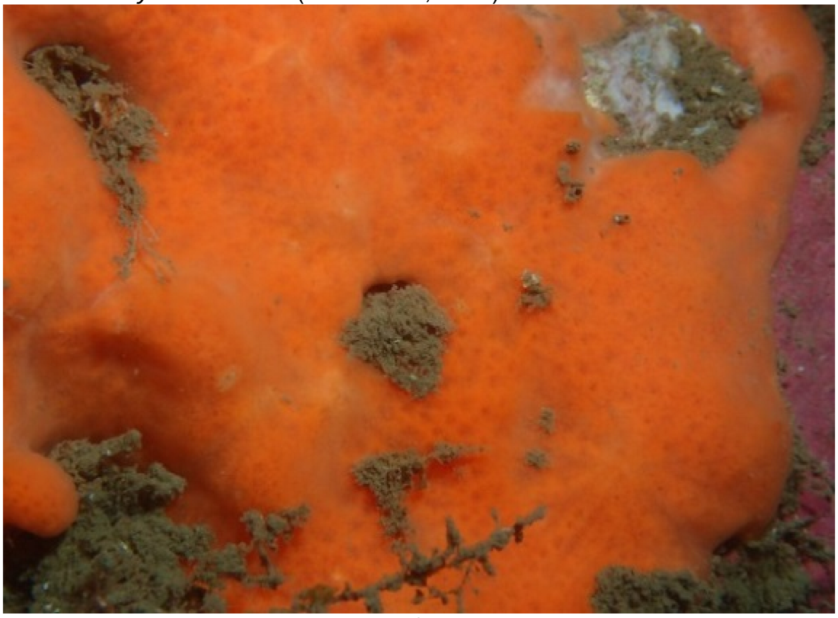


Photo 27. *Haliclona urceolus* (Rathke & Vahl, 1806)

3.6.2 Notes on selected species

Eurypon* sp*. There are known to be several undescribed *Eurypon* species, many of which occur throughout the UK, and work is currently being done on this group by Bernard Picton of the Ulster Museum.

Microciona* cf. *armata. This is an undescribed species that has been recorded previously from Skomer Island, Pembrokeshire.

***Hymedesmia (Stylopus)* sp**. Several new species of *Hymedesmia* have recently been described, and further undescribed species are known to exist. Species in the subgenus *Stylopus* are characterised by their lack of microsclere spicules – i.e. they only have megascleres.

Hymedesmia (Stylopus) hibernica Stephens, 1916. This is a relatively uncommon species, originally described from County Kerry, Ireland and found at Rathlin Island in 2007, but appears to occur fairly frequently in Scotland.

Hymedesmia (Stylopus) primitiva Lundbeck, 1910. Originally described from deep water (108-840m) around Iceland and the Faroe Islands. It was found at Rathlin Island in 2007, and several samples were recently collected from the Firth of Lorn, Loch Fyne, the Sound of Mull and the Firth of Clyde, therefore it would seem to be fairly common in Scotland.

Plocamionida ambigua (Bowerbank, 1866). It is thought there may be more than one species within this genus currently all accepted as being the same. Taxonomic research is currently being carried out which will likely result in a re-description.

3.7 Conclusions

General

1. The Sound of Mull trials, using a different suite of taxa to those recorded in Portrush and a more-balanced dataset with large numbers of replicated records, again found high levels of variability in surveyors records for most of the recorded species. The following conclusions provide additional details.

Recording whole community or part community (taxonomic group) data

2. The results of multivariate analyses show that both *in situ* recording and photo analysis of percentage cover, can be used to detect differences in community data between quadrats, but that detection is largely dependent on the abundances of a small number of dominant and conspicuous taxa. The contribution of the less abundant taxa is so influenced by inconsistencies in surveyors' records that any apparent differences detected will not be reliable.

3. Multivariate analyses of count data, compared to % cover data, was much poorer at detecting differences between quadrats. This is because, for many species, the variability in surveyors' counts within quadrats was so high that it masked actual differences between quadrats. While surveyors' estimates of % cover could also be very variable, there were a number of species for which the real variability between quadrats was greater than the variability between surveyors. This difference may not be the same for all communities or taxonomic groups.

4. Training and familiarisation reduced the inconsistencies in the *in situ* recorded whole-community data from and thereby increased the sensitivity of multivariate analysis, but only to a very limited extent.

5. Less information can be acquired from photographs compared to *in situ* recording. However, consistency between surveyors was often slightly better from photo analysis than *in situ* recording, and seldom worse. The effect of training and familiarisation on photo analysis was not directly tested, and the limited comparison that can be made between surveyors who were or were not on the fieldwork did not show any clear trends (only two of the surveyors were not on the fieldwork and they had very different levels of experience and training). Nevertheless, as concluded after the Portrush survey, it is thought likely that, for some communities, it would be easier to train surveyors in consistent identification and abundance estimation from photographs compared to *in situ* recording. Thus, multivariate analysis of community data from photographs may provide a useful methodology as long as good quality images are acquired and it is accepted that the amount of information will be

relatively less (with many species under-estimated) and that time is invested in training. However, the results of both studies suggest that photo analysis will always be difficult for algal dominated habitats.

6. The presence of large amounts of algae, often layered on top of each other and upon other taxa, is one factor that will tend to reduce the consistency of recording. Other factors include the presence of dense turfs of hydroids and erect bryozoans, and an abundance of crevices or other strongly textured rock features.

Recording species richness

7. Analysis of the community data also shows a large amount of variability in the number of taxa recorded *in situ* by surveyors, even when recording has been limited to selected taxonomic groups that surveyors can concentrate on and receive focused training upon. While some of this variability is due to surveyor bias and there is also a detectable effect of survey fatigue, the majority appears to be arbitrary variation and may not be controllable. Training and familiarisation resulted in some improvements, particularly in reduced surveyor bias, but variability was still very high. Thus, species richness, as a metric for monitoring change in an epibenthic community recorded from a single or small number of fixed quadrats, is not reliable and may only be able to detect large-scale change.

8. The Portrush study found similarly high levels of variability in species richness, but also a much greater level of surveyor bias. The reduced surveyor bias in the Sound of Mull data is probably due to a number of factors, including the training and familiarisation mentioned above, the improved survey protocols and a more-experienced and focused team of surveyors (having had the experience of the Portrush study and less distractions from logistical difficulties and site conditions). Thus, if surveyor bias is limited, notable changes in species richness may be detected more reliably if numerous records are collected – that is, numerous quadrats (sampling units) from the same habitat. If surveyor bias is significant then the use of species richness will remain unreliable, however many records are collected. If the same surveyor collects the data on every survey there should be less bias, but this is not certain as the recording characteristics of surveyors can change (see Conclusion 10 below).

9. Fewer species, on average, were identified from the photographic analysis than from *in situ* recording, but variability between surveyors was often greater among the *in situ* records. This was also found in the Portrush study. Fewer species records are to be expected, but do not necessarily mean that the method is less appropriate for monitoring of some communities, particularly if variability and surveyor bias can be reduced (see Conclusion 5 above).

Recording individual species and their abundance

10. Analysis of data for individual species and taxa shows variability in identification for many species and considerable variation in abundance recording for almost every species. Much of the variability in surveyor recording is due to the small size and inconspicuous nature of many taxa or colonies under scrutiny, which may or may not be noticed by one or more surveyors. Whether a taxa is noticed and recorded often appears to be arbitrary, but there is also a strong effect of surveyors developing a good search image and becoming familiar with the morphology of the target taxa. However, sometimes a surveyor may have a good search image for target species in one dive, but not consistently in all dives (i.e. the surveyor's focus may change). There is clearly a greater chance of taxa being seen if they are listed on the

recording form, and training does improve the ability of surveyors to develop the necessary search images for cryptic patterns, e.g. the small anemones. Improvements were evident for a number of species, but there was still notable surveyor bias in Phase 3. Some surveyors never recorded taxa that other surveyors recorded frequently, even if it was listed on the form and relatively easy to identify once seen.

11. Notwithstanding Conclusion 3, there was, for some taxa, a greater potential for variability and surveyor bias with estimates of % cover than with counts. Estimating % cover was particularly difficult for taxa that were present in the form of numerous small individuals or multiple irregular colonies scattered across much of the quadrat, e.g. barnacles, small encrusting corallines, small sponge crusts. One reason for this is that while the recording protocols stated that estimates should not include the gaps between branches or between closely spaced individuals; applying this appears to have been difficult for certain surveyors, creating bias, and needed to be emphasized during training and discussions.

12. Recorded abundances (counts and % cover) of encrusting sponges, separated into colour categories of orange, yellow and other, were very variable. Training and familiarisation did not improve consistency and surveyor bias remained considerable throughout. Aggregating the data across the colour categories, found little or no improvement in consistency, though surveyors reported that the separation into colour categories was not always easy and also took more time and concentration.

13. While surveyor experience was not a feature that was focussed upon in this study, there was a notable effect of certain surveyors expertise with particular taxonomic groups (e.g. algae). This biased the results for taxa difficult to identify or differentiate within those groups. Consistency improved as surveyors became more familiar with some of those taxa, but variability and bias remained high.

14. The applicability of photo analysis for monitoring individual species obviously depends on the species. For many of the more conspicuous and easy to identify species, consistency between surveyors was often slightly better from photo analysis than *in situ* recording, However, the records of many other species, including the less conspicuous taxa, were under-represented and more variable. Less information can be acquired from photographs compared to *in situ* recording, that is, estimates of abundance (% cover or counts) were generally lower from photographs, but, as mentioned above, the method can provide useful data for monitoring certain species in some habitats, particularly those not dominated by macroalgae.

Recording sponge morphologies

15. The Auliston Point trials did not provide a thorough test of sponge morphology recognition, as the variety of sponges in the quadrats was limited. However, the *in situ* data did show that there was almost as much, and sometimes more, variability in the counts of sponges morphologies as there was of the individual sponge taxa, some of which was due to the difficulty of assigning sponge colonies to the defined morphology categories. There was greater consistency in the encrusting sponge morphology data from photographs, compared to the individual encrusting taxa and compared to Phases 1 and 2 of the *in situ* data, but consistency was still poor.

16. Training and familiarisation resulted in some improvements in consistency for some morphologies, particularly the encrusting colonies. Consistency of pedunculate sponge counts also improved when surveyors learnt that *Suberites carnosus* has a

stalk. This highlights the benefits to morphology recording if the surveyors have at least some skill and experience in sponge identification.

17. Much of the difficulty with counting the encrusting sponges, *in situ* and in photographs, is that they can range in size from minute to very large and their irregular outline can make it difficult to distinguish where one patch ends and another starts, particularly where sediment or other organisms obscure edges. The other morphologies are likely less prone to that difficulty, but data was limited.

18. It is considered likely that training from surveyors who have experience with the method and development of sponge morphology recording protocols would greatly improve the consistency of encrusting sponge counts.

19. Counts of morphologies from photographs were, on average, less than counts from *in situ* records, but only slightly. A similar comparison in a study in the Skomer Marine Nature Reserve (Mark Burton, pers. comm.) showed a much greater difference, particularly in counts of encrusting and papillate sponges. However, this was clearly due to significant amounts of silt in the photographed quadrats (i.e. not wafted), while the *in situ* recording was carried out after wafting. The Skomer staff concluded that wafting before photography would have been appropriate, but now have a large dataset and do not want to change their methodology.

20. Counting sponge morphologies in photographs is likely to be the most appropriate and cost-effective method of monitoring them. However, their value as indicators of site condition has not yet been confirmed.

Other effects

21. The survey methodologies, protocols, recording forms and QA procedures were designed to reduce the risk of recording errors, but a number of such errors still occurred. Most of those noted, e.g. when a surveyor overlooked a conspicuous species that everyone else did record, were simply oversights, but simple errors in the recording of an abundance were also apparent and others will have been less obvious. A proportion of such errors is inevitable. It is likely that such errors will increase if surveyors are distracted by tidal currents, swell or equipment problems and as surveyors become fatigued.

22. While quality of the photographs was considered to be good, some surveyors who analysed them commented that they thought some parts of some images were slightly out of focus or blurred. It is likely that imperfect image quality will always be an issue and that surveyors will seek the highest resolution images possible, which may not be practicable. Experience from long-term photo monitoring programmes suggests that variations in water clarity has a much greater effect on quality and consistency of monitoring data and that improvements in technology (at reasonable cost) are unlikely to provide better quality data for monitoring purposes (Mark Burton, pers. comm.).

Logistics

23. For the methods used in the Sound of Mull surveys, the average number of quadrats completed per dive by a pair of surveyors was very similar for the two sites – approximately 9.5. This was slightly lower than the averages for all three sites in the Portrush study (comparing times with Part surveys, not Comprehensive surveys), which is thought to be due to the increased experience and focus of the surveyors in

the Sound of Mull study. Following the Portrush study it was concluded that it should be possible for two pairs of experienced surveyors to collect data for a total of at least 15 quadrat samples (along a single transect) in one day. This is considered still valid. It assumes that the fixed transect can be re-established by the first pair of divers, leaving 6 man-dives for recording.

24. The Sound of Mull survey was carried out largely according to plan, with no major difficulties caused by weather, site conditions, equipment or any other logistical issues.

4 Guidelines on the identification of algae and sponges

4.1 Algae

Ensuring consistent and correct identification of seaweeds between different recorders can be problematical. Some of the issues that will arise are covered here and if addressed should help increase consistency in recording. Bunker *et al* (2010) provides more guidance on algae identification and references to more-detailed identification keys.

For any monitoring site a species list should be drawn up based on careful collecting- and laboratory-based identification. Making collections and spending time in the laboratory examining specimens and discussing identification issues is the best way to proceed before recording begins. It is important to spend enough time in the laboratory for personnel to feel confident that they can identify the suite of species present, when they return to the field to record. Making notes and sketches of key features on recording slates can act as a good *aide memoire*. Simple identification tests of unlabelled specimens in the lab assessed by an expert are another good learning tool.

Having good laboratory equipment (and the skills to use it) is important for successful identification of seaweeds. Good quality stereo and compound microscopes with calibrated graticules are essential. The form and size of microscopic plant structures and cells are frequently diagnostic in the algae. It often necessary to take sections to examine cellular detail and this skill should be practiced.

Some algae, even common species, can be difficult to identify and even experts may differ in identifications of the same specimen. So, when employing field teams, it is important to get agreement on species naming and identification.

A labelled, preserved (normally pressed), collection should be kept for reference for each site. This is not only useful at the time of a survey but particularly so for subsequent surveys.

Inconsistency in identification can often occur where two or more species have overlapping characteristics. For example, the branched green seaweeds *Cladophora albida* and *Cladophora sericea* have many similar characteristics and it may be that correct naming can only be resolved by DNA sequencing. In such a case it should be accepted that not all specimens can be identified to species level, and that there may be either (or both) species present, necessitating survey recording at the genus level, e.g. *Cladophora* sp.

In the field it may be that only certain specimens have particularly diagnostic features to enable identification, e.g. reproductive structures. Where this occurs it may be advisable to extrapolate and name a whole turf on the basis of one or two specimens with reproductive structures, although care should be taken to make sure that there are not two similar species present in the turf. A good example of this is with the terete (the stem is round in cross-section) Gracilariaceae species *Gracilaria gracilis* and *Gracilariopsis longissima*. These species can be indistinguishable in the field unless there are female plants bearing cystocarps present. The cystocarps of these species can easily be seen with the naked eye and those of *G. gracilis* resemble little figs whereas those of *G. longissima* are volcano or pustule shaped. To check whether or not a mixed population is present, holdfasts of non-reproductive plants (which differ between the species) should be examined and sections should be taken to examine the cellular structures, which are diagnostic.

Where plants are damaged by grazing or subject to abrasion by sediment, identification can be problematical. In these situations there are usually some whole plants nearby which can be matched to stumps, and holdfast form can be helpful. Again, taking sections and examining these microscopically can help secure a proper identification.

Key field identification features include form of frond (e.g. filamentous, branched, flattened terete etc.), height, width of axes and branches, pattern of branching, holdfast type, presence or absence of stipe and its length, robustness, colour, texture, presence or absence of veins or midribs and type of reproductive structures where present.

Placing a plant on a white background (e.g. a recording slate) can help highlight some features. Veins and midribs show up particularly well when a specimen is held up towards the light.

When collecting specimens, whole plants should be taken including the holdfasts, which are readily scraped off with a knife. If possible specimens that are reproductive should be taken for analysis, and for filamentous species where structures cannot readily be seen, several individuals should be collected to increase the likelihood that reproductive structures will be found. When making collections, do not mix specimens of the genus *Desmarestia* in with others in the bag as it contains destructive acid. Also, remove grazing animals such as sea hares or they can eat the collection before it is possible to study it in the laboratory.

It is often possible to recognise filamentous species or species with filamentous branches in the field following confirmation in the laboratory based on microscopy. An example of this is the common red seaweed *Polysiphonia elongata*, which can be identified readily under a microscope by its characteristic spindle-shaped branchlets together with the presence of four peri-central cells (which surround the central cells of the stem) when viewed in cross-section. Once identified in the laboratory, the form of this species in the field is characteristic and can be identified reliably without further collection.

Plant form may vary over the course of a year. Again taking the example of *Polysiphonia lanosa*, this species is very different in the autumn and winter to the spring and summer. In the spring and summer it produces young fresh branchlets and these are shed in the winter leaving the tough old axes.

Juvenile plants or sporelings can be problematical to identify and it is always best to perform monitoring in summer when most species are reproducing rather than in winter or early in the growing season.

4.2 Sponges

4.2.1 Sponge morphology

The morphology of a sponge can be an aid to identification, but it should be noted that some species can have a variety of forms depending on the habitat they are in or their stage of development. When carrying out a morphological study it is important that surveyors have a good prior understanding of the terms used to describe the different forms. As there are some variations in the morphological categories and definitions that have been used for different studies, it is obviously important that the surveyors are familiar with those being used for the particular programme. The morphologies used in the Auliston Point survey were those of Bell & Barnes 2001 (see Figure 3.37) which have no associated text descriptions. The categories and definitions below are those used by other sponge experts and are based on descriptions in the website of Picton *et al* (2007, see the *Glossary* herein). The main differences are in the addition of a *Cushion* category and a difference in the morphology associated with the term *Repent*. Other workers have also been developing morphology specific rules to aid recording (e.g. Stanwell-Smith *et al* 2010).

Encrusting - A thin horizontally developing sheet normally less than 3mm thick.

Cushion - Horizontally developing between 3-10mm in thickness.

Massive - More than 10mm thick, developing horizontally and vertically, can be lobose.

Globular - Round, with the base of the sponge directly attached to the substrate

Pedunculate - Attached to the substrate by a stalk.

Tubular - A single tube shaped sponge with an opening. Can be stalked but should not be called pedunculate.

Flabellate - Fan shaped. Can be solid or with fused branches shaped like a fan.

Branching erect (arborescent) - Branching vertically, like a tree, directly from the substrate.

Branching repent - Branching horizontally across the substrate.

Papillate - With numerous short papillae extending up from a cushion or massive base.

Notes to consider

As this report highlights, confusion can sometimes occur if some, but not all, surveyors are familiar with a species, as in the case of *Suberites carnosus*. This sponge has a short stalk, i.e. Pedunculate morphology, which in small specimens is obvious, but in larger specimens is covered by the body and not visible. A surveyor who did not know the species might label it Globular. Other common examples are of species that initially develop as an Encrusting patch, but then grow into a Massive colony. To maintain consistency it will be necessary to develop protocols / definitions (relevant to the methodology, i.e. for *in situ* surveys or photo / video analysis) and train surveyors on how they record these morphologies. For example, protocols could include a reminder to check apparently globular sponges for stalks and define a practical distinction between encrusting and massive sponges. It will also be appropriate to put emphasis on the morphology that surveyors see rather than the morphology they expect from their knowledge of the species.

Some sponges develop tassels, but these should not be taken into account when measuring the thickness of the base. Tassels should also not be mistaken for branches as this could result in a cushion or massive form wrongly being labelled branching. If the Bell & Barnes 2001 categories are being used then clarity on the use of tassels in the Repent morphology will be required.

4.2.2 Species Identification

Sponges are not an easy group to identify *in situ* as there are several very similar looking species that can be easily confused, particularly within the branching and encrusting groups. Identification can also be very difficult if a species has many different forms. The only sure way to accurately identify a species is to collect a sample for laboratory analysis of the spicules and skeleton. However, there are certain features of a sponge that can aid identification and which remain the same even in very different growth forms of a species, as given below. Picton *et al* (2007) provides more guidance on sponge identification and references to more detailed identification literature.

Apertures (oscules, pores)

Oscules or openings vary between species in form and number, and where they are situated on a sponge. They can be large and conspicuous or small and barely visible, they can be raised or lie flush with the surface. In branching sponges they can be at the tip of a branch or in rows along it. Occasionally they can have grooves radiating from them e.g, *Axinella dissimillis*. Oscules can sometimes contract when disturbed, therefore they should be observed before any touching or wafting. With practice, they can prove very useful in helping to determine the identity of a species.

Surface appearance

The surface of a sponge can also aid identification. Some appear smooth and clean, others can be 'hispid' (hairy) to varying degrees and collect silt. Some species have conspicuous channels or veins, or deep grooves. Certain sponges have a bumpy appearance caused by numerous small tubercles e.g. *Dysidea fragilis*.

Colour

The colour of a sponge can be a useful feature, although not in all cases. However, the colour of a sponge should be noted *in situ*, as it can look very different in a photograph.

Notes to consider

With experience, it is possible to identify a sponge *in situ* by observing the above features, even in different forms. Photographs are very useful to look more closely at detail afterwards. The habitat and distribution of a species should also be checked before survey to ascertain likelihood of its presence in a location. However it must be stressed that if there is any doubt, a sponge should be labelled only tentatively. For consistency, if a species is not known, then it should be recorded with a good description e.g. 'Orange cushion with large oscules', 'hispid red crust'. This can help to ensure that all surveyors are recording each entity in the same way.

5 Recommendations

The following recommendations are relevant to the design of sublittoral epibenthic surveys using visual methods – *in situ* recording by divers or analysis of photographs (stills) taken either by divers or by a remote camera system – to collect qualitative or quantitative data on individual species or multi-species assemblages (communities) for monitoring site condition and detecting notable ecological changes. Many of the recommendations are concerned with the variability (inconsistency) in surveyors recording as it is assumed that most epibenthic monitoring programmes will need to cater for teams of surveyors (in the case of *in situ* recording), rather than single individuals, and for changes in survey personnel during the course of the programme.

Issues of poor consistency in sublittoral epibenthic recording, and other reasons behind the recommendations given below, are known to many surveyors and monitoring programme managers. Recording protocols, training and QA procedures are already applied in most monitoring programmes (e.g. Whittington *et al* 2007) and a number of the following recommendations are included in the JNCC Marine Monitoring Handbook (Davies *et al* 2001) or due to be included. However, the scale of these issues and their effects on the quality and meaningfulness of monitoring data are not widely appreciated. Thorough application of many of these recommendations may require considerable investments in time and money and it may be difficult to maintain the desired rigour. Thus, many of the following recommendations are not new, but their importance for improving the value of monitoring is emphasised.

5.1 *General*

1. Experience from long-term intertidal and subtidal epibenthic community monitoring programmes suggest that it takes a number of years of annual recording and sampling to acquire sufficient data on species composition, natural variability (temporal and spatial) and sources of error before one can select meaningful monitoring attributes with reasonable confidence. Making efforts to collect consistent data from the start and to maintain rigorous QA procedures will provide better quality data, reduce the time required to understand the community and increase confidence in the selected attributes.

2. To have any chance of collecting reasonably consistent data it is essential that all recorders (*in situ* recording or analysis of photographs, for species or morphologies) have at least moderate experience and interest in epibenthic species recording and at least moderate familiarity with epibenthic fauna and flora in general and the key taxa being surveyed in particular. Consistency will also be improved by good site conditions (weather, tides and visibility), good reliable diving and survey equipment and good condition of surveyors (physical fitness and level of fatigue/availability of quality sleep). It is important to be aware of the potential for surveyor fatigue during long survey days or adverse conditions.

5.2 *In situ* recording by divers

3. A realistic appreciation of the potentially high variability in epibenthic species recording by different surveyors needs to be considered in the design of the monitoring programme. Initial assessment should consider the characteristics of the habitat / community and features that may tend to increase variability in recording (e.g. presence of erect fauna and flora, crevices etc.). A pilot study, including tests of recording consistency for all key taxa by multiple surveyors, would be very valuable to this process. In particular, it will be advantageous to understand any notable biases in

surveyors' identification skills (including powers of observation) and abundance estimation. This will inform the selection of attributes that can be monitored with adequate robustness and highlight where bespoke training (see below) is required. A pilot study will also be valuable for assessing the most appropriate measure of abundance (including % cover, counts per unit area, cell frequencies in a gridded quadrat or frequency of occurrence in multiple quadrats) – consistency of recording will also be appropriate to that decision.

4. Bespoke training of all surveyors in the identification of species known to be present at a monitoring site and in abundance estimation will improve consistency. A collection of typical quadrat photographs from the site, including a range of taxa in varying forms and abundances, will be very useful for such training. Use of such photographs for training (i.e. calibrating or testing) surveyors in abundance estimation will be even better if the % cover of each discernible taxa in the photographs has been measured using image analysis software.

5. A catalogued collection of digital photographs of species known to be present at a monitoring site, preferably taken from the site, will be very useful for training and for reference after *in situ* surveys and during analysis of monitoring photographs.

6. A catalogued voucher specimen collection of species present at a monitoring site, preferably taken from the site but outside any fixed stations, will be invaluable, both as a training resource and for QA purposes. This will be particularly important for long-running programmes during which it is likely that the taxonomy of some species will change.

7. There is merit in having all surveyors tested on the species they must identify before they take part in a monitoring programme. Testing will be most useful if it is specific to the location and could become part of the standard QA procedures for the programme. It may be appropriate to develop a generic approach to such tests that is included in standard QA procedures used by the statutory nature conservation bodies.

8. While training to increase familiarity with the species and community, and with estimating their abundance, will improve the consistency of identifications and recorded abundances, it is considered likely that consistency will remain poor for many species. If it can be shown that these inconsistencies are not due to biases, then sufficient replication of surveys will provide robust average abundance measures. If bias is suspected, this must be taken into account when interpreting recorded abundance changes over time.

9. Good lighting and good quality magnifying lenses greatly improve the ability of diving surveyors to see the fine details that are often important for accurate identification of benthic algae and invertebrates. Depending on the type of monitoring, it may be appropriate to develop protocols for the use and strength of magnification (e.g. only to be used for identifying specimens that have already been observed; not for finding tiny species that cannot be seen with the naked eye).

10. As a guide, the author suggests that: for *in situ* recording to provide sufficient quality of data for monitoring notable change in a whole community or multi-species assemblage (i.e. using multivariate analysis) there would need to be:
    i) a suite of species of which more than half are both conspicuous (i.e. stand-out from the background substrata and the rest of the community) and are easily identified by:
    ii) surveyors who are very well trained and very familiar with the species.

For species-rich communities, whole community recording will also require a lot of quality time spent on every quadrat (sampling unit).

11. To reduce bias in records of species richness sufficiently to make them of any use for monitoring notable change in epibenthic communities will require a considerable investment in training, development of survey protocols and ensuring the surveyors are familiar with the community and committed to quality recording. Without that, any monitoring targets based on species richness will need to be severely limited (i.e. accepting a relatively very low number of species as the target).

12. Selection of individual taxa or taxonomic group(s) appropriate for monitoring should take account of how conspicuous and easily identified they are likely to be and how easy it is to accurately (and quickly) record abundance. In the absence of site specific data from a pilot study, the results in this report may provide useful information on the consistency of different taxa.

13. Rigorous recording procedures need to be developed to minimise potential for surveyors to miss common species. The development of waterproof digital devices for recording underwater will make it easier to include automatic QA checks and procedures.

14. The quality of *in situ* records is sensitive to any factors that interfere with the surveyor's ability to get a good view of the epibiota and concentrate on recording it. It will be useful for QA and interpretation of results if surveyors make note of any notable factors that might have interfered with his/her recording.

15. In habitats characterised by sufficient amounts of silt on the epibiota thatobscure them or some of their features, it is recommended that it is wafted away from the survey areas before surveying begins. This should preferably be done some time before the survey so that the cloud of silt has time to disperse, but not so long before so that a new deposit of silt settles on the survey area.

5.3 Photographic monitoring

16. Photography, as a means to providing contextual information on the site, habitat, survey methodology and species present, should be routinely included in any sublittoral monitoring programme unless the water clarity is very poor.

17. Photography for consistent identification and abundance estimation of epibenthic taxa requires good water clarity, good even lighting and high resolution (good quality digital camera set on highest resolution and lowest compression), in that order. For the majority of UK sites, where water clarity cannot be relied upon within logistically available monitoring schedules, the photo-monitoring set-up should be designed to keep the subject-to-lens distance to a minimum (40cm in the Portrush study). However, the photo-monitoring design (i.e. size, number and placement of quadrats) will also need to consider the 3-dimensional characteristics of the community. It is likely that there will be a trade-off, unless the habitat and community are very flat, and occasional issues with image quality are inevitable.

18. Photo-quadrat monitoring should be developed for use where a community that has been targeted for monitoring is characterised by a low lying assemblage of taxa (i.e. not obscured by large algae or other dominant organisms) that are both conspicuous (stand-out against the background substrata) and readily identifiable in the photographs. As with *in situ* recording, a pilot study with analysis of the photographs by multiple surveyors will provide valuable information on the consistency of the recording. Training (see Recommendation 4) and the development of recording protocols will be appropriate.

19. Photo-quadrat methods are not appropriate for monitoring of epibenthic community composition if the community is dominated by erect algae, that is, most infralittoral habitats, or by other features (e.g. crevices) that may hide a notable proportion of the target taxa. In such habitats experienced *in situ* observations are the preferred method of collecting monitoring data. Sampling may be appropriate for some algal assemblages and habitats, e.g. epiflora on kelp stipes and limited sampling of algal communities on pebbles, cobbles or small boulders.

20. If it is shown that photography can provide data that is sufficient for monitoring purposes, then there is a clear cost-benefit in applying it. However, it is recommended that the two methods (*in situ* recording and photography) are carried out in tandem in the first instance as they complement each other very well. As noted in Recommendation 6, initial surveys should also place emphasis on the collection of specimens for identification of all key species and to compile a voucher specimen collection. If the photo-monitoring identifies notable changes in species composition that are not easily identifiable, then further *in situ* recording and specimen collection will be appropriate.

21. As with *in situ* recording (Recommendation 15), it is recommended that silt is wafted away from the survey areas before taking photographs. This should preferably be done some time before the survey so that the cloud of silt has time to disperse.

5.4 Monitoring sponge morphologies

22. Counting sponge morphologies in photographs is likely to be the most appropriate and cost-effective method of monitoring them, assuming that the target habitat is not dominated by algae or other obscuring features.

23. As described in Recommendation 3 for species recording, an appreciation of the potential inconsistencies in sponge morphology recording should be considered in the design of the monitoring programme.

24. As further emphasis of Recommendation 2, the quality of sponge morphology recording will be much improved if the surveyors are familiar with the sponge fauna of the region, have skills and experience in their identification and are also familiar with any non-sponge fauna of the region that could be mistaken for sponges.

25. Bespoke training (see Recommendation 4) and the development of recording protocols for sponge morphologies, particularly encrusting forms, is recommended for any monitoring programme. The experience of the Skomer Marine Nature Reserve staff, who have been monitoring sponge morphologies since 2002 (from photographs collected annually since 1993) (Burton *et al* 2014) will be very valuable.

5.5 Further studies

26. Further trials using both photography and *in situ* recording (using acknowledged experts in different taxonomic groups) would be very useful in the development of a dual approach to epibenthic monitoring.

27. It is suggested that there is requirement for an alternative measure of abundance that can be effectively applied to all taxa (i.e. not based on individual counts or percentage cover), is not time consuming to record (i.e. not individual counts or cell-frequency counts), can be consistently recorded (i.e. not the MNCR SACFOR scale) and is limited to a reasonable, but achievable, level of precision:

- For *in situ* based methods, there is potential for semi-quantitative measures of abundance to be developed and that these should be tested in field trials.
- For photo-quadrat based methods, there is potential for a point-intercept based system of data collection, such as that employed by van Rein *et al*. (2011b), to be trialled as these methods have been demonstrated to collect objective, quantitative and “traceable” data from the sample imagery.

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Appendix 1 Field logs

See Acknowledgements for staff names.

A1.1 Portrush, Activity record, August 2013

Thursday 1st August

JNCC and ASML team travel to Portrush.

Friday 2nd August

0900-1100	Team meet in lab, discuss program for day. Introduction from Gary Burrows (Centre manager). Unpack van and set up lab.
1100-1400	Introduction to draft work programme from JM. Discussion and plan of action. GB offers us a DPV. Team prepare diving equipment and carry out checks on each other's equipment. JM and HE prepare transect lines. FB emails Steve to chase up NT's supervisor certificate.
1400-1900	GB and NG dive for site reconnaissance on kelp forest near Blue Pool. Unfortunately they struggle to find suitable habitat and go too far to the north and have to swim ashore having buoyed a site too far away. Wind strong from south so too awkward to work in that area. JM and JW dive to relocate transect and decide that vertical walls are the best-available habitat, as horizontals have kelp too dense and not much diversity (mainly crustose seaweeds and a few foliose algae).
2130	FB and JM return to lab to put specimens in trays.

Saturday 3rd August

0900-1400	Meet in lab. Team work on specimens. HE and NG take bottles to Aquaholics in Portstewart; however, their compressor is broken so Aquaholics take cylinders to Ballycastle. JM and FB go on a reconnaissance dive to make sure transect suitable for recording.
1400	JW and FB collect bottles at Portaferry.
1530-1700	Team diving on Kelp Wall transects. NG and DB, JM and JW, HE and BH.
1700-1930	FB and NG drive to Ballycastle with bottles. Rest of team in lab looking at specimens etc.

Sunday 4th August

0900-1100	Lab. The swell is too much to dive after a windy night. Team spend time in the lab going over the species on the Kelp Wall transects. Discussion session on diving supervision buddy checks and use of SMBs on the transect. Decided that we would use SMBs. Joe Breen visits and informs us that the boats would be coming around tomorrow.
1100-1300	Team split to achieve different tasks. Making up transect lines, getting quadrats ready, printing proformas, pressing seaweeds etc.
1300	Lunch. Swell dropping.
1400-1600	JM and FB dive. Too much swell and conditions are no good so abandon after 17 minutes.

Monday 5th August

0800	Meet in lab.
0900	Team prepare to dive on the Kelp Wall transect.
1000-1245	First wave of survey diving on Kelp Wall. Joe Breen visits.
1400-1800	Second wave of survey diving on Kelp Wall

1800 Finish diving for day. JW and HE to Ballycastle with cylinders. Delayed by provider, unableto return before 2100.

1900-2000 Enter data

Tuesday 6th August

0800 Meet in lab. Prepare for day. More difficulties with air suppliers. FB works on dive plan.

1100 Drove to Harbour. Got more transect fixings. Two delivery lorries blocked road.

1200 Diving on Skerries. FB skipper *Capitella* with TM, HE and DB. NG skipper *Modiolus* with JM, HvR, RS. Found the shot had been moved requiring two dives moving it back. Did a reconnaissance dive on monitoring site.

1500 In harbour to change bottles. JW took tanks for refilling.

1600-1800 Dive Kelp wall site. Too much swell so only three pairs went in (diving from the boats).

1800 *Capitella* moored in harbour. Went back after HE and NG dived. JM and FB did not do quadrats, instead JM dived with HvR.

1830 *Modiolus* moored, sort out gear and back to lab.

1900-1940 Lab sort out.

Wednesday 7th August

0800 Lab. Go through id of pics taken at Skerries. Make a list. Make up pro-formas, print forms. HgE, TM and RS go to E of Skerries and put in some bolts etc. on the site to fix transects securely.

1100 Go to boats

1300 Diving from *Modiolus* and *Capitella*. All surveyors did recording from quadrats. JM and FB did all species and the others concentrated on ascidians and one or two other species. BH didn't get down because of strong current.

1600 Return to Portrush

1700-1930 Back in lab. NG and NT filling bottles. Debrief after diving. Transcribe data, sort van and get ready for morning.

Thursday 8th August

0800 Lab. Data entry from previous tasks. Prepare to dive. Pre-dive brief. Give new random numbers to team members.

1030 On quayside and get gear prepared for diving.

1130 *Modiolus* and *Capitella* leave quay side for Skerries.

1215 Start diving on site. FB found tank had not been filled. Luckily one spare so re-rigged for pony use.

1500 Return to quayside. FB goes to get air.

1700 Diving at Kelp Wall site with HvR, BH, JM. Also GB and NG dive to collect aquarium specimens.

1830 Finish diving and boat round to harbour.

1900 Meet in lab. De-brief and draw up plan for next day.

Friday 9th August

0800 Lab and get ready. JM gives talk on bryozoa which we hope to study east of the Skerries.

1000 Portrush harbour. Get boats and load.

1100 Boats on the site east of the Skerries too rough to dive so go to *Zostera* bed south of the Skerries.

1300 *Capitella* goes with HgE and Mike Allen, DB and JW. We carry on diving from *Modiolus*.

1400 *Modiolus* drops HvR and FB on Kelp Wall site. Claire Goodwin visits team.

1500 *Modiolus* engine breaks down. FB and HvR swim ashore. GB and JM swim out to help. Replace a blown fuse with one from a hire van.

1700 *Modiolus* back at harbour.

1730 Pack away and wash gear.

A1.2 Sound of Mull, August 2014

Dive No. given in front of each dive

Wednesday 13th August

JNCC and ASML team travel to Lochaline Dive Centre.

Thursday 14th August

am Preparing boat, making transect line, team briefing, preparation for diving.

pm Dives on Lochaline Hotel beach wall
1 NG & NT – relocate and fix transect and boat mooring.
2 HE & JM – fix transect line and assess quadrats
3 FB & DB – pilot recording in quadrats

eve Making quadrats

Friday 15th August

pm Dives on Lochaline transect
4 FB & DB – fixing quadrats on transect.
5 HE & JM – recording in quadrats (form v1, barnacles and coralline crusts)

pm Dives on Lochaline transect
6 NG & NT – recording in quadrats (form v2, algae and barnacles)
7 FB & DB – recording in quadrats (form v2, algae and barnacles)
8 HE & JM – recording in quadrats (form v2, algae and barnacles)

eve Data entry

Saturday 16th August

am Dives on Lochaline transect
9 FB & DB – recording in quadrats (form v3, algae, anthozoa and barnacles)
10 NG & NT – recording in quadrats (form v3, algae, anthozoa and barnacles)
11 HE & JM – recording in quadrats (form v3, algae, anthozoa and barnacles)

pm Algae ID training and data entry
Dives on Lochaline transect
12 FB & DB – recording in quadrats (form v4, algae, anthozoa and barnacles)
13 NG & NT – recording in quadrats (form v4, algae, anthozoa and barnacles)
14 HE & JM – recording in quadrats (form v4, algae, anthozoa and barnacles)

Sunday 17th August

am Data entry and data analysis

pm Data discussion, development of protocols
ID and % cover training
Preparation for Sunart transect

Monday 18th August

am Dives on Lochaline transect
15 FB & NG – recording in quadrats (form v4, algae, anthozoa and barnacles)
16 HE & NT – recording in quadrats (form v4, algae, anthozoa and barnacles)
17 DB & JM – recording in quadrats (form v4, algae, anthozoa and barnacles)

pm Algae ID training and data entry
Dives on Lochaline transect
18 FB & NG – recording in quadrats (form v4, algae, anthozoa and barnacles)
19 HE & NT – recording in quadrats (form v4, algae, anthozoa and barnacles)
20 DB & JM – recording in quadrats (form v4, algae, anthozoa and barnacles)

Tuesday 19th August

am Load equipment onto Sound Diver (skipper Alan) and head up Sound of Mull
Dives on Auliston transect
21 JM & NG – set up transect and quadrats
22 FB & HE – recording in quadrats (form v1, sponges, morphologies & anthozoa)
23 DB & NT – recording in quadrats (form v1, sponges, morphologies & anthozoa)

pm Dives on Auliston transect
24 JM & NG – recording in quadrats (form v1, sponges, morphologies & anthozoa)
25 HE & FB – recording in quadrats (form v1, sponges, morphologies & anthozoa)
26 DB & NT – recording in quadrats (form v1, sponges, morphologies & anthozoa)
Return to Lochaline

Eve Data entry and sponge & anthozoa ID training

Wednesday 20th August

am Board Sound Diver and head up Sound of Mull
Dives on Auliston transect
27 HE & FB – collecting sponge specimens & recording in quadrats (form v2)
28 DB & NT – recording in quadrats (form v2, sponges, morphologies & anthozoa)
29 JM & NG – recording in quadrats (form v2, sponges, morphologies & anthozoa)
Lunch in Tobermory

pm Dives on Auliston transect
30 HE & FB – collecting sponge specimens & recording in quadrats (form v2)
31 DB & NT – recording in quadrats (form v2, sponges, morphologies & anthozoa)
32 JM & NG – recording in quadrats (form v2, sponges, morphologies & anthozoa)
Return to Lochaline

Eve Data entry and sponge & anthozoa ID training

Thursday 21st August

am Board Sound Diver and head up Sound of Mull
Dives on Auliston transect
33 NT & FB – recording in quadrats (form v2, sponges, morphologies & anthozoa)
34 JM & HE – recording in quadrats (form v2, sponges, morphologies & anthozoa)
35 DB & NG – recording in quadrats (form v2, sponges, morphologies & anthozoa)
Lunch in Tobermory

pm Dives on Auliston transect
36 NT & FB – recording in quadrats (form v2), start removing quadrats
37 JM & HE – recording in quadrats (standard and large) (form v2)
38 DB & NG – recording in quadrats (standard and large) (form v2), remove transect line
Return to Lochaline

Eve Data entry

Friday 22nd August

am Dives on Lochaline transect
39 FB & DB – recording in quadrats (form v4, algae, anthozoa and barnacles)
40 HE & NG – recording in quadrats (form v4, algae, anthozoa and barnacles)
41 NT & JM – recording in quadrats (form v4, algae, anthozoa and barnacles)

pm Data entry
Dives on Lochaline transect
42 FB & DB – recording in quadrats (form v4). Remove part of mooring weight
43 HE & NG – recording in quadrats (form v4). Remaining mooring weight pulled off cliff.
44 NT & JM – remove quadrats and transect line
Retrieve boat. Packing

eve Data entry and debrief

Saturday 23rd August

JNCC and ASML team travel home.

Appendix 2 Tabulation of detailed results from multivariate and univariate analyses

A2.1 *Kelp Wall – Selected taxa list (red algae, anthozoans and bryozoan crusts only)*

Q1 - Are there differences between the observations of surveyors with different experience levels?
Q2 - Are there differences between *in situ* observations and photoquadrat image observations?

PERMANOVA Factors

Name	Abbrev.	Type	Levels	Notes
Experience	Ex	Fixed	2	1 = low, 2 = high
Method	Me	Fixed	2	*In situ*, Photo
Transect	Tr	Fixed	2	1 , 2
Quadrat (Transect)	Qu	Fixed	14	All quadrats

All selected taxa data included except Sample P26.LB (no data)

PERMANOVA table 1

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ex	1	6858.5	6858.5	10.995	**0.0001**	9957
Me	1	6646.4	6646.4	10.655	**0.0001**	9944
Tr	1	3158.8	3158.8	5.0639	**0.0018**	9953
Qu(Tr)	21	67926	3234.6	5.1854	**0.0001**	9847
ExxMe	1	2208.2	2208.2	3.54	**0.0129**	9951
ExxTr	1	1443.2	1443.2	2.3136	0.0727	9957
MexTr	1	875.48	875.48	1.4035	0.2384	9957
ExxQu(Tr)	8	7248.4	906.06	1.4525	0.0759	9892
MexQu(Tr)	16	27021	1688.8	2.7074	**0.0001**	9850
ExxMexTr	1	1121.7	1121.7	1.7983	0.1323	9941
ExxMexQu(Tr)	5	1709.8	341.97	0.54821	0.91	9921
Res	101	63002	623.78			
Total	158	2.39E+05				

Experience x Method
Experience (1 vs 2)

Method	df	t	P(perm)	Unique perms
In situ	66	3.3373	**0.0001**	9942
Photo	35	2.2478	**0.0031**	9960

Experience x Method

Method (*In situ* vs Photo)

Experience	df	t	P(perm)	Unique perms
1	90	3.772	**0.0001**	9965
2	11	3.4995	**0.0001**	9945

Exp.	Method	Av.Sim	Taxa	Av.Abund	Av.Sim	Contrib%
1	*In situ*	**48.38**	*Delesseria sanguinea*	20.42	40.94	84.63
			Bryozoa (orange enc)	2.25	4.3	8.89
			Cryptopleura ramosa	1.92	1.58	3.27
1	Photo	**55.7**	*Delesseria sanguinea*	17.4	56.13	97.28
2	*In situ*	**52.26**	*Delesseria sanguinea*	31.61	37.92	72.55
			Bryozoa (orange enc)	5.74	5.23	10.01
			Corallinaceae (enc)	6.52	4.35	8.33
			Hypoglossum hypoglossoides	2.35	1.91	3.66
			Cryptopleura ramosa	2.45	1.12	2.15
2	Photo	**61.18**	*Delesseria sanguinea*	21	53.37	87.24
			Corallinaceae (enc)	3.1	4.12	6.73
			Bryozoa (orange enc)	2.5	3.57	5.83

A2.2 *Kelp Wall – Full taxa list (experienced surveyors only)*

Q2 - Are there differences between *in situ* observations and photoquadrat image observations?

PERMANOVA
Factors

Name	Abbrev.	Type	Levels
Method	Me	Fixed	2
Transect	Tr	Fixed	2
Quadrat	Qu	Fixed	9

PERMANOVA table 2

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Me	1	4214.1	4214.1	4.0797	**0.0131**	9944
Tr	1	5305.5	5305.5	5.1364	**0.0013**	9957
Qu(Tr)	9	22628	2514.2	2.4341	**0.0001**	9883
MexTr	1	619.9	619.9	0.60014	0.6422	9957
MexQu(Tr)	6	5261.4	876.89	0.84893	0.6683	9920
Res	11	11362	1032.9			
Total	29	54026				

SIMPER table 2

Method	Av.Sim.	Species	Av.Abund	Av.Sim	Contrib%
In situ	**41.6**	*Delesseria sanguinea*	31.61	18.24	43.86

SIMPER table 2

Method	Av.Sim.	Species	Av.Abund	Av.Sim	Contrib%
		Spirobranchus	14.78	5.78	13.91
		Balanus crenatus	15.23	5.08	12.21
		Bryozoa (orange enc)	5.74	2.16	5.19
		Pseudolithoderma	12.5	2.05	4.92
		Corallinaceae (enc)	6.52	1.84	4.41
		Aplidium punctum	2.78	1.2	2.89
		Scrupocellaria	4.41	1.19	2.87
		Hypoglossum hypoglossoides	2.35	0.81	1.95
		Dictyota dichotoma	3.79	0.7	1.69
		Crisiidae	2.15	0.52	1.25
Photo	**49.51**	*Delesseria sanguinea*	21	28.71	57.97
		Spirobranchus	17.67	8.83	17.84
		Balanus crenatus	5.59	6.58	13.29
		Corallinaceae (enc)	3.1	2.35	4.74
		Bryozoa (orange enc)	2.5	2.13	4.29

A2.3 *Circalittoral – Selected taxa list (ascidians only)*

Q1 - Are there differences between the observations of surveyors with different experience levels?
Q2 - Are there differences between *in situ* observations and photoquadrat image observations?

PERMANOVA Factors

Name	Abbrev.	Type	Levels	Notes
Experience	Ex	Fixed	2	1 = low, 2 = high
Method	Me	Fixed	2	*In situ*, Photo
Transect	Tr	Fixed	2	1 , 2
Quadrat	Qu	Fixed	28	All quadrats

PERMANOVA table 3

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ex	1	665.1	665.1	0.68338	0.5843	9965
Me	1	2048.4	2048.4	2.1046	0.1171	9965
Tr	1	1671.2	1671.2	1.7171	0.181	9969
Qu(Tr)	37	70485	1905	1.9573	**0.001**	9841
ExxMe	1	300.69	300.69	0.30895	0.7862	9952
ExxTr	1	1327.7	1327.7	1.3641	0.275	9961
MexTr	1	3696.1	3696.1	3.7977	**0.0161**	9961
ExxQu(Tr)	4	2974.2	743.55	0.76398	0.6602	9938
MexQu(Tr)	22	19146	870.27	0.89418	0.6633	9904
ExxMexTr	1	1389.7	1389.7	1.4279	0.2579	9964
ExxMexQu(Tr)	3	984.39	328.13	0.33715	0.9192	9947
Res	43	41850	973.26			
Total	116	181650				

Experience x Method
Experience (1 vs 2)

Method	df	t	P(perm)	Unique perms
In situ	33	0.58075	0.7736	9964
Photo	10	0.73921	0.5787	9966

Experience x Method
Method (*In situ* vs Photo)

Experience	df	T	P(perm)	Unique perms
1	36	2.5549	**0.0017**	9969
2	7	1.7336	**0.0499**	9942

SIMPER table 3

Experience	Method	Av.Sim	Taxa	Av.Abund	Av.Sim	Contrib%
1	*In situ*	**48.97**	*Clavelina lepadiformis*	0.76	15.66	31.97
			Polycarpa fibrosa (? mat)	0.74	15.57	31.79
			Polycarpa scuba	0.7	14.49	29.59
			Pycnoclavella aurilucens	0.21	1.02	2.09
1	Photo	**63.31**	*Polycarpa fibrosa* (? mat)	0.94	36	56.86
			Polycarpa scuba	0.65	12.81	20.23
			Clavelina lepadiformis	0.61	11.67	18.43
2	*In situ*	**40.88**	*Polycarpa scuba*	0.82	11.66	28.53
			Polycarpa fibrosa (? mat)	0.64	8.83	21.59
			Pycnoclavella aurilucens	0.55	4.56	11.16
			Synoicum incrustatum	0.45	3.4	8.31
			Clavelina lepadiformis	0.36	3.39	8.3
			Polycarpa (? orange)	0.45	3.15	7.72
			Aplidium turbinatum	0.36	1.83	4.47
			Molgula manhattensis	0.36	1.82	4.45
			Didemnidae (white spiky)	0.27	1.02	2.51
2	Photo	**56.2**	*Polycarpa fibrosa* (? mat)	1	45.83	81.55
			Polycarpa scuba	0.44	5.56	9.88
			Clavelina lepadiformis	0.33	2.78	4.94

A2.4 *Circalittoral – Full taxa list (experienced surveyors only)*

Q2 - Are there differences between *in situ* observations and photoquadrat image observations?

PERMANOVA
Factors

Name	Abbrev.	Type	Levels
Method	Me	Fixed	2
Transect	Tr	Fixed	2
Quadrat	Qu	Fixed	6

PERMANOVA table 4

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Me	1	4944.4	4944.4	7.539	**0.0031**	9940
Tr	1	9770.5	9770.5	14.898	**0.0004**	9939
Qu(Tr)	5	11125	2224.9	3.3925	**0.0002**	9918
MexTr	1	1937.9	1937.9	2.9549	0.0393	9960
MexQu(Tr)**	4	1393.4	348.34	0.53114	0.8798	9955
Res	7	4590.8	655.83			
Total	19	36975				

Method vs Transect
Method (*In situ* vs Photo)

Transect	df	t	P(perm)	Unique Perms
1	1	1.5118	0.0616	10
2	6	3.3209	**0.0016**	9415

Method vs Transect
Transect (1 vs 2)

Method	df	t	P(perm)	Unique Perms
In situ	4	3.0076	**0.009**	7216
Photo	3	3.0903	**0.0103**	262

SIMPER table 5

Transect	Method	Av.Sim	Taxa	Av.Abund	Av.Sim	Contrib%
1	*In situ*	**56.78**	*Actinothoe sphyrodeta*	1	7.38	13
			Balanus crenatus	1	7.38	13
			Caryophyllia smithii	0.8	4.77	8.39
			Polycarpa fibrosa (? mat)	0.8	4.77	8.39
			Alcyonidium diaphanum	0.8	4.69	8.27
			Clavelina lepadiformis	0.8	4.69	8.27

SIMPER table 5

Transect	Method	Av.Sim	Taxa	Av.Abund	Av.Sim	Contrib%
			Alcyonium digitatum	0.8	4.2	7.4
			Hypoglossum hypoglossoides	0.8	4.2	7.4
			Crisia	0.6	2.23	3.92
			Erythroglossum laciniatum	0.6	2.23	3.92
			Cellaria (fine)	0.6	1.98	3.48
			Polycarpa scuba	0.6	1.98	3.48
			Securiflustra securifrons	0.6	1.93	3.4
1	Photo	**57.56**	*Actinothoe sphyrodeta*	1	7.52	13.06
			Caryophyllia smithii	1	7.52	13.06
			Alcyonidium diaphanum	1	7.52	13.06
			Clavelina lepadiformis	1	7.52	13.06
			Polycarpa fibrosa (? mat)	1	7.52	13.06
			Polycarpa scuba	1	7.52	13.06
			Bugula	0.67	2.67	4.63
			Alcyonium digitatum	0.67	2.47	4.29
			Rhodophyta (flat)	0.67	2.47	4.29
2	*In situ*	**57.09**	*Flustra foliacea*	1	6.02	10.54
			Scrupocellaria	1	6.02	10.54
			Polycarpa scuba	1	6.02	10.54
			Actinothoe sphyrodeta	0.83	3.98	6.97
			Balanus crenatus	0.83	3.98	6.97
			Bugula flabellata	0.83	3.98	6.97
			Polycarpa (? orange)	0.83	3.98	6.97
			Pycnoclavella aurilucens	0.67	2.43	4.26
			Crisia	0.67	2.36	4.13
			Aplidium turbinatum	0.67	2.36	4.13
			Alcyonidium diaphanum	0.67	2.32	4.07
			Hypoglossum hypoglossoides	0.67	2.32	4.07
			Ophiura	0.5	1.28	2.24
			Didemnidae (dark blue)	0.5	1.28	2.24
			Polycarpa fibrosa (? mat)	0.5	1.28	2.24
			Neogastropoda (small)	0.5	1.2	2.1
			Didemnidae (white spiky)	0.5	1.2	2.1
2	Photo	**50.1**	*Flustra foliacea*	1	13.8	27.55
			Polycarpa fibrosa (? mat)	1	13.8	27.55
			Scrupocellaria	0.83	9.38	18.72
			Actinothoe sphyrodeta	0.67	5.6	11.17
			Calliostoma zizyphinum	0.5	2.51	5
			Bugula flabellata	0.33	0.89	1.77

A2.5 *Zostera bed – percentage cover data only (excl. Zostera counts)*

PERMANOVA Factors

Name	Abbrev.	Type	Levels	Notes
Experience	Ex	Fixed	2	1 = low, 2 = high
Method	Me	Fixed	2	*In situ*, Photo
Quadrat	Qu	Fixed	18	All quadrats

PERMANOVA table 6

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ex	1	8663.8	8663.8	8.5354	**0.0002**	9948
Me	1	3971	3971	3.9121	**0.0063**	9936
Qu	17	54856	3226.8	3.179	**0.0001**	9866
ExxMe	1	2111	2111	2.0797	0.0827	9961
ExxQu	7	6127	875.28	0.86231	0.6796	9889
MexQu	9	10678	1186.5	1.1689	0.2729	9891
ExxMexQu	7	13160	1880	1.8521	**0.0131**	9898
Res	20	20301	1015			
Total	63	123710				

Experience x Method
Experience (1 vs 2)

Method	df	T	P(perm)	Unique perms
In situ	13	1.8792	**0.0161**	9946
Photo	7	2.8925	**0.0037**	9960

Experience x Method
Method (*In situ* vs Photo)

Experience	df	t	P(perm)	Unique perms
1	10	1.2572	0.2134	9950
2	10	2.4891	**0.0045**	9952

SIMPER table 7

Experience	Method	Av.Sim	Taxa	Av.Abund	Av.Sim	Contrib%
1	*In situ*	**43.76**	Rhodophyta (fil. branching)	6.5	35.47	81.05
			Bacillariophyceae (fil brown diatoms)	3.93	6.62	15.13
1	Photo	**44.29**	Rhodophyta (fil. branching)	5	36.4	82.19
			Chlorophyta (fil)	1	5.19	11.73
			Bacillariophyceae (fil brown diatoms)	1.08	1.49	3.35
2	*In situ*	**39.03**	Rhodophyta (fil. branching)	6.16	19.17	49.13
			Bacillariophyceae (fil brown diatoms)	6.54	18.04	46.23

2	Photo	**49.05**	Rhodophyta (fil. branching)	4	25.79	52.58
			Bacillariophyceae (fil brown diatoms)	2.38	14.48	29.51
			Polysiphonia elongata	1.46	5.82	11.86
			Ulva (tubular)	0.54	2.04	4.17

A2.6 *Recording time*

Habitat	Taxa	Method	Experience	Mean effort (mins)	St. Dev.	St. Error
Kelp Wall	Full	*In situ*	2	15.3	3.0	0.7
Kelp Wall	Full	Photo	2	10.0	3.2	0.9
Kelp Wall	Part	*In situ*	1	4.6	2.8	0.3
Kelp	Part	Photo	1	6.2	3.0	0.4
Circalittoral	Full	*In situ*	2	8.1	2.0	0.9
Circalittoral	Full	Photo	2	11.1	8.3	1.0
Circalittoral	Part	*In situ*	1	3.4	2.1	0.5
Circalittoral	Part	Photo	1	3.9	3.4	0.6
Zostera	Full	*In situ*	2	-	-	-
Zostera	Full	Photo	2	3.8	2.8	0.8
Zostera	Full	*In situ*	1	3.6	1.0	0.9
Zostera	Full	Photo	1	2.1	0.7	0.9

				In situ		Photo	
Habitat	**Taxa**	**Method**	**Experience**	**Mean effort (mins)**	**St. Error**	**Mean effort (mins)**	**St. Error**
Kelp Wall	Full	*In situ*	HIGH	15.3	0.7	10.0	0.9
Kelp Wall	Part	*In situ*	LOW	4.6	0.3	6.2	0.4
Circalittoral	Full	*In situ*	HIGH	8.1	0.9	11.1	1.0
Circalittoral	Part	*In situ*	LOW	3.4	0.5	3.9	0.6
Zostera	Full	*In situ*	HIGH	-	-	3.8	0.8
Zostera	Full	*In situ*	LOW	3.6	0.9	2.1	0.9

Appendix 3 Recording forms

The following recording forms were used during the field survey:

- Kelp wall – Part surveys - selected taxa only (red algae, anthozoans and bryozoan crusts, for less-experienced surveyors)
- Kelp wall – Comprehensive surveys – all conspicuous taxa (for more-experienced surveyors)
- Circalittoral – Part surveys - selected taxa only (ascidians, for less-experienced surveyors)
- Circalittoral - Comprehensive surveys – all conspicuous taxa (for more-experienced surveyors)
- Lochaline transect version 2 - Foliose algae, barnacles and coralline crusts
- Lochaline transect version 4 - Foliose algae, anthozoa, barnacles and various crusts
- Auliston transect version 1 - Sponge morphologies (counts), Sponge taxa (indicator spp) (counts), and anthozoa (% cover and counts)
- Auliston transect version 2 - Sponge morphologies (counts), Sponge taxa (indicator spp) (% cover and counts), and anthozoa (% cover and counts)

Blank copies of each form are given below:

Portrush: Kelp wall quadrats, Part surveys **Date:** .... **Surveyor:** ....

Conditions OK?: .... Method: 0.1m^2 quadrats, % cover / Counts ....

Transect (1 or 2)															
Distance (0.5 to 9)															
Position (T/B L/R)															
Time start (hhmm)															
Time end (hhmm)															
Completed? (Y/N)															
Acrosorium venulosum %															
Cryptopleura ramosa %															
Delesseria sanguinea %															
Dilsea carnosa %															
Erythroglossum laciniatu. %															
Hypoglossum hypogloss. %															
Plocamium lyngbyrn. %															
Pterosiphonia parasitica %															
Pterothamnion plumula %															
Rhodymenia ardissonei %															
Rhodymenia pseudopalm. %															
Schottera nicaeensis %															
Actinothoe sphyrodeta C															
Alcyonium digitatum C															
Caryophyllia smithii C															
Corynactis viridis C															
Sagartia elegans C															
Urticina felina C															
Bryozoa (orange enc) %															

Portrush: Kelp wall quadrats, Comprehensive surveys **Date:**......................... **Surveyor:**.......................

Conditions OK?: .... Method: $0.1m^2$ quadrats, **%** cover / **C**ounts...

Transect (1 or 2)															
Distance (0.5 to 9)															
Position (T/B L/R)															
Time start (hhmm)															
Time end (hhmm)															
Completed? (Y/N)															
Corallinaceae (enc) %															
Acrosorium venulosum %															
Cryptopleura ramosa %															
Delesseria sanguinea %															
Erythroglossum laciniatu. %															
Hypoglossum hypogloss. %															
Plocamium lyngbyrn. %															
Pterosiphonia parasitica %															
Pterothamnion plumula %															
Rhodymenia ardissonei %															
Rhodymenia pseudopalm. %															
Schottera nicaeensis %															
Dictyota dichotoma %															
Laminaria hyperborea C															
Laminaria (sporelings) %															
Leuconia %															
Sycon ciliatum C															
Actinothoe sphyrodeta C															
Sagartia elegans C															
Pomatoceros C															
Balanus crenatus %															
Calliostoma zyziphinum C															
Bryozoa (orange enc) %															
Crisiidae %															
Scrupocellaria %															
Aslia lefevrei C															
Aplidium punctum C															
Botryllus schlosseri %															
Clavelina lepadiformis %															
Morchellium argus %															

Portrush: Circalittoral quadrats, Part surveys **Date:.........................** **Surveyor:.......................**

Conditions OK?: .... Method: 25cm x 25cm quadrats, Presence / absence, Ascidians

Transect (1 or 2)															
Distance (0.5 to 9)															
Position (T/B L/R)															
Time start (hhmm)															
Time end (hhmm)															
Completed? (Y/N)															
Clavelina lepadiformis															
Ascidia virginia – large solitary, pink & clean															
Aplidium nordmanni – colonial, thick mat / lobes															
Synoicum incrustans – small colonial, flat topped, single central large hole, ringed by smaller holes															
Aplidium punctum – small / medium, colonial club-shaped, orange, 1 red dot															
Morchellium argus – colonial globular mass with clefts, white papillae, 4 red dots															
Sidnyum turbinatum – small colonial, club-shaped, ring of white papillae															
Polycarpa scuba – small /medium solitary, pink, long siphons															
?Polycarpa - small /medium solitary, orange, long siphons															
?Polycarpa - small /medium solitary, white patchy long siphons															
Dense mat - small solitary, sand covered, small siphons															
Molgula manhattensis – solitary, shiny white / grey, long siphons															

Portrush: Circalittoral quadrats, Comprehensive surveys **Date:........................** **Surveyor:......................**

Conditions OK?:...................................... Method: 25cm x 25cm quadrats, Presence / absence.......................................

Transect (1 or 2)															
Distance (0.5 to 9)															
Position (T/B L/R)															
Time start (hhmm)															
Time end (hhmm)															
Completed? (Y/N)															
Clavelina lepadiformis															
Synoicum incrustans															
Sidnyum turbinatum															
Polycarpa scuba															
?Polycarpa - orange															
?Polycarpa fibrosa															
Molgula manhattensis															
Raspailia ramosa															
Nemertesia antennina															
Alcyonium digitatum															
Caryophyllia smithii															
Balanus crenatus															
Balanus balanus															
Alcyonidium diaphanum															
Electra pilosa															
Flustra foliacea															
Securiflustra securifrons															
Scrupocellaria															
Bugula ?flabellata															
Bugula plumosa															
Clavelina lepadiformis															
Corallinaceae															
Schottera nicaeensis															
Rhodymenia holmesii															
Delesseria sanguinea															
Hypoglossum hypoglosso															
Erythroglossum laciniatum															

Sound of Mull: Lochaline **Date: ....** **Surveyor: ....**

Conditions OK?: .... Method: m^2 quadrats, % cover / Counts..

Transect (U or L)													
Distance (nearest 0.1m)													
Time start (hhmm)													
Time end (hhmm)													
Completed? (Y/N)													
Bonnemaisonia asparago.													
Compsothamnion thuyoid.													
Delesseria sanguinea													
Dictyota dichotoma													
Erythroglossum laciniat.													
Heterosiphonia japonica													
Heterosiphonia plumosa													
Hypoglossum hypoglosso.													
Lomentaria clavellosa													
Lomentaria orcadensis													
Phycodrys rubens													
Plocamium cartilagineum													
Plocamium lyngbyanum													
Rhodophyllis divaricata													
Rhodophyllis irvineorum													
Schottera nicaeensis													
Trailliella intricata													
Enc. coralline													
Barnacle %													
Barnacle counts													

Sound of Mull: Lochaline upper transect **Date: ....** **Surveyor: ....**

Distance (nearest 0.1m)													
Time start (hhmm)													
Time end (hhmm)													
Completed? (Y/N)													
Bonnemaisonia asparago.													
Compsothamnion thuyoid.													
Delesseria sanguinea													
Dictyota dichotoma													
Erythroglossum laciniat.													
Heterosiphonia japonica													
Heterosiphonia plumosa													
Hypoglossum hypoglosso.													
Lomentaria clavellosa													
Lomentaria orcadensis													
Phycodrys rubens													
Plocamium cartilagineum													
Plocamium lyngbyanum													
Rhodymenia ardissonei													
Rhodophyllis divaricata													
Rhodophyllis irvineorum													
Schottera nicaeensis													
Trailliella intricata													
Enc. coralline													
Enc. brown													
Enc. red													
Enc. Bryozoa													
Barnacles %													
Caryophyllia smithii													
Hormathia coronata													
Sagartia elegans													
Sagartia troglodytes													

Sound of Mull: Auliston Pt, Loch Sunart **Date: ....** **Surveyor: ....**

Conditions OK?: .... Method: 25cm x 25cm quadrats, % cover / Counts.............................

Distance (nearest 0.1m)													
Time start (hhmm)													
Time end (hhmm)													
Completed? (Y/N)													
Hemimycale columella %													
Hymedesmia pauper. %													
Iophon %													
Myxilla incrustans %													
Pachymatisma johnsto. %													
Stelligera stuposa %													
Suberites carnosus %													
Encrusting													
Massive													
Globular													
Pedunculate													
Tubular													
Flabellate													
Repent													
Arborescent													
Papillate													
Burrowing													
Alcyonium digitatum C													
Alcyonium glomeratum C													
Caryophyllia smithii C													
Corynactis viridis C													
Hormathia coronate C													
Parazoanthus angui. C													
Protanthea simplex C													
Sagartia elegans C													
Sagartia troglodytes C													
Alcyonium digitatum %													
Alcyonium glomeratum %													
Caryophyllia smithii %													
Corynactis viridis %													
Hormathia coronate %													
Parazoanthus angui. %													
Protanthea simplex %													
Sagartia elegans %													
Sagartia troglodytes %													

Sound of Mull: Auliston Pt, Loch Sunart **Date: ....** **Surveyor: ....**

Distance (nearest 0.1m)														
Time start (hhmm)														
Time end (hhmm)														
Completed? (Y/N)														
Encrusting C														
Massive C														
Globular C														
Pedunculate C														
Tubular C														
Flabellate C														
Repent C														
Arborescent C														
Papillate C														
Burrowing C														
	C	**%**	**C**	**%**	**C**	**%**	**C**	**%**	**C**	**%**	**C**	**%**	**C**	**%**
Hemimycale columella														
Hymedesmia paupertas														
Iophon														
Leucosolenia														
Myxilla incrustans														
Pachymatisma johnstonii														
Stelligera stuposa														
Suberites carnosus														
Orange encrusting														
Yellow encrusting														
Other encrusting														
Alcyonium digitatum														
Alcyonium glomeratum														
Caryophyllia smithii														
Corynactis viridis														
Hormathia coronata														
Parazoanthus anguicom.														
Protanthea simplex														
Sagartia elegans														
Sagartia troglodytes														

Appendix 4 Complete lists of taxa recorded, 2014

The following tables list all taxa recorded during the methodological trials, taxonomic authorities, abundance type (M) and numbers of *in situ* records (Recs). Abundance types: C = counts, % = percentage cover.

Lochaline wall

V1 to V4: dots mark taxa that were listed on recording forms (versions 1 to 4)

Entity	Authority	M	V1	V2	V3	V4	Recs
Porifera (enc)	Grant, 1836	%					19
Actiniaria (anemone)		C					9
Sagartia	Gosse, 1855	C					1
Sagartia elegans	(Dalyell, 1848)	C			●	●	27
Sagartia troglodytes	(Price in Johnston, 1847)	C			□	●	20
Hormathia coronata	(Gosse, 1858)	C			□	●	40
Edwardsiella	Andres, 1883	C					2
Caryophyllia smithii	Stokes & Broderip, 1828	C			□	●	53
Cirripedia %	Burmeister, 1834	%	□	□	□	●	223
Cirripedia C	Burmeister, 1834	C	□	□			64
Bryozoa (enc)		%			□	●	34
Rhodophyta (enc)	Wettstein, 1901	%			□	●	10
Rhodophyta (fil)	Wettstein, 1901	%					5
Rhodophyta (Small flat blade)	Wettstein, 1901	%					5
Bonnemaisonia asparagoides	(Woodward) C.Agardh, 1822	%		□	□	●	105
Bonnemaisonia hamifera (*Trailliella intricata*)	Hariot, 1891	%		□	□	●	68
Corallinaceae (enc)	Lamouroux, 1812	%	□	□	□	●	220
Schottera nicaeensis	(J.V. Lamouroux ex Duby) Guiry & Hollenberg, 1975	%		□	□	●	15
Plocamium	J.V.Lamouroux, 1813	%					5
Plocamium lyngbyanum	Kützing, 1843	%		□	□	●	45
Plocamium cartilagineum	(Linnaeus) P.S.Dixon, 1967	%		□	□	●	8
Rhodophyllis irvineorum	Kützing, 1847	%		□	□	●	14
Rhodophyllis divaricata	(Stackhouse) Papenfuss, 1950	%		□	□	●	36
Rhodymenia ardissonei	(Kuntze) Feldmann, 1937	%				●	3
Lomentaria clavellosa	(Lightfoot ex Turner) Gaillon, 1828	%		□	□	●	1
Lomentaria orcadensis	(Harvey) F.S.Collins, 1937	%		□	□	●	3
Compsothamnion thuyoides	(Smith) Nägeli, 1862	%		□	□	●	48
Pterothamnion plumula	(J.Ellis) Nägeli, 1855	%					1
Cryptopleura ramosa	(Hudson) L.Newton, 1931	%					2
Delesseria sanguinea	(Hudson) J.V.Lamouroux, 1813	%		□	□	●	147
Hypoglossum hypoglossoides	(Stackhouse) F.S.Collins & Hervey, 1917	%		□	□	●	2
Phycodrys rubens	(Linnaeus) Batters, 1902	%		□	□	●	120
Erythroglossum laciniatum	(Lightfoot) Maggs & Hommersand, 1993	%		□	□	●	8
Heterosiphonia japonica	Yendo, 1920	%		□	□	●	105
Heterosiphonia plumosa	(J.Ellis) Batters, 1902	%		□	□	●	91

Polysiphonia	Greville, 1823	%					3
Polysiphonia elongata	(Hudson) Sprengel, 1827	%					2
Pterosiphonia parasitica	(Hudson) Falkenberg, 1901	%					1
Cutleria multifida (*Aglaozonia parvula* (brown enc))	(Turner) Greville, 1830	%			□	●	26
Dictyota dichotoma	(Hudson) J.V.Lamouroux, 1809	%		□	□	●	41
Desmarestia	J.V.Lamouroux, 1813	%					2
Laminaria (sporelings)	J.V. Lamouroux, 1813	%					8
Saccharina latissima	(Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders, 2006	%					3
Derbesia marina (Haliclystis ovalis)	(Lyngbye) Solier, 1846	%					1

Auliston Point

V1 & V2: dots mark taxa that were listed on recording forms (versions 1 & 2)

Entity	Authority	M	V1	V2	Recs
Porifera (Morphology: Encrusting)		C	□	□	164
Porifera (Morphology: Massive)		C	□	□	79
Porifera (Morphology: Globular)		C	□	□	16
Porifera (Morphology: Pedunculate)		C	□	□	19
Porifera (Morphology: Tubular)		C	□	□	9
Porifera (Morphology: Flabellate)		C	□	□	3
Porifera (Morphology: Repent)		C	□	□	6
Porifera (Morphology: Arborescent)		C	□	□	20
Porifera (Morphology: Papillate)		C	□	□	19
Porifera (Morphology: Burrowing)		C	□	□	0
Porifera (enc)	Grant, 1836	%			6
Porifera (orange cushion)	Grant, 1836	C			31
Porifera (orange cushion)	Grant, 1836	%			29
Porifera (orange enc)	Grant, 1836	C		□	100
Porifera (orange enc)	Grant, 1836	%		□	89
Porifera (other enc)	Grant, 1836	C		□	40
Porifera (other enc)	Grant, 1836	%		□	41
Porifera (red enc)	Grant, 1836	C			1
Porifera (white enc)	Grant, 1836	C			3
Porifera (white enc)	Grant, 1836	%			2
Porifera (yellow enc)	Grant, 1836	C		□	81
Porifera (yellow enc)	Grant, 1836	%		□	75
Clathrina lacunosa	(Johnston, 1842)	C			8
Clathrina lacunosa	(Johnston, 1842)	%			8
Leucosolenia	Bowerbank, 1864	C		□	3
Leucosolenia	Bowerbank, 1864	%		□	4
Sycon ciliatum	(Fabricius, 1780)	C			8
Sycon ciliatum	(Fabricius, 1780)	%			8
Grantia compressa	(Fabricius, 1780)	C			1
Grantia compressa	(Fabricius, 1780)	%			1
Pachymatisma johnstonia	(Bowerbank in Johnston, 1842)	C	□	□	7
Pachymatisma johnstonia	(Bowerbank in Johnston, 1842)	%		□	4
Suberites carnosus	(Johnston, 1842)	C	□	□	27

Suberites carnosus	(Johnston, 1842)	%		□	18
Polymastia	Bowerbank, 1864	C			13
Polymastia	Bowerbank, 1864	%			13
Stelligera stuposa	(Ellis & Solander, 1786)	C	□	□	14
Stelligera stuposa	(Ellis & Solander, 1786)	%		□	12
Myxilla incrustans	(Johnston, 1842)	C	□	□	49
Myxilla incrustans	(Johnston, 1842)	%		□	40
Iophon	Gray, 1867	C	□	□	19
Iophon	Gray, 1867	%		□	8
Hymedesmia	Bowerbank, 1864	C			1
Hymedesmia	Bowerbank, 1864	%			1
Hymedesmia paupertas	(Bowerbank, 1866)	C	□	□	45
Hymedesmia paupertas	(Bowerbank, 1866)	%		□	39
Hemimycale columella	(Bowerbank, 1874)	C	□	□	4
Hemimycale columella	(Bowerbank, 1874)	%		□	1
Haliclona urceolus	(Rathke & Vahl, 1806)	C			3
Haliclona urceolus	(Rathke & Vahl, 1806)	%			3
Haliclona viscosa	(Topsent, 1888)	C			1
Haliclona viscosa	(Topsent, 1888)	%			1
Dysidea fragilis	(Montagu, 1814)	C			1
Dysidea fragilis	(Montagu, 1814)	%			1
Aplysilla sulfurea	Schulze, 1878	C			15
Aplysilla sulfurea	Schulze, 1878	%			15
Alcyonium hibernicum	(Renouf, 1931)	C			2
Alcyonium hibernicum	(Renouf, 1931)	%			2
Alcyonium digitatum	Linnaeus, 1758	C	□	□	41
Alcyonium digitatum	Linnaeus, 1758	%	□	□	43
Alcyonium glomeratum	(Hassal, 1843)	C	□	□	35
Alcyonium glomeratum	(Hassal, 1843)	%	□	□	34
Parazoanthus anguicomus	(Norman, 1868)	C	□	□	30
Parazoanthus anguicomus	(Norman, 1868)	%	□	□	29
Protanthea simplex	Carlgren, 1891	C	□	□	19
Protanthea simplex	Carlgren, 1891	%	□	□	18
Sagartia	Gosse, 1855	C			8
Sagartia	Gosse, 1855	%			8
Sagartia elegans	(Dalyell, 1848)	C	□	□	8
Sagartia elegans	(Dalyell, 1848)	%	□	□	8
Sagartia troglodytes	(Price in Johnston, 1847)	C	□	□	6
Sagartia troglodytes	(Price in Johnston, 1847)	%	□	□	7
Hormathia coronata	(Gosse, 1858)	C	□	□	23
Hormathia coronata	(Gosse, 1858)	%	□	□	23
Edwardsiella carnea	(Gosse, 1856)	C			6
Edwardsiella carnea	(Gosse, 1856)	%			6
Corynactis viridis	Allman, 1846	C	□	□	2
Corynactis viridis	Allman, 1846	%	□	□	2
Caryophyllia smithii	Stokes & Broderip, 1828	C	□	□	124
Caryophyllia smithii	Stokes & Broderip, 1828	%	□	□	121