

THE CHARACTER AND STATUS OF ROCKY SHORE COMMUNITIES AT LUNDY: HISTORIC AND RECENT SURVEYS

by

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ABSTRACT

A study of species on some Lundy shores was made by ten marine ecologists in August-September 2008 with subsequent surveys and observations up until 2015. Comparisons were made with site-specific species lists made by L.A. Harvey from the late 1940s and obtained in 2009. Species numbers and identity were similar between 2008 and 2015 to those in the late 1940s. The few notable differences can largely be attributed to serendipitous finds of normally subtidal species and specialist taxonomic knowledge of some personnel. Taxa associated with turfs of coralline algae seemed slightly less rich but broadly similar after 60 years.

Keywords: *Lundy, rocky shores, Harvey, species records, coralline turfs*

INTRODUCTION

Changes in the flora and fauna of north-east Atlantic shores are expected as a result of rising temperatures (see, for example, Hiscock *et al.* 2004) and the arrival of non-native species (see, for example, Minchin *et al.* 2013). However, reliable survey data from locations that can be resurveyed are frequently lacking. In the case of rocky shores at Lundy, the existence of detailed field notes from the late 1940s and 1950 makes a comparison with recent years possible.

An account of the species found on certain rocky shores at Lundy compared to some of the observations of Leslie and Clare Harvey in the late 1940s and early 1950s was given in Hiscock (2008) and the current paper should be read in combination with that earlier one. The sources of those records are catalogued in the appendix to the paper by Hiscock (2008) and include papers in the Annual Report of the Lundy Field Society (Anonymous, 1949; Harvey, 1951; Harvey, 1952). In 2009, Professor Richard Warwick, who had inherited further original records from Harvey, forwarded those records to Keith Hiscock. Those records included significant additional material in the form of detailed handwritten notes and species lists for particular shores surveyed in 1947, 1948, 1949 and 1950. After being photocopied for retention by the author (KH), the original papers were lodged with the Data Archive for Marine Habitats and Species at the Marine Biological Association (Reference: DASSHLit000201). The additional records (those passed on in 2009) are noted in 'Methods'.

In addition to those of Harvey, there are other historical records that need to be taken into account in any comparison of Lundy rocky shore species over, now, a period in excess of 80 years. They are the lists of algae from the mid-1930s (summarized in Tregelles, 1937), the lists of algae from surveys in the late 1960s and early 1970s published in Irvine *et al.* (1972), and the animal species from various surveys in the 1970s listed for each major taxonomic group in the 'Lundy Marine Fauna' series published in the Annual Report of the Lundy Field Society (see Hiscock, 1997). The semi-quantitative surveys of zonation on rocky shores at four locations (North Rat Island, Brazen Ward, East of Lametry Bay and Dead Cow Point) (Hiscock & Hiscock, 1979) were of widely distributed species that feature in the census surveys and, although providing an important reference point for later re-survey, were not used in the comparisons here. Tugwell (1856) mentions a few species that he encountered at Lundy when he went with 'our man and the crowbar' to explore rocky shores.

This paper brings together the results from those various sources and from further surveys and observations after the 2008 paper was published. In particular, it reports on the results of a study in 2008 that specifically aimed to re-visit some of the locations surveyed by Harvey and his co-workers.

METHODS

RECORDS FROM THE HARVEY ARCHIVE

Whole shore surveys: The records from L.A. Harvey for separate shores that were passed to KH in 2009 were added to the Microsoft™ Excel spreadsheet that was originally prepared in 2008 (see Hiscock, 2008). The shores were:

- Ladies Beach on 2 September 1947 (predicted low water height: 0.8m)
- Gannets' Combe [Bay] on 19 August 1948 (predicted low water height: 1.2m)
- Jenny's Cove on 20 August 1948 (predicted low water height: 1.1m)
- Goat Island on 24 August 1948 (predicted low water height: 1.1m) and 15 April 1949 (predicted low water height: 0.0m)
- Puffin slope on 25 August 1948 (predicted low water height: 1.4m)
- Gannets' Rock north on 25 August 1948 (predicted low water height: 1.4m) and 14 April 1949 (predicted low water height: -0.1m)
- Rat Island south on 17 April 1949 (predicted low water height: 1.0m)
- Rat Island south gulley (transect) on 7, 8, 9 August 1948 (predicted low water height: 0.2m, 0.3m, 0.6m) [These records were available in 2008 but had not been entered to the spreadsheet as number of quadrat occurrences.]

The names of species given by Harvey were entered on spreadsheets together with their most recent names and the names of species added during the recent surveys described here. The World Register of Marine Species - WoRMS (www.marinespecies.org) was used for animal names and the revised check-list of seaweeds of Britain (Brodie *et al.*, 2015) was used for seaweed names.

The abundance of the taxa recorded from each location was not given by Harvey but the set of records from low to high water along a gulley at south of Rat Island censused 17 quadrats of 50×50cm along a transect. Each species was only recorded as 'present' in a quadrat, but the number of quadrats in which a species was found could be registered, giving some idea of frequency of occurrence.

Records of algae from the late 1940s and listed in Harvey (1951) almost certainly included observations made by Clare Harvey. There had been previous surveys of algae (Tregelles, 1937) and the later surveys by Irvine *et al.* (1972) in 1969, 1970 and 1971 which were not added to the spreadsheets used in our study but were referred to in making comparisons.

Harvey also seems to have used 'weed washing' (extracting animals by agitating seaweeds in a bucket of water), but this was not undertaken in our study.

There were identifications of species in the Harvey archive that were subsequent to the publication of the 'Total list, at August 1950' (Harvey, 1951). They are in letters from specialists and the records have been added to the spreadsheets, the last one found being identification of crustaceans by G. Crawford and dated 15 February 1951.

Samples of geniculate (branching) Corallinaceae: Harvey collected coralline turf (species of *Corallina* and *Jania rubens*) in order to separate, identify and count the number of individuals of the associated fauna. The taxa present in 34 samples from 10 different locations were enumerated. However, it has not been possible to discover how the samples were collected and what quantities were collected at Lundy. Harvey was in the habit of using honey jars (likely capacity 300ml) to take samples in the Isles of Scilly (R. Warwick, pers. comm.) and we speculate that each separate count was from one honey jar full of coralline alga. Records from seaweed samples at Ladram Bay (South-east Devon) undertaken at about the same time as the Lundy studies and included in the Harvey archive, suggest wet masses of samples of 70-100g and recorded volumes of 20-30ml, which might be achieved if the samples were compressed (see amounts sampled in 2008 below).

The records (totals of each taxon identified at each site) from the Harvey dossier were copied to a Microsoft™ Excel spreadsheet.

Samples from kelp holdfasts: Harvey sampled the fauna from kelp holdfasts. There was some confusion in interpreting records as the handwritten lists of species refer to samples from '*Laminaria stipes*' but the typed transcription is headed '*Laminaria* holdfasts'. It has to be assumed that the typed sheets have the definitive title. The handwritten notes refer to '1 compound of 4 or 5 holdfasts, 2 double (or large simple) holdfasts' apparently in relation to the 1949 records and '2 small simple holdfasts' apparently in relation to the 1950 records. The number of species recorded is large and suggest samples from *L. hyperborea*. *L. hyperborea* is a subtidal species that can be sampled from the open shore on extreme low water spring tides or by reaching into the subtidal at low water. The records (totals of each taxon identified at each site) from the Harvey dossier were copied to a Microsoft™ Excel spreadsheet. There has been no comparative sampling undertaken in recent years.

RECORDS FROM RECENT SURVEYS

Survey methods 2008-2015

Whole shore surveys: In 2008, a field trip was organized that invited intertidal ecologists to the island to more thoroughly survey the shores that Harvey had described. The team was split into small groups to survey different shores (Table 1). Records were transferred to paper copies of the spreadsheets of Harvey's and subsequent records. There were some observations in later years including a systematic census of conspicuous species on the shore at Devil's Kitchen on 6 and 7 July 2012 by KH (which were also added to the spreadsheet).

Whole shore surveys were undertaken by mainly searching for and recording conspicuous species on the assumption that this was the approach taken in the 1940s. Where organisms could not be identified *in situ*, small samples were collected for examination in the laboratory. A number of seaweed species were preserved as herbarium specimens and are deposited in the algal herbarium (BM) of the Natural History Museum in London.

The names of sites are those given in Figure 1 (which is modified from Hiscock, 2008).

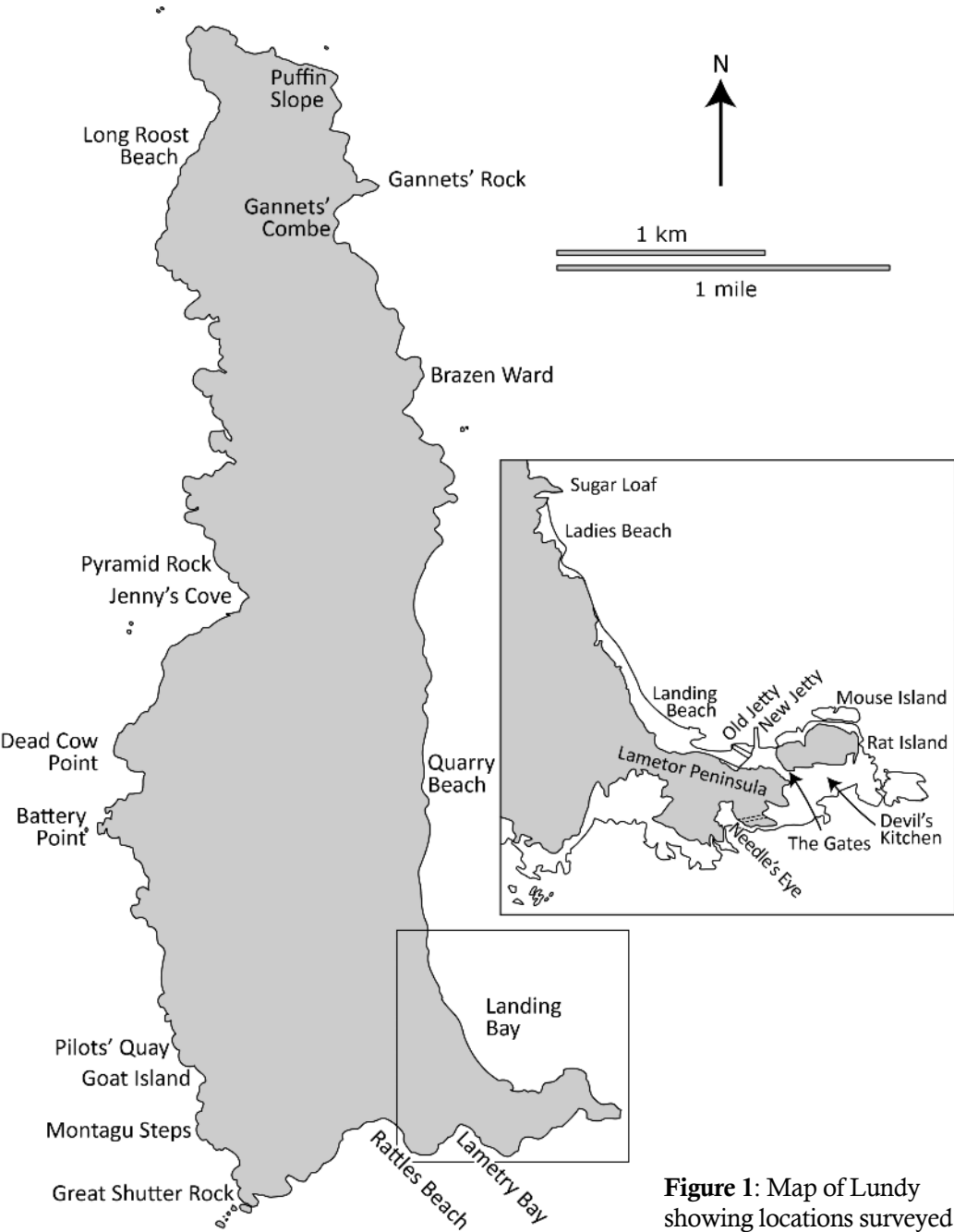


Figure 1: Map of Lundy showing locations surveyed

Table 1: Locations surveyed and survey personnel in 2008

Date and Predicted Low Water Height	Site Name	Location (Degrees & Decimal Degrees)	Personnel
30 August Predicted low water height: 1.0m	Devil's Kitchen	51.162460, -4.652283	Juliet Brodie, Steve Hawkins, Keith Hiscock, Nova Mieszkowska, Judith Oakley, Chris Pirie, Jack Sewell
	Between the Old Jetty and the Landing Beach	51.162831, -4.655780	Gavin Black, Steve Hawkins, Marc Hubble, Nova Mieszkowska, Ian Reach
31 August Predicted low water height: 0.7m	Goat Island	51.163087, -4.674132	Juliet Brodie, Keith Hiscock, Judith Oakley, Jack Sewell
	South of Battery Point	(precise location not registered)	Steve Hawkins, Nova Mieszkowska
	Jenny's Cove (Pyramid Rock)	(precise location not registered)	Steve Hawkins, Nova Mieszkowska
	North Rat Island	51.163520, -4.652358	Gavin Black, Marc Hubble, Chris Pirie, Ian Reach
1 September Predicted low water height: 0.7m	Ladies Beach	51.167424, -4.660664	Gavin Black, Marc Hubble, Chris Pirie, Judith Oakley, Jack Sewell
	Brazen Ward	51.190426, -4.663636	Juliet Brodie, Keith Hiscock, Steve Hawkins, Nova Mieszkowska
	Rat Island (near beach hut)	(precise location not registered)	Steve Hawkins, Nova Mieszkowska
2 September Predicted low water height: 0.8m	South Lametor Peninsula	51.161335, -4.657067	Gavin Black, Keith Hiscock, Marc Hubble, Chris Pirie
	North Rat Island inc. Mouse Island	51.163554, -4.652431	Juliet Brodie, Judith Oakley, Ian Reach, Jack Sewell, Nova Mieszkowska
	The Cove (Old Jetty)	(precise location not registered)	Steve Hawkins, Nova Mieszkowska

Samples of geniculate (branching) Corallinaceae: In order to make comparisons of the fauna associated with branching coralline algae with the quantitative lists documented by Harvey, we sampled 500ml of erect coralline alga from four rockpools on the north side of Rat Island in 2008. Some material was sorted on site to separate out animals (by eye) while fresh, and all samples were preserved in 4% formalin for later analysis. Separated fauna were preserved in alcohol. The wet weight of the *Corallina* was measured by decanting off the formalin, washing the samples in tap water five times (to remove the formalin), draining the final wash thoroughly, weighing the sample in the jar, emptying the jar and then re-weighing the jar.

Marine Biodiversity and Climate Change (MarClim) sampling: During the course of the 2008 work, Professor Steve Hawkins and Dr Nova Mieszkowska undertook quantitative surveys of certain intertidal animal species that may respond to climate change. Although limited work on climate-sensitive molluscs had been carried out in 1977, 1978 and 1980 (Hawkins & Hiscock, 1983), the MarClim study in 2008 provides a reference point at Lundy in a Great Britain survey and will be reported separately as a part of that work (see, for example, Mieszkowska *et al.*, 2006).

RESULTS

Records from the Harvey archive and recent surveys

The three spreadsheets (whole shore surveys in all years, records from the Harvey archive of fauna associated with *Corallina* turfs and records from the Harvey archive of fauna associated with kelp holdfasts) can be accessed from the Lundy Field Society website (www.lundy.org.uk/resources/).

Species and number of species recorded

Whole shore surveys: The comparisons and notes given next are based on the records of whole shore surveys in the spreadsheet 'Lundy shores all consolidated. Final. August 2015'.

The lists of taxa from separate shores in the Harvey archive recorded:

- At Ladies Beach, 59 animal taxa (no algae were recorded) on 2 September 1947 when low tide was a predicted 0.8m relative to Chart Datum.
- At Devil's Kitchen, 32 algal and 63 animal taxa from a transect surveyed over three days and during very low spring tides.
- At Goat Island, 42/24 algal and 27/39 animal taxa on two separate visits (a total of 51 algal and 50 animal taxa). Notably, there were a large number of filamentous red algae species identified – boosting the number of algae recorded on 24 August 1948. On 15 April 1948, the largest number of animal taxa was recorded when the tide was a predicted 0.0m above Chart Datum, so that usually subtidal species would be exposed and sampled.
- At Gannet's Rock north, 38/31 algal and 48/48 animal taxa on two separate visits (a total of 49 algal and 76 animal taxa). Notably, there were several normally subtidal algae and animals recorded on 14 April 1949 when low tide was a predicted -0.1m relative to Chart Datum.

The 'comprehensive' surveys on 6 and 7 July 2012 by the author (KH) at Devil's Kitchen recorded three lichen, 42 algae and 70 animal taxa (conspicuous species only) during tides predicted as 0.9m above Chart Datum. Three additional algal and eight additional animal taxa were added to that list from studies on 30 June 2012 by Judith Oakley and on 2 August 2012 by Keith Hiscock.

For algae, Juliet Brodie recorded 72 algal taxa from Devil's Kitchen (during a low tide predicted as 0.8m above Chart Datum) on 30 August 2008 compared to a maximum of 51 algal taxa on a 'Harvey' shore.

Algae

Of the 146 algal taxa that had been recorded by the Harveys from intertidal areas, 56 were not recorded in recent surveys whilst 40 taxa were added to the Harvey list during the 2008 survey.

Amongst the red algae, Tregelles (1937) especially noted the presence of *Antithamnionella ternifolia* (as *A. sarniensis*), which is a species non-native to Britain originating from the southern hemisphere. It was recorded by Harvey but neither by Irvine *et al.* (1972) nor in the 2008 survey. Clare Harvey was the first person to find the *Falkenbergia* phase of the non-native red alga *Asparagopsis armata* in Britain at Lundy in 1949 (Harvey & Drew, 1949). The harpoon-weed stage was rarely seen at Lundy until the latter part of the 2000s and it has subsequently been frequently encountered in rockpools around Rat Island and

has been a visually dominant part of the shallow subtidal biota in the vicinity of the jetty. Another non-native alga, wireweed (*Sargassum muticum*), which was first observed at Lundy in 2000 (Reach, 2003) was added to the records of Harvey. Whilst the non-native *S. muticum* (wireweed) was abundant in pools and in the region of the jetty in 2008, it was observed (KH) as having declined in abundance subsequent to about 2011. The species is now (2015) rarely seen in Devil's Kitchen, at least in part because of a programme of clearance. However, after a few years of apparently reduced abundance in the Landing Bay, approximately 80 floating plants were counted east of the new jetty on 2 August 2015 during a very low spring tide by KH. A third taxon, *Pyropia leucosticta*, which has been in the British flora for over 100 years (Brodie, pers. comm.), had been recorded by Harvey but was only recently confirmed as non-native (see Sutherland *et al.* 2011).

One notable absentee from the records listed by Harvey (1951) and from those of Tregelles (1937) was the conspicuous southern seaweed *Bifurcaria bifurcata* which was present in 2008 in small amounts in pools at Devil's Kitchen and Brazen Ward, and substantial amounts in pools on the offshore rock outcrop south of the Lametor Peninsula. Irvine *et al.* (1972) also recorded the species. Furthermore, the warm water kelp *Laminaria ochroleuca* was not recorded by Harvey although was most likely looked for (a reprint of the paper describing its first recorded occurrence in Britain in 1948 was in the Harvey archive). We found it at several sites on the lowest shore. Lundy continues to be the most northerly site that it has been recorded in the British Isles (see John, 1969).

There were several green algae added to existing lists in 2008 by Juliet Brodie (*Blidingia marginata*, *Ulva linza*, *U. prolifera*, *U. pseudocurvata*, *U. scandinavica*, *Chaetomorpha linguistica* and *C. linum*). *U. linza* was recorded by Tregelles (1937). There were also several green algae reported in previous lists for intertidal areas that were not found in 2008: *U. clathrata* (recorded as *Enteromorpha clathrata* by Tregelles and Irvine *et al.* 1972), *Monostroma grevillei* (a spring species), *Cladophora lehmanniana* (as *C. utriculosa* by Tregelles and Harvey, *C. lehmanniana* by Irvine *et al.* 1972).

The Harveys had a particularly detailed list of Cladophoraceae, several species of which were not recorded in 2008: *Cladophora pellucida*, *C. laetevirens* (as *C. falcata*), *C. lehmanniana* (as *C. utriculosa*), *C. flexuosa*, *C. albida* and *C. fracta*.

Acrosiphonia arcta (as *Cladophora lanosa*) was recorded by Tregelles (1937) and by Irvine *et al.* (1972) but not by Harvey or in 2008. However, there have been recent nomenclatural and taxonomic revisions and these are noted on the spreadsheet. Significantly, *Corallina caespitosa* is an additional species of erect Corallinaceae found at Lundy that was new to science in 2009 (Walker *et al.*, 2009). It is a species with a southern distribution in the British Isles (see Brodie *et al.*, 2013; Williamson *et al.*, 2015). The Harveys' recorded *Ceramium* species that were not identified in the 2008 survey: *C. gracillimum* and *C. tenuissimum* (both now *C. diaphanum*); *C. strictum* (now *C. tenuicorne*); *C. circinatum*; *C. arborescens*; *C. flabelligerum* (now *C. gaditanum*); *C. echionotum*; *C. acanthonotum* (now *C. shuttleworthianum*). Because of changes in the understanding of species concepts in *Ceramium* (notably Maggs & Hommersand, 1993), direct comparisons between Harvey's lists and those of 2008 are difficult to make. There were other red algal species recorded by the Harveys but not in recent years on the shore, some of which are subtidal species and may have been drift specimens.

Animals

Amoeboid protists: Harvey recorded species of Foraminifera and *Gromia* sp. from what were almost certainly weed washings. These are microscopic organisms that would not have been seen in recent surveys of conspicuous species.

Hydrozoa: *Coryne muscoides* (recorded from all of the shores by Harvey) continued (see Hiscock, 2008) not to be found. The many records of *Candelabrum cocksii* from several shores and from four of the kelp holdfast samples in the Harvey records are remarkable as the species has not been found with certainty in recent years although there was a queried record in Devil's Kitchen in 2008.

Anthozoa: The species reported in the late 1940s were similar to those found in 2008-2015 although *Urticina felina* (as *Tealia felina* in Harvey surveys) was not reported on open shores during recent surveys. It was, however, present in shallow pools on the floor of Needle's Eye cave on 28 September 2011. Harvey does not mention the 'strawberry' beadlet anemone *Actinia fragacea*, now frequently found in the Landing Bay and Devil's Kitchen at least, and he may have included it with *Actinia equina* in records. The records of 'dense groups of *Sagartia anguicoma*' (now *Sagartiogeton undatus*) on the roofs of caves continues to be puzzling (see Hiscock, 2008) as, although one record of the species was reported from 1969 in Hiscock (1975), the species has not been found intertidally in recent years and the suspicion remains that what Harvey saw was *Sagartia elegans*, which were present in abundance on some cave roofs in recent years.

Scyphozoa: Intertidal species recorded at Lundy are the stalked jellyfish *Depastrum cyathiforme*, *Lucernariopsis campanulata* and *Haliclystus auricula*. Harvey (1952) observed '... occasional ... individuals of *Lucernaria* and *Haliclystus* attach themselves to the fronds'. Charles Boyden recorded *H. auricula* as 'Common' in 'The Gates' (most likely Devil's Kitchen) in the early 1970s (Hiscock, 1975). Only two individuals (one of each of those species) were found in 2008, reflecting the decline which has occurred since about the mid-1970s in south-west England of stalked jellyfish.

Mollusca: The keyhole limpet *Diodora graeca* (as *Diodora apertura*) was recorded 'rarely' by Harvey (1952) and one was found in Quarterwall Bay in 1975 (Picton, 1979) but has not been recorded in recent years. Referring to the north shore of Rat Island, Harvey (1952) reports 'very characteristically, the mussel, *Modiolus modiolus*, and the sea-slug, *Goniodoris nodosa*'. '*Modiolus*' is also frequently reported in samples of *Corallina* turf but this northern species has not been recorded at Lundy in recent years. *Goniodoris nodosa* has not been recorded in recent years from Lundy shores.

Crustacea: *Austrominius* (= *Elminius*) *modestus*, a non-native barnacle that had first been reported at Lundy by Hiscock & Hiscock (1980), was found but in very small numbers in 2008. The crustacean *Munida rugosa*, which was noted as present on shores in Hiscock (2008), has not been found in recent years and Harvey did not record it. Harvey recorded

the hermit crab *Pagurus prideaux* (as *Eupagurus prideauxii*) in five of 17 quadrats at Devil's Kitchen and, although the species continues to be recorded subtidally, there are no intertidal records in surveys from the 1970s onwards. Harvey records the prawn *Palaemon adspersus* (as *Leander squilla*) at four quadrats in the Rat Island transect and makes a point (in Anonymous, 1949) of mentioning 'the small prawn *Leander squilla*' on the southern shore of Rat Island. The species is considered scarce around Britain and has not been recorded at Lundy since the work of Harvey. Although Harvey draws attention to the small leptostracan *Nebalia bipes*, he seems to have found few and there are none recorded in recent years.

Bryozoa: The 2008 survey sampled significantly more species of Bryozoa than those described by Harvey, most likely because we took samples from overhangs and under boulders.

***Corallina* turf samples**

Species identified and counted from each sample and wet weights of each sample are given in Table 2.

The wet mass of the 2008 samples was between 104 and 162g, a little more than the masses recorded by Harvey in Ladram Bay samples. However, Harvey records volumes of 20-30ml for Ladram Bay samples, much less than the 2008 sampling at Lundy but which could, perhaps, be achieved by compressing the samples.

The taxa present and number of individuals of each taxon were broadly similar to those sampled in the late 1940s. Harvey also recorded attached fauna including sponges and hydroids which we did not. The two samples which Harvey took north of Rat Island contained 30 taxa (excluding sessile species and amphipods identified to species then but which were not considered from 2008), compared to 32 taxa from four samples in the same area in 2008. Considering all of the samples from the late 1940s, species richness seemed likely to be less in 2008 compared to the late 1940s but not by a great deal. However, differences in sampling methods and especially uncertainty over quantities taken in the 1940s made comparison difficult.

The storms of 2013-14

Observations were made of the shores at Devil's Kitchen and in the area of the jetty in early 2014 looking for any conspicuous effects of the storms that had caused widespread damage around the coasts of south-west England from December 2013 to February 2014. The most obvious impact was the removal of a great deal of the shingle at Hell's Gates, to the extent that a new rockpool was formed. The pool was colonized by fast-growing or ephemeral algae, especially the kelp *Alaria esculenta* and by green algae, *Ulva* sp(p). However, the pool had been infilled by June 2014. There was a collapse of some of the slate wall of a pool in Devil's Kitchen and loss of associated biota with some infilling of the pool by shale pebbles. Otherwise, there was no obvious impact. The species present at monitoring sites seemed as always and the communities present in a small cave on the north side of Rat Island (a monitoring site established in 1983) were photographed to compare with images taken in 1983 and found to be very similar.

Table 2: Taxa separated from 500ml samples of erect coralline algae in 2008

Taxon	Number of Individuals				Comparison with Harvey Samples
	Sample 1 128g	Sample 2 116g	Sample 3 104g	Sample 4 162g	
Nemertea indet.	1			2	Samples taken by Harvey were most likely slightly smaller.
Polychaeta indet.	36	8	25	51	1-35 in Harvey samples
Turbellaria indet.		1			
? <i>Corophium</i> sp.		1			
Amphipoda indet.	13	63	47	21	3-453 in Harvey sample
<i>Dynamene bidentata</i>		10	5		0-12 ' <i>Sphaeroma</i> ' in Harvey samples
Sphaeromatidae indet.	1	62	3	5	
<i>Idotea granulosa</i>			2		0-67 in Harvey samples
<i>Idotea</i> sp.		11			
<i>Jassa falcata</i>			1		
Isopoda indet	1			1	
Decapoda indet (juv. crab)			1		
? <i>Nymphon gracile</i>		1			
? <i>Pycnogonum littorale</i>		1			
Opisthobranchia indet.				1	
<i>Ibittium reticulatum</i>	1				0-2 in Harvey samples
<i>Buccinum undatum</i>	1 (juv.)				
? <i>Cerithiopsis tubercularis</i>	1				
? <i>Lacuna vincta</i>				1	
? <i>Littorina littorea</i> (juv.)				1	
? <i>Littorina neritoides</i>			1		
<i>Littorina obtusata</i>		3	2	1	Often more in Harvey samples with 71 in one
<i>Littorina saxatilis</i>	2	3		1	Not specifically recorded by Harvey
Rissoidae indet. (smooth)		7	1	18	Often not recorded. 1-16 but 104 in one
Rissoidae indet. (ridged)	1	8		7	
<i>Anomia/Heteranomia</i> sp.	1	1		1	1 and 6 in only two samples
<i>Hiatella arctica</i>	4	11	1	6	Often none but 12 in one
? <i>Modiolus barbatus</i>		1		1	1s and 2s but 16 in one
<i>Musculus discors</i>	7	3	3	12	<i>Musculus marmoratus</i> (now <i>Modiolarca subpicta</i>) recorded by Harvey. 1s and 2s but 20 in one
<i>Asterina</i> sp.		1			1 in Harvey samples
<i>Luidea ciliaris</i>	1 (12mm)				
Ophiuroidea indet.	37	25	71	144	0-52 <i>Amphipholis squamata</i> in Harvey samples

DISCUSSION

Introduction

The field studies that were undertaken by L.A. Harvey and his co-workers have provided a 'snapshot' of the species that could be found on Lundy shores in the late 1940s and in 1950. Harvey's surveys of whole shores were descriptive in nature, as were ours, and it is important to recall the words in Harvey (1951): 'Even after three years of visiting these Lundy shores, it cannot be claimed that more than a proportion of the shore population is known; and the lists which are appended to this brief article do not pretend to be more than a start on the task of cataloguing the fauna and flora.' Despite those cautionary words, we found that the records of species present made by Harvey were thorough and reliable. Such records are invaluable as a source of comparison with observations today and in the future as a way of tracking changes in species occurrences brought about by natural fluctuations, by climate change and by human activities.

Comparisons and conclusions

Comparisons: The slightly longer lists of taxa for whole shore surveys during the intensive survey in 2008 and on some subsequent occasions than those produced by Harvey and co-workers most likely result from there being more eyes on the ground and because of specialist knowledge. The differences between the species reported as present on specific whole rocky shores in the late 1940s compared to the period from about 1970 to 2015 are likely to be largely a matter of natural variability in occurrence, the specialist taxonomic interests of recorders identifying more species in particular groups, and serendipitous finds of usually subtidal species especially if the shore was surveyed on a very low spring tide. For the algae, there are a number of possible reasons for differences in the lists. A considerable amount of work has been undertaken on their taxonomy over the last half century, particularly for the red and green seaweeds, leading to a better understanding of species concepts, the inclusion of newly described species and the arrival of non-native species in the flora. In addition, the Harveys worked in the spring and summer. Our records are from summer surveys and it might be that there are species which are present in the spring but typically gone by the summer.

Sampling of the fauna of *Corallina* turf from only four rockpools at Rat Island compared to the 34 sampled at 10 different locations by Harvey does not allow for a comprehensive comparison of species richness. However, the range of taxa and the species present was similar. The numbers of individuals of each taxon identified from each of the 2008 samples was also similar including allowing for the most likely slightly larger size of samples taken in 2008. The conclusion that the 2008 samples were not as rich as in the 1940s might need some further investigation.

The observation that the abundance of wireweed, *Sargassum muticum*, in the Landing Bay and Devil's Kitchen appears to have declined since about 2011 might be due in part to systematic removal from those locations by the first author but reduced abundance may be a natural although perhaps temporary decline. The presence of at least 80 floating plants visible on a low spring tide in July 2015 suggests that any decline in abundance may have been short-lived.

Looking down the total list of species from Harvey (1951), almost all can be found today around Lundy. However, the following are conclusions of significant differences comparing late 1940s observations with the situation from 2006 to 2015:

1. There are additional non-native species present (*Sargassum muticum* and *Elminius modestus*) to those recorded in the late 1940s although *E. modestus* was very difficult to find in 2008.
2. *Sargassum muticum* appears to have declined in abundance since about 2011 but was again abundant in 2015.
3. Effects of seawater and air warming since the 1940s are most likely the reason for increased abundance of *Asparagopsis armata*, and increased abundance (compared to 1980 but not necessarily the late 1940s) of *Phorcas lineatus* (was *Monodonta lineata*). There may also be a decline in abundance of the dahlia anemone *Urticina* (= *Tealia*) *felina* which Harvey recorded in three out of 17 quadrats at Devil's Kitchen but surveys in the 2000s did not record intertidally except in the cave that is the Needle's Eye.
4. Stalked jellyfish (Scyphozoa) were obviously much more common in the late 1940s than they are today at Lundy. Similarly, the hydroids *Clava multicornis* and *Candellabrum cocksi* were easily found by Harvey but have not been seen in recent years. The greatly reduced abundance is the same for those species throughout south-west England (author's (KH) own observations and with reference to the Plymouth Marine Fauna: Marine Biological Association, 1957).
5. The record of *Pagurus prideaux* is suspect as the hermit crab is normally associated with the anemone *Adamsia carcinopados*, which was not recorded along the transect by Harvey. It seems likely that the crab was a different species of pagurid.
6. The prawn *Palaemon adspersus* (as *Leander squilla*) is considered scarce around Britain and has not been recorded at Lundy since the work of Harvey. However, Harvey makes the point (in Anonymous, 1949) of mentioning 'the small prawn *Leander squilla*' on the southern shore of Rat Island and separately records *Palaemon serratus*, so quite possibly a disappearance.
7. The records of 'Modiolus' made by Harvey (*M. modiolus*, *M. barbatus*, *M. phaseolinus* in Harvey, 1951) are puzzling as *Modiolus modiolus* is a northern species not found around Lundy during surveys re-started in the 1970s. Many of the records made by Harvey are of large numbers of 'Modiolus' (<42) in *Corallina* samples. Although *Mytilus edulis* was recorded by Harvey, it is to be speculated that they may in fact have been *Mytilus edulis* spat. Although Harvey recorded '*Fucus anceps*' (now *Fucus distichus*) from Jenny's Cove, he later realized (Harvey, 1949) that the species was *Fucus vesiculosus* var. *evesiculosus* (now forma *linearis*), the name used in the spreadsheet. Harvey recorded the tortoiseshell limpet *Testudinalia testudinalis* (as *Patelloidea tessulata*) at Gannet's Rock north in the field records but this record is not in the final list of species (Harvey, 1951) and was most likely a misidentification realized before the final list was assembled. If it was present, it would be a remarkable record as the species is northern in distribution with the furthest south record in the Isle of Man.

Conclusions: The overall conclusion must be that the species present and the number of different species to be found on the shores around Lundy remains today much as they were in the late 1940s. However, there are few species where a description of their abundance was given for the late 1940s and so quantitative comparisons are not generally possible.

The rocky shores of Lundy range from those subject to extreme wave action, particularly on the west and south coasts, to ones in the Landing Bay that are sheltered from wave action for much of the time. The marine life that colonizes particular shores reflects that degree of exposure to wave action and the sub-habitats that are present such as rockpools, under boulders, overhangs and caves. The rocky shores are thus very varied providing a range of habitats that encourages an overall rich variety of species. Such physical conditions are unchanging and the species recorded in recent years are therefore unsurprisingly similar to those in the late 1940s and earlier. What is changing is climate and the arrival of non-native species, something that has the potential to greatly change the character of some shores.

There remains work to be done that will help to understand what changes have and have not occurred on rocky shores around Lundy. In particular, the shore immediately north of Gannets' Rock deserves thorough resurvey as Harvey identified it as a very rich location (that was not re-visited in the work described here). The rocky shore transects surveyed by Hiscock & Hiscock (1979) should be ones chosen for survey exercises aimed at describing zonation and identifying change. The cave site at Rat Island that was established as a monitoring site in 1984 should be re-surveyed systematically. New survey locations should be established to identify the abundance of non-native algae, to monitor change in abundance and to assess their effect on native species.

The similarity of the species recorded in the various recent surveys with those undertaken by the Harveys demonstrates the value of old data sets that describe the character of a location and with which comparisons can be made with contemporary data.

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Plates 1-12 show some of the algae and animals discussed in this paper. The photographs were taken by the author, Keith Hiscock, except that Plate 2 was taken by Jack Sewell, Plate 7 was taken by Andrew Cleave and Plate 12 was taken by a passer-by.



Plate 1: The two forms of *Asoparagopsis armata*. Left: the asexual tetrasporophyte plant (once described as a separate species, *Falkenbergia rufolanosa*) (recorded for the first time in Britain at Lundy in 1949: Harvey & Drew, 1949) and right: the sexual (gametophyte) plant known as 'harpoon weed' because of the modified fronds that hook into other algae. The gametophyte stage has become abundant since about 2008 in the most sheltered parts of the Landing Bay. Old Jetty, July 2012. Image width c. 30cm



Plate 2: *Alaria esculenta* (dabberlocks) is a northern species characteristic of wave-exposed coasts and disturbed habitats. Plants were sparsely distributed on the lowest shore on the west coast in 2008, as they were in the late 1940s, despite the possibility of abundance declining due to warming seas. Goat Island on 31 August 2008. Image width c. 50cm



Plate 3: Brown forking weed *Bifurcaria bifurcata*, a southern species that occurs in many upper shore pools at Lundy. Here on the shallow upper shore pool on the rock outcrop off the Lametor Peninsula. *B. bifurcata* was not listed in the Harvey records or by Tregelles (1937) but was by Irvine *et al.* (1972). It is a species that has possibly extended its range since the 1940s.
Image width c. 1m



Plate 4: The daisy anemone, *Cereus pedunculatus*, protruding through a mat of consolidated sand on bedrock in Lametry Bay on 3 August 2012. The habitat is unusual and may be ephemeral. The anemone was not reported in the Harvey records, including for surveys in the Landing Bay, in Devil's Kitchen, at Goat Island, at Brazen Ward, at Ladies Beach or in Lametry Bay where it is now recorded. It was mentioned as present at Lundy by Tugwell (1856). Image width c. 20cm



Plate 5: The stalked jellyfish *Haliclystus auriculata* found in a seaweed sample from Goat Island. Both *H. auriculata* and *Lucernariopsis campanulata* were reported by Harvey as 'occasional' but in very small numbers in 2008. Image width c. 25mm



Plate 6: A colony of the serpulid worm *Filograna implexa* (which has operculae) or *Salmacina dysteri* (which does not have operculae). Identification to species is not possible without specimens or images of the crown of the worm. Not previously recorded intertidally. Under an overhang at Goat Island. Image width c. 5cm



Plate 7: The three species of rock limpets that occur at Lundy: *Patella vulgata*; *Patella ulyssiponensis*; *Patella depressa*. *P. depressa* was not recorded by Harvey in the late 1940s but may not have been differentiated from *P. vulgata*. Image width c. 7cm



Plate 8: Shaded overhangs may be dominated by erect branching Bryozoa (species of *Crisia* and *Scrupocellaria* here) with a branching sponge, most likely *Stelligera rigida*. Species of bryozoans and sponges were not identified to any extent by Harvey and branching sponges are anyway very rarely seen on the shore. Image width c. 12cm



Plate 9: The saccoglossan sea slug *Elysia viridis* was occasionally found on *Codium* sp. in 2008. The slug is known as the 'solar powered seaslug' because of the algal chloroplasts that are ingested, incorporated into its tissues and that continue to photosynthesize. They also help to camouflage the animal. This image is from Wembury in south Devon. Image width c. 30mm



Plate 10: The small cushion star *Asterina phylactica* in a large shallow upper shore pool off the Lametor Peninsula. Harvey recorded the cushion star *Asterina gibbosa* from several shores and it is still frequently found. *A. phylactica* was described as new to science in 1979 (Emson and Crump, 1979) and may have been present in the 1940s but listed as *A. gibbosa*. It is now recorded from a few locations at Lundy. Image width c. 40mm



Plate 11: The winter storms of 2013-14 displaced a great deal of the shingle from Hell's Gates and created a new rock pool rapidly colonized by *Alaria esculenta* and species of *Ulva* in particular. Photographed on 17 May 2014. By the end of June 2014, the shingle had returned and infilled the new pool



Plate 12: The survey team in 2008. Left to right: Chris Pirie (English Nature), Nova Mieszkowska (Marine Biological Association), Jack Sewell (Marine Biological Association), Marc Hubble (APEM Ltd), Keith Hiscock (Marine Biological Association), Judith Oakley (Oakley Intertidal), Gavin Black (English Nature), Juliet Brodie (Natural History Museum), Ian Reach (English Nature), Steve Hawkins (University of Bangor)