LITTORAL ROCKY SHORES OF THE CENTRAL SUNSHINE COAST, QLD.

A QUALITATIVE ASSESSMENT 2010-2011

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Contents

INTRODUCTION

Rocky shores are vital features in many parts of the world.

They provide crucial resources and recreational opportunities for human populations. Within our landscape, they play a vital role as wave barriers on open, wave-exposed shorelines and act as anchoring points in the dynamics of soft shores and beaches. These ecosystems are a result of complex interactions between diverse organisms, supporting multiple food chains and the complexity of ecological processes which result in an array of habitats.

The intertidal or 'littoral' zone, adds an additional dimension to this interaction and processes as it is subject to varying conditions that increase from the lower to upper littoral. Consequently, the biota of the littoral zone frequently exhibits physiological and behavioural adaptations which allow them to inhabit, compete and survive these rigours.

The open coastline of the Sunshine Coast in Queensland has several finite headlands and accompanying rocky shores - from Noosa south to Caloundra - with littoral zones that contain diverse biotic assemblages (see Endean et al. 1956, Davie et al. 1998, Meagher 2010). As well as their inherent value as fascinating ecosystems and places of human enjoyment, there is an expectation they may become islands of refuge, or stepping stones for some biota to extend their habitat southwards in response to climate change impact on marine systems.

Generally, pressures from human use and coastal development are known to impact or have the potential to impact these ecosystems elsewhere in the world. Concern regarding the potential for human impact led to the Coolum District Coast Care Group (CDCCG) establishing a community-based program to assess the littoral zones from Point Perry to Point Arkwright. The first survey, advised by scientists from the University of Queensland, commenced in 1999-2000, with the second survey in 2010-2011.

This report provides a qualitative assessment of the data set collected from the 2010-2011 survey and provides a brief comparison of the presence or absence of littoral species in the 1999-2000 and 2010-2011 data sets.


Peacock Rock Skippers


Striped Agile Shore Crab


Green Mat Coral

STUDY AREA

The study area for the research project extended from Point Arkwright {GPS coordinates: -26.54668, 153.10269} north to the rock platform around Point Perry {GPS coordinates: -26.53588, 153.09658} south of Coolum, Queensland.

The shore between the two headlands bears NNW for about 1.9km and comprises a wave platform ranging from 20-40m in width. The open shoreline is subject to moderate to high wave exposure and predominantly south-easterly and easterly storm and weather patterns. High wave exposure characterises the headlands with a more moderate wave exposure experienced in the central shoreline.

The littoral zone includes a rock platform of relatively smooth, low-aspect rock surfaces, which are adjacent to each headland, with the platform becoming more dissected between the headlands, having multiple vertical and high-angled rock faces. The shoreline contains three smaller, discrete, mobile sandy beaches at First Bay, Second Bay and Third Bay, located south of Point Perry.

The sampling regime was constrained to examining the ecology associated with the rocky littoral shore - taking into account the stormwater discharge points into First and Second Bays. The report also noted groundwater discharge occurring at various locations on the coastline and flow variations in relation to rainfall patterns and precipitation intensity. The landward cliffs of the shoreline support a narrow belt of natural coastal forest with urban development inshore which allows the shoreline to be a popular place for recreation.

METHOD

The sampling methodology followed the method employed in the 1999-2000 survey. Transect lines perpendicular to the shore were set up at 100m intervals throughout the study area and $1m^2$ sampling quadrats were established along each transect line, aiming to obtain random sample areas from each zone – upper, middle and lower littoral.

For each transect line, a tape was run from the high-tide mark Mean High Water Spring (MHWS) defining the upper littoral extreme, to the lowest point achievable on the sampling day depending on the weather.

The lowest point was at, or near, the low tide mark Mean Low Water Spring (MLWS) and defined the lower limit of the lower littoral zone. Either:

1) A random number generator was used to determine the location of the sampling quadrat within a zone along the transect line. A 3x3m square was marked out at the designated point and, again using a random number generator, a $1m^2$ site was selected within it. This was repeated within each zone along the transect line.

OR

2) A $1m^2$ quadrat frame was randomly tossed adjacent to the transect tape in each of the three littoral shore zones. In most cases, the sample site was adjusted to exclude rock pools and deep fissures in the rock.

A GPS waypoint was determined for each quadrat site and the site was photographed. Physiographic information (aspect, slope, rock type and shape etc.) and related information (evidence of grazing) about each site were recorded [*see Appendix* 1].

Where there was a marked 'spray zone' above the tide-defined upper littoral limit, resident ecology was noted, as were any mobile biota in the immediate area adjacent to the quadrat site. While these observations were not part of the formal sampling regime, they added anecdotal evidence to the range of organisms within the study area. For each quadrat site, the contained biota was identified to species level where possible, aided by various identification guides and several taxonomic experts who assisted the survey groups.

In some cases, species identification could be made only to a generic level. This was especially so for some algae where microscopic assessment is required. Abundance was estimated for each species using the SACFOR abundance scale developed by the Joint Nature Conservation Committee, UK [*see Appendix* 2].

DATA & ASSESSMENT

The data from this survey of the Point Perry to Point Arkwright study area has been archived into the Moreton Bay Oil Spill Recovery Program UniDap database, along with the data from the earlier CDCCG survey of the area in 1999-2000.

Each data set includes, among other things, the location of quadrat sites, species names and abundance estimates, and the associated physiographic and observational data, all contained in a structured reporting format.

This qualitative assessment of the 2010-2011 survey information aims to provide an overview of the biodiversity and biotic representation within zones of the study area, and to provide an initial comparison of the presence or absence of species reported in the current and earlier surveys.

The qualitative approach taken in this assessment should provide a useful and valid picture of the state of the rocky shores in the study area.


Magnificent Banded Fan Worm


Blue Mottled Swimmer Crab


Textile Cone

RESULTS

The field activities of the 2010-2011 survey of the rocky shores between Point Perry and Point Arkwright were carried out from south to north over a seven month period from April 29 to November 7, 2010 and a one-month period between June 15 - July 4, 2011. Recognising the extremely variable distributions (or patchiness) of biota within the littoral zone of rocky shores, the sampling regime provided for a relatively intensive approach, resulting in the establishment of 29 transects and 98 quadrat sites being assessed for their plant and animal residents [*see Table 1 below*].

TABLE 1 - LITTORAL QUADRAT DISTRIBUTION

Transect #	Quadrat	Upper	Middle	Lower
1	4			4
2	3			3
3	4	1	1	2
4	4	3		1
5	5	1	2	2
6	4	1	2	1
7	3	1	1	1
8	2	1	1	
9	3	1	2	
10	8	3	5	
11	3		1	2
12	2		1	1
13	5	1	3	1
14	4	2	1	1
15	3	1	1	1
16	2	1		1
17	2		1	1
18	3	1	1	1
19	4	2	1	1
20	3	1	1	1
21	3	1	1	1
22	3	1	1	1
23	3	1	1	1
24	3	1	1	1
25	3	1	1	1
26	3	1	1	1
27	3	1	1	1
28	3	1	1	1
29	3	1	1	1
TOTAL	98	30	34	34

UPPER LITTORAL ZONE

Both presence and abundance of resident (slowly mobile and fixed) species were dominated by a small number of species.

Few algal species extended into the upper littoral. The exceptions include the encrusting alga *Ralfsia expansa* which is highly adapted against desiccation and stunted algal turfs which have the ability to trap water in their microhabitat aggregations. The presence of sea lettuce *Ulva australis* in Transect 19 was likely related to a point of freshwater discharge associated with groundwater release.

The sentinel species of the upper littoral zone - littorinids (*Nodilittorina spp.*) and mulberry whelks (*Morula marginalba*), were broadly represented throughout the study area. The carnivorous predator, *M. marginalba*, had an extended vertical range across both the upper and middle zones, predating on resident barnacles and littorinids in the upper zone.

The herbivorous zebra top mollusc, *Austrocochlea porcata*, showed a similar littoral range but was less present and less abundant in the upper sites. The sessile, filter-feeding barnacle species *Tetraclitella purpurascens* and *Tesseropora rosea*, were similarly distributed. All these species are highly adapted morphologically and/or behaviourally to withstand extended periods of intertidal exposure. The littorinids showed their characteristic adaptation of extending high into the spray zone associated with the most wave-exposed locations near Point Perry and Point Arkwright, well above the tidally-defined upper boundary. At the most wave-exposed locations (Transects 3-5 and 26-29), littorinids were the only, or most abundant, animal species.

Adjacent to the headlands, the surface aspect of the rocky shore is predominantly horizontal or gently sloping, the platforms fully exposed to high-wave energy and sun during intertidal conditions. However, in the centre of the study area (Transect 8-20) wave exposure is more moderate and the rock substratum is more dissected or formed of boulders.

This substratum offers an array of vertical surfaces to provide a diversity of microhabitats that are variably protected from full sun. In these habitats, drying during intertidal exposure is reduced. This has provided an opportunity for some species to extend their vertical range from the middle to lower fringe, independent of wave exposure.

This pattern seems to be reflected in the broad distribution and abundance of species. For example, several species more commonly associated with the middle were found higher on the littoral shore than expected, including the limpet *Cellana tramoserica*, oyster *Saccostrea glomerata* and the black nerite *Nerita atramentosa*.

MIDDLE LITTORAL ZONE

The biota showed both an enhanced number of plant and animal species and an increased density or major species compared with the upper zone.

Algae were more widely represented, as most are anatomically or morphologically adapted to periods of intertidal exposure. The broad pattern of algal distribution was contained in the area between Transect 6 and 16; this is compatible with a causal relationship between successful algal colonisation and the presence of a high proportion of vertical surfaces within the substratum.

Both the occurrence and percentage cover determined for the green algae - *Ulva australis* and *Enteromorpha spp.* – are probably enhanced by freshwater discharges associated with natural groundwater flows and periodical discharges from stormwater drains.

The surveys were carried out after summer-autumn periods of extended and record rainfall conditions. The sentinel species for the mid-littoral zone (limpets e.g. *Cellana tramoserica* and chitons e.g. *Acanthopleura gaimardi*) – were recorded in most quadrats, usually in relatively high-density aggregations.

Generally, the whelk (*Morula marginalba*) was associated with the limpet aggregations, which appear to be a major prey species for the whelk in this zone of the littoral shore. The chiton *A. gaimardi* was often associated with the anemone *Oulactis muscova*, in fissures of the rocky substratum where moisture was retained during intertidal exposure.

These microstructures in the rock tended to harbour most of the other gastropod species, anemones and zoanthids. While there were an enhanced presence and abundance of barnacles (*T. rosea, T. purpurascens and C. antennatus*) across the study area, *C. antennatus* was found in only two sample quadrats. In a number of quadrats, a mixture of live and dead barnacles was observed. Many of the dead barnacles had fine (about 1mm) holes drilled in them, probably as a result of heavy predation from *M. marginalba*.

LOWER LITTORAL ZONE

This zone sustained a diversity of animal species that exhibited a greater abundance than in the mid-littoral. Mobile species and obvious rockpool species have been deleted from the table and are reported elsewhere. The separation of rockpool influence on the data set is more difficult than in the higher zones due to increased commonality between zonal and rockpool species. Transects 1, 6, 8, 11, and 16 were mostly affected.

The lower littoral was characterised by algal assemblages with extensive carpets increasing through the fringe and into the sub-littoral zone. This pattern reflects the greatly diminished periods of intertidal exposure and the naturally associated reduction of the potential for desiccation.

Articulated calcareous algae (e.g. *Corallina officinalis*, *Jania crassa*) were increasingly represented in the lower littoral. While the adaptable species of *Ralfsia* and *Ulva* were present, they were cosmopolitan across the littoral shore. Many of the algae formed mixed assemblages that retain water during exposure periods; red algal species were particularly common in these communities.

Again, freshwater from groundwater discharges and from drains [*see Transects* 18 *and* 19] may have had some influence on the distribution of *Enteromorpha spp.* and *Ulva australis*.

The sentinel species (*Cellana tramoserica*, *Acanthopleura gaimardi*) and the predator whelk (*Morula marginalba*) extend into the upper fringe of the lower littoral. Additional limpet species (e.g. *Cellana turbator*, *Siphonaria denticulata*) and a variety of other marine molluscs were present.

The cunjevoi sea squirt (*Pyura stolonifera*) was a common resident, often occurring in relatively high densities. Sponges and low algal turf were sometimes found in conjunction with *P. stolonifera* in the lower littoral fringe. Littorinid species were absent from the lower littoral zone.

Barnacles were represented in patchy distribution patterns, generally associated with the wave-exposed sectors of the area. It is likely the constrained distribution of *Tesseropora rosea* and *Tetraclitella purpurascens* to the upper fringe of the lower zone reflects increased competition with algal cover for space. So much so, that barnacle spat is unable to successfully settle.

Most predatory molluscs were located in the upper areas of the lower littoral zone.

NON-RESIDENT & ROCK POOL SPECIES

The presence of mobile species (crabs and fish) observed in, or immediately adjacent to, the quadrats was recorded to provide an anecdotal record for the area. This data is not comprehensive (e.g. crab specimens were often briefly observed before seeking refuge in inaccessible crevices, thus identification of species was limited. Information on rockpool species was entwined within some of the sample quadrat data, as noted above.

Inspection of the data has allowed removal in most instances of species that were possibly representative residents of rockpools included in quadrats. The result is a first approximation of plants and animals that were either resident (and representative of the particular littoral zone) or mobile non-resident species within a quadrat. As a consequence, the quality of the particular quadrat data was degraded. Given these caveats, the non-resident and rockpool species data has provided useful anecdotal information to help our understanding and appreciation of the study area.

The non-resident and rockpool species increased in diversity and abundance between the upper and lower zones. Few species were found in the upper zone. Here, rock pools are relatively infrequent and those that occur are subject to elevated conditions of both temperature and salinity during intertidal exposure. These conditions undergo sharp change when flooding tide exchanges the water mass, making for a stressful environment.
A greater number of plant and animal species was observed in the middle and, on occasion, the ecology represented moderate to high density. An array of non-resident and rockpool species was found in the lower littoral, including worms, sponges, anemones, corals, crabs and fish.

The relatively short periods of intertidal exposure experienced by the lower zone and frequent wave surges on this moderately exposed coast reduce the desiccation regime and the necessity for biota to have inherent adaptation for survival. Clearly, competition is a marked factor in the ecology of the lower shore. Corals were observed to be present in deep, relatively large rockpools and in some surge channels of the lower shore.

Dr Carden Wallace, Museum of Tropical Queensland assisted the 2010-2011 survey, identifying nine species of hard corals in rockpools in the wave platform of Point Perry (*Acanthastrea echinata*, *Acanthastrea bowerbank*, *Acanthastrea hemprichii*, *Acanthastrea lordhowensis*, *Plesiastrea versipora*, *Montastrea curta*, *Platygyra lamillena*, *Acropora glauca and Favia favus*). *Pocillopora damicornis* and *Goniastrea sp.* had been noted at an earlier time. All coral species noted are common with Moreton Bay (*Wallace et al.* 2009).

SPECIES LIST


Yellow-footed Hermit Crab


Pink Coral


White-Spotted Sea Anemone

A total of 190 species of marine plant and animal were recorded by the two surveys (120 in 1999-2000 and 133 in the 2010-2011 survey [*see Figure 1*].

Some 58 species are mobile or non-resident species. Generally, non-resident species were associated with rockpools formed in the littoral zone which provide habitat for species that have an affinity with the sub-littoral zone. A total of 11 species of goby and blenny have been recorded as part of the inventory of mobile species and 14 species of crab were recorded.

Most of the crab species could be considered part of the biota of the littoral zone. However, their great mobility allows their transition across the zone and extension into the sub-littoral.

The dissected and fissured rock substratum provides an abundance of cryptic habitat, making identification and estimating the abundance of individual species difficult. Consequently, the record for crab species can be considered anecdotal.

Comparison of the species records for the two surveys indicates a strong core of species common to each survey, particularly the sentinel species and other dominant species characteristic for each littoral zone.

In the upper zone, the littorinid species were more widely spread and three species were recorded in the 2010-2011 survey (*Nodilittorina acutispira* - two quadrats, N. *pyrimadalis* - 12 quadrats and N. *unifasciata* - 22 quadrats) compared to distribution between 11 quadrats and the occurrence of only two species in the previous survey (N. *pyrimadalis* - 1 quadrat and N. *unifasciata* - 11 quadrats).

The littorinids remained abundant sentinel species in both surveys and the differences could reflect the variability in annual patterns or a minor influence of the 2009 oil spill.

While the abundance of barnacles in the upper and middle zones continued to be high, there were marked differences in distribution between the two surveys.

The distribution of *Tesseropora rosea* was reduced from being present in 46 quadrats in the 1999-2000 survey to 23 quadrats in the 2010-2011 survey. However, *Tetraclitella purpurascens* was an apparently new entry to the study area, occupying 15 quadrats. *Chthamalus antennatus* was represented in two quadrats of each survey. Generally, the barnacle communities were composed of a variety of sizes, suggesting a series of successful recruitments of spat.

The limpet and whelk communities showed some variation between the two surveys. Limpet species were less widely distributed, adjudged by the number of quadrats in which each major species was present. So too for the distribution of the whelk *Morula marginalba* and the chiton *Acanthopleura gaimardi*. Most other gastropods were found to have a similar occurrence in each survey.

Whether these variations in the distribution and occurrence are within the natural envelope of variability and natural cycles is not known.

A better understanding of the ecological dynamics and resultant patchiness could provide insight.

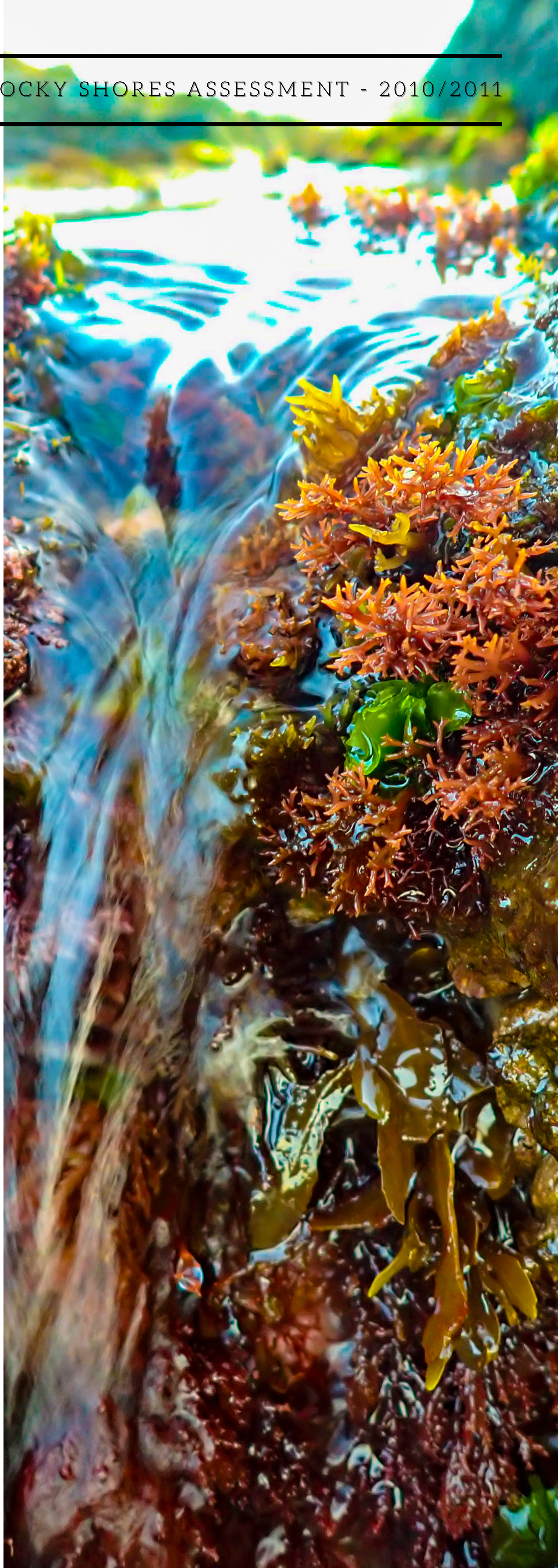
Overall, the algal species showed a greater distribution, with the majority of dominant species occurring in more quadrats in the 2010-2011 survey than the 1999-2000 survey.

It is unlikely that these differences are indicative of chronic pollution and elevated nutrients; further understanding of the differences could be gained from improved knowledge of seasonality and ecological processes.

The difference in the presence of species between the two surveys can be seen, with some species absent in the second survey and some species new to the inventory in the second survey. The differences are associated with plant and animal species that were of limited distribution across the study area (1 or 2 quadrats) and usually present in very low abundance.

This reflects the patchiness of the littoral zone and may be a function of interannual variability in reproductive propagule distribution and seasonality.

Further, incomplete identification of some species during each survey may have attributed some “noise” to the species numbers.



DISCUSSION

The study area has a littoral zonation pattern and biotic diversity in keeping with the descriptions of classical intertidal rocky shores (see discussions in Endean *et al.* 1956, Meagher et al. 2010).

There is a strong vertical zonation characterised by sentinel species associated with each littoral zone; for example, littorinids in the upper littoral, limpets and chitons in the mid-littoral, and algal assemblages in the lower littoral.

Biodiversity increases from the upper littoral to the lower littoral in response particularly to the changing influences of the degree of exposure to desiccation during intertidal periods and of ecological processes including predation and competition.

Wave energy regimes and the slope and aspect of the rock substratum undoubtedly contribute to the existence of an array of microhabitats and the expected patchiness in biotic distribution. The biodiversity is relatively high.

A survey of the littoral zone in 2010 determined that the current study area had the greatest variety of species of the three rocky headlands in the central Sunshine Coast – Pt Arkwright, Alexandra Headland and Pt Cartwright (Meagher et al. 2010).

Further, their data of 40 species from 28 samples (quadrats) was comparable with a partial dataset of the 1999-2000 survey done by the CDCCG: 49 species from 65 samples after removal of apparent rockpool influences.

Inspecting the datasets from the two CDCCG surveys and removing the “mobile and non-resident species” attributed to rockpool influences. The CDCCG 2010-2011 survey has yielded a species richness of 96 species from 98 quadrats, whereas the complete dataset from the 1999-2000 survey yielded 86 species from 103 quadrats that were spread more representatively across the littoral zone.

The higher intensity of sampling across the study area by the two CDCCG surveys probably included more examples of diverse and finer-scale microhabitats than the Meagher et al survey. All three data studies support the conclusion that the study area contains relatively high biodiversity.

Species abundance is relatively high for all sentinel species which are relatively cosmopolitan within each littoral zone across the study area. Other species with a more patchy horizontal distribution within a zone frequently formed clusters of high density or percentage cover.

This was more apparent in the middle littoral and especially lower littoral zone. These qualitative results from the analysis of this survey and the comparison of species richness with the 1999-2000 survey data provide a valuable picture confirming the vitality of the rocky shore study area.

More is promised from the datasets from the two surveys of the study area and valuable fine distinctions about processes and temporal trends and shore status could be expected to result from the application of a number of strong statistical tools.

However, while the datasets from each survey are a result of random and purportedly fully stratified sampling methods, a fully statistical assessment will require a more intensive examination to remove rockpool sample sites and a thorough review of the standardisation and rigour of application of the sampling regimes.

Then, various post-hoc considerations are needed to ensure the assumptions required to be met before the valid application of critical and powerful parametric statistical methods, such as analysis of variance (see, for example, Underwood 1994, 1997).

The rocky shore study area is a popular recreational area resulting in a range of actual or potentially significant pressures on the system, for example, walking and specimen collecting, spear and line fishing, harvesting (gleaning), stormwater discharge and land-based pollution.

Anecdotal information suggests that recreational fishing is of low intensity. Observations during this survey provided little evidence for use of littoral species for bait and the frequent evidence of grazing in a variety of algae across the middle and lower zones suggests a healthy stock of herbivorous fishes, at least, are in the area.

The relatively high biodiversity and abundance of molluscs (limpets, gastropods, oysters, barnacles and chitons) suggest shoreline harvesting or gleaning by people for food are either absent or of limited occurrence.

So too, specimen collection of non-rockpool species would appear to be of little consequence. An understanding of the collection of targeted aquarium specimens, such as nudibranchs, blue-ringed octopus, blennies and gobies, would benefit from a specialised, structured study of rockpool biota; observations made during the study show the presence of some of these animals and a range of accessible coral species, but data are not quantifiable.

Feather Duster Worm

Cartrut

Fire Worm

Freshwater discharge to the littoral rocky shore is clearly evident. Stormwater drain discharges of freshwater and probably pollutants, especially from road surface drains, occur at several finite locations.

It is highly probable the presence of dead barnacles and oysters at sites near First Bay and Second Bay is a function of intense rain periods and concomitant stormwater discharges around the time of the survey. The extent of the mortality was localised as would be expected in the context of water movement on the high energy shore.

Groundwater seepage in the littoral zone was not uncommon and there were observed associations with the presence and abundance of the green algae noted above.

The quality of the groundwater and its potential to contain elevated nutrients and pollutants remains open. Overall, the littoral rocky shore between Pt Perry and Pt Arkwright appears to be a highly biodiverse, functioning ecosystem that is currently subject to relatively low direct human pressures.

However, with increasing population and a changing and more intense coastal land-use pattern evolving, best coastal management practices would encourage a program of active monitoring of the status of the system and of the intensity and impacts of human pressures.


Cleft-fronted Bait Crab


Blue Soft Coral


Milk-Spotted Cowrie


Ascidian

FIGURE 1a - Sponges, Corals & Bryozoans

Species Tally Comparison (1999-2000 v 2010-2011)

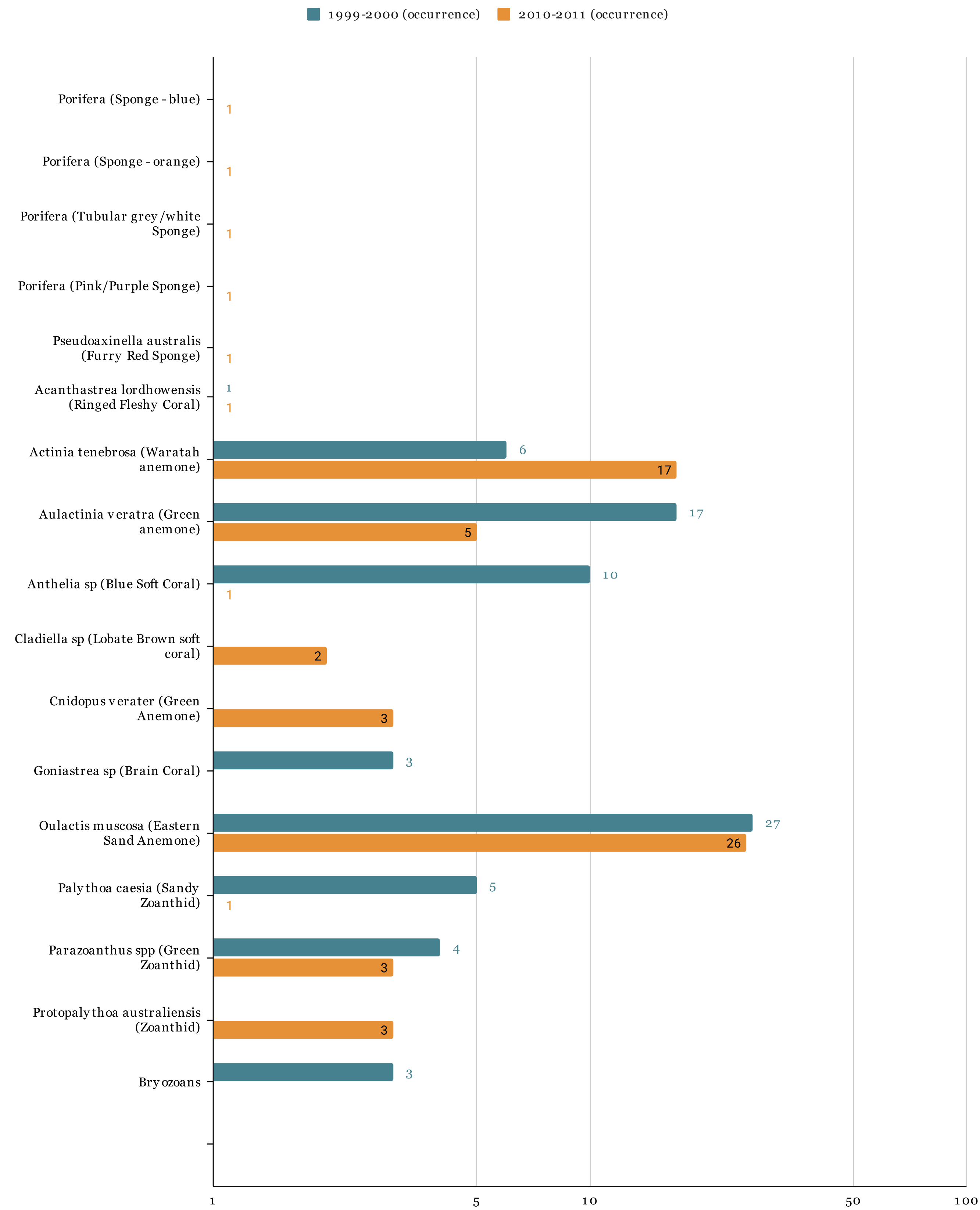


FIGURE 1B - MOLLUSCS

Species Tally Comparison (1999-2000 v 2010-2011)

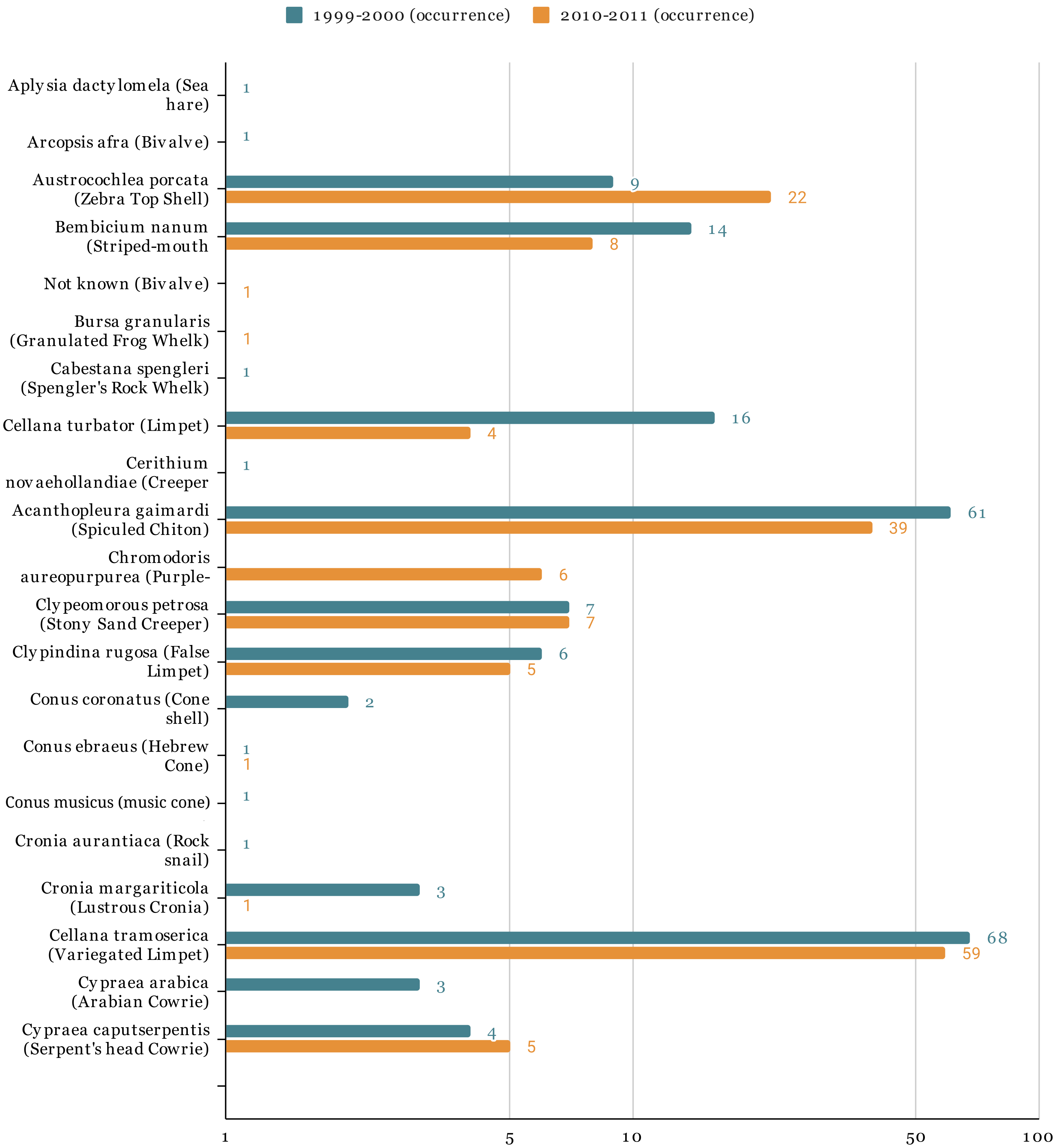


FIGURE 1B - CONTINUED

Species Tally Comparison (1999-2000 v 2010-2011)

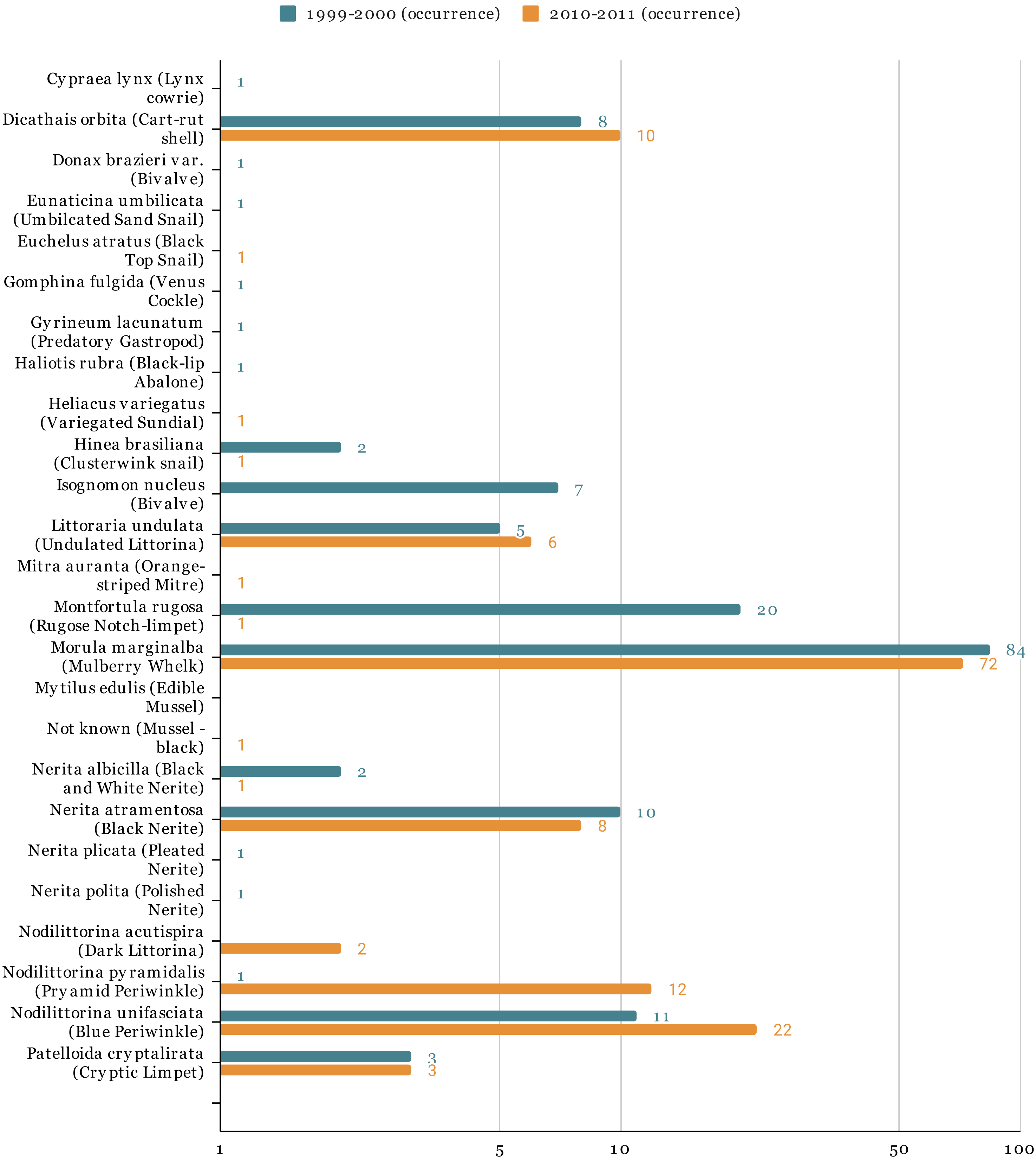


FIGURE 1B - CONTINUED

Species Tally Comparison (1999-2000 v 2010-2011)

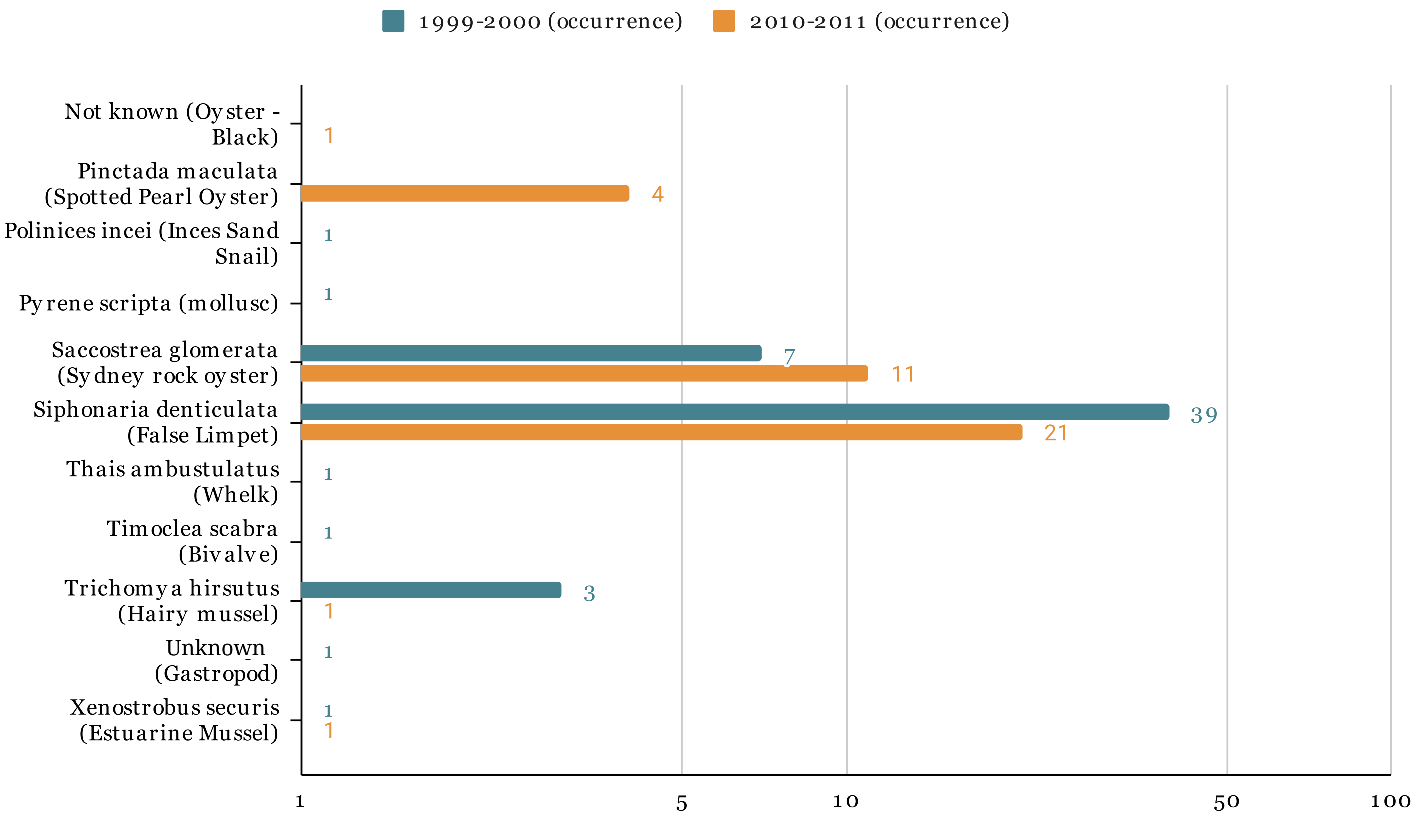


FIGURE 1C - WORMS & CRUSTACEANS

Species Tally Comparison (1999-2000 v 2010-2011)

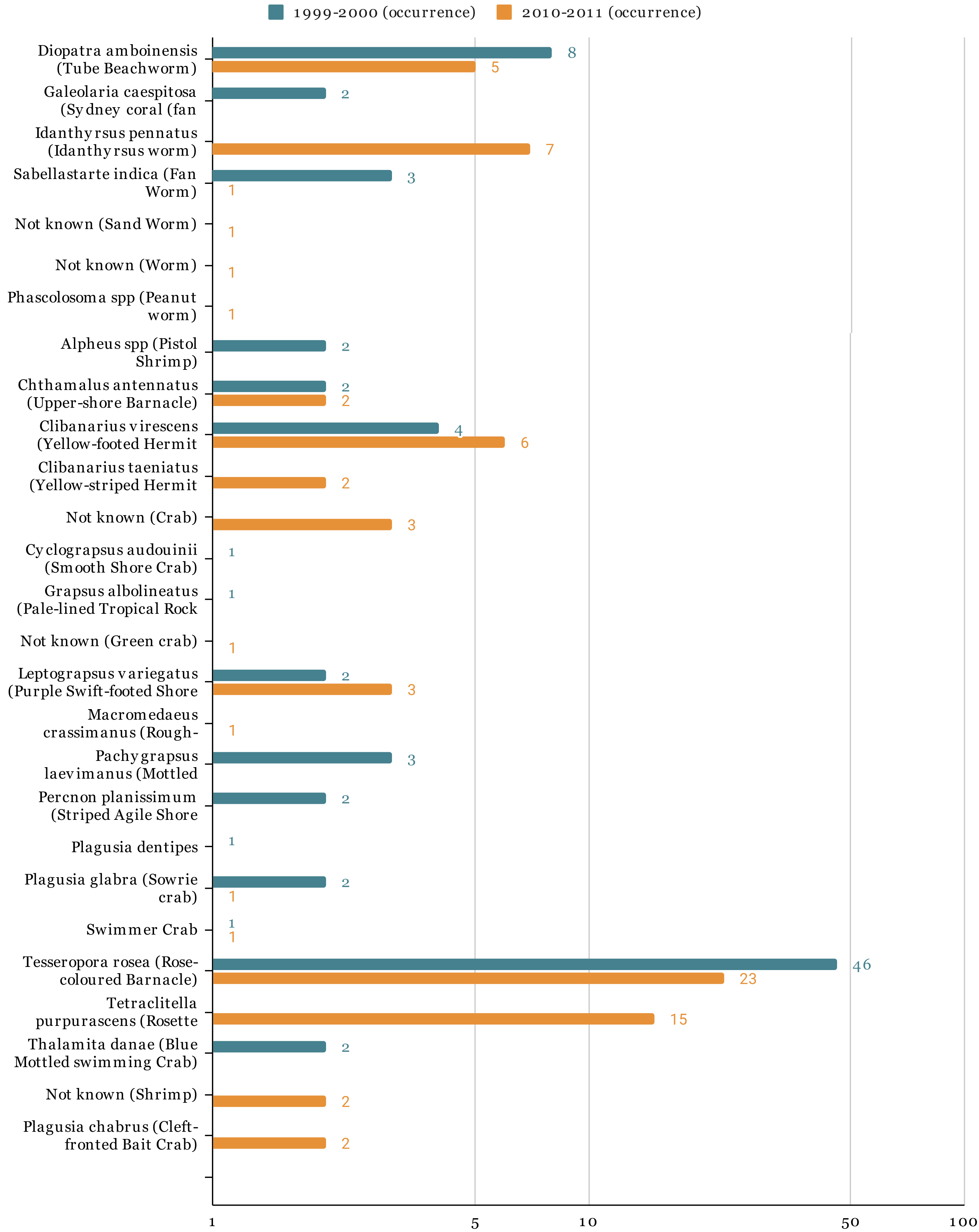


FIGURE 1D - ECHINODERMS, ASCIDIANS AND FISHES

Species Tally Comparison (1999-2000 v 2010-2011)

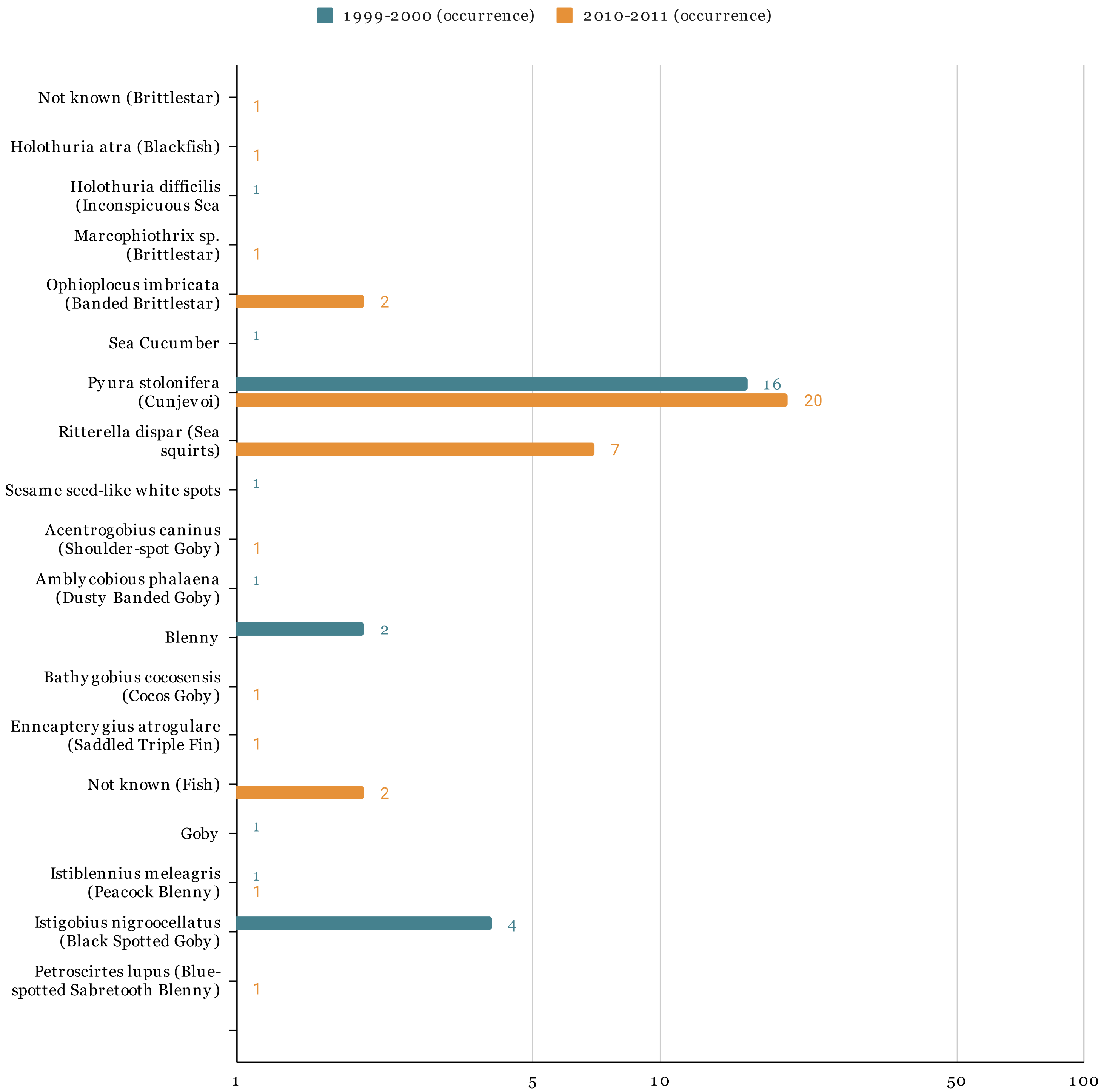


FIGURE 1F- ALGAE/SEAWEEDS

Species Tally Comparison (1999-2000 v 2010-2011)

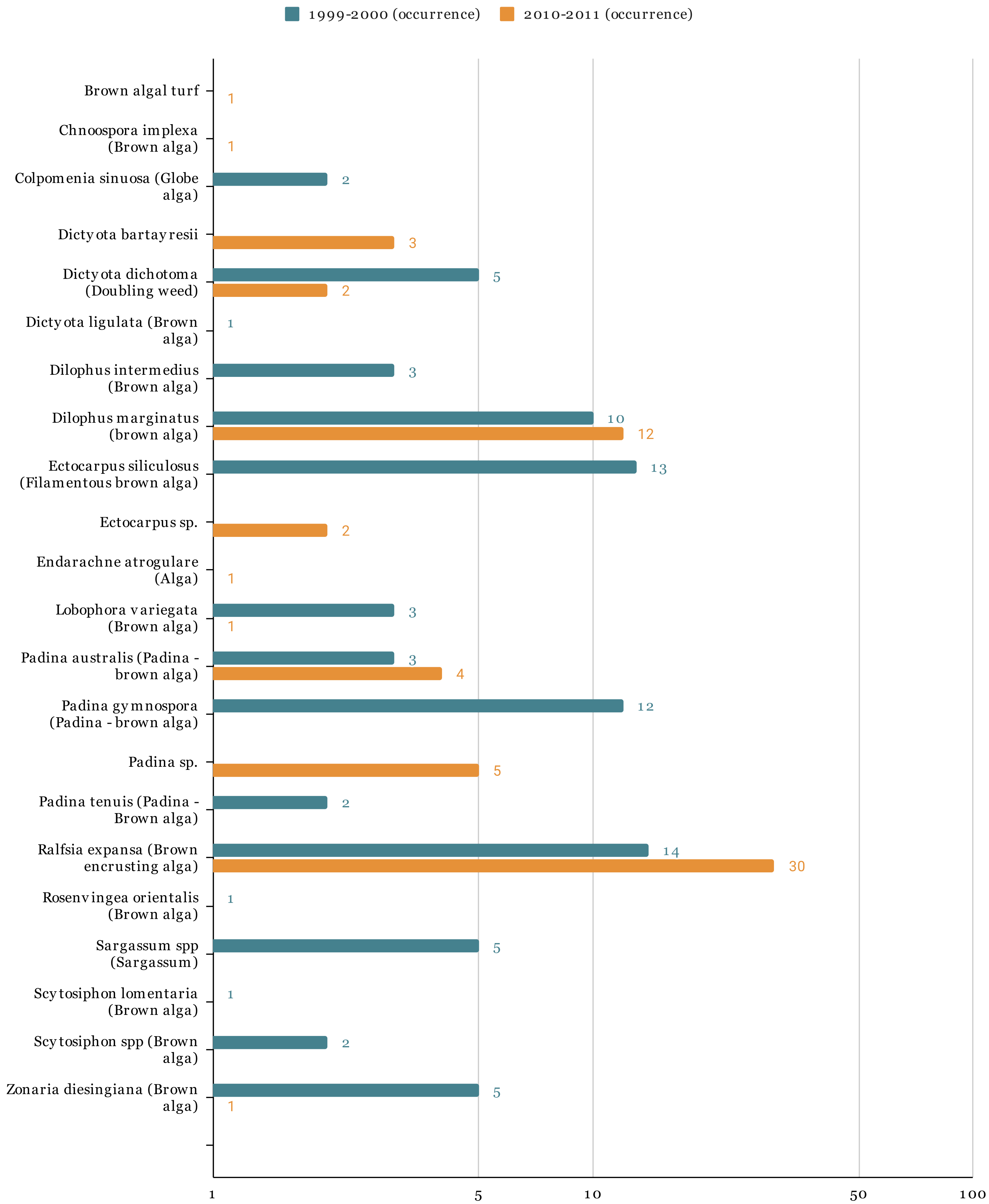


FIGURE 1F - CONTINUED

Species Tally Comparison (1999-2000 v 2010-2011)

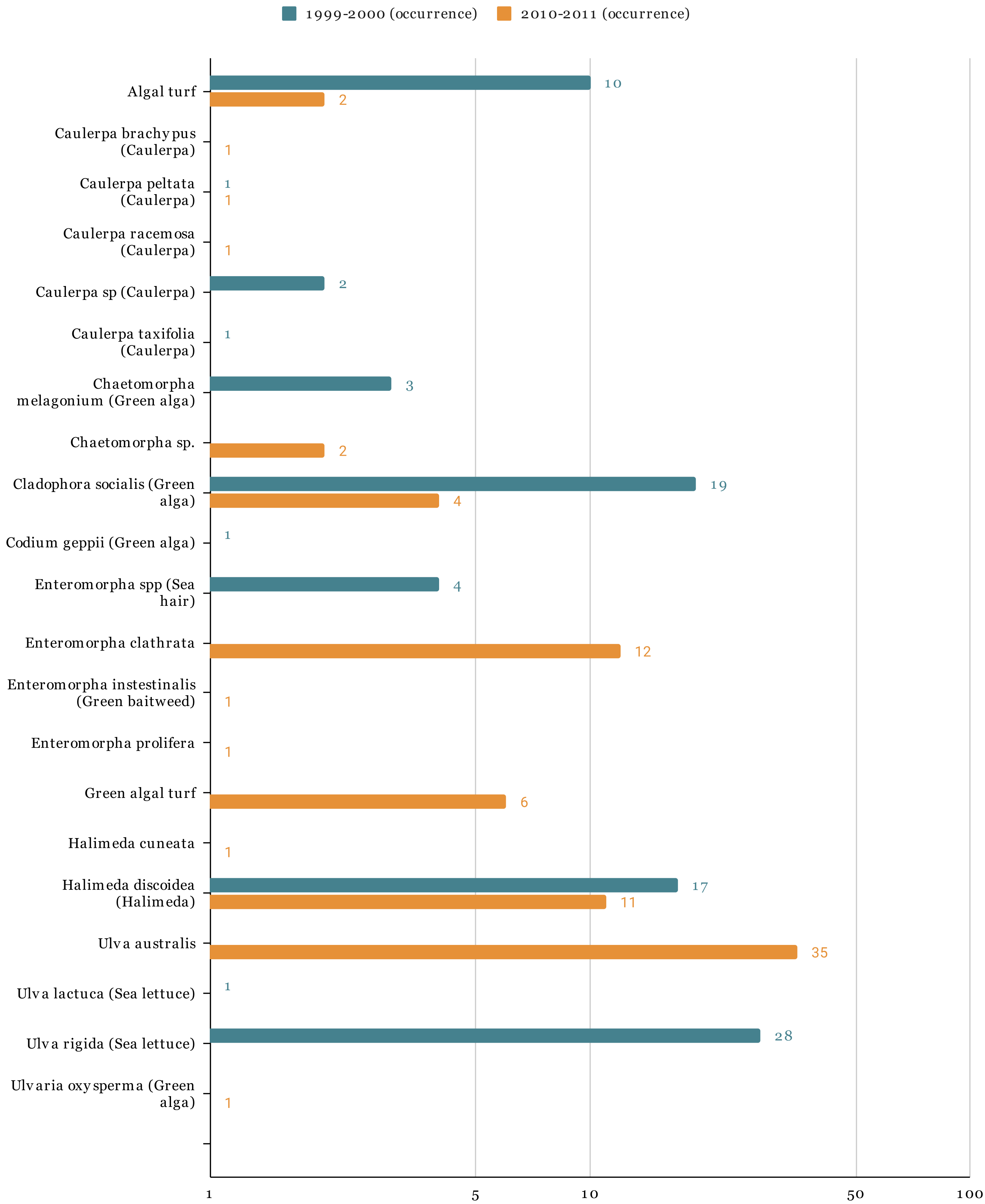


FIGURE 1F - CONTINUED

Species Tally Comparison (1999-2000 v 2010-2011)

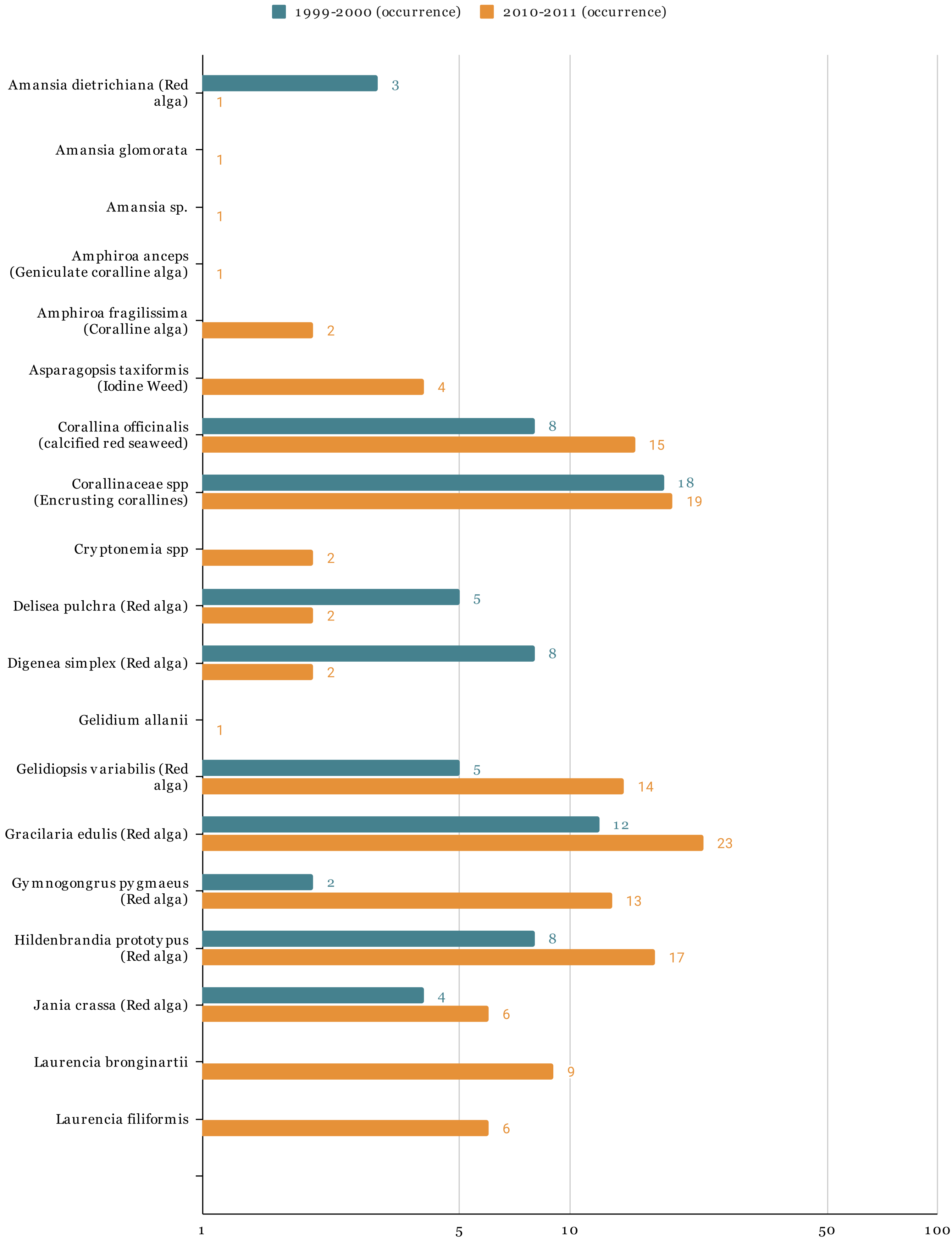
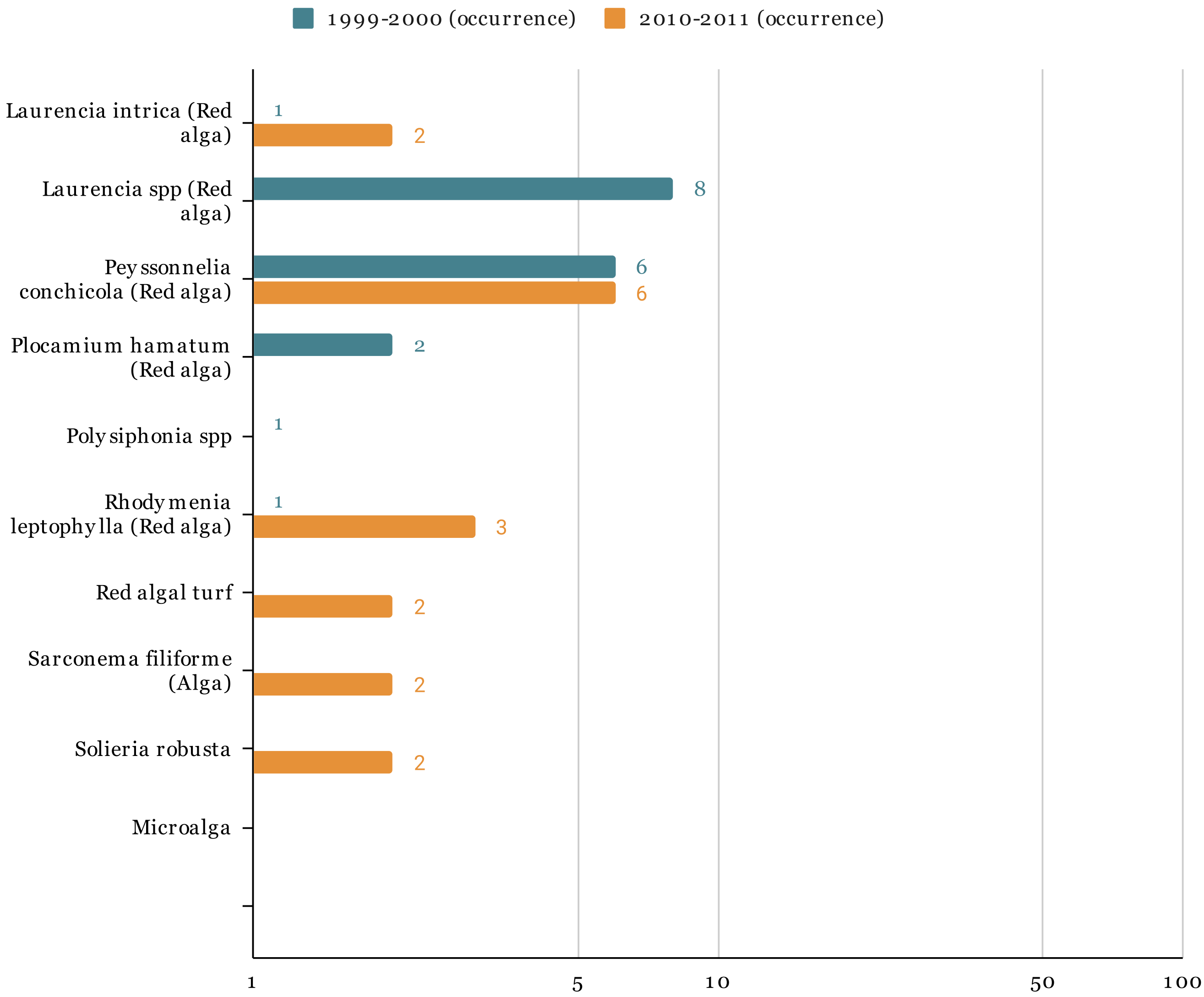


FIGURE 1F - CONTINUED

Species Tally Comparison (1999-2000 v 2010-2011)



SACFOR Abundance Scale

This scale was used to determine abundance of species found in each zone during the 2010-2011 survey.

Species abundance measured by the SACFOR abundance scale included:

- animal species generally were assessed as density units (individuals per unit area);
- plant species were generally assessed as percentage cover [see Appendix Two]

Letter code for relative abundance: S, super-abundant; A, abundant; C, common; F, frequent; O, occasional; R, rare.

In some cases, multiple quadrats were determined in the zone on one transect and their abundance measures are differentiated by commas.

TABLE 2 - SPECIES ABUNDANCE IN THE UPPER LITTORAL ZONE

Transect number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Species																													
Nodilittorina acutispira				F																									
Nodilittorina pyramidalis			C	F,F,O						,R,F					C							C			R				O
Nodilittorina unifasciata			C	F,O,F	F		F	C						F,F										F	F	F	O	O	C
Tetraclitella purpurascens																										R	F	O	O
Tesseropora rosea					F	R		C						R,															
Cellana tramoserica						F		C		C,,									,C	O				O					O
Morula marginalba						F	F	F	C					O,F		O		R	O,F	F			O	R	O				
Austrocochlea porcata						R				R,,			F	,F		O			R	O									
Saccostrea glomerata								C						A,					C										O
Acanthopleura gaimardi								C																					
Bembicium nanum																C				O			O		O				
Algal Turf																													O
Enteromorpha sp.																													
Green algae								R																					
Microalgae			A																										
Ralfsia expansa									C											O							RO		
Ulva australis																			A,R										

TABLE 3 - SPECIES ABUNDANCE IN THE MID-LITTORAL ZONE

Transect number	3	5	6	7	8	9	10	11	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29
Species																									
Nodilittorina acutispira																	F								
Nodilittorina pyramidalis	O															R									
Nodilittorina unifasciata	O					A,	C,,,A,C			O,,F															
Tesseropora rosea	C	,A	,C							,C,		F	F												
Tetraclitella purpurascens							C,,,,		A								O			R	F	C		F	O
Chthamalus antennatus	O						,,,,F																		
Cellana tramoserica	O	C,A	F,C	C	A	,C	,C,F,R,C	C	A	F,C,F	C	C	A	A	C	F		F	A	C	A	C	C	C	C
Morula marginalba	C	C,C	R,A	C	F	,R	R,C,O,,F	F	F	F,F,F	C	O	O	O	O		O	O	F	R		C	O	F	F
Saccostrea glomerata	C		,C				A,,,,C														F				O
Acanthopleura gaimardi	F	A	,F		A	,O	R,R,C,,			C,C,F	A			C	F			O	F		O	F	O	F	O
Austrocochlea porcata			C		F		F,,,R,			F,,F			F	F	C	F		O							
Bembicium nanum	O	F									C					O									
Euchelus atratus	F																								
Siphonaria denticulata	F			C			O,,,,						F								C	O			
Oulactis muscova		C			F	,O	,,F,,	F	A	,A,C	A		F	A	F			O					O		
Green zoanthid		F							F																
Littoraria undulata		O,O					O,,,R,					O													
Aulactinia veratra							,,F,,						C						C						
Pyura stolonifera									A				C								O				
Actinia tenebrosa			,C				,,F,,		C	C,,						R					O	O			R
Clypemorous petrosa			C												F										
Pinctada maculata			O												O										
Diopatra amboinensis			O								C						R								
Dicathais orbita				C			,R,,,												R	O					
Hinea brasiliana					O																				
Trichomya hirsutis							,,,F,																		
Nerita atramentosa										,,F						R									
Xenostrobus securis											C														
Mitra auranta																	R								
Patelloida cryptalira																				R					
Mytilus edulis																						O			
Digenea simplex																								R	
Brown algae					R																				
Chaetomorpha antennina																								R	
Corallina officinalis			R		F			O											F						
Corallina spp.				F	A	,F	,O,C,,	O		,O,															
Ectocarpus spp.																						O			
Enteromorpha prolifera				R																					
Enteromorpha sp.		O	F	F	R	C,		O	O																
Gelidiopsis variabilis	R		A			,F		S	C	,R,					C	O									
Gracilaria edulis							,F,,,	C	F	,O,												O			
Gymnogongrus pygmaeus						,C	,R,,,				C		R												
Hildenbrandia prototypus			,O	F																					
Jania crassa									F																
Pterocladia capillacea						,F	,C,,,												F						
Ralfsia expansa	S						,,R,,R			,O,	O	R	R		F			R		A	C	R	F	R	R
Ulva australis						,O	O,O,,,O	O	F		R	R	O	O	R			R						R	

TABLE 4 - SPECIES ABUNDANCE IN THE LOWER LITTORAL ZONE

Transect number	1	2	3	4	5	6	7	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Species																										
Tesseropora rosea	F,O,O,F	O,,	A,F	F	C						S	S														
Tetraclitella purpurascens																		A					R	F		
Balanus sp.																						F		F		
Cellana tramoserica	C,	F,C,C	F,O	A	A,C		F	A,C	C	C	A	C			O		C	C		F			F	F		F
Cellana turbator	,F,F,	,,F			,C																					
Morula marginalba	C,F,O,A	O,F,F	C,C	F	R,F	R	F	A,S	C	F	C	C				F	O	F	O		F	F	O	P	F	O
Saccostrea glomerata											C															
Acanthopleura gaimardi		,C,A	A,A		A,A			R,	S	F	A	A			F			F		R		F			F	O
Austrocochlea porcata				C												F	F			R						
Siphonaria denticulata	C,,,A	,S,	C,C		C		C	R,	A		C	C						C			F		F			O
Oulactis muscova		O,,C			A			O,O		A		A		C	A	F	R				C					
Green zoanthid					C																					
Montfortula rugosa					R																					
Aulactinia veratra					R						C	C		C					R							
Pyura stolonifera	F,C,F,C	,A,F			O,A	R		R,O	C					A	C	C			O					F		
Actinia tenebrosa			,R	F	R,C			O,R	C								F					F				
Cnidopus verater										C	C					C										
Pinctada maculata								R,							C											
Diopatra amboinensis					O														R							
Dicathais orbita		,F,						F,O			C									R			O		F	
Cladiella sp.														O		R										
Nerita atramentosa																				R						
Nerita albicilla																						F				
Amphiroa fragilissima							R									R										
Asparagopsis taxiformis		,,R					R																		R	
Caulerpa brachypus																			R							
Chaetomorpha antennina																						O				
Chnoospora implexa								,O																		
Corallina officinalis	A,C,F,	A,,R						R,					R							F	A	C	F			
Corallinaceae spp.							F	R,	R	S	R	R		R	R				F					O	A	O
Cladophora socialis												F								O						
Cryptonemia sp.													R													
Dictyota bartayresii								F,									R				R					
Dictyota dichotoma																					R	O				
Dilophus marginatus		R,,				F		,F	S				A	C					C		R	C			S	S
Ectocarpus sp.																					O					
Endarachne binghamiae																			R							
Enteromorpha spp.		C,,C			A			,F																		
Gelidiopsis variabilis					R			,C	O									O		O						
Gracilaria edulis		A,O,F			,O		R	,F	R	F		R					A	C	A	A	C	C	F	F	O	
Gymnogongrus pygmaeus		C,,C									R				R	C			F		O	O		C		
Halimeda discoidea	,,R,O	O,O,R				O							R	C							O					
Halimeda cuneata						O																				
Hildenbrandia prototypus	C	,,C	R,		F,F	R							R		O						O	A	R	F	F	R
Jania crassa	,,,A												S							F	A		C			
Laurencia bronginartii					,O			,O	O							R						A		O	F	R
Laurencia filiformis					,O	O			O	S															R	R
Laurencia intricata																			C	F						
Lobophora variegata														O												
Padina sp.		O,,				R															R					
Peyssonnelia conchicola								F,R	R											F						R
Pterocladia capillacea							F	A,F				O		A												R
Ralfsia expansa		A,F,O		F	R					A	R	C			C	F					O					R
Red algal turf	,A,,																								F	O
Rhodymenia leptophylla																	R									
Sarconema filiforme																			R			R				
Ulva australis	,,R,	C,R,R	R,O		,R	R		R,F	R	R	R	R			F	F		R	R	R	R	R				
Valoniopsis pachynema																			R							
Zonaria diesingiana								,F																		

TABLE 5 - SPECIES ABUNDANCE WITHIN AND ADJACENT TO QUADRAT SITES

Table 5. Species abundance of non-resident and rock pool species within and adjacent to quadrat sites.

Transect number	1	2	3	6	7	8	10	11	12	13	14	15	16	17	18	19	20	23	24	25	26	27	28	29
Species																								
Upper littoral zone																								
Heliacus variegatus											,F													
Protopalythoa australiensis											,F													
Ritterella dispar											,R													
Clypemorous petrosus																C								
Clibanarius virescens																F								
Littorana undulata																,O								
Aulactinia veratra																		O						
Gelidiopsis variabilis																R								
Peyssonelia conchicola																R								
Pterocladia capillacea																R								
Mid-littoral zone																								
Ophioplocus imbricata				R																				
Conus ebraeus				R																				
Cronia margariticola				R																				
Clypidina rugosa				C		O	R,,,,																	
Idanthyrsus pennatus					A			R	C											F				
Ritterella dispar					O				C															
Pseudaxinella australis									R															
Sponge									R															
Protopalythoa australiensis										,F,														
Ophioplocus imbricata				R																				
Clibanarius taeniatus														C										
Clibanarius virescens											F													
Leptograpsus variegatis																					O			
Crab							R,,,,					R,												
Bivalve										R,,														
Amphiroa anceps							,R,,,																	
Asparagopsis taxiformis										,R,														
Caulerpa racemosa																		R						
Cladophora socialis										F,,													R	
Cryptonemia spp.										,R,														
Dictyota bartayresii							,O,,,																	
Dilophus marginatus							,C,,,																	
Gelidium allanii							,C,,,																	
Halimeda discoidea				R						,R,														
Laurencia bronginartii							,R,,,																	
Padina spp				R			,O,,,																	
Rhodymenia leptophylla				R				O																
Solieria robusta							,O,,,			,R,														
Lower littoral zone																								
Clypemorous petrosa	,F,F,														O	F								
Clypidina rugosa				R					A															
Idanthyrsus pennatus								R,C	S															
Ritterella dispar	R	F,O,																	O					
Cypraea caputserpentis				R								A												
Sponge				R									R											
Protopalythoa australiensis														O										
Palythoa caesia														F										
Acanthastrea lordhowensis				F																				
Patelloida cryptalira	,A,F,																							
Bursa granularis	,O,,																							
Sabellastarte indica				R																				
Black mussel																F								
Chromodoris aureopurpurea	R,O,O,R			R				,R																
Enneapterygius atrogulare	R,																							
Shrimp	R,O,																							

TABLE 5 - CONTINUED

Transect number	1	2	3	6	7	8	10	11	12	13	14	15	16	17	18	19	20	23	24	25	26	27	28	29
Fish	,R,O,																							
Istiblennius meleagris				R																				
Petroscirtes lupus				R																				
Bathygobius cocosensis				R																				
Acentrogobius caninus						F																		
Macrophiothrix sp.		,R,																						
Brittlestar		R,,																						
Worms		,R,																	FR					
Plagusia chabrus		,R,	,R																					
Swimmer crab		,,R																						
Green crab																						R		
Leptograpsus variegatus			C,C																					
Grapsus albolineatus								,R																
Clibanarius taeniatus														C										
Clibanarius virescens													R		F	F								
Crab					R																			
Amansia dietrichiana								,O																
Amansia glomerata										O														
Amansia sp.				R																				
Brown algal turf	,,A,																							
Caulerpa peltata				R																				
Delisea pulchra																	R							
Green algal turf	O,A,R,O	,R,																						
Solieria robusta																								

APPENDIX 1 - DATA SHEET FOR ROCKY SHORE SURVEY

LITTORAL HABITAT

Site #: Site Name:

Habitat #: Date: Time: Surveyors:

Zone (Tick One)

Upper:

Middle:

Lower:

Sublittoral:

Percentage Inclination

Overhangs:

Vertical Faces (80° - 100°):

Very Steep Faces (40° - 80°):

Upper Faces (0° - 40°):

Under-boulders:

Percentage Substratum

Bedrock:

Boulders - very large >1024mm:

large 512 - 1024mm:

small 256 - 512mm:

Cobbles (64 - 256mm):

Pebbles (16 - 64mm):

Shellgrit:

Sand:

Rock Features (1-5 scale)

Surface Relief (even - rugged):

Texture (smooth - pitted):

Stability (Stable - mobile):

Scour (none - scoured):

Silt (none - silted):

Fissure >10mm (none - many):

Crevices <10mm (none - many):

Rockpools (none - all):

Rock Shape (rounded - angular):

Tick Applicable

Gully:

Cave:

Rockmill:

Boulder/cobble - on rock:

Boulder/cobble - on sediment:

Boulder Holes:

Sediment On Rock:

Modifiers (tick applicable)

Freshwater Runoff:

Wave Exposure - wave surge:

- sheltered:

Grazing:

Shading:

Pollution:

Main cover or characterising species/taxa:

APPENDIX 2 - ABUNDANCE SCORE USED IN ROCKY SHORE SURVEY

JNCC

SACFOR abundance scale used for both littoral and sublittoral taxa from 1990 onwards

1 Use of the MNCR SACFOR abundance scales

This is an extract from Hiscock, K (ed.) (1996) Marine Nature Conservation Review: Rationale and methods. Coasts and seas of the United Kingdom. MNCR series. Joint Nature Conservation Committee, Peterborough.

The MNCR cover/density scales adopted from 1990 provide a unified system for recording the abundance of marine benthic flora and fauna in biological surveys. The following notes should be read before their use:

1. Whenever an attached species covers the substratum and percentage cover can be estimated, that scale should be used in preference to the density scale.
2. Use the massive/turf percentage cover scale for all species, excepting those given under crust/meadow.
3. Where two or more layers exist, for instance foliose algae overgrowing crustose algae, total percentage cover can be over 100% and abundance grade will reflect this.
4. Percentage cover of littoral species, particularly the fucoid algae, must be estimated when the tide is out.
5. Use quadrats as reference frames for counting, particularly when density is borderline between two of the scale.
6. Some extrapolation of the scales may be necessary to estimate abundance for restricted habitats such as rockpools.
7. The species (as listed above) take precedence over their actual size in deciding which scale to use.
8. When species (such as those associated with algae, hydroid and bryozoan turf or on rocks and shells) are incidentally collected (i.e. collected with other species that were superficially collected for identification) and no meaningful abundance can be assigned to them, they should be noted as present (P).

2 Key

S	A	C	F	O	R	P
super-abundant	abundant	common	frequent	occasional	rare	present

3 SACFOR abundance scale

% cover scale	Growth form		Size of individuals/colonies				Density scale	
	Crust/meadow	Massive/Turf	<1cm	1-3 cm	3-15 cm	>15 cm		
>80%	S		S				**>1/0.001 m^2 (1x1 cm)**	**>10,000 / m^2**
40-79%	A	S	A	S			**1-9/0.001 m^2**	**1000-9999 / m^2**
20-39%	C	A	C	A	S		**1-9 / 0.01 m^2 (10 x 10 cm)**	**100-999 / m^2**
10-19%	F	C	F	C	A	S	**1-9 / 0.1 m^2**	**10-99 / m^2**
5-9%	O	F	O	F	C	A	**1-9 / m^2**	
1-5% or density	R	O	R	O	F	C	**1-9 / 10m^2 (3.16 x 3.16 m)**	
<1% or density		R		R	O	F	**1-9 / 100 m^2 (10 x 10 m)**	
					R	O	**1-9 / 1000 m^2 (31.6 x 31.6 m)**	
						R	**<1/1000 m^2**	

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