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Change, what change?

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Introduction

The title of this paper is the title of a presentation that I gave on 18th March 2023 at the Porcupine Marine Natural History Society conference 'Waves of Change'. The title was provocative, and participants may have assumed that it was going to be a presentation that denied change. In fact, the talk illustrated different sorts of change, and lack of change, that had been recorded in marine habitats.

Here, I put types of change into the context of reporting the 'State of our Seas' – something that the South-West Marine Ecosystems (SWME) webinars, conferences and reports have been describing since 2014 (see www.swmecosystems.co.uk).

For a descriptive account of change in the marine environment with examples and images, the reader can turn to the chapter on 'Change' in Hiscock (2018). Here, I take examples from the SWME Annual Reports and published literature to identify a vocabulary and description of different sorts of 'change'.

Types of Change: Classification & Listing

Seasonal change

Many events occur at certain times of year. They include times of reproduction, times of growth, times of senescence, times of migration or activity/inactivity. The time that expected change occurs is important to record although we seem a long way off the accuracy with which change in terrestrial species (for instance, dates of flowering) occurs. It is important that observations of seasonal change are recognised as such and not as the result of human activities or adverse pulse, environmental conditions. Some events are related to breeding and to activities such as moulting (for instance, spiny spider crabs *Maja brachydactyla* Balss, 1922). In the Plymouth Sound area, eggs of the cuttlefish *Sepia officinalis* Linnaeus, 1758 are expected in late April but in 2017 some were found 'early' (Figure 1). Such phenological change may be significant.

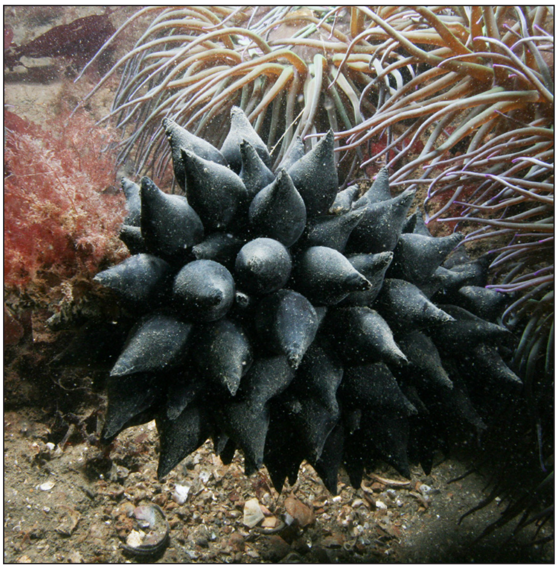

Fig. 1: 'Early' eggs of cuttlefish Sepia officinalis *Linnaeus, 1758 on 9th April 2017 in Plymouth Sound. From the SWME Report for 2017, (Hiscock* et al. *2018). Photo: Keith Hiscock*

Episodic (or 'sporadic' and including 'acute' and 'stochastic') change

Some events occur over a short time frame (although that might be a few consecutive years). We expect such events to occur but do not know when they will. They can include 'unpleasant surprises' such as the bacterial disease that affected pink sea fans *Eunicella verrucosa* (Pallas, 1776) in the early 2000s (and likely did in the 1920s – see the Plymouth Marine Fauna (Marine Biological Association 1957)) and the avian influenza that killed many seabirds (especially gannets) in 2022. Such changes can include 'acute' events brought on by human activities such as spills of poisonous or debilitating material.

Most episodic changes are of species that have not been seen for many years or have not been seen in large numbers for many years, one example being the 'bloom' of barrel jellyfish seen in 2015 and a few subsequent years (Figure 2). Sometimes, what seems a one-off episodic event can become a long-term change including some recovery events (for instance, the return of crawfish *Palinurus elephas* (Fabricius, 1787) and of bluefin tuna *Thunnus thynnus* (Linnaeus, 1758)).

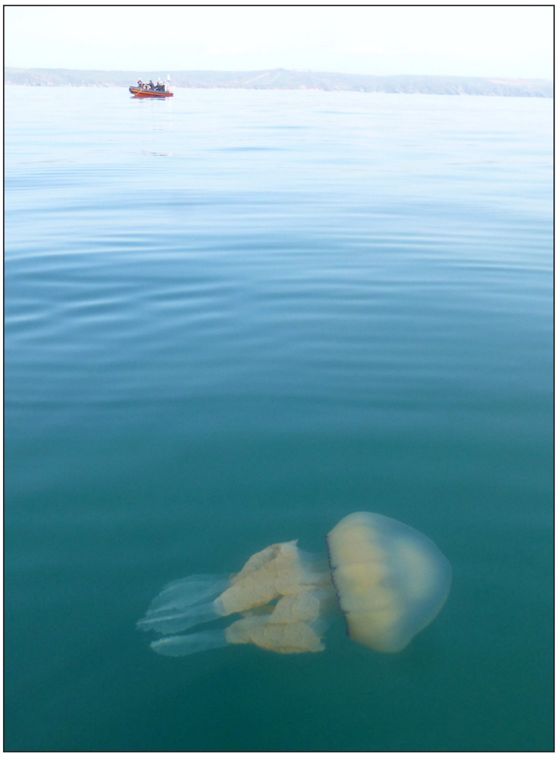

Fig. 2: The barrel jellyfish Rhizostoma pulmo *(Macri, 1778), 15th April 2015 in Whitsand Bay. Barrel jellyfish occurred in large numbers in 2015 as did some other jellyfish. From the SWME Report for 2015 (Hiscock & Earll 2016). Photo: Keith Hiscock*

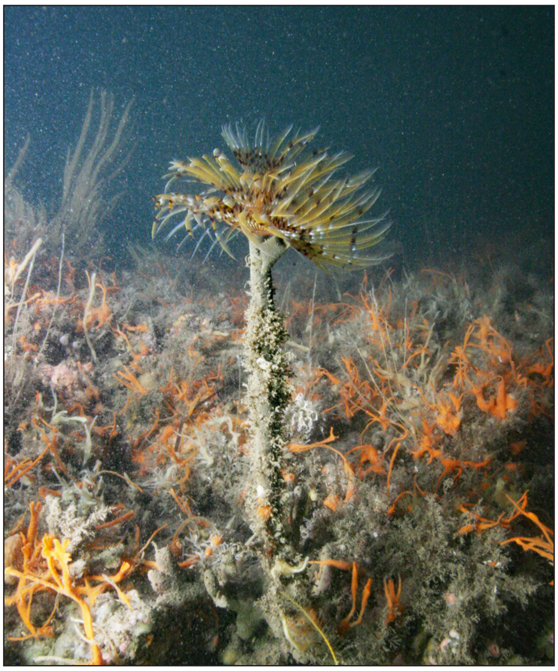

Fig. 3: There will be range extensions of species native to the northeast Atlantic such as the feather duster worm Sabella spallanzanii *(Gmelin, 1791) that was recorded from Plymouth Sound in the 2021 SWME Report (Hiscock & Earll 2022) but had not (in validated records) been previously recorded in Britain. Photo: Keith Hiscock*

Range changes (species native to the NE Atlantic)

Species that have not been considered part of the Britain and Ireland fauna and flora but occur further south along the European coast may be found or may change from rare to frequent in occurrence. Some species may show a reduction in range or abundance. Fish are especially likely to respond rapidly to increased temperatures – they can swim. Low mobility invertebrate species may need the occasional jet-stream current to bring their larvae from further south. Several fish species new to Britain have settled and now breed in the south-west: black-faced blennies *Tripterygion delaisi* Cadenat & Blache, 1970 and ring-neck blennies *Parablennius pilicornis* (Cuvier, 1929) for instance. Invertebrates that have 'turned up' include the feather duster worm *Sabella spallanzanii* (Gmelin, 1791) in Plymouth Sound and Gosport Marina; the latter location creating suspicion that a human vector may have been important (Figure 3). On the 'other side of the coin', the purple sea urchin *Paracentrotus lividis* (Lamark, 1816) was once found in the Wembury area, in parts of Cornwall, the Isles of Scilly and is still occasionally found in Scotland in Great Britain but there are no validated records at Wembury at least since 1939. The species has also declined in western Ireland. The cold-water sunstar *Crossaster papposus* (Linnaeus, 1767) was recorded (in the Plymouth Marine Fauna) as "the most plentiful starfish in 1892" but, in southwest England, is now only recorded on the coast of Somerset.

Range changes (non-native species)

There are about 100 non-native marine species recorded from Britain. Possibly because of increased awareness and vigilance, one or two additions to the list are recorded every few years. 'Hotspots' for their presence and often first recorded occurrence are especially marinas and ports but also around shellfish (oyster) farms. Non-native species associate with ships' hulls or, in the case of oysters, the nooks and crannies that the shells provide.

Range extensions (vagrants)

In the 'bird world', the occurrence of species that are not part of the native fauna of Britain cause great excitement and invasions

Fig. 4: A walrus Odonenus rosmarus *(Linnaeus, 1758), normally found in Arctic waters, on part of its tour of the southwest in 2021. Photo: Lizzie Larbalestier from the SWME report for 2021 (Hiscock & Earll 2022)*

by 'twitchers' of wherever the bird has been seen. A non-avian example is the presence of a walrus *Odonenus rosmarus* (Linnaeus, 1758) in southwest Wales and England during 2021 (Figure 4). Subsequently, a different individual was sighted in the Solent in 2022. Such occurrences are 'normal' and are expected to occur.

Re-introductions

Some species that were once known to have been present at a location but are no longer seen or are seen in much lower numbers than in historic times may be re-introduced. There are several projects underway to re-introduce or boost populations of native oysters *Ostrea edulis* Linnaeus, 1758 and of seagrass (*Zostera noltei* Hornemann, 1832 and *Zostera marina* Linnaeus, 1753).

Irrecoverable change

Some changes, which may be increases or decreases in the abundance of species, seem not to reverse or recover in the case of losses. They include the loss of native oyster, *Ostrea edulis* beds and of seagrass *Zostera marina* beds. For some changes, only time will tell if the change is a lasting one (such as the increase in abundance and re-colonisation of previously fished-out areas of crawfish *Palinurus elephas* since about 2014).

Pulse change

Usually the result of some event that is outside of the normal range of environmental conditions at a location. Pulse change may result from chronic pollution events, from an unusually cold winter, from violent storms (or just strong wave action from an unusual direction) etc.

Decadal scale changes

There are few examples of decadal scale changes, in part because very few research programmes continue in a constant way over such long time scales. However, there are some such as the Continuous Plankton Recorder surveys. Also, frequent but often sporadic observations and sampling of benthos and plankton started at the beginning of the 20th century and that continue today. My 'classic' quote is from Cushing & Dixon (1976): "…. macroplankton and summer spawners …. were reduced in 1930/1 and 'recovered' 40 years later in 1970/1". Such long-term 'disappearances' may also be 'noticed' for charismatic megafauna such as basking sharks *Cetorhinus maximus* (Gunnerus, 1765) which although, at one time were commonly seen in summer in parts of the south-west of England, have not been seen in those significant numbers since about 2011.

Trend changes (change in the same direction year-after-year)

It may take a few consecutive years to realise that a change is not a 'one-off' and that the change reflects ongoing increase or decrease in abundance or geographical extent of 'already present' or 'returning' species. With detailed data, it may be possible to illustrate the trend change graphically (Figure 5). Examples include the enormous increase in the abundance of football seasquirts *Diazona violacea* Savigny, 1816 on some parts of the coast of southwest England since about 2011 and the re-appearance of St Piran's hermit crab *Clibanarius erythropus* (Latreille, 1818) in southwest England from 2016 and its subsequent spread along the coast. Nevertheless, even a change over several years may be part of a boom-bust scenario.

Detecting a 'trend' is difficult to achieve without long-term data and some short-term changes may turn-out to be long-term trends after many more years of data. A particularly good example in this category is the seasonal oceanographic conditions of stratification

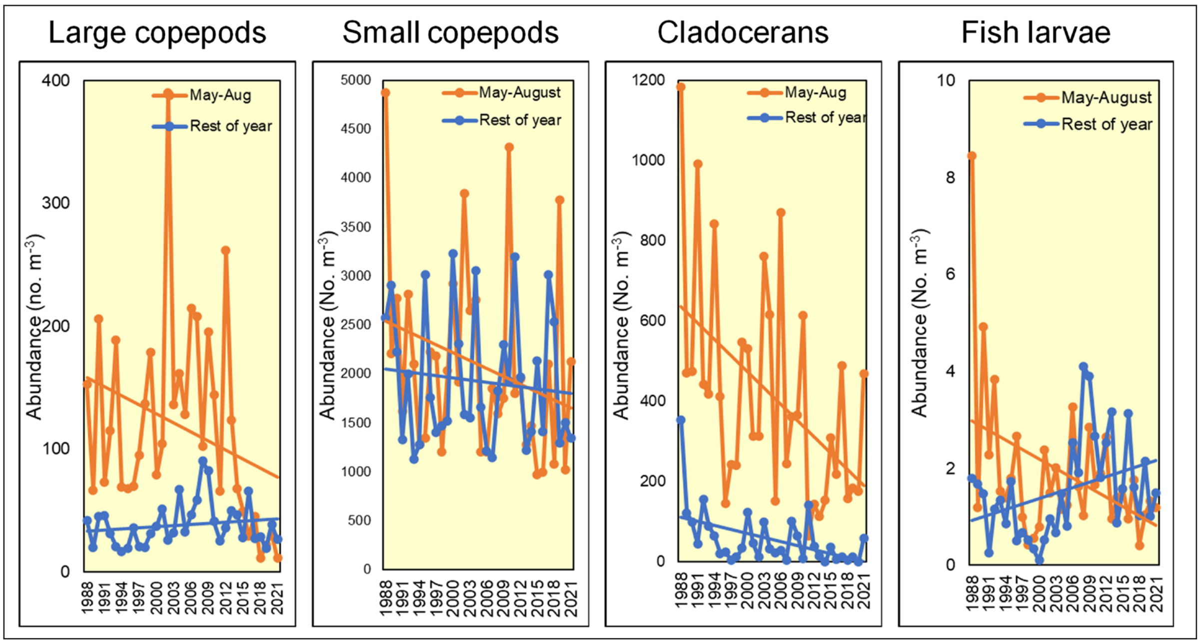

Fig. 5: Long-term trends (1992–2020) of some key phytoplankton taxa at L4 [monitoring station halfway between Plymouth breakwater and the Eddystone]. From the 2021 SWME Report (Hiscock & Earll 2022)

and mixing and planktonic populations which follow a pattern that is now well described by Angus Atkinson in the SWME annual reports. Atkinson (in Hiscock & Earll 2022) has elaborated a 'new normal' describing how the planktonic communities off Plymouth have changed. "There were no major or unusual plankton blooms in 2021. However, there was a continuation of a widespread, long-term, mainly summer decline in key elements of the food web (larger phytoplankton and copepods) during the summer months with other members of the plankton partially replacing those larger phytoplankton and copepods".

Recovery (from human activities and severe natural events)

Where monitoring or systematic observations have demonstrated recovery from some adverse human activity, for example following pest control, or a natural 'pulse' event such as a severe storm or very cold winter, the results can inform environmental protection and management strategies as well as (often) reassuring the public that recovery is possible, including how long it might take and how complete it might be. There are many examples in scientific literature and the topic is a book in itself. 'Recovery' may occur in the next year or can often take a few years (say five to eight years for heavily impacted communities) but may take much longer (crawfish numbers only recovered from over-exploitation after about 40 years – see Hiscock, 2019).

Persistence

Whilst this article is about 'change', it is important to draw attention to the persistence of some species and biotopes in the same locations and up to 170 years apart. Such persistence is often for a particular species in a particular location. One example frequently given (by the author) is the reliable presence of the scarlet and gold star coral *Balanophyllia regia* in a 'concavity' at Ilfracombe where it was first found (and was new to science) in 1852 by Philip Henry Gosse (Gosse, 1853). The same species occurs in a 'small cave' (and now surrounding rockpools) in Plymouth Sound, having been first noted there in 1906 (Plymouth Marine Fauna). Another example from the SWME report for 2021 is for a polychaete worm, *Poecilochaetus serpens* Allen 1904 and seagrass *Zostera marina* Linnaeus, 1753 at a location in Plymouth Sound (Figure 6).

For communities of species, there are historical records some of which date back to the 1950s (for instance, Crisp & Southward 1958; Forster 1954 and Knight-Jones and Nelson-Smith 1977) and that have been followed up in recent years (the ongoing Marine Biodiversity & Climate Change - MarClim programme; Hoare

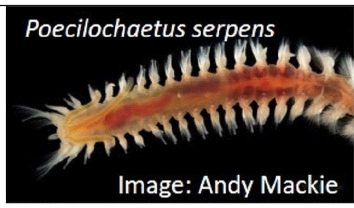

Plate 6.6. Marra Pool in Plymouth Sound and the worm *Poecilochaetus serpens*. Seabed image: Keith Hiscock.
As an example of 'persistence', two notable species from Marra Pool (Batten Bay) in Plymouth Sound: the rarely recorded worm *Poecilochaetus serpens* (re-found by Andy Mackie on 8th October) and patches of *Zostera marina* (known there for several recent years). In a paper published in 1904, "The local area of distribution .... is very restricted. It consists of patches of sand covered with *Zostera* ... with intermediate patches on which no *Zostera* grows .... The worm lives only in these intermediate patches." Allen, E. J. (1904). The anatomy of *Poecilochaetus*, Claparède. *Quarterly Journal of Microscopical Science*, London. 48: 79-151.

Fig. 6: An example of 'persistence', copied from the SWME Report for 2021 (Hiscock & Earll 2022)

& Peattie 1979; Hiscock 2005). Some marine biologists and amateur observers are still making observations at the same locations now 50–60 years on. The studies most often testify to persistence with some slight changes.

Region-wide changes

The 'region' referred to here is the northeast Atlantic. Globally, there are increasing numbers of examples of large-scale events covering extensive geographic areas which may have profound effects on many marine species and ecosystems. The effect of increasing seawater temperature on coral bleaching and long-term damage to coral reefs is well known. Similarly, off the Australian coast increased seawater temperatures have been attributed to major changes to coastal algal communities (Smale & Wernberg 2013). Anoxic dead-zones are becoming routinely reported (Diaz & Rosenberg 2008). There are collaborative programmes that pool their observations, for instance on changes in the character of kelp-dominated biotopes and on intertidal species especially of barnacles and molluscs (see Smale 2020; Mieszkowska *et al.* 2021).

As yet, we haven't seen changes in the southwest on the scale described in the previous paragraph, but we would be in a good position, via the SWME Annual Reports, to report should such changes occur. However, to demonstrate that change is widespread in the northeast Atlantic and not just occurring locally, similar programmes to SWME need to be established in other regions.

'New normal'

When large-scale change occurs, there may be a switch to a 'new normal'. Such a change occurred in the mid-1980s in the North Sea and has been described as a 'regime shift' (an abrupt change in the structure and function of ecosystems). Sguotti *et al.* (2022) concluded that "fishing and warming have caused a previously undetected and potentially irreversible regime shift".

There are 'new normals' that relate to the much reduced abundance (native oysters) or extent (seagrass) of species compared to a century ago and where lack of recovery from commercial fishing and disease (oysters) and disease (seagrass) is puzzling. The composition of level seabed communities out of Plymouth (and no doubt, elsewhere) has changed since surveys undertaken 120 to 50 years ago, as a result (it is concluded) of demersal fishing (Capasso *et al.* 2010). Another 'new normal' relates to the enormously reduced stocks of commercial fin fish (via overfishing) - in 2021, landings of demersal fish were around 15 per cent of the quantity landed in 1938 (UK Sea Fisheries Statistics 2021 published by the Marine Management Organisation). On the other hand, some warmer water fish species (for instance, seabream) are being caught more frequently. Whether the recovery in presence and abundance of Atlantic bluefin tuna (after fisheries management measures came into force) and of spiny lobsters in south-west England becomes a 'new normal' remains to be seen.

There are local or less all-encompassing 'new normals' that occur. For instance, there has been a gradual but significant change in dominant kelp species on shallow reef areas along the Atlantic coast of Europe (Smale 2020). Other examples are changes affecting native fauna and flora, such as the domination of some shores by non-native Pacific oysters *Magallana gigas* (Thunberg, 1793), or of level seabeds in some open coast areas of the English Channel and in some estuaries becoming dominated by slipper limpets *Crepidula fornicata* (Linnaeus, 1758). However, many would not call domination by non-native species 'normal'.

Reasons for change

Making the link between a cause (such as extreme storms) and an effect (such as wash-outs of burrowing species) is often convincing and is based on knowledge of likely effect of storms in this example. Recovery following cessation of some damaging activity is also often clearly linked to that activity because the damaging activity had such a severe effect. For instance, where there is survey information before change has occurred and monitoring after the damaging activity has ceased. An extreme example would be cessation of pulp mill effluent (where recovery occurred after about eight years (Rosenberg 1976)). Similarly, Southward (1979) for recovery following the Torrey Canyon oil spill. It is important that measures introduced to minimise or ameliorate the impacts of human activity such as these are subject to monitoring, so that changes in the species or habitats adversely affected are tracked.

'Recovery' in the marine environment is passive and relies on natural processes of recruitment and competition. Recovery may not be to exactly the same community as was present before damage occurred, referred to as 'hysteresis' (see Elliott *et al.* 2007).

Human induced change

We are familiar with a wide range of changes to the marine environment caused by man's activities and many of these are documented in the SWME annual reports.

Six types of human induced change are described here:

1. Acute Events. Specific, time bound events. For example, the polyisobutylene (PIB) or butyl rubber incident affecting seabirds, or sonar testing linked to dolphin strandings, and oil spills.

2. Chronic impacts. For example, year on year sewage pollution and eutrophication from storm overflows and agricultural runoff into rivers, estuaries and the open sea.

3. Recovery via management/regulation. For instance, rat eradication on islands and seabird breeding recovery; fisheries management allowing stock recovery – likely a reason for recovery of bluefin tuna.

4. Recovery via cessation of damaging activities. For instance, of seabed biodiversity after cessation of scallop dredging (Bradshaw *et al.* 2001), or closure of a damaging industrial output such as effluent from a pulp mill (Rosenberg 1976).

5. Restoration. If there is human intervention (for instance, introduction of laboratory-reared oysters or of seagrass seeds or rhizomes), then it is restoration that is being carried-out. Some refer to this as 'nudging nature'.

6. Replacement. 'Restoration' may include introduction of replacement habitats, for instance, artificial reefs where natural reefs have been lost. 'Replacement' may also be introduced as 'planning gain', e.g. offsetting the loss of one habitat (due to development) by another, different, habitat.

Natural change

There are many examples of 'change' in the scientific literature and most of what is recorded in the annual SWME reports will be natural fluctuations in abundance. Systematic long-term studies are few but are essential if we are to give context to current events. In southwest England, we can look to the varied studies that were commenced at the beginning of the 20th century by the Marine Biological Association to study benthos, fish and plankton. Those studies continue, including as part of the Western Channel Observatory (https://www.westernchannelobservatory.org.uk/). The longevity of some of the variability that occurs can be remarkable. To establish if a perceived change is 'natural' or to check if a change or event (such as the time of egg laying in a species) is already recorded or can give context to a current observation, the observer needs 'touchstones'. Those touchstones may be the lists of flora and fauna that exist such as the Plymouth Marine Fauna or compilations of knowledge such as can be found in www.marlin.ac.uk and via resources such as Wikipedia.

There may be recorded fluctuations in abundance that can be linked to environmental conditions. For instance, Mieszkowska *et al*. (2021) link periods of heatwaves and of cold spells to changes in intertidal species abundances.

What do we need to do?

We need to record our observations of change and suggestions of the reason for those changes using a defined vocabulary. The SWME process offers a model for such an approach.

We need to provide a context to observations especially if change can be demonstrated as a particular sort of change using a defined vocabulary.

We need, as far as possible, to give context based on observations/records of similar events historically. That historical context may well come from individuals that have long experience of studying/observing a species, habitat or location.

We need to 'know the literature'. Although some experienced (usually 'old') ecologists have knowledge gleaned from reading journals and from networking at conferences, over coffee tables etc., finding information is now most efficiently done by using relevant search terms in a search engine.

We need to make gathered information available in a form that is readily accessible and used by those charged with asking 'does it matter' questions in an environmental protection and management context. Such information is also valuable when 'fielding' enquiries from the press or countering uninformed reactions to events. The resource might be the 'Additional information' on the MarLIN website. The problem will be getting advisors and researchers to access the information and not assume that they are starting from scratch and making unnecessary mistakes.

We need to present information as clearly as possible (clearly enough for media, politicians and the general public). Bird watchers and anglers have their own methodologies for cataloguing rare species. As we see what were previously regarded as rare or scarce species becoming more abundant, we need to be able to adjust the terminology applied to them – this means reviewing methods for assessing 'rarity' of marine species and keeping lists up-to-date (the current 'rare and scarce species' touchstone remains Sanderson 1996).

I conclude with some words of wisdom. "To record change is no problem. There is too much, and it would be a remarkable investigation that showed none. The major need is to ensure that the change recorded is real and relevant" (Lewis 1976).

Acknowledgement

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