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NOTES ON SEAWEEDS IN RELATION TO WATER FRAMEWORK DIRECTIVE MONITORING

Monitoring for the WFD requires use of macrophytes.

In coastal and transitional waters this means seaweeds and seagrasses (and possibly salt-marsh plants).

These notes concern the seaweeds.

What are the seaweeds?

Difficult to define as this is not a scientific term. Essentially multicellular marine algae, usually attached to surfaces although a few can (unusually in Britain) be free living. But there are some attached large unicells.

On open coast they belong to three classes or colour groups – red, green and brown (although a few cyanobacteria – formely blue-green algae – are usually counted). In mid and upper parts of estuaries red and sometimes brown are absent but certain xanthophytes (*Vaucheria* spp.) and certain multicellular diatoms forming macroscopic growths would be included.

Wide variety of morphological types:

- Large cartilaginous forms e.g. kelps and fucoids
- Foliose forms
- Gelatinous forms
- Tubular forms
- Filaments – branched and unbranched – macroscopic and microscopic
- Crustose forms – calcareous and non-calcareous
- Epihytes are common including 2nd and 3rd order ones – getting progressively more microscopic
- Endophytes usually microscopic within larger algae
- Endozoic forms burrowing in calcareous shells and in tests of hydroids

Apparently very different forms can be different generations in the same life-cycle. We do not know all the tie-ups yet as it needs lab culture determination and many species have not been cultured.

How many are there?

About 620 species in British Isles.

Number of species at a single site is variable, but on a clean, habitat-diverse, solid bedrock, open coast shore may exceed 100 species - a high proportion of BI total! British Isles

An average total for a clean open coast shore would be in range 50-90 with average about 70.

max – 100
ave

red intolerant to pollution

This high total results from identification of all the morphological types above. On unimpacted open coast red > brown > green. Balance may shift if impacted. In upper estuary there is a switch over to the other way round green > brown > red.

On an open coast shore there will normally be only a few dominant species with many subsidiary or ephemeral.

Each species not present throughout the whole shore extent. Zoned in relation to tidal height.

Causal factors:

- Desiccation
- Salinity – more variable on upper shore – rain and runoff
- Biotic – mainly competition on lower shore

Modifying factors – alter zonation pattern in relation to shore features which usually vary on a horizontal basis:

- Severity of wave action
- Aspect
- Slope
- Rock type
- Subhabitats
- Biotic – grazing (especially by periwinkles and limpets intertidally and urchins subtidally) and competition.

Species number declines with increasing height on shore:

- Lower shore – conditions more marine and less stressful – many species – more biotic interactions – vertical distribution limits more likely to be set by biotic factors
- Upper shore – conditions more variable and less marine – more physical stress - fewer species – few biotic interactions – physical tolerance more important ands more likely than biotic factors to set vertical limits of species.

May be big changes over time due to successions, even in dominant species:

- Cyclic successions in which fucoids replaced by barnacles and back again.
- Seral successions can take place but not always obligatory – when cleared space – simple fast-growing opportunist species (green) progressively replaced Ulothrix by larger filamentous and foliose browns and reds, culminating in large cartilaginous dominants.

Wave action:

- Exposed shores tend to be sessile animal dominated with clear-cut zonation
- Sheltered shores tend to be dominated by large seaweeds in very clear zones
- Intermediately exposed shores (which is most of them) have many different communities which can be present at various heights on shore. Gives a mosaic distribution which makes zonation less obvious. Adjacent patches may be at different stages in succession which means mosaic will change with time.

How can seaweeds be quantified?

- Species richness – number of species on shore
- Species composition – actual species present on shore
- Species abundance – usually for seaweeds as % cover but biomass/unit area may be more important for some purposes

Species richness – remains constant over time – at same season

Number varies as explained earlier but a full total requires wide range of morphological and habitat types to be identified. Remarkable feature is high proportion of British total on a single rich shore.

Much of what follows is hypothesis based on various examples over last 25 years in my own work and on that in Emma Wells' thesis. (references are not given here for brevity but various can be given if needed)

In absence of major disturbance or change species richness remains broadly constant. Seems to apply at same season in consecutive years but also shown to apply over 25 years and even possibly 100 years.

However there may be seasonal variation with up to c.30% fewer species in winter.

Wide variation in species richness on shore means that differences which can be allied to modifying factors and sub-habitats are not great except for severe wave action.

Against expectation, animal-dominated shores have broadly similar richness to algal-dominated shores (except for severe wave action and animal dominance combined).

Species composition

Although species richness broadly constant actual ephemerals vary. Means that same total in consecutive years may only have 60-80% species in common. Same applies also over longer time scales. Means that species list compiled over several seasons or years may give falsely high idea of species richness.

Occasionally even a dominant may opt out of a shore for some years – several examples of *Himanthalia* doing this.

Species abundance

% cover is immensely variable even on a shore without severe disturbance – note earlier example of cyclic successions involving massive cover changes of dominant fucoids. Exceptional circumstance of opportunist (usually green) domination of nutrient enriched shores (green tides) cannot be quantified by % cover. High cover of such species can result from natural factors e.g summer growth, sand abrasion. Green tides need biomass as well as cover to adequately represent. Important to realise that there are many apparent signs of ill health on rocky shores (e.g. green tides) that can have natural explanation (good summary in "The Coastline" by Barnes – chapter on rocky shores by Jack Lewis).

What has all this got to do with monitoring?

Reference sites are likely to be very variable in species composition and abundance over time and within the site at a single time.

We could argue that the ephemerals that come and go from year to year are sensitive but we cannot produce a list of expected sensitive species because they will not be constantly present even on a single unimpacted shore.

Abundance only useful for green tides which does not cover most sorts of impacts.

Species richness seems the most constant feature with potential for use in monitoring – but this needs much further work for wider verification

Determination of full species richness requires taxonomic knowledge which is generally lacking. Can it be simplified.

Possible means of simplification of community assessment to avoid identification problems:

- Identification only to higher taxonomic levels
- Assessment by diversity of life-forms or functional groups
- Use of biotopes as in conservation work

None of these are straightforward or verified

Identification only to higher taxonomic levels does not help in the end as taxonomic/identification skills are still needed to place entities in families, genera etc

Functional groups need much more investigation – can argue that more likely to be stable as species coming and going will not change species totals in functional groups, only identities within the groups - most groups are present on most shores irrespective of the impacts – needs number of species in each group which may not need full skills for putting a name to a species but still needs ability to tell species apart which is not so simple once you get away from the common larger species – I would worry about an overcounting of species by those who did not know about wide variability of some species (wide morphological plasticity is a particular feature of seaweeds which contributes to misidentification by non-specialists). May need further work to test it on a wide range of shores and to develop more useful functional group classifications that can be easily applied by non-specialists

Biotopes are currently fashionable and are useful to conservationists for classifying the distribution of major shore types and their associated communities. They do not tell us about the detailed composition of the communities and the relation between them and environmental disturbance. It may be unwise to assume that they can be used to characterise pristine reference sites in a way that will enable non pristine sites to be clearly seen to be different and to be quantitatively assessed. Needs much more work on variability within specific biotopes in relation to water quality.

Can be useful to examine historical data to seek condition of a site at a past time before impacts took effect – to suggest what it might recover to with abatement of pollution – several studies now show problems with this – need to revise past species lists in accordance with present day taxonomic understanding and nomenclature – timescale of past collections has an effect on species richness recorded – collections amasses over seasons or years will give false idea of richness. On a smaller scale same applies to any sampling – size of area sampled and time taken will affect results.

Some suggested research needs

Species richness seems one of the most constant feature of seaweed communities with potential for use in monitoring – but this needs much wider verification on a wide range of shores representing different situations

Diversity of functional groups needs further work to test it on a wide range of shores but particularly to develop more useful functional group classifications that can be easily applied by non-specialists

Study of variability of other community features that might be related to water quality within specific biotopes in a variety of situations to estimate value of biotope approach

Detailed study of effect of sampling techniques (time, area, approach, level of expertise) on end results to seek a robust protocol

Seeking approaches taken in other countries – Scandinavian countries have proposed classifications of sensitivity of species in relation to water quality, e.g. saprobic indices – unlikely to be widely applicable but needs checking

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