5. MARINE FOOD WEBS

Key Messages

- The food web descriptor in the Marine Strategy Framework Directive is about the flow of energy and matter between marine plants and animals and the interactions between species which constitute the food web.
- In the Irish Sea, the abundance of key commercial species is closely linked to the seasonal cycle of water movement and the plankton production season.
- Food webs are complex and evaluating their status presents a challenge to scientists and environmental managers. By integrating existing monitoring programmes and conducting modelling studies we have the capability to gain information on the status of food webs in waters around Northern Ireland.
- Awareness of the role played by zooplankton and a better understanding of what represents good environmental status of food webs require further study.

What is a food web?

The term food web is used to refer to the complex interactions between the plants and animals found in nature. At the simplest level it is a food chain which is a pathway of the transfer of energy and matter between feeding levels. For example, large fish may feed on smaller fish which feed on microscopic animals which in turn feed on microscopic plants known as phytoplankton. Phytoplankton capture energy from sunlight and forms the base of the chain. Each feeding level is called a trophic level and there may be more than one species (perhaps several predators feeding on the same prey) at the same trophic level. A food web is made up of many inter-linked food chains (Figure 5.1).

The organisms in marine food webs range in size from microscopic plants and animals in the plankton to fish such as cod *Gadus morhua*, haddock *Melanogrammus aeglefinus* and whiting *Merlangius merlangus* and large sea mammals such as dolphins and whales. All of the animals in the sea, including those that live on and in the sea bed together with sea-birds, depend ultimately on the phytoplankton. The large solid arrows in Figure 5.1 show the main ways by which energy and matter flow from phytoplankton to higher trophic levels. Micro-organisms recycle the energy and matter from dead organisms and the waste material from animals (the dashed arrows in Figure 5.1).

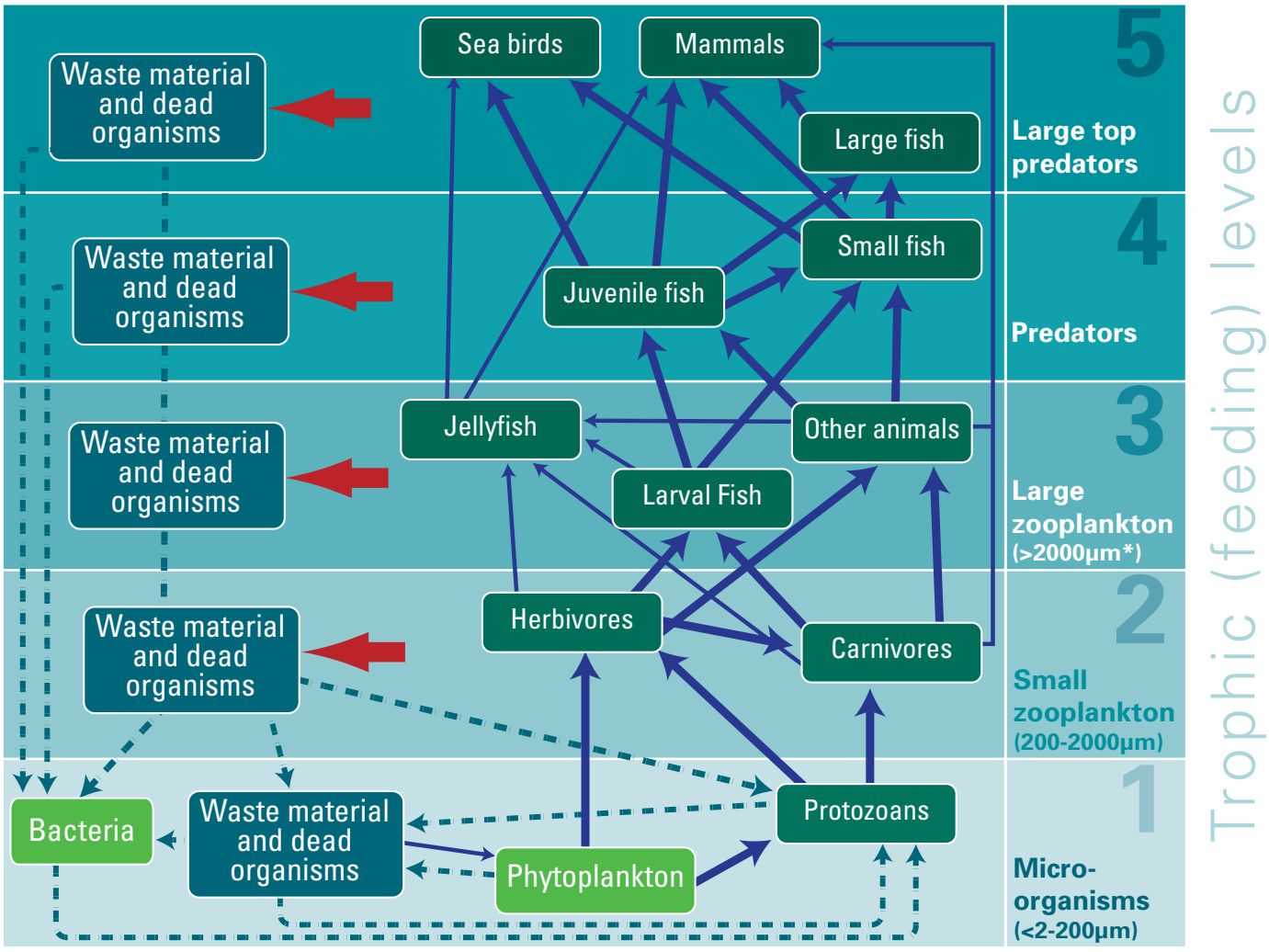

Figure 5.1. A simplified food web showing the links between the different groups of organisms that live in the sea. The links to the sea bed are not shown.

How does human activity influence food webs?

Humans make use of marine food webs in a number of ways. Our coastal waters provide important food (fisheries and mariculture), assimilate some of our waste and are a source of recreation and leisure. Human activity can affect both the bottom and top of the food web. In either case, the affect is transferred to other parts of the web. Nutrients from agricultural and domestic sources stimulate plant growth at the bottom of the web which can lead to eutrophication (Chapter 6). The exploitation of fisheries (Chapter 4) affects the top of the web. Reducing the number of large fish might mean that fewer smaller fish are eaten by them, with consequences for the organisms the small fish eat. Fishing with bottom trawl nets and dredging will have an effect on the food web of the animals that live around the seabed and of course on any other organisms that depend on them for food.

Monitoring food webs in Northern Ireland's waters

Over the last 20 years a wealth of information has been collected from our coastal waters. Nutrients have been monitored in inshore waters and the seasonal abundance of phytoplankton in the 5 sea loughs has been recorded. Examples of this can be seen in Figure 5.2. Carlingford Lough has been studied in particular detail. Based on all this information, mathematical models are used to calculate how many shellfish can be stocked in a particular area. This ensures that overstocking does not affect other species by removing their food. [1]

The offshore region of the western Irish Sea supports important commercial fisheries and AFBI has undertaken long-term studies of the species that make up these fisheries and their environment in this region. Fish stocks have been monitored as part of the procedure for determining catch sizes (Chapter 4).

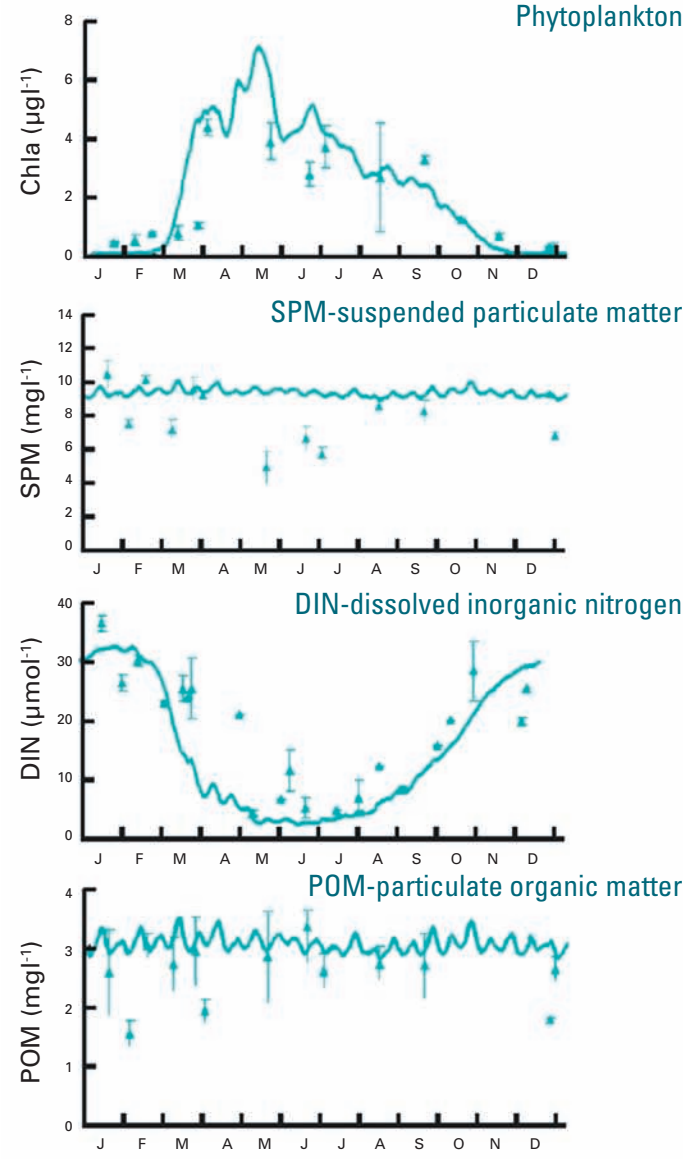

Figure 5.2 Examples of actual and modelled data for Strangford Lough[1] over a period of a year.

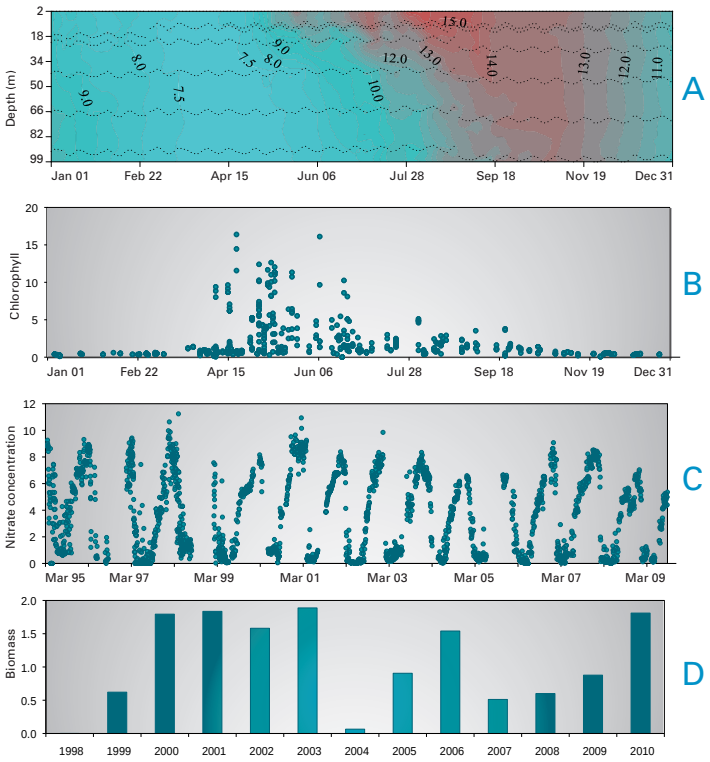

Figure 5.3. Environmental data from the AFBI moored instrument station in the western Irish Sea.
A: the seasonal development of temperature stratification in 2001 with warm (red) water overlying colder (blue) water;
C: the seasonal cycle of dissolved inorganic nitrate (micro mol l^{-1}) showing winter maximum and summer minimum concentrations;
B: the seasonal cycle of phytoplankton biomass as chlorophyll showing the spring peak that marks the beginning of the production season;
D: changes over time in the wet weight of animals living in the soft sediment.

The physical environment has been monitored since the early 1990s (Figure 5.3A) and detailed measurements of plant nutrients and phytoplankton biomass have been monitored since the mid 1990s (Figures 5.3B and 5.3C). Animal communities in the mud patch where Dublin Bay prawn live were intensively surveyed and key stations have been monitored annually for long term trends in abundance and biomass (Figure 5.3D)[2].

Physical features have a pronounced influence on the food web of this region. During spring, the surface water warms up and forms a layer over the cold deeper water - technically the water stratifies (Figure 5.3A). Due to the rotation of the earth, the surface layer rotates slowly anticlockwise. The seasonal cycle of growth and production is closely linked to this stratification and much of the food web in this region of the Irish Sea is typical of temperate shelf seas that stratify.

A burst of phytoplankton growth, 'the spring bloom', begins when the water column stratifies. Growth ceases in the autumn when the water cools and mixes[3]. The phytoplankton production season sets the pattern for many of the animals in the Irish Sea. Tiny animals less than a millimetre long (copepods) dominate the zooplankton of the Irish Sea and these feed on the phytoplankton[4].

In turn, the copepods provide food for the larval stages of the Dublin Bay prawn *Nephrops norvegicus* and several species of commercial fish[5],[6]. The spawning of cod, haddock and whiting and the release of eggs by the female


Common sunstar, *Crossasstor papposus*

Dublin Bay prawn takes place in March in time for their larvae (young stages) to have an ample supply of zooplankton for food. The rotation of the surface water keeps the larvae and their food together and stops Dublin Bay prawn larvae from drifting away, keeping them over the mud patch they will inhabit as adults[6],[7].

Much of the organic matter produced by phytoplankton in the surface waters settles to the sea bed and supports the animals that live there. From a fisheries point of view, the most commercially important is the Dublin Bay prawn but there are many other species that play a role in the mud patch community. This is a good example of a food web. What happens on the surface of the sea directly affects animals living deep below them.

The food web descriptor in the Marine Strategy Framework Directive outlined in the table below is about the flow of energy and matter between the plants and animals that live in and around our seas and the interactions between species. Assessing these two elements will require a different approach from the way the marine environment has been monitored in the past.

To date, much of the inshore monitoring effort has been focused on the question of whether these waters are eutrophic (Chapter 6). The Marine Strategy Framework Directive and especially the food web descriptor, will require additional monitoring and assessment. The recent plankton studies in Carlingford Lough should be extended to the other Northern Ireland sea loughs. For more open waters the available data needs to be assembled to assess the environmental status of the food webs in these waters.

Legislation
Marine Strategy Framework Directive Descriptor 4 'All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.'

References

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(2) Hensley R.T. 1996 A Preliminary Survey of Benthos from the *Nephrops norvegicus* Mud Grounds in the North-western Irish Sea. Estuarine Coastal & Shelf Science 42: 457-465.

(3) Gowen R.J., B.M. Stewart, D.K. Mills, & P. Elliott 1995 Regional differences in stratification and its effect on phytoplankton production and biomass in the north western Irish Sea. Journal of Plankton Research 17: 753-769.

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(5) Hill J.M. 2007 Structure and flow of carbon and nitrogen to the western Irish Sea *Nephrops norvegicus* fishery: a stable isotope approach Ph.D. thesis, School of Biological and Chemical Sciences, Queen Mary, University of London 262 pp.

(6) Dickey-Collas M, R.J. Gowen & C.J. Fox 1996 The distribution of larval and juvenile fish in the western Irish Sea relationship to phytoplankton, zooplankton biomass and recurrent physical features. Marine & Freshwater Research 47: 169-181.

(7) White R.G, A.E. Hill & D.A. Jones 1988 Distribution of *Nephrops norvegicus* (L.) larvae in the western Irish Sea, an example of advective control of recruitment. Journal of Plankton Research 10: 735-747.