Table 8.1: supplementary online material

Seven models of continental shelf ecosystems giving their geographic locality, the principal primary and secondary production processes and other key components and characteristics at higher trophic levels (adapted from Longhurst 1995).

Model	**Geographic location**	**Primary and secondary production**	**Higher trophic levels**
Model 1 Polar irradiance-mediated production peak in regions permanently ice-covered	Eastern Siberian and Laptev Sea coasts of Siberia. Northeastern and Northern coasts of Greenland. Northern coasts of Canadian archipelago to west Beaufort Sea. Almost entire coast of Antarctica.	Productivity is light-limited, with seasonal cycle symmetrical about local irradiance maximum. Latter corresponds with solar maximum or minimal snow cover. Below ice, phytoplankton productivity and zooplankton	Benthic invertebrates are abundant and diverse providing food for abundant but low-diversity populations of fish and squid. Large euphausiids (krill), characteristic of open-water regions, are replaced by small *Euphausia crystallophorias*

Model	Geographic location	Primary and secondary production	Higher trophic levels
		biomass are low, but abundant flora in the infiltration zone at the ice-seawater matrix. Underside of ice <2 m thick may support dense growth of diatoms associated with abundant polychaetes, copepods, and amphipods.	and provide food for pelagic fish (*Pleurogramma* spp.) and crab-eater seals.

Model	Geographic location	Primary and secondary production	Higher trophic levels
Model 2 Polar irradiance-mediated production peak in regions where ice-cover disperses partially or completely in summer, or only where broken pack-ice develops.	Coasts of Greenland. North America from Newfoundland to the Aleutians. Northern Asia from Finland to the Sea of Okhotsk. Short sectors of Antarctic coast in midsummer in eastern Ross Sea, to east of Ronne ice shelf and in Dumont d'Urville Sea.	Shallow polar halocline induces water column stability very early in open-water. Productivity is light limited, its seasonal cycle being symmetrical about the local irradiance maximum. Where pack-ice remains, conditions may resemble Model 1. After ice-melt, in open water, phytoplankton accumulates during the period when	Production exceeds consumption in the water column and supports rich and diverse macrobenthos, especially in boreal regions, where shelf areas uncovered by ice are much more extensive than around Antarctica. Low-diversity fish fauna, especially in the Antarctic, where small Notothenids dominate. The

Model	**Geographic location**	**Primary and secondary production**	**Higher trophic levels**
		productivity increases, and then tracks its initial decline. Phytoplankton is dominated by diatoms, a subsurface chlorophyll maximum is often observed; in shoal water, significant biomass of benthic macroalgae develop. Planktonic herbivores are represented by abundant large copepods, euphausiids and salps, of which some	wider Arctic shelves support a greater diversity of Gadidae, Sebastidae, *Anarhichas* spp. Grey whale, walrus, and bearded seal are boreal benthic feeders, having no austral equivalents.

Model	**Geographic location**	**Primary and secondary production**	**Higher trophic levels**
		species form swarms that support major stocks of baleen whales and seals.	
Model 3 Canonical spring-autumn blooms of mid-latitude continental shelves	On mid-latitude continental shelves, under the influence of the global westerly winds. From Finland to Iberia and off the Mediterranean. From Newfoundland to Florida. Off Tasmania and southern Australia.	After winter mixing, a pulse of productivity and chlorophyll is induced by establishment of water column stability. Thereafter summer stratification is associated with relatively low productivity. Progressive mixing in autumn may induce renewed	Most autotrophic production passes directly or indirectly through the macrobenthos, which is abundant, diverse, and characteristic of each sediment type. Diversity of fish fauna exceeds that in polar ecosystems (typically 200

Model	Geographic location	Primary and secondary production	Higher trophic levels
		productivity fuelled by nutrients accumulated below the summer pycnocline. This sequence is modified by intermittent wind-induced coastal convergence and divergence, and persistent water column mixing in regions where tidal velocities exceed critical value. Effects of estuarine turbidity plumes may mask the canonical	species of >50 families). In boreal regions, major stocks of shoaling Clupeidae and Scombridae together with mainly demersal Gadidae, Percidae, and Pleuronectidae. In much more restricted austral shelf regions, clupeids occur as in the north, together with a more-difficult-to-specify demersal fauna. Energy flow from pelagic invertebrates is

Model	Geographic location	Primary and secondary production	Higher trophic levels
		sequence, which weakens towards the equator. The balance between pico-autotrophs and larger algal cells is more equitable than in very high latitudes. In shoal water, especially at higher latitudes (Norway, Iceland, Newfoundland, Tasmania) there is significant autotrophic production in kelp beds. Small copepods dominate the	mainly to clupeids and scombrids, from benthos mainly to demersal fish fauna.

Model	Geographic location	Primary and secondary production	Higher trophic levels
		inshore herbivorous plankton, larger species nearer the shelf edge, often over-wintering in deep water. Their seasonal cycle of abundance follows that of phytoplankton.	
Model 4 Topography-forced summer production	Falklands shelf, the southern North Sea, the shelf of the Gulf of Alaska where tidal mixing consistently dominates the stability of the water mass, temperate North Pacific where	The seasonal productivity schedule, otherwise appropriate to Model 3, is instead forced by other factors (see adjacent column), differing regionally.	In many respects the heterotrophic biota, and energy flows, are broadly similar to those appropriate to Model 3 ecosystems.

Model	Geographic location	Primary and secondary production	Higher trophic levels
	the oceanic permanent halocline passes inshore across the shelf, so constraining winter mixing to water above the pycnocline. New Zealand and similar locations where, topographically-forced upwelling sites in shallow water dominate the productivity sequence.	Consequently, phytoplankton productivity tends to peak in mid-summer rather than in spring. In many respects the autotrophic biota, and energy flows, are broadly similar to those appropriate to Model 3 ecosystems.	

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Model	Geographic location	Primary and secondary production	Higher trophic levels
Model 5 Intermittent production at coastal divergences.	The Atlantic from Iberia to Senegal and Gabon to Benguela. The Pacific from Oregon to Mexico and Peru to southern Chile. The Indian Ocean from Oman to Kenya.	These are the 'classical' coastal upwelling regions of eastern boundary current and other coasts, some of which occur at relatively low latitudes. The shelf is characteristically narrow, and the influence of river effluents minor. The equator-ward component of the Trade winds induces strong and persistent offshore	Benthic consumers are abundant, but not diverse, and there is much physical export of organic material into deep basins on the shelf or across the shelf edge into deep water. Along the shelf edge, deep-water rockfish (Sebastes) are abundant, characteristic, and diverse. Anchovies (*Engraulis*, *Cetengraulis*) are ubiquitous

Model	Geographic location	Primary and secondary production	Higher trophic levels
		Ekman drift, inducing upwelling of nutrient-rich deep water. This process is usually strongest during summer. Similarly, in the Indian Ocean the South-west Monsoon forces offshore drift, principally off Somalia. Upwelling results in a rapid increase in primary production of phytoplankton, principally diatoms, and chlorophyll	vertebrate herbivores, with in addition, sardines (*Sardinella longiceps*) in the Indian Ocean. Populations of predators, mostly pelagic clupeids (*Sardina*, *Sardinops*), mackerel (*Scomber*), hake (*Merluccius*, *Micromesistius*), sealions, and piscivorous seabirds are characteristic of these regions.

Model	**Geographic location**	**Primary and secondary production**	**Higher trophic levels**
		accumulation coincides with the duration of upwelling periods. The biota have low diversity and high collective biomass. Specialized invertebrate herbivores are large calanoid copepods (typically *Calanus* or *Calanoides*), euphausiids and filter-feeding anomuran crabs, each having life history tactics that take them into	

Model	Geographic location	Primary and secondary production	Higher trophic levels
		deep water, or the shallow sea-floor, during non-upwelling periods. Kelp forests reach their maximum development and generate significant autotrophic production and accumulation of biomass. There is heavy, intermittent settlement of large phytoplankton cells and faecal material to the sediments, frequently resulting in an	

Model	Geographic location	Primary and secondary production	Higher trophic levels
		oxygen deficit at certain depths on the narrow shelves.	
Model 6 Small amplitude response to trade wind seasonality in regions with significant coastal river discharges which dominate over oceanic processes that	Amazon, Niger, Congo, Indus, Ganges, Irrawaddy, Mekong, and others. These are wet tropical coasts, dominated by the effluent of a few major rivers or many smaller river systems. In the Atlantic, the Gulf of Guinea, the Guianas, and northern Brazil. In the eastern	Trade wind regimes force only weak seasonality in mixed layer depth, observed minor changes represent the geostrophic response of the pycnocline to seasonality in trade wind stress rather than mixing. The basin-wide slope of the thermocline has important consequences in	Benthic community types conform to sediment types, and where these resemble those of cooler seas, members of the global suite of benthic infaunal communities occur (e.g. clams such as *Venus*). Inshore, organic-rich sediments may be extensive

Model	Geographic location	Primary and secondary production	Higher trophic levels
would otherwise determine seasonal changes.	Pacific, from Columbia to southern Mexico. In the Indo-Pacific, from the South China Sea to south-western India, including much of the Indonesian Archipelago and the northern coast of Australia.	the Pacific and Atlantic Oceans; to the west it lies deeper than the shelfedge, but in the east it is at mid-shelf level. In the east, therefore, the benthic regime has typical tropical character shorewards of this line, but more temperate characteristics in cool water seawards. On eastern Atlantic and Pacific coasts, the	and support stocks of crustacea dominated by penaeid shrimps. These sediments are prone to resuspension by wave action in monsoon seasons. Fish fauna is diverse at all taxonomic levels and includes a higher proportion of pelagic species than in Models 3 and 4 at higher latitudes.

Model	Geographic location	Primary and secondary production	Higher trophic levels
		nutrient cline is perennially shallower than the photic depth, except during exceptional events, and vertically-integrated production rate is not normally light-limited. Everywhere, river discharges into the low-salinity surface layer have strong seasonality, reflecting regimes of wet and dry seasons, so that the seasonal	

Model	Geographic location	Primary and secondary production	Higher trophic levels
		schedule of primary production rate is governed by nutrient input from the land and possibly reduced irradiance due to prolonged heavy cloud cover during wet seasons. Autotrophic organisms are typically small cells, except in coastal blooms fuelled by river-borne nitrate, which are dominated by *Coscinodiscus* and other	

Model	Geographic location	Primary and secondary production	Higher trophic levels
		diatoms. The biomass of coastal subtidal macroalgae is not significant due to water turbidity. Consumers are numerically dominated by small copepods, but diatom blooms support large stocks of herbivorous clupeids (Atlantic—*Ethmalosa*, *Brevoortia*; Indo-Pacific—*Sardinella longiceps*). A large proportion of diatom material	

Model	**Geographic location**	**Primary and secondary production**	**Higher trophic levels**
		sinks to the seabed.	
Model 7 Small amplitude response to trade wind seasonality in regions off dry coasts with relatively minor river discharges.	In the Atlantic, only the Caribbean. In the Indo-Pacific parts of the Arabian Sea, the Red Sea, north-east Australia, and of the Indonesian archipelago.	Ecosystem of shallow seas off the coasts of the dry tropics, where river effluents are minimal. Many isolated islands and archipelagos in tropical seas are surrounded by reduced Model 7 ecosystems, of which the dominant characteristic is the development of coral reefs where topography permits,	The macrobenthos associated with coral reef formations is exceptionally diverse at all taxonomic levels. On open sandy sediments, unencumbered with reefs, very high densities of filter-feeding crabs (*Pinnixa*, *Xenophthalmus*) are typical, together with other organisms, especially filter-feeding clams.

Model	Geographic location	Primary and secondary production	Higher trophic levels
		elsewhere unconsolidated sediments are dominated by carbonate sand. There is weak seasonality in mixed layer depth, and nutrient cline is usually shallower than the photic depth, except during exceptional events. Most primary production occurs in the benthos. Macroalgae (*Sargassum*),	Fish fauna is also diverse, both taxonomically and functionally. Parrot-fish (Scaridae) are among the most important herbivores, directly consuming coralline and other algal mats, and these may form a large-fraction of total fish biomass. An intense and complex network of trophic links

Model	**Geographic location**	**Primary and secondary production**	**Higher trophic levels**
		encrusting coralline green (*Halimedia*) and red algae, cyanophyte mats and sea-grass meadows dominate community production, in addition to the activity of symbiotic dinoflagellates within the tissues of many invertebrates: scleractinian corals, giant clams (*Tridacna*), coelenterates (alcyonians, anthozoans, and	between fish and benthic invertebrates is characteristic of this ecosystem. This trophic complex supports a wide variety of large predators.

Model	Geographic location	Primary and secondary production	Higher trophic levels
		scyphozoans), large ascidians and encrusting sponges. Nutrient sources and fluxes are various: advection, upwelling, vertical flux in fractured basement rocks, some terrestrial runoff. Nitrogen-fixing bacteria occur in the tissues of some corals, and cyanobacteria fix nitrogen within algal mats. Internal exchanges of nutrients within	

Model	Geographic location	Primary and secondary production	Higher trophic levels
		and between organisms is highly complex. Export from the benthic ecosystem, except in the form of carbonate eroded to sand and gravel factions, is a small but complex flux. Water clarity is high, and phytoplankton is dominated by the pico- and nano-fractions, as in oligotrophic ocean ecosystems. These are	

Model	Geographic location	Primary and secondary production	Higher trophic levels
		consumed by protists and small zooplankters themselves the prey of many filter- and tentacular-feeding polyps of corals and other coelenterates.	