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6.4 PELAGIC ENVIRONMENT

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INTRODUCTION

The pelagic environment is considered here as the sea's water column, the organisms it contains and the processes occurring there, from the surface to just above the seabed. Pelagic water depths are shallow in areas close to the coast and range from shallow to very deep, with increasing distance from the coast as seabed depth increases. The Agulhas Current, one of the world's strongest continental boundary currents, is the prevailing offshore pelagic feature, transporting billions of litres of warm, salty water southwards every second. The inshore edge of the current is normally close to the coast (10-15 km offshore) off southern and northern KZN, but up to 50 km offshore off central KZN, and can extend down to depths of >2 km. The wide current core varies from 50-100 km offshore, but meanders can bring warm, clear, nutrient-poor, current water onto the shelf and close to the coast, and this is consistently so in the northern parts of the province. Large Mozambique channel eddies also regularly influence KZN shelf waters as they progress southwards. Pelagic waters on the shelf are cooler than in the current, and off central KZN, are more turbid owing to terrestrial runoff and the characteristically rough seas caused by an unprotected coast and regular winds. Marine life in the pelagic habitat ranges from minute (plankton) to massive (whales) and is much less prolific than off the Western Cape, although there is higher diversity. Many larger pelagic organisms make use of the wider Agulhas Current or its inshore processes for regional or local migration.

DRIVERS

The pelagic environment of KZN is very closely influenced by the Agulhas Current. Seasonal differences in Agulhas Current flow and the recent broadening and warming of the current are being driven respectively by spatial and temporal disparities between, and an increase in, wind speeds in the southern Indian Ocean. The latter is partly mediated by changes in frequencies of Mozambique channel eddies and meanders. These are proximate oceanic-scale drivers, with the broadening and warming of the current linked to anthropogenic climate change (Beal and Elipot 2016, Sections 3.1, and 3.2). A local, proximate driver is that of reduced terrestrial outflow of nutrients to the marine environment because of river abstraction via, amongst other interventions, dams.

PRESSURES

Volumetrically and spatially, the pelagic environment is the largest of the marine habitats. It is a strong driver of climate and weather on the KZN coast and on the southern African region,

and is globally influential too. Most marine organisms spend part of their life history in pelagic habitats; some are permanently pelagic. Currents in the water column distribute nutrients, eggs and larvae locally and more widely, assisting organisms to maintain their distributions and to widen recruitment, if settlement conditions permit. The habitat supports some pelagic fishing: a small, seasonal, commercial beach-seine fishery, recreational fishing and industrial longlining (Sections 7.3 and 8.6). Coastal pelagic habitats receive run-off and effluent from the land (Section 2.3), and when these contaminants settle out of the water column, they affect other habitats. Finally, the sea provides a medium for most of the global trade undertaken by shipping.

STATE

Historic perspective

The dominance of the southward-flowing Agulhas Current has been long established, with indications that its temperature and mean position of the flow have been stable for around 150 000 years (Winter and Martin 1990), although Prell *et al*. (1980) suggest that during the Last Glacial Maximum (which peaked ca. 21 000 years ago), the current was cooler, probably shallower, and with considerable seasonal variation. If so, the upper pelagic environment off KZN would have been considerably cooler than currently, and the pelagic ecology would have differed too. For example, the Sardine Run would have extended much further north (Freon *et al*. 2010). Heydorn *et al*. (1978), Schumann (1988) and Lutjeharms (2006), and references therein, give overviews of the more recent historical physical oceanography that characterises much of KZN's pelagic environment. The Agulhas Current was known to at least partially account for the subtropical nature of the pelagic habitat; the current itself being warmer, particularly in the upper layers, than the adjacent shelf waters. Water temperature at great depths could be as low as 4°C though. Meanders in the current were known to cause inshore current reversals, and the core of the current could move by as much as 30 km in one day. In the absence of continuous monitoring, seasonal patterns could not be determined. The turbulent nature of KZN's seas was recognised as being a consequence of the narrow continental shelf and exposed coast, which lacks barrier reefs or offshore islands; the lack of embayments meant limited retention of coastal waters. This turbulence and the relatively high rainfall meant that inshore water clarity was known to be low off central KZN, and not uncommonly so off the south coast. Primary productivity (phytoplankton) was concentrated in the upper pelagic layers and was known to be low compared to that on the South African west coast. There was unanimous acceptance that, at least in the central region, productivity was mainly driven by the Agulhas Current causing prevailing shelf-edge upwelling in the region off Richards Bay, supplemented at times by inputs from the uThukela River. Peaks in secondary (zooplankton) productivity were known to be associated with phytoplankton blooms in these areas; zooplankton diversity was high in the Agulhas Current, but low on the shelf and beyond the Current. Ecological knowledge of higher pelagic organisms focused on the winter run of sardines and their associated predators to KZN, the spring nesting and summer hatching of turtles, and the seasonal migration and dispersal of these and other animals using the regional and/or local currents associated with the Agulhas Current. Seasonal spawning to disperse pelagic eggs and larvae of even non-pelagic fisheries species such as lobsters and fishes was initially thought to occur via the Agulhas Current itself, but inshore shelf currents were later demonstrated, instead, to be the main vector.

Current state

The characterisation of the oceanography of the pelagic environment provided in the overviews by Heydorn *et al.* (1978), Schumann (1988) and Lutjeharms (2006) is still largely relevant today. The review and bibliography by Fennessy *et al.* (2016), based on more recent (2010) synoptic surveys of much of the pelagic environment off KZN, provides updates and refinements of this knowledge. Subsequent overviews and findings from episodic surveys have been drawn on here as well. There has finally been formal measurement of Agulhas Current seasonality, showing a 25% increase in strength in summer relative to winter (Beal *et al*. 2015, Hutchinson *et al.* 2018), and that the current has warmed (Rouault *et al.* 2009) and broadened (not strengthened) in the last 30 years (Beal and Elipot 2016). Shelf current directions alternate between southward (predominantly) and northward, influenced by prevailing north-easterly and south-westerly winds and the proximity of the Agulhas Current to the coast; a semi-permanent cyclonic eddy south of Durban is responsible for an inshore north-flowing current "swirl" north of Durban. Pelagic waters off central KZN can be displaced into the Agulhas Current and propagated downstream, or can be retained centrally for some time, or can be pushed northwards on the inner shelf. While the Agulhas Current is still recognised as a major driver of upwelling off Richards Bay, shelf-edge upwelling of cool water is also now known to be driven by north-easterly winds. Sea surface temperatures close to the coast range from 16-28°C, lowest in August and highest in February, with an annual average of around 24°C (Figure 6.6); offshore surface temperatures are up to 5°C higher. In winter, shelf water salinity may be slightly lower than in the current, but in summer it can be much less due to riverine outflows, with associated increased turbidity.

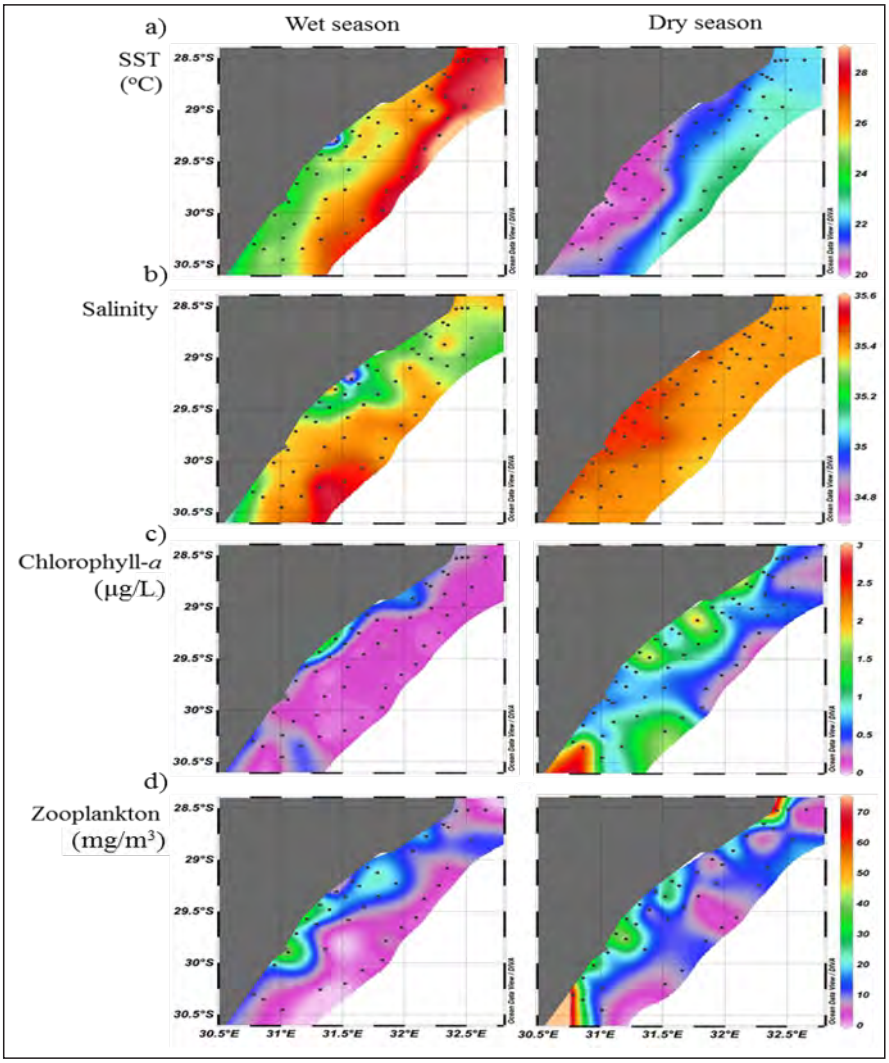

Figure 6.6: Surface environmental variables during Wet (January) and Dry (August) seasons recorded in the most recent (2010) comprehensive synoptic surveys of the KZN pelagic environment. Adapted from Pretorius *et al.* (2016).

Average seawater nutrient levels and planktonic primary productivity are low (Figure 6.6), as upwelling features are not extensive. The upwelling off Richards Bay is still believed to be the main source of nutrients off central KZN,

although their retention in the system is very variable owing to the dynamic oceanography. Riverine organic inputs are important in the central inshore pelagic ecosystem during the summer, while organic matter of marine (upwelled) origin is a pelagic driver offshore, and during winter. In the phytoplankton of upper water layers, where light penetration is greatest (< 200 m depth), diatom-flagellate communities predominate in cooler shelf waters, while prokaryotic phytoplankton are prominent offshore in the warmer Agulhas Current. Bacterial prokaryotes in contrast are more abundant close to the coast, particularly around river mouths. Zooplankton biomass is dominated by copepods, and is very variable, but is concentrated in the upper 100 m and is much higher on the shelf than in the Agulhas Current; concentrations are higher in winter, particularly north of Richards Bay. Generally, variability in zooplankton biomass is associated with varied short-term oceanographic features, rather than seasonal effects.

Fish larvae are patchily distributed but are more concentrated on the shelf, with greater diversity further offshore, reflecting the role of the Agulhas Current in transport of more tropical species; composition also varies seasonally (ORI, *unpubl. data*). Pelagic fish abundance is dominated by sardines and anchovies, the former migrating to KZN during winter, although there are fewer observations of the phenomenon in recent years (Fitchett *et al.* 2019). Medium-sized pelagic fishes occur seasonally on the shelf and, although there are no recent population assessments, there are concerns about the status of several species (Mann 2013, Section 7.3). Larger pelagic fishes such as tunas and billfishes mainly occur offshore and are also seasonally abundant; the population status of the majority of these in KZN is even less well known, as they form part of regional stocks (Section 8.6). It is probable that the abundance of all exploited pelagic fishes off KZN, except for Cape anchovies which have recently expanded their distribution into KZN (Horton and van der Lingen 2019), has

Sharks break up a mass of sardines
Photo: Ryan Daly

declined substantially since the mid-20th century. Pelagic marine mammals, particularly whales and common dolphins, become increasingly common off KZN during their winter migration from southern waters and there has been a substantial increase in the numbers of humpback whales migrating to KZN in recent years (Findlay *et al.* 2011).

IMPACT

Cross-shelf, alongshore and depth-related variability in the characteristics of pelagic waters off KZN are driven by changes (meanders and pulses) in the position of the inshore edge of the Agulhas Current, as well as by the occurrence, persistence and dynamics of passing offshore cyclonic eddies emanating from the Mozambique Channel and southern Madagascar (Lamont *et al.* 2016). Spatial and temporal changes in the Agulhas Current directly impacts coastal upwelling (and hence pelagic ecosystem productivity) and the exchange of water (and its constituents, such as larvae and pollutants) between the coast and the open ocean. Longshore shelf currents and their role in larval recruitment, retention and dispersal, as well as migration of harvested fishes (Beckley 1993, Roberts *et al.* 2010, Hutchings *et al.* 2002) will also be affected. Instabilities and changes in the Agulhas Current can potentially exacerbate warming and extreme weather events (Beal and Elipot 2016). Reduced riverine outflows will result in reduced nutrient availability for the KZN shelf pelagic ecosystem in summer (de Lecea *et al.* 2016), with potential reduced productivity and availability of organisms in higher trophic levels, such as fishes. Although not yet demonstrated, turbidity on the central shelf will also probably be reduced, with concomitant changes in pelagic fish species composition, prejudicing species favouring high turbidity.

RESPONSE

Notwithstanding recent advances in understanding of the dynamics and impact of the Agulhas Current on the KZN coast, much remains to be learnt. The oceanography driving the pelagic ecosystem changes rapidly in time and space, which makes for difficulties in observing and predicting, further aggravated by operational and financial challenges to deployment of instrumentation. However, long-term in situ monitoring, remote sensing and improved ocean models will improve fundamental understanding of the role of the Agulhas Current and how the changes it is undergoing will affect the pelagic ecosystem.

Data Requirements
There is very limited regular in situ monitoring of the pelagic environment off KZN. Knowledge is based on episodic oceanographic surveys, or monitoring of disposal outfalls, or inferred from indirect surveys such as for fisheries, or from remote sensing by satellite. Ideally long-term monitoring transects are needed, sampled throughout the water column, at shallow and deep depths, from the coast to far offshore, at regular intervals, for a suite of parameters, including temperature, salinity, turbidity, oxygen, pH and nutrients; samples need to be collected of phytoplankton, zooplankton, pollutants and contaminants. Fisheries monitoring and compliance is required.