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6.1 CORAL REEFS

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INTRODUCTION

Corals are colonial, reef-building animals that are renowned for their beauty, productivity and biodiversity. They are sensitive to disturbance and perturbation and readily reflect the consequences of climate change and pollution. Coral reefs are found in all tropical seas but in KZN are confined to the northeast waters, where they are less accretive than their tropical counterparts, being at the limits of their southward distribution (Schleyer *et al.* 2018). Relative cover on these reefs will provide the best measure of reef condition, both in terms of the percentage cover of the various benthic components and of the total living cover. Changes in cover caused by perturbation may be temporary, followed by recovery, or permanent leading to an alternative stable state (e.g., a permanent shift from coral to algal cover) (Celliers 2001). Additional criteria are important when measuring relative reef cover and protocols can be adapted to target problems such as pollution, coral bleaching, increased coral disease, and excessive damage from overuse, episodic storms and ship groundings. The results derived can be interpreted as to cause, but in the case of climate change, must be accompanied by temperature monitoring.

DRIVERS

Climate change or global warming that results in elevated temperatures can cause coral bleaching, the loss of colour by corals as their pigmented symbiotic algae die under stress (Celliers and Schleyer 2002, Porter and Schleyer 2017, Porter *et al.* 2018a), and associated disease (Séré *et al.* 2015), particularly when accompanied by high insolation (bright sunlight, cloudless skies, clear water). Acroporidae (branching corals) are particularly susceptible to this; their branching forms are also fragile and prone to diver damage (Schleyer and Tomalin, 2000). Associated with this, the increased levels of atmospheric CO_2 that underly climate change lead to greater dissolution of CO_2 in the oceans, shifting their pH slightly towards acidity. The consequences of this are not fully understood and possibly not as severe as anticipated. An increase in the frequency and intensity of extreme weather events is predicted to be associated with climate change, and stormy seas that accompany such episodic events will add to reef damage.

Corals are sensitive to ecosystem changes and certain indicator species can be monitored to reflect change on coral reefs. Examples of these organisms are the fragile and sensitive *Acropora* spp. and 'weed' species that come and go according to reef condition (e.g., 'swarming' soft corals and macroalgae). Corals are susceptible to natural pests such as Crown of Thorns Starfish (COTS) and the gastropod, *Drupella* spp., both favoring Acroporidae as prey. COTS are conspicuous, whereas *Drupella* spp. are cryptic and difficult to detect. In all such situations, reef communities can shift to an alternative stable state, becoming dominated by soft corals or macroalgae, the latter particularly if herbivores are diminished in number.

Theonella swinhoei **is a conspicuous, fairly abundant sponge which is royal blue in colour** ***Photo: Mike Schleyer***

PRESSURES

Organochlorine pesticides (OCPs) are believed to be affecting corals significantly. Information published in the last decade has shown that high levels of OCPs are found in freshwater bodies adjacent to the coastal dune cordon of northeast KZN (e.g., Buah-Kwofie and Humphries 2017). A long-term downward trend in soft coral abundance on the coral reefs immediately offshore of the coastline was also noted towards the end of the last decade (Porter and Schleyer 2017; see Figure 6.1). Selected sessile reef organisms were checked for OCP levels as an explanation for the decline of 20% soft coral cover over the last twenty years (Schleyer *et al.* 2008, Porter and Schleyer 2017). Preliminary research considered five sites and spanned 50 km of coastline and showed surprisingly high levels of OCPs (Figure 6.3; Porter *et al.* 2018b).

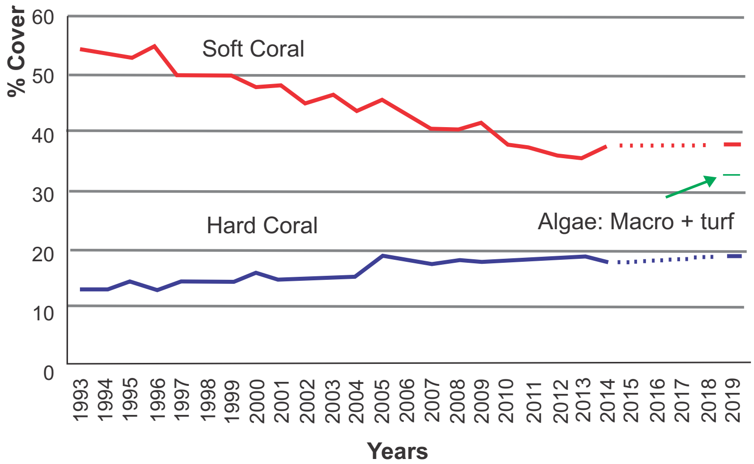


Figure 6.1: Changes in percentage cover of soft (red) and hard (blue) corals from 1993 to 2019 at Sodwana Bay monitoring site (Porter and Schleyer 2017).

Recreational activities (diving, fishing) can damage corals and the associated reef benthos (Schleyer and Tomalin 2000) and affect the reef fish community structure (Floros *et al.* 2013). Intensive diving appears to chase large predatory fish away, allowing preyed species to become more abundant (e.g. Figure 6.2, Floros *et al.* 2013). This can affect the reef benthic structure as small corallivorous and herbivorous fish increase in number. Diving may be accompanied by poaching, which generally targets giant clams (*Tridacna* spp.), certain anemones and triton shells (*Charonia tritonis*) (Schleyer and Porter 2018).

Some reef fish species also provide indicator value of reef condition or extraction and use (e.g., reduced herbivore numbers and extraction or displacement of predators by fishers and divers respectively; e.g. Figure 6.2) (Floros *et al.*

2013). Monitoring the numbers of these animals can provide an indication of such activities, provided the baseline for the reefs under consideration is known.

STATE

Historic perspective

Reef surveys and monitoring have been conducted on the South African coral reefs for three decades (Schleyer *et al.* 2008, Porter and Schleyer 2017). On Nine-mile Reef, in the Central Reef Complex, information has been obtained by extracting percentage cover data of the reef benthos recorded in photo-quadrats, providing a permanent comparative record. This simple technology can include observations on reef condition (coral bleaching, damage, disease), and provides data comparable with local and international records.

Previously mentioned potential indicator species have occurred and remained at background levels on the coral reefs, except for an outbreak of COTS in the mid- to late 90s (Schleyer 1998, Celliers 2001; Celliers and Schleyer 2006), a reduced numbers of giant clams (Schleyer and Porter 2018) and a reduction in indicator fish species on certain of the South African coral reefs (Floros *et al.* 2013). This is probably due to protection and regulated use of the reefs within a conservation area (iSimangaliso Wetland Park). However, reefs within the core of this conservation area, which should receive the greatest protection, are subjected to some of the highest recreational usage.

Current state

Reef cover has been well-documented on all the South African coral reefs and continues to be monitored (Schleyer *et al.* 2008, Porter and Schleyer 2017). Reef surveys have shown that the South African coral reefs are, overall, in good condition, being protected within the iSimangaliso Wetland Park (Schleyer *et al.* 2018).

The reefs are considered marginal as they occur at high latitude, at the limits for coral growth, and are thus not truly accretive like more tropical reefs. In consequence, soft coral cover is higher than that of hard corals (30.4 ±14.4% vs 22.5 ± 14.7%) (Porter and Schleyer 2019). While sea temperatures rose by 0.15°C p.a. up to 2000, they have since been dropping by 0.03°C p.a. Elevated summer temperatures have caused minor coral bleaching, the worst episode occurring in 2000 when ≤12% of the living cover was affected (Celliers and Schleyer 2002). More recent bleaching events have affected ≤1% of the cover, which suggests that resilience is possibly emerging in the coral community (Porter *et al.* 2018a). Nevertheless, there have been changes in the community structure at the long-term monitoring site (Schleyer *et al.* 2008, Porter and Schleyer 2017) which has revealed that hard coral cover has been rising by 0.26% p.a. and soft coral cover has been reducing by 0.95% p.a. (Figure 6.1).

Being marginal, the reefs are susceptible to change. The effects of recreational use are evident in the fish communities on heavily dived reefs and in heavily fished areas. Reduced numbers of key predators such as the potato bass, *Epinephelus tukula* (Figure 6.2), and the green jobfish, *Aprion virescens* are noted (Floros *et al.* 2012, 2013). Areas historically infested by COTS have shown slow recovery and some underwent a phase shift in community structure from hard to soft corals (Celliers 2001).

The effects of pollution on the environment are well-established (e.g., Bouwman *et al.* 2013), ranging in corals, for example, from impaired reproduction and stunted growth (Glynn *et al.*

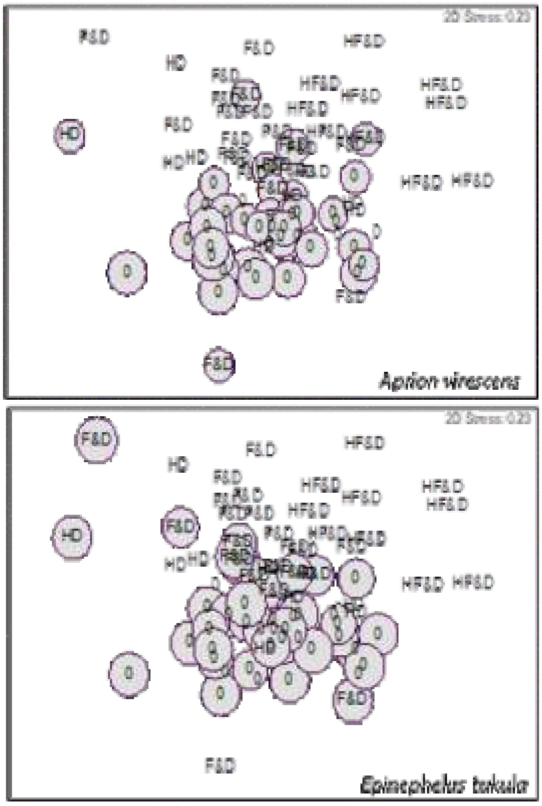


Figure 6.2: Abundance of *Epinephelus tukula* and *Aprion virescens* superimposed on non-metric multi-dimensional scaling (MDS) ordination based on 4th root transformed fish abundance and factored for human activities. 0=no diving or fishing, HD=high diving intensity, F=restricted fishing, HF=high fishing intensity, D=diving. The magnitude of the symbols reflects the number of fish at that sampling site.

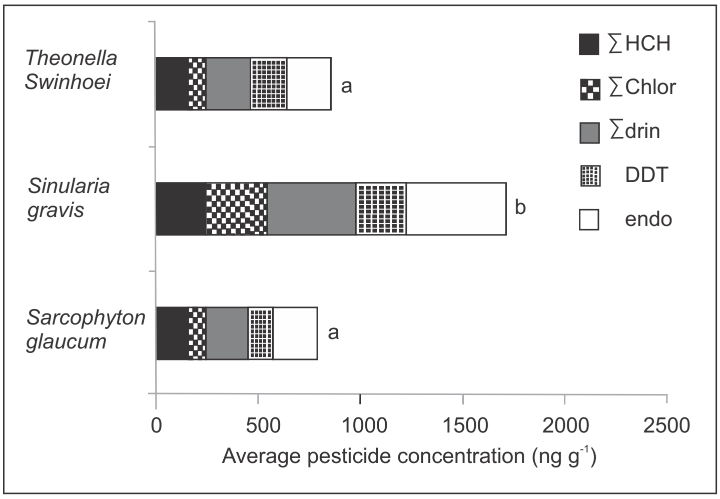


Figure 6.3. Average pesticide concentrations (n = 15) according to pesticide 'family' in organisms (dry weight) sampled on the South African coral reefs (Porter *et al.*, 2018b). Letters adjacent to bars indicate where significant differences were detected in post-hoc comparisons (α = 0.05).

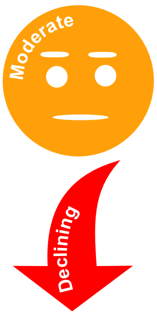
1995; Markey *et al.* 2007) to increased vulnerability to disease (Séré *et al.* 2015) and outright mortality. In the present case, OCPs are known to occur in excessive levels in freshwater bodies adjacent to South Africa's coral reefs (Buah-Kwofie and Humphries 2017). Preliminary research has shown that these pesticides are found in concentrations globally considered high in benthic reef organisms collected on the coral reefs, particularly where seepage occurs through the coastal dune cordon (Porter *et al.* 2018b). This makes monitoring of pesticide levels in the reef benthos an ideal 'state of the coast indicator', particularly as they may be related to changes in reef community structure. There is little information on OCP concentrations in sponges and corals. However, the average ∑OCP concentration recorded in a global analysis of hard and soft corals was 760 ng g^{-1} dry weight; this study included known contaminated sites. An average value of 1100 ng g^{-1} dry weight was recorded for ∑OCPs in preliminary analyses on the South African coral reefs, which was notably higher than this global average. Furthermore, few of the pesticides tested occurred in sponges elsewhere at the concentrations found in the local sponge (*Theonella swinhoei*). Less information is available on soft and hard corals but the same was true of these organisms. Examples of the South African results are presented for the sponge and soft corals (*Sarcophyton glaucum* and *Sinularia gravis*) (Figure 6.3).

IMPACT

A reduction in coral cover, changes in reef community structure or a deterioration in reef condition will affect their biodiversity and economic value. Coral reefs are as rich or richer in biodiversity than tropical rain forests, and, therefore, have irreplaceable biodiversity value. In terms of economic value, coral reefs yield food, pharmaceuticals, coastal protection, cultural benefits and even building materials to otherwise impoverished coastal communities throughout the tropics. In the South African context, coral reefs in Maputaland provide benefits to its coastal communities and support a thriving diving and ski-boat angling industry.

There is some evidence that pesticides at concentrations measured in the tissues of hard and soft corals lead to bleaching and mortality. Insecticides and fungicides have also been shown to affect multiple coral life stages and, at detection limits, negatively affect coral larvae because the larvae are lipid-rich and OCPs are lipophilic.

RESPONSE



Monitoring of proposed indicator organisms and ongoing conservation of the reefs is imperative. Several research initiatives are under consideration to further elucidate the effects of high OCPs on South African coral reefs. This is essential, as well as monitoring of trends in levels of the OCPs to develop sensible responses to and mitigation of this serious form of pollution. Cessation of the use of DDT in malarial control and wiser use of agrochemicals would stop further exacerbation of the problem but dealing with extant deposits of these pesticides is difficult to conceive as they will continue to seep onto the reefs for years. Possibly the only effective mitigation will be to ensure that the reefs suffer no further assaults that would reduce their resilience, e.g., excessive ecotourism and fish extraction, unremedied COTS outbreaks.

Conservation should be accompanied by greater enforcement of compliance and an improved system of closed sanctuaries. While reefs in the 'buffer' zones of the iSimangaliso Wetland Park are well protected, reefs in the 'core', in the Central Reef Complex, are amongst the most heavily used in the world. Nine-mile Reef, the remote, northernmost reef at Sodwana Bay in the Central Reef Complex, should be given sanctuary status. This will improve the security of this reef complex, providing it both a breeding refuge for larval replenishment and a baseline site to validate monitoring results. It remains unknown whether some of the differences in the Central Reef Complex are natural or anthropogenic (human-induced) without such a baseline site. Mitigation must be considered if changes are detected, e.g. by reducing recreational use and the elimination of pest species.

International adherence to IPCC recommendations to mitigate climate change is imperative and the South African government is to be encouraged to support such action in international fora. South Africa itself needs to reduce its CO_2 output.

Data Requirements

- The most cost-effective **coral cover data** can be derived from random photo-quadrats. These provide a permanent record for percentage cover of the reef benthos.
- **OCPs** are extracted from field-collected samples and subjected to sophisticated gas chromatography and mass spectrometry to measure pesticide residues in the samples relative to recognised standards; the process is thus costly.
- Numbers of **indicator species** can be quantified per unit area from quadrats according to the size and density of the target organisms. In the case of giant clams and COTS, long transects or timed swims are appropriate. Point counts are used to assess fish abundance and community structure.