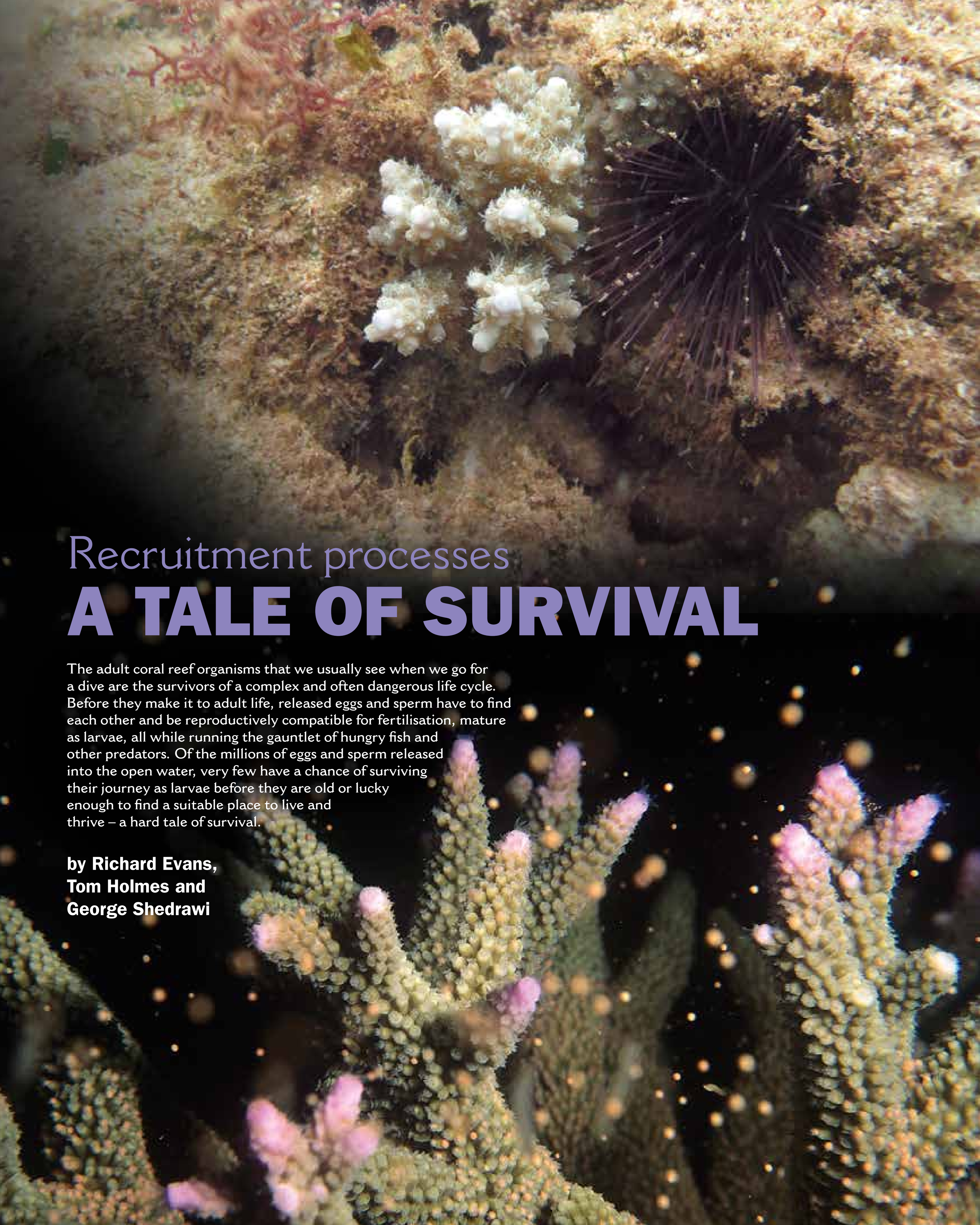

Recruitment processes

A TALE OF SURVIVAL

The adult coral reef organisms that we usually see when we go for a dive are the survivors of a complex and often dangerous life cycle. Before they make it to adult life, released eggs and sperm have to find each other and be reproductively compatible for fertilisation, mature as larvae, all while running the gauntlet of hungry fish and other predators. Of the millions of eggs and sperm released into the open water, very few have a chance of surviving their journey as larvae before they are old or lucky enough to find a suitable place to live and thrive – a hard tale of survival.

by Richard Evans, Tom Holmes and George Shedrawi

Many marine organisms have what is known as a bi-partite life cycle, in which adults release eggs and sperm, also known as spawn, which fertilise to produce tiny larvae that disperse in the open oceans before returning to benthic habitats to continue their lives as juveniles and adults. While older individuals who move locations are often well adapted to the habitats they may find at their end point, larvae may find themselves in a scary new world when they reach their new home, one in which they have no prior experience. So what happens when these larvae arrive at their new homes?

The dispersal of larvae through the water column is important for the connectivity and survival of populations of marine species, but for the young (recruits), the conditions they find on the reefs when they arrive also affects their survival at the start of a new stage in their life cycle. Firstly, larval organisms need to survive the gauntlet from the water column past the 'wall of mouths' (predators typically in the form of fish) to the reef substrate. Many reef-based animals see naïve young larvae as a tasty mid-morning snack, so it pays to find ways to reduce or entirely avoid this threat from predators. Fish approach this challenge in three key ways. Firstly, they settle at night and generally around the new moon, when darkness is greatest and most potential predators are asleep. Secondly,

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Top *Acropora* recruit *in situ* with urchin.
Photo – Richard Evans/Parks and Wildlife
Bottom Coral spawning.
Photo – Geoff Taylor/Lochman Transparencies

Above Coral reef fish hiding among the busy coral reef landscape.

Right Young *Chromis viridis* hiding among the branches of an Acroporid coral.
Photos – Matt Kleczkowski

they settle in large numbers like waves of soldiers storming a beach, flooding the potential predators with choice and maximising the chance that some will survive. Thirdly, they generally remain transparent in colour until they reach protection, decreasing their visibility to watching eyes (see also 'Now you see me …' on page 22).

Once there, they face a whole new set of challenges, including further predation, competition for space and access to an adequate food supply. For immobile organisms such as corals the list continues, and includes other threats such as smothering from sediment, abrasion and dislodgement, exposure and heat stress. For example, if coral larvae settle out of the water column onto a reef covered in sediment, they are probably not going to find a suitable place to attach successfully or if the competent larvae manage to, they may be smothered before they can grow to maturity. Other challenges for organisms that attach to the bottom include competition for space by existing benthic organisms such as sponges, ascidians, bryozoans, other corals; and predation from other benthic organisms such as snails, slugs, boring worms or scraping and excavating herbivorous fish. They are also subject to environmental influences that may occur during the settlement period, such as heavy rainfall affecting salinity. Having no eyes and very little motility to find the sweet spot is a challenge and corals have to use other methods to increase their chance of survival. They time their spawning so that their eggs and sperm are released at night on a relatively dark moon phase, and more importantly they settle in complete darkness near the new moon a week later to decrease predators' ability to see them.

"It would not be a relaxing existence being a juvenile fish or coral on a big coral reef!"

Far left A thriving reefscape.
Photo – George Shedrawi/Parks and Wildlife

Left A juvenile coral trout.
Photo – David Williamson

Above Parks and Wildlife scientists installing coral settlement tiles in Shark Bay.
Photo – Michael Rule/Parks and Wildlife

Coral larvae use settlement cues, probably through chemical receptors to find a good place to settle on the reef, helping them distinguish 'friend' from 'foe' on suitable substrata. One such place is underneath existing reef structures where they hide from the torrent of pressures influencing their survival.

Coral reef fish typically have excellent swimming abilities and good senses of sight and smell, but they still have to find a place to hide that is not occupied by other creatures and is appropriate to the individual species' dietary needs, body shape and behaviour. They must then duck out of this sanctuary to find food every day, always under the watchful eye of the bigger and faster predatory fish like coral trout, snappers and wrasses. Even during the night it is not safe due to the voracious nocturnal predators such as sharks, cephalopods (octopus and squid) and crabs. It would not be a relaxing existence being a juvenile fish or coral on a big coral reef!

CORAL RECRUITMENT STUDIES

Since 2010, Parks and Wildlife marine scientists have travelled to some of WA's most iconic coral reefs to gather settlement and recruitment data. This program extends from Shark Bay Marine Park in the south to the reefs off Onslow and Barrow and Montebello Islands marine reserves. Understanding rates of settlement, recruitment and shifts in the size-structure of corals can increase management effectiveness by describing the underlying patterns of declining or recovering coral communities in response to large-scale natural and human stresses. This information may then be used to make informed strategic management decisions which recognise resilient and susceptible areas under differing levels of management. This is important because coral reef recovery can take years, as is currently the case in some Western Australian reefs, where corals have been impacted by dredging, bleaching, and cyclones in recent years.

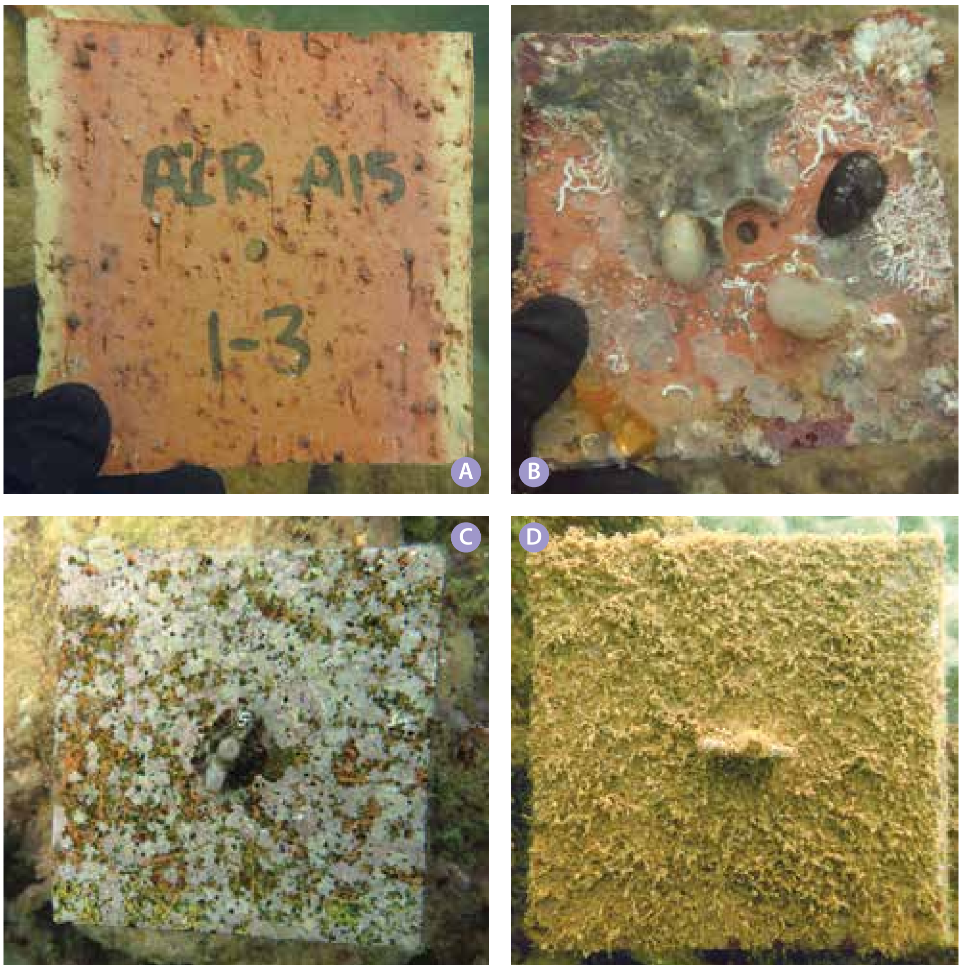
To gain an understanding of how these events affect coral communities presently and into the future, terracotta tiles were deployed at various reefs throughout WA. Coral settlement tiles are a standard unit for measuring coral larval supply and are used in many science projects throughout the world. The 100x100-millimetre tiles attract various creatures settling to the reef and among those are young competent larvae, if they are able to find them among the vast coral reefs. The tiles are deployed during the peak reproductive times for corals, which are mainly during the autumn months of March and April.

Assessing early coral survival and coral recruitment on the actual reef is also being done in conjunction with counting the corals on settlement tiles. The tiles are a measure of supply to the reef but the juvenile corals counted on the reefs are a measure of survival. Corals that can be observed with the human eye are generally one to two-plus years old so there is a lag time comparing the tiles to the young corals on the reef. By combining these two methodologies we find the reefs that have had consistent settlement to tiles and high levels of early survival through the recent heat stress years, are more resilient and able to recover quicker from disturbance.

The research conducted within Ningaloo Marine Park during the past six years has shown us that settlement and recruitment survival is highly variable. Coral cover has been low at Bundegi in the park's north-east, since the bleaching events of 2010–11, and has had consistently low settlement and recruitment rates and subsequently coral recovery is slower than other locations. The minimal amount of live reproductive adults, natural oceanographic factors or high sediment loads may hinder recruitment and survival of corals at this reef through time. What we've found at Bundegi is that after four years, recruitment of encrusting form corals, which are an important first step to recovery, are beginning to increase. However, settlement and recruitment of those large habitat-forming corals such as branching- and plate-shaped Acroporidae are still very low and Bundegi may take at least 12 to 15 years to return to its former glory. The abundance of recruits has also decreased around the Muiron Islands but these are limited to young branching corals and it is expected that recruitment may not be as limited as that found at Bundegi due to the relatively smaller impact of the bleaching event in this area. In contrast, the north-western Ningaloo reefs (and Coral Bay in the southern part of the marine park) have maintained healthy adult corals and have had consistently high settlement rates even after the multiple disturbance events.

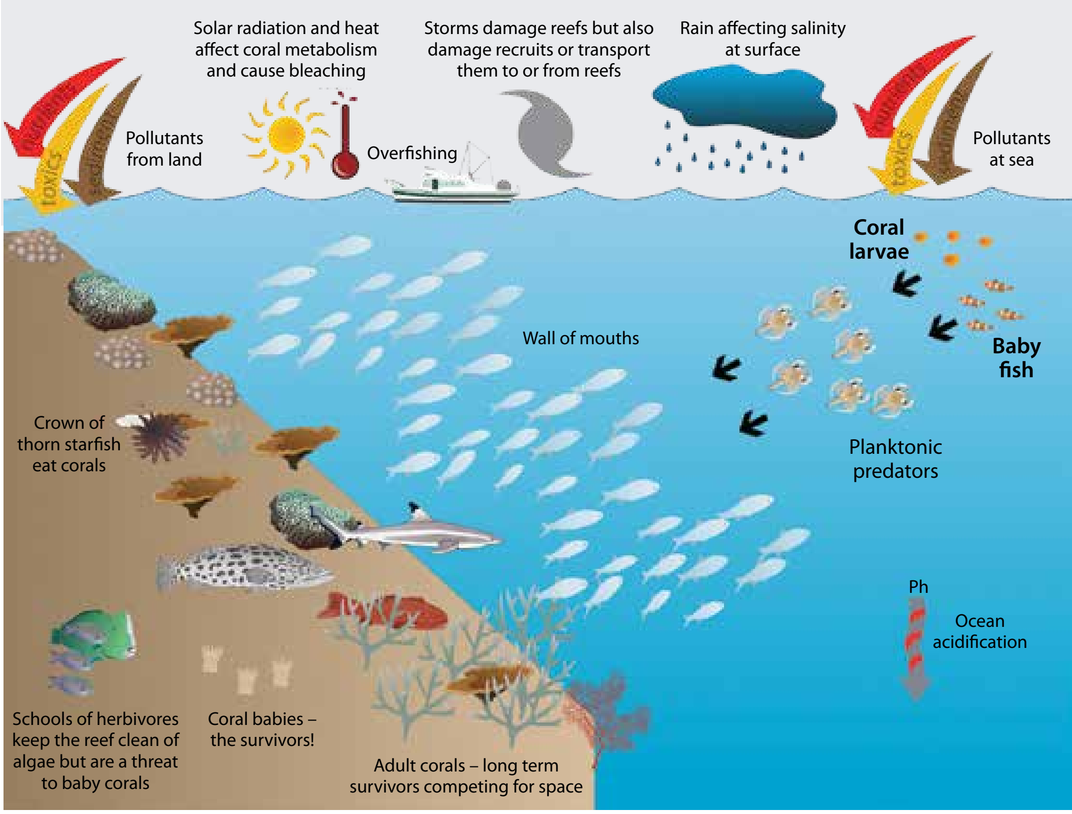
These are particularly important findings as these areas may become the supply for reefs in those affected areas of the marine park. Studies linking recruitment supply and abundance will help us to determine which reefs are likely to be source populations and which are likely to receive new recruits from other locations. Genetic connectivity studies can be done to further understand these links (see 'Understanding marine connectivity', *LANDSCOPE*, Winter 2016, for a detailed description of these processes).

In a simultaneous study, the Chevron-funded Wheatstone offset project



Above A 'wall of mouths' at Murion Islands.
Photo – Matt Kleczkowski

Left When the tiles are deployed (A) they are clean. After three months on the reef, many critters settle on the underside of the tiles (B). The top of the tile is exposed to many interactions and are only covered in the critters that can survive. (C) shows parrotfish scrape marks through some coralline and turf algae. But at some locations sediment smothers all (D).
Photos – Richard Evans/Parks and Wildlife



investigates connectivity and the resilience of important habitat producers and associated animals. As part of this study, coral recruitment and survival has been investigated after several thermal stress events which reduced coral cover from approximately 50 per cent to as low as five per cent. The real challenge for the corals of this region is that they live in an area with high natural sediment regimes, which is not ideal for young corals. In addition to the bleaching that occurred in 2011 and 2012, a dredge operation off Onslow moved up to 46 million cubic metres of marine sediment from 2013–15. The purpose of this study is to identify potential stressors to the reefs and discover their influence on the recovery potential of western Pilbara reefs. This study had been conducted over the past three years and is still in progress.

FISH RECRUITMENT STUDIES

While corals have to decide on a single perfect home for the rest of their lives, fish are mobile and have the opportunity to shift habitats as they grow, choosing different areas that are most appropriate to their changing size, diet and reproductive needs. Initially, many fish settle in nursery grounds that are low in predator numbers, provide a reliable supply of food appropriate for small fish and ample hiding spaces to survive until they are big and strong enough to move to more challenging environments. For some coral reef fish, this may simply be a specific type of coral that offers a complex array of hiding spaces for small individuals. However, for others this may involve settling in nearby seagrass, mangrove or macroalgal (seaweed) habitats that offer greater protection and food sources for juvenile fish of certain species.

While much of the previous work on nursery habitats has focused on the importance of seagrass and mangrove communities, recent work by Parks and Wildlife scientists and their collaborators, highlights the significant role that macroalgae also plays. Often considered the ‘enemy’ of coral reefs due to the perception that they out-compete the more beautiful corals following disturbance events (such as cyclones and coral bleaching), macroalgae actually plays an important role in tropical reef ecosystems. This is particularly the case in the Gascoyne, Pilbara and wider north-west shelf regions of WA, where

Above right Some of the stressors and processes affecting the settlement and recruitment of baby coral and fish to adulthood on coral reefs.
Illustration – Richard Evans with symbols courtesy of Integration and Application Network, University of Maryland Centre for Environmental Science

Right Ribbon grass.
Photo – Clay Bryce/Lochman Transparencies

Left Blue spotted turkfish.
Photo – Clay Bryce/Lochman Transparencies

Below left Algal reef habitat acts as a nursery.
Photo – Matt Kleczkowski

Below A young turbinaria survivor.
Photo – Richard Evans/Parks and Wildlife

large areas of shallow inshore waters are covered by vast macroalgal fields. Researchers have found that these areas provide essential nursery habitat for a range of ecologically and fishery important species in this region, including parrotfish, emperors, snappers and tuskfish.

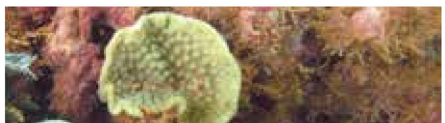
Initially focused on the Ningaloo region as a wider study of fish recruitment patterns within the marine park, the work was extended to the Montebello and Barrow Islands marine reserves in 2010 as part of the Gorgon gas development monitoring, evaluating and reporting program. In both cases, macroalgal fields immediately adjacent to coral reefs were found to support an amazing diversity of juvenile fishes, many of which are known to live in coral habitats later in life. While the Montebello/Barrow Island work provided an excellent snapshot of how these patterns may extend into the wider Pilbara region, the Ningaloo research continues to provide insights into how these patterns change through time and why fish may recruit to certain areas.

The research has found recruitment to be a highly variable process, with some years producing extremely high numbers, and others next to none. While there is likely a high degree of natural inconsistency, the strength of fish recruitment appears to be closely related to ocean and weather conditions over the summer period (when reproduction and recruitment occur). In particular, the strength of the Leeuwin Current (the southward flowing warm water current along the Western Australian coast) seems to be particularly important, with years of stronger current flow resulting in higher recruitment.

Location also appears to play a role, with some areas along the Ningaloo coast consistently recording higher numbers of fish recruits than others. This appears to be closely related to both oceanic conditions and certain characteristics of the coral or algae in which they settle. For example, some commercially important species, such as the spangled emperor (*Lethrinus nebulosus*), prefer to settle in algal areas that are dense and have a high canopy height.

These studies are but a few focusing on recruitment as an important process to help WA coral reefs recover from natural and human influences. Marine science staff are involved in collaborative recruitment studies alongside The University of Western Australia, Australian Institute of Marine Science, CSIRO, Australian National University and University of Tasmania in various locations including the Dampier Archipelago, Montebello Islands, the Kimberley, Ningaloo reef and even the cold waters (for a coral) of Shark Bay, Jurien Bay and Perth.

If you would like more information about how the young marine animals run the gauntlet through the wall of mouths to start their lives on the busy metropolis of coral reefs contact the Marine Science Program.



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