

Status of St. Maarten's Reef

Last September, major category 5+ Hurricane Irma caused widespread damage to St. Maarten. This was a strong reminder of the urgency to preserve the natural buffers that protect our islands from storm damage, such as coral reefs and mangroves, and increase their resilience. Coral reefs are marine biodiversity hotspots that are not only invaluable for coastal protection but also have a high economic value through associated tourism and fishery.

There is limited information on the status of St. Maarten's reefs over the past three decades as only a few studies have taken place. First rapid observer coral reef assessments since Hurricane Irma showed that the damage is extensive and significant, in the coming month qualitative coral reef research via the GCRMN method will be done to assess the reef damage. Post hurricane data will be analyzed and compared to recent pre-hurricane GCRMN reef assessments conducted in August 2017 and 2016. This will provide insights in the reef structure and can be used to assess the changes in reef condition since this major hurricane stroke St. Maarten.

1. Geography and Reef Structure

St. Maarten is an island made of magma and limestone rocks located in the North Eastern Caribbean, on the Anguilla Bank. It is part of the outer arc of the Lesser Antilles, which consists of the islands Sombbrero up to and including Marie Galante. The oldest rock strata date from +/- nearly 50 million years ago and the island is older than Saba and St. Eustatius (Rojer, 1997)..

St. Maarten is the largest of the Dutch Caribbean's Windward Islands, with a land area of 37 km² and a maritime area of 434 km². St. Maarten is actually part of a larger landmass (96 km²) that is divided between two sovereign governments - the Dutch and the French. St. Maarten makes up the smaller, southern side and is an autonomous country within

the Kingdom of the Netherlands. Saint-Martin makes up the larger (59 km²), northern side and is a French Overseas Territory (MacRae, 2007).

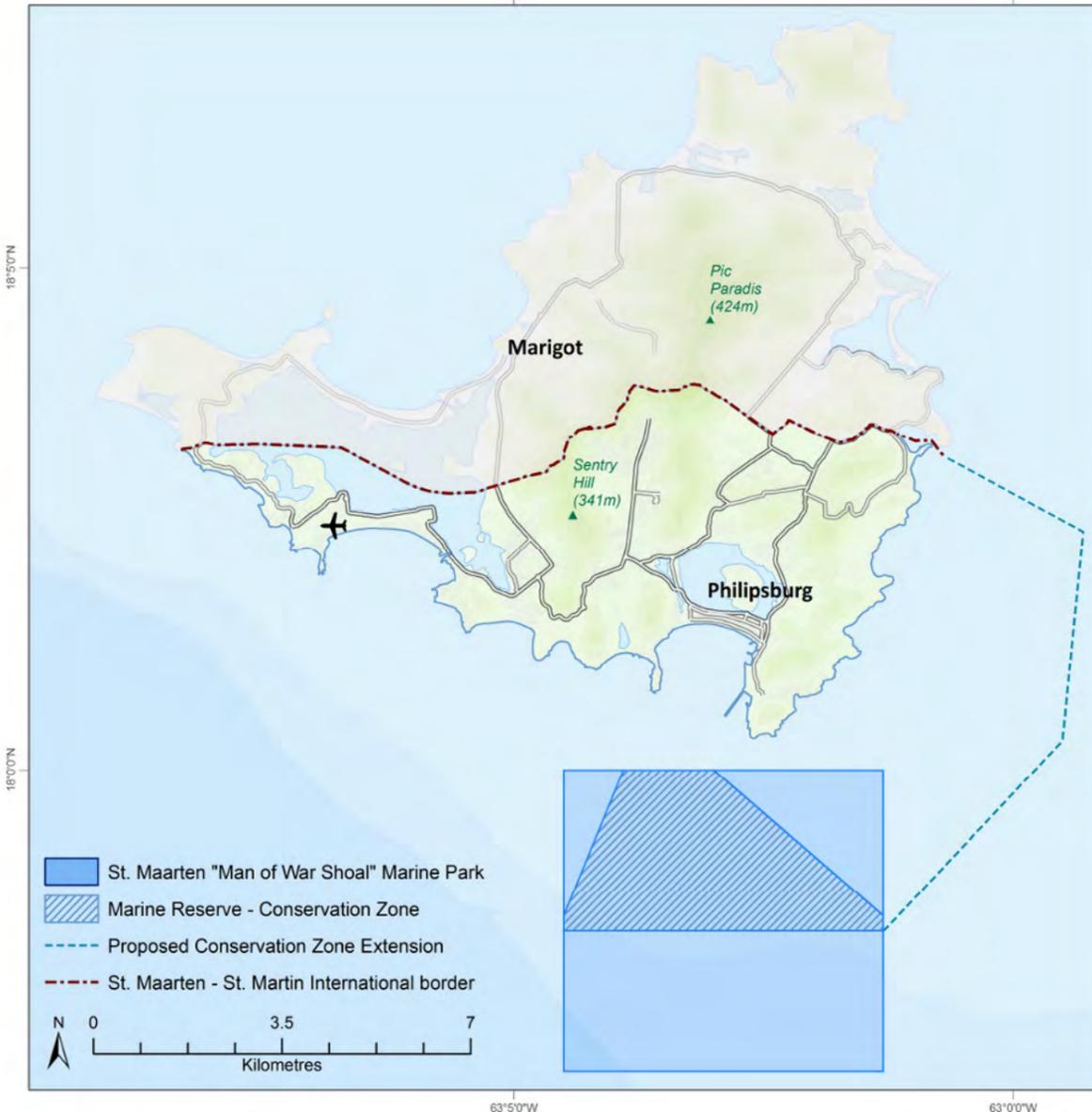
Except for the lowlands in the west, St. Maarten is hilly. The east end has a range of conical hills: Cole Bay Hill (215m), Sentry Hill (344m), Saint Peter's Hill (317m) and Flagstaff (386m) (Rojer, 1997). Before hurricane Irma, the island was covered with evergreen forests, deciduous and mixed evergreen thorn woodlands, and succulent evergreen shrubland (NFSXM, 2017a).

The numerous bays and lagoons along St. Maarten's coast give the island its irregular shape (Rojer, 1997). The west end is dominated by Simpson Bay Lagoon, one of the largest lagoons in the Lesser Antilles. The lagoon, as well as RAMSAR site Mullet Pond, are home to the island's largest mangrove forests (NFSXM, 2017a). Seagrasses are found mainly along the southern and south-western shores, from Great Bay to Cupecoy Beach. The rest of the coastline, which measures in total 27 km², is made up of steep rocky cliffs and white sandy beaches. The island is surrounded by a number of small uninhabited islands such as Pelican Rock and Molly B'day. These offshore islands are important nesting sites for migratory and resident seabirds and have been listed by Birdlife International as Important Bird Areas (DCNA, 2017).

St. Maarten's reefs are primarily fringing reefs (Jackson et al., 2014). Patch reefs are found in shallow waters close to shore along the eastern, western and southern coasts. Many upper reef slopes on the eastern part of the island have spur and groove formations (NFSXM, 2017b). The Dutch Caribbean's youngest protected area, the Man of War Shoal Marine Park, was established in 2010. The Marine Park is located off the southern shore of the island and covers an area of 31 km². St. Maarten was also declared a shark sanctuary in 2011.

Map of St. Maarten.

Image by: © DCNA



2. Status of the reefs of St. Maarten

There has only been a limited number of studies over the past twenty years that have investigated the health of St. Maarten's reefs (Table 1). In the late 1999, the reefs of the windward Netherlands Antilles were assessed at 24 sites to assess the damage caused by hurricane Lenny (Klomp & Kooistra, 2003). The Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol was used with modifications to detect the hurricane impact. In 1999 and 2001, a joint project between Nature Foundation St. Maarten (NFSXM) and ReefKeeper International surveyed coral species at 3 of the island's main dive sites (Hen & Chicken, Molly Bédard and Mike's Maze) (St. Maarten ReefMonitor Update, 1999; 2001). In 2013 two dive sites in the Man of War Shoal Marine Park were filmed as part of the Catlin Seaview Survey to assess the state of coral reefs over larger scales and in more precise (www.globalreefrecord.org).

Most recently, conservation organizations from Saba, St. Eustatius and St. Maarten joined a research expedition organized by the Scripps Institution of Oceanography and the WAITT Foundation in November 2016 to conduct a rapid scientific assessment of the coral reefs around the windward Caribbean islands (Sandin et al.,

2016). The Global Coral Reef Monitoring Network protocol for the Caribbean (GCRMN Caribbean) was used to establish a regional scale perspective of coral reef health across the islands, with surveys taking place in the forereef habitat at depths between 7 and 15 meters (Sandin et al., 2016). In addition to coral reef assessments following the GCRMN protocol, eleven coral reef environments on St. Maarten were mapped using 3D imagery (Sandin et al., 2016). Photography and advanced image post-processing are used to create photomosaic images of large reef areas up to 100 square meters. These images provide a snapshot view of large-area coral reef communities and their compositions, enabling data collection of benthic communities. The results of these surveys have not yet been released but footage can be seen here: <https://drive.google.com/drive/folders/oBy3cTucxJ9GFbmdGd1lFZ3dualk> [100IslandChallenge.org, Scripps Institution of Oceanography at UC San Diego, in partnership with the Waitt Institute]. The goal is to repeat the assessment in two years so that changes in reef health can be gauged. Currently NFSXM is making damage assessments of among others St. Maarten's reefs after the island was hit by the powerful hurricanes Irma.

Table 1: Summary of major coral status surveys conducted on St. Maarten's coral reefs

Studies	Time period	Survey Description	# Sites Surveyed
AGRRA, Klomp, Kooistra (2003)	1999	Post hurricane (Lenny) rapid assessment of reefs including measures on coral cover and bleaching.	-
Catlin Seaview Survey	2013	Underwater scooter-assisted SV II survey camera system to conduct reef surveys.	2
NFSXM and ReefKeeper International	1999 and 2001	Survey of coral species.	3
Esteban, Kooistra (2005)	2005	Report on observations of coral bleaching in St Maarten's Marine Park.	-
GCRMN	Since 2016	Abundance and biomass of key reef fish taxa, relative cover of reef-building organisms (corals, coralline algae) and their dominant competitors (macroalgae), assessment of health of reef-building corals, recruitment of reef-building corals, abundance of key macro-invertebrate species (i.e. <i>Diadema antillarum</i>), and water quality (i.e. water transparency (Secchi-disk).	7 (mainly within the Man of War Shoal Marine Protected Area)
Scripps Institute of Oceanography and the WAITT Foundation	2016	Coral reef assessments following the GCRMN protocol and selection of 11 coral reef environments were mapped using 3D imagery.	18

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2.1 Benthic cover

Coral cover

In 1999, live coral cover of the reefs of the Dutch Caribbean's Windward islands was assessed at 18%, with most hard corals made up of small-sized colonies (Klomp & Kooistra, 2003). However, the joint study between NFSXM and ReefKeeper International in 1999 found St. Maarten's reefs to be in good health with an overall hard coral bottom cover of 34% and a moderate species diversity of 13 hard coral species (St. Maarten ReefMonitor update, 1999). When the study was repeated in 2001, hard coral cover had dropped to 30% (St Maarten ReefMonitor update, 2001).

In the early 2000s, St. Maarten's reefs showed signs of disturbance, notably sedimentation and bleaching - bleaching was noted in 44% of colonies (Klomp & Kooistra, 2003). The island's reefs have suffered from a number of severe bleaching events over the years, notably in 1998 and 2005. Following the severe bleaching event of 2005, many coral colonies were found to be affected (Esteban & Kooistra, 2005). At Mike's Maze

dive site, 70% of all fire coral were bleached. At Proselyte Reef, 60% of all hard corals were affected at a depth of 14 meters. At Fort Amsterdam, at least 75% of corals were severely affected at a depth of 6.5 meters, including branching, mound and brain corals, as well as various soft corals (Esteban & Kooistra, 2005). In 2006, a fairly high level of residual coral bleaching was observed, notably in *Montastrea cavernosa* and *Agaricia agaricites* colonies (Goreau, 2006).

Major category five storm Irma this September caused widespread damage to the island, a strong reminder of the urgency to preserve our natural buffers that protect our islands from storm damage, such as coral reefs, and increasing their resilience. *"Although in-depth coral reef assessments have not yet been made, rapid observer assessments have established that there has been significant storm damage to the 'Man of War Shoal' Marine Park. An estimated 50% of the reef has suffered some kind of damage and there is significant siltation still in the Marine Park. The Marine Park has only been in existence for six years and the resiliency of the area to recover from this significant weather event remains to be seen"*

(NFSXM, 2017d). Latest survey results show large coral and sponge die-off, especially at the shallow reefs and direct damage to branching corals such as Elkhorn corals. NFSXM estimated a 30% die off of the reef, mainly corals and sponges, due to sediment cover caused by strong surge and water motion of hurricane Irma (NFSXM, 2017c).

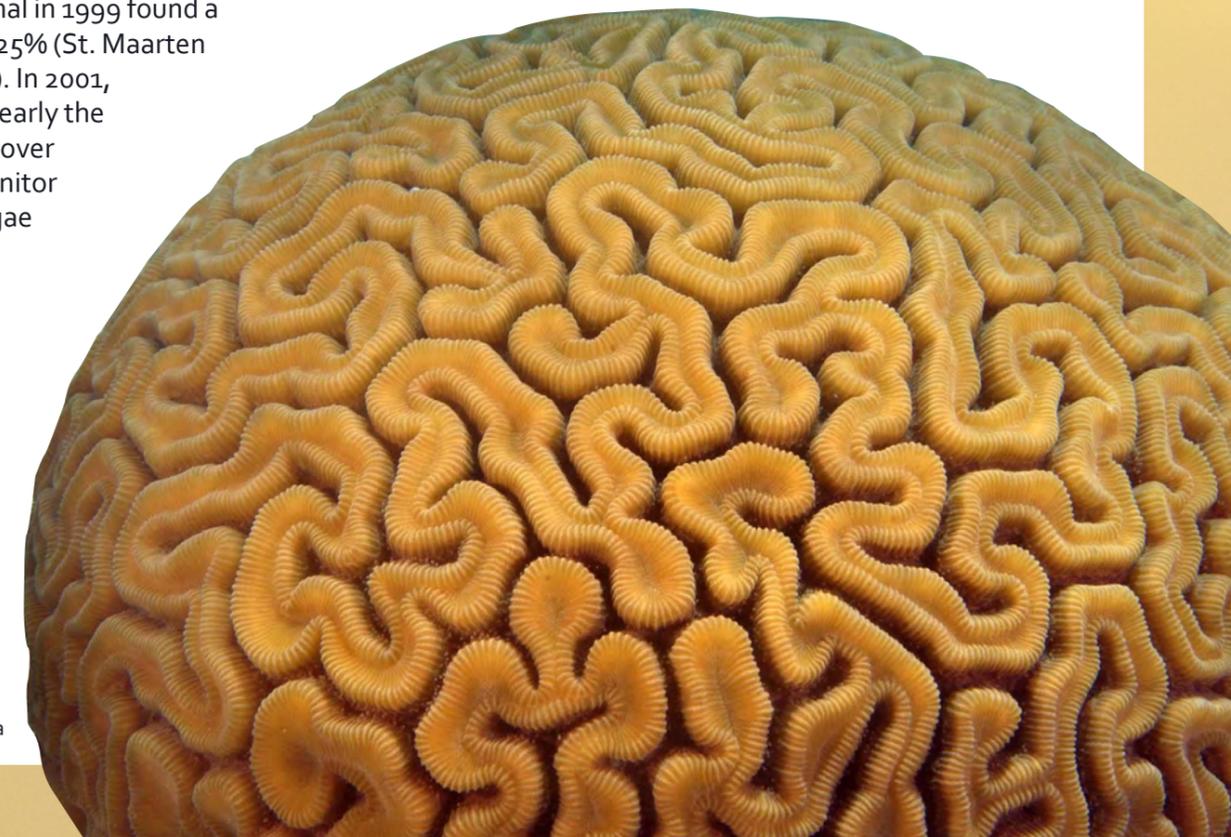
Macroalgae

Macroalgae negatively impact corals by inhibiting coral recruitment and survival, slowing coral growth and making them more prone to diseases (Jackson et al., 2014). Macroalgal cover was found to be low for the reefs of the Windward islands in 1999 (Klomp & Kooistra, 2003). This was partly attributed to the high biomass of grazing herbivorous fishes in the region (Klomp & Kooistra, 2003). However, the joint study between NFSXM and ReefKeeper International in 1999 found a much higher algal cover of 25% (St. Maarten ReefMonitor Update, 1999). In 2001, all the reefs surveyed had nearly the same percentage of algae cover (27%) (St. Maarten ReefMonitor Update, 2001). The high algae cover by Dictyota was also

reported by Goreau (2006): *"there are moderately high nutrient levels even in areas that are not exposed to land based sources of nutrients. This suggests that there are high natural inputs from deep cold waters, probably caused by the shallow thermocline and the activity of breaking internal waves in Atlantic waters to the east of Sint Maarten. High natural nutrient backgrounds offshore indicate that even stricter control of land-based sources of nutrient pollution is needed to prevent explosive weedy algae overgrowth, or eutrophication, of coastal waters."* (Goreau, 2006).

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Photo by: © Marion Haarsma



2.1 Fish

St. Maarten's reefs are home to 153 species of reef fish. The most common reef fish species are blue tang (*Acanthurus coeruleus*), bluehead (*Thalassoma bifasciatum*), sergeant major (*Abudefduf saxatilis*), spotted goatfish (*Pseudupeneus maculatus*) and ocean surgeonfish (*Acanthurus bahianus*) (NFSXM, 2017a). The fish communities of the island's offshore and protected areas have recently been described as "noticeably robust and intact" with relatively common sightings of bigger fish, which highlights the success of fish management initiatives on St. Maarten (Research group at Scripps Institution of Oceanography UC San Diego, personal communication, June 15, 2017).

The island has a healthy shark population. Since 2015, Baited Remote Underwater stereo Video (stereo-BRUV) has been used to gather data on St. Maarten's shark population. Caribbean reef sharks (*Carcharhinus perezi*) and nurse sharks (*Ginglymostoma cirratum*) are the most abundant shark species. Between February and August 2016, 477 Caribbean reef sharks were sighted, along with 70 nurse sharks (*Ginglymostoma cirratum*) and 1 hammerhead shark (*Sphyrnidae sp.*) (DCBD, 2017). The abundance of these species is higher in the



Caribbean Reef Sharks, Photo by: © Jim Abernethy

marine park, and is markedly more abundant within the park's Conservation Zone (Kramer & Odinga, 2015). This may be the result of their preference for reef habitats. Their distribution could also be affected by the shark-feeding excursions that used to be organized for tourists (Kramer & Odinga, 2015).

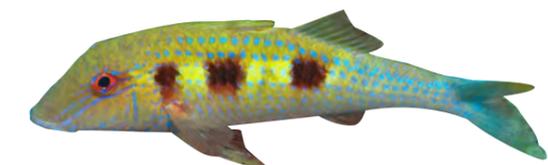
3. Local stressors on St. Maarten's reefs

While there is limited information regarding the current status of St. Maarten's reefs, there are clear indications that these reefs are under a number of man-made and natural pressures. In 2003, signs of disturbance such as sedimentation and increased bleaching were already noticeable compared to the other Windward Islands (Klomp & Kooistra, 2003). It is important to reduce local threats to increase the resilience of the reefs to the global stressors caused by climate change such as intensified bleaching and storm events (Bender et al., 2010; Walther et al., 2002). In light of the considerable worth of the island's reefs, adequate management measures must be put in place to protect this invaluable resource.

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Ocean Surgeonfish, Photo by: © Hans Leijnse



Spotted Goatfish, Photo by: © Marion Haarsma

The economy of St. Maarten is extremely dependent on marine-based activities, with the reefs generating approximately USD \$58 million through coral reef associated tourism and fishery (Bervoets, 2010). Tourism has increased greatly over recent decades, and continues to do so. From 2011 up to the end of 2015, the island has seen the number of stay-over tourists grow from 424,340 to 505,374 (Heyliger, 2017). Most visitors make use of the marine environment, from lounging on a beach to enjoying a fishing or boating excursion and taking part in watersports activities such as snorkelling and SCUBA diving. St. Maarten is also a major port of call for Caribbean cruise ships (Klomp & Kooistra, 2003), and in 2015 Port St. Maarten catered to over 1.9 million cruise passengers (Port St. Maarten, 2016). These passengers also partake in the island's many water-based activities.

The rapid and continuous growth in tourist numbers as well as residents (from 5,000 in 1960 to 41,338 in 2017) has led to thoughtless landscaping and building near the waters' edge to accommodate them. Unsustainable development is one of the most serious threats to St. Maarten's reefs. It causes sedimentation and nutrient enrichment of the marine environment which in turn smothers

and kills reef organisms (MacRae, 20007; NFSXM, 2017b). Development for tourism has resulted in further habitat destruction and degradation of habitats such as the lagoon and the numerous salt ponds on the island (Yokoyama, 2010).

The increase in the permanent and temporary population of St. Maarten has also led to an increase in pollution. Pollution on St. Maarten mainly comes from sewage, fuel and litter. These directly affect the health of the seabed environment. The resulting raised nutrient concentrations stimulate the growth of algae, which can out compete hard corals for settlement space. The seagrasses in Simpson Bay Lagoon and in Oyster Pond have all but disappeared as a result of pollution, anchoring and eutrophication caused by excessive nutrients entering coastal waters (MacRae, 2003). However, the little available evidence indicates that water quality is generally good within St. Maarten's open water environments (MacRae, 2003).

Small-scale commercial and artisanal fishing takes place on the island's reefs. There are seven active fishing vessels with an estimated 490 kg total catch per week (Lindop et al., 2015). Commercial fishing targets snappers (*Ocyurus*

chrysurus and *Lutjanus campechanus*), pelagic species (*Acanthocybium solandri*, *Coryphaena hippurus*, *Thunnus sp.* and *Selar crumenophthalmus*), and lobster (*Panulirus argus*) (Dilrosun, 2004). The island's fishing grounds have been described as poor with few large specimens of carnivorous fish such as groupers and snappers, most likely the result of overfishing throughout the 1970s and 1980s (MacRae, 2007; Dilrosun, 2004). Illegal spearfishing takes place to some extent, and conch are taken unsustainably (MacRae, 2007). The creation of the Man of War Shoal Marine Park in 2010 has had a positive impact on commercial species. In 2013, grouper and snapper populations increased by 10-15% within the Marine Park, with fishers reporting an increase in catch (Bervoets, 2014).

Besides, St. Maarten is also dealing with invasive species, notably lionfish that were first sighted in 2010 and are reported to negatively impact native coral fish populations (Albins and Hixon, 2008). In its efforts to manage and control the infestation NFSXM has been catching these fish and distributed lionfish collection materials to the various dive centers and fishermen. Twice a year the Nature Foundation also holds a lionfish derby.

St. Maarten is located in the Atlantic hurricane zone, and on average is hit by a hurricane every 4 to 5 years. These hurricanes not only limit reef development but also cause great damage to island's seabed (Klomp & Kooistra, 2003). In the late 1990s, six hurricanes hit St. Maarten and had profound impacts on the island's reefs (hurricanes Luis and Marilyn in 1995, hurricane Bertha in 1996, hurricane Georges in 1998 and hurricanes Jose and Lenny in 1999). For example, the heavy seas generated by Hurricane Luis shifted sand which smothered coral colonies, and shallow strands of *Acropora palmata* suffered breakage (Smith et al., 1997). In September 2017, St. Maarten was hit by the strongest hurricanes in history in the Atlantic 'Irma' and caused severe major damage to the environment and infrastructure. In addition to storm damage, St. Maarten's reefs have also suffered from other natural impacts. An outbreak of white band disease between 1980 and 1982 killed 90% of the Caribbean's populations of *Acropora cervicornis* and *Acropora palmata*. This was followed by a mass mortality of *Diadema antillarum*, one of the most important grazers on Caribbean reefs (MacRae, 2007).

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Blackfin Snapper, Photo by: © Hans Leijnse