Session 20

Reef fish ecology, conservation, and fisheries: the scientific legacy of Glenn Almany

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Reef fish ecology, conservation, and fisheries: the scientific legacy of Glenn Almany

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This session was originally envisioned as a small memorial tribute by friends and colleagues of the late Glenn Almany, a highly successful reef fish expert lost to cancer at far too young an age (Hamilton 2015). Ultimately, the mammoth session spanned 3 full days and included over 80 oral and poster presentations. Therefore, we organizers cannot do justice to even a reasonable fraction of the contributions by reviewing specific presentations in this limited space. Instead, we offer our collective synthesis of the main findings conveyed both at the ICRS and in recent (and some classic) literature on reef fish ecology, conservation, and fisheries (for far more encyclopedic coverage, see Sale 1991, 2002; Polunin and Roberts 1996; Hixon 2011; Mora 2015). Given the many threats facing coral-reef ecosystems, we particularly focus on findings relevant to conservation and management, printing in bold font the generalizations we believe to be of greatest importance for managers and policy makers.

Fishes and Reefs

While it has long been known that reef fishes often require the shelter and food sources provided by living corals, recent research has shown that relatively healthy reefs also

provide critical settlement cues for reef fish larvae. For example, Dixson et al. (2014) demonstrated experimentally in Fiji that settlement-stage fish larvae of various species are preferentially drawn to chemical extracts of living coral compared to extracts of seaweeds. **While fish need healthy reefs, it is also true that reefs need healthy fish populations to survive, especially in the face of climate change**. It has been increasingly documented that herbivorous fishes are often essential for preventing macroalgae from displacing corals (recent reviews by DeMartini and Smith 2015; Hixon 2015a). This ecological service is fundamentally important for enhancing ecological resilience by allowing reefs to recover following mass coral bleaching events (Mumby et al. 2007; Graham 2015; McClanahan 2015). Reef fishes also benefit corals by providing nutrients from their feces and urine (Meyer et al. 1983).

Reef Fishes and Non-Reef Habitats

So-called "reef" fishes often depend on non-reef habitats during some phase of the life cycle, especially nursery areas. Thus, coral reefs and associated fishes are often embedded in a mosaic seascape that includes mangrove forests (Mumby et al. 2004), seagrass beds (Heck et al. 2003), and hardpan plains of algae or habitat-forming invertebrates (e.g., gorgonians, sponges). Ontogenetic habitat shifts occur as the most suitable habitat for new settlers vs. growing juveniles vs. larger adults shifts through time (e.g., Dahlgren and Eggleston 2000). Additionally, groupers, snappers, and other species that undergo long-distance migrations to annual spawning aggregations may pass through a variety of non-reef habitats (review by Claydon 2004). **Therefore, efforts to save coral reefs must proceed hand-in-hand with conservation of connected non-reef habitats**.

Larval Dispersal, Retention, Connectivity

The majority of reef fishes undergo a biphasic life cycle consisting of relatively sedentary adults that spawn pelagic larvae. Recent advances in biophysical modeling and empirical tracking of larval dispersal via otoliths and genetics have demonstrated that larvae can both return to their natal reefs (i.e., larval retention, e.g., Jones et al. 1999, 2005; Swearer et al. 1999; Paris and Cowen 2004; Almany et al. 2007; Planes et al. 2009) and disperse to reefs considerable distances away (i.e., larval connectivity, Christie et al. 2010; Harrison et al. 2012). **Documenting patterns of larval dispersal is of immense importance in terms of demarcating stock and metapopulation boundaries, as well as demonstrating whether networks of marine protected areas areeffective fisheries management tools** (reviews by Warner and Cowen 2002; Thorrold 2006; Cowen et al. 2007; Cowen and Sponaugle 2009; Jones et al. 2009; Christie et al. 2010; Harrison et al. 2012; Jones 2015).

Reef Fish Food Webs

Two recent findings regarding predatory reef fishes have major implications for fisheries management and conservation. First, piscivorous fishes have strong top-down effects on reef-fish communities, causing so-called trophic cascades of alternating relative abundances of successive trophic levels (recent reviews by Hixon 2015b, DeMartini and Smith 2015). Where top predators have been overfished, mesopredators become more abundant and/or efficient, thereby reducing the abundance of smaller fishes, including new recruits of larger species (e.g., Stallings 2008). Second, predatory fishes have been increasingly documented to provide a source of density-dependent mortality capable of regulating local population sizes of reef fishes (e.g., Webster 2003; Steele and Forrester 2005; Schmitt and Holbrook 2007; Hixon et al. 2012).

Therefore, overfishing of predatory fishes can have major negative consequences for prey fishes by destabilizing their population dynamics.

Reef Fisheries

Reef fishes account for about 10% of the global fisheries catch and are the major source of animal protein for many island nations (review by Polunin and Roberts 1996). **While the high catches possible on healthy coral reefs are sufficient to sustain local communities, overall fish productivity is insufficient to support intensive export fisheries** (Birkeland 2015). Many reef fishes have life histories that are not well-suited for withstanding intensive fishing: slow growth, late maturity, and long lifespan. Additionally, the vast majority of reef fisheries are either unmanaged or undermanaged, and most go unassessed (Friedlander 2015). Especially threatened by overfishing are larger species, such as groupers overexploited at their spawning aggregations, the largest species of parrotfish and wrasse, and sharks (often killed only for their fins). Especially damaging are destructive fishing methods, including dynamite, cyanide, and bleach fishing (DeMartini and Smith 2015) – all forms of Mathusian overfishing (Pauly 1990) – as well as the live reef-fish trade that strips reefs to supply high-end Asian restaurants (Sadovy de Mitcheson and Yin 2015).

Threats to Coral Reef Fishes

The loss of coral reefs is accelerating due to a variety of local human stressors (sedimentation, eutrophication, etc.) and inexorable global ocean warming and acidification. Ocean warming is causing massive coral bleaching that is increasingly killing corals, and ocean acidification is negatively affecting coral calcification rates at accelerating rates (recent reviews by Descombes et al. 2015; Gaylord et al. 2015, Kwiakowski et al. 2015). Reef fishes are negatively affected both indirectly by the loss of coral habitat, and directly by physiological stresses caused by ocean warming and acidification (review by Pratchett et al. 2015). **Combined with severe overfishing, the new reality is that local and global environmental threats are causing population declines of coral-reef fishes and actually increasing the risk of extinction** (Jones et al. 2004; Munday 2004; McClenachan 2015; Sale 2015). Additionally, the invasion of Atlantic coral reefs by predatory Indo-Pacific lionfish is causing severe declines in the abundance of smaller native reef fishes (reviews by Albins and Hixon 2013, Côté et al. 2013), even to the point of triggering extirpations (Albins 2015, Ingeman 2016).

Solutions for Sustainable Fisheries and Conservation of Reef Fishes

Before substantial European contact, many tropical island societies had developed effective means of sustaining reef fisheries (Johannes 1978, 1981). Paramount among these was a local community-based focus where stock monitoring and management feedbacks were rapid, socially enforced, and effective. Importantly, these customary management systems are not simply relics of the past. Cinner et al. (2016) examined 2500 coral reefs around the world and found that reefs which had higher biomass than expected, given socioeconomic and environmental conditions, tended to have customary tenure and taboo arrangements. **The promise for the future of reef fishes and fisheries is blending of such traditional ecological knowledge with novel holistic or ecosystem-based Western science** (Birkeland 2015; Cinner and Kittinger 2015; Friedlander 2015; Cinner et al. 2016). Important tools include marine protected areas to replenish and sustain fish populations combined with local control of fishing rights to ensure that fisheries are both productive and sustainable. However, these tools will be successful only if they are effectively managed and designed to take the ecology of focal species into account while complementing human uses and values (Green et al. 2014a,b). Importantly, with rapidly accelerating ocean warming and acidification, the future will be unlike the past, necessitating rapid adaptive management.

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