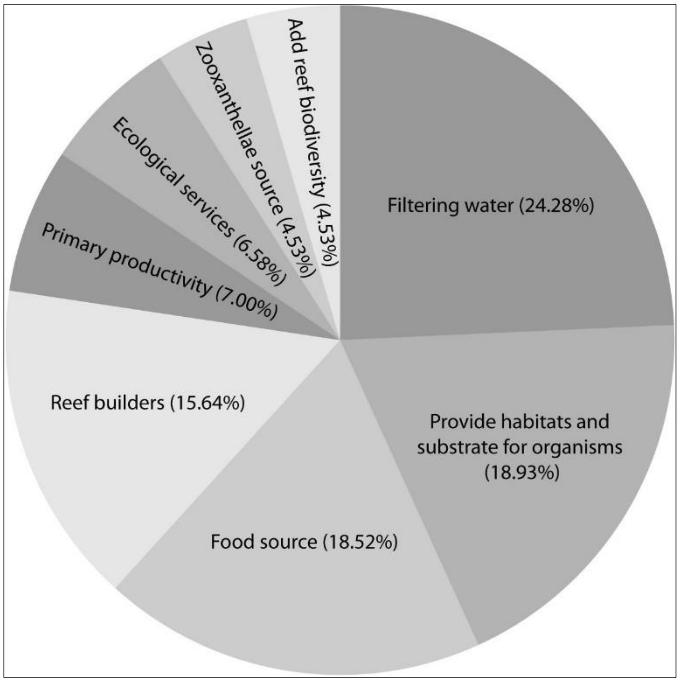

Fig. 2. Scientists' (n=102) perceptions on the ecological roles fulfilled by giant clams.

clams on coral reefs, suggest that coral reef scientists still have a strong appreciation and substantial knowledge of giant clam issues and importance. We find this encouraging, and slightly surprising, considering that relatively few researchers are currently actively studying these charismatic organisms.

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Impacts of concrete jetties on the composition of shore molluscan assemblages

By Leanne Bonnici, Joseph A. Borg, Julian Evans & Patrick J. Schembri

Rocky shores have undergone considerable modification worldwide through resource harvesting, disturbance and the introduction of artificial structures, among other impacts. Construction of artificial structures results in the destruction of natural habitats and the creation of novel colonisable surfaces. The ability of particular species to settle and survive on such surfaces will depend on the properties of the new substratum (Perkol-Finkel *et al*., 2006), the hydrodynamic regime (Lam *et al*., 2009) and the extent of colonisable area (Chapman, 2003), but construction of structures such as jetties often causes irreversible changes to these physical factors. For instance, jetties jutting out from the shoreline modify the hydrodynamic regime of the area in their vicinity. In particular, jetties have vertical or near-vertical sides, whilst the natural shores they replace are often gently sloping. Vertical faces tend to deflect waves, rather than enabling wave break and dissipating the wave energy, and hence molluscs on jetty walls are subjected to higher energy impacts than on sloping shores (Lam *et al*., 2009). Artificial structures may also retain or dissipate heat in a modified manner, such that they could be cooler than natural shorelines (Williams & Morritt, 1995). In addition, the composition of the substratum determines its surface chemistry, microtopography and durability, which in turn could affect settlement and recruitment of benthic organisms (Chapman, 2003; Spieler *et al*., 2001). Moreover, the surfaces of jetties and other artificial structures tend to be smoother than those on natural shores, which are naturally rugged (Chapman, 2006). Rugged surfaces present a multitude of microhabitats such as rock pools, crevices and overhangs, each with different microclimates, and molluscs that are constrained to such microhabitats may be unable to survive on smooth surfaces.

Since erection of jetties leads to irreversible alteration of the physical environment, we hypothesised that the shore molluscan assemblages would not recover to their original state following construction works. Thus, extensive habitat modification via construction of artificial structures and the associated destruction of natural habitat would lead to permanent changes in the structure and composition of molluscan assemblages inhabiting the shore and could potentially lead to the loss of particular species. Understanding the impacts of concrete jetties on molluscan assemblages can provide insight into the conservation measures that would be required to minimise such impacts and ensure sustainable

Fig. 1. Jetty structures at White Tower Bay; a highly modified shoreline.

development of the coast. We tested this hypothesis at two localities in the north-east of the Maltese Islands: Ghajn Zejtuna and White Tower Bay. These two localities were chosen because they have similar exposure and geomorphology, and have sections that have been modified through the construction of concrete jetties more than a decade ago (Fig. 1) and others where the natural rocky substratum is still unmodified. We chose to focus specifically on the molluscan assemblages of the mediolittoral zone because on the microtidal Maltese shores (maximum tidal range 20 cm), the vertical walls of jetties also result in a reduction in the extent of this zone (≤ 50 cm on jetties in contrast to 1-3 m on the natural shoreline).

Two concrete jetties and two natural rocky shores at the two study localities were sampled along three replicate transects on each. Only the jetties' seaward-facing vertical side was considered since this has the same orientation with respect to the sea as the natural shore in its vicinity. Each transect covered the extent of the mediolittoral zone and the molluscs collected were identified to the lowest possible taxon and counted. Twenty species of molluscs were recorded on natural shores only; nine species were found on both jetties and natural shores, while no species were found exclusively on jetties (Tables 1 and 2). This suggests that some mollusc species typically found on natural shores find it difficult to survive on jetties. A number of species encountered on the natural shores at both localities were either absent or had very low abundances on jetties. These were very small in size, usually juveniles (not exceeding 6 mm in shell length), and included species of the genera *Eatonina* and *Cerithium*, which on the natural shores are typical of moisture-retaining and sheltered microhabitats in the upper infralittoral or lower mediolittoral zones. Such microhabitats are mostly absent on jetties since these lack crevices. Interestingly, species of the genera *Patella* and *Gibbula* reached higher densities on jetties than on natural shores. This could be due to reduced interspecific competition, since the abundance of other grazers on the artificial substratum was low.

Overall our results show that mollusc assemblages are greatly impoverished on jetties relative to natural rocky shores, with only a few genera being represented and an even smaller fraction being able to reach similar or higher densities than on the natural shores. The argument sometimes made, that jetties merely replace the natural rock and would eventually be colonised by the same suite of species, is not supported by our results. Hence, new constructions should attempt to mimic as closely as possible the topography of natural shores to include a viable wider range of microhabitats.

Table 1. Average abundance of species found on both shore types (* 1-25 ind/m^2, ** 26-50 ind/m^2, *** >50 ind./m^2).

Species	Natural shore	Concrete jetties
Brachidontes pharaonis	**	*
Eatonina cossurae	***	*
Eatonina fulgida	***	**
Gibbula spp.	*	***
Mytilaster minimus	*	*
Patella caerulea	*	***
Patella ulyssiponensis	*	**
Patella rustica	*	**

Table 2. Species recorded only on natural shores.

Opistobranchia sp.	*Lepidochitona corrugata*
Acanthochitona sp.	*Mitra cornicula*
Alvania lanciae	*Ocinebrina edwardsii*
Omalogyra atomus	*Phorcus turbinatus*
Cardita calyculata	*Paludinella* sp.
Cerithium spp.	*Pisania striata*
Columbella rustica	*Pisinna glabrata*
Conus ventricosus	*Setia* spp.
Irus irus	*Odostomia* sp.
Jujubinus gravinae	*Rissoa* spp.

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