

Abstracts & publications

Restocking and stock enhancement of coastal fisheries: potential, problems and progress

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Source: Fisheries Research 80(1):1–8. August 2006.

The demand for fish is expected to rise substantially by 2020. Although aquaculture must provide much of the additional fish, it remains to be seen whether restoration or enhanced production of various capture fisheries can also help fill the projected gap in supply. The key challenges for these capture fisheries involve reducing fishing effort, removing excess fishing capacity and building the institutional arrangements needed to restore spawning biomass to more productive levels, and to reverse degradation of the supporting habitats. Two interventions, based largely on hatchery technology, have the potential to reduce the time needed to rebuild some severely over-exploited fisheries, or improve the productivity of other “healthy” fisheries. These interventions are “restocking”, which involves releasing cultured juveniles to restore spawning biomass to levels where the fishery can once again support regular harvests, and “stock enhancement”, which involves release of cultured juveniles to overcome recruitment limitation. However, despite the potential of these interventions, few restocking and stock enhancement programmes have met expectations. The main problems have been a pre-occupation with bio-technical research at the expense of objective analysis of the need for the intervention, and integration of the technology within an appropriate management scheme that has the participation and understanding of the users. The papers presented at the Special Symposium on this subject at the 7th Asian Fisheries Forum provide a series of valuable lessons to guide objective assessment of the potential for restocking and stock enhancement, and how to implement these interventions responsibly and effectively where they are deemed to add value to other forms of management. Above all, these studies help demonstrate that restocking and stock enhancement programmes are applied in complex human-environment systems, involving dynamic interactions between the resource, the technical intervention and the people who use it.

Achievements and lessons learned in restocking giant clams in the Philippines

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Source: Fisheries Research 80(1):46–52. August 2006.

For almost 20 years, the Marine Science Institute (MSI), University of the Philippines, has been culturing giant clams to restore depleted populations of these large bivalves in the Philippines, and to promote giant clam farming as a sustainable livelihood. Restocking activities were done in collaboration with local groups by providing training in the culture and ocean rearing of giant clams, and by implementing a “user pays” approach. Initially, a variety of giant clam species were used but once F1 broodstock of *Tridacna gigas* were reared, restocking focused on this species due to its scarcity and fast rate of growth. About 20 000 *T. gigas* were placed on coral reefs with assistance from the Pew Foundation and the Philippine Tourism Authority. In addition, >50 000 clams (*T. gigas*, *T. squamosa*, *T. derasa*, *T. crocea*, *T. maxima* and *Hippopus hippopus*) were distributed through other means. Altogether, >40 sites throughout the Philippines received cultured giant clams. Grow-out trials to test the viability of supplying giant clams for the aquarium trade to create new sources of income were conducted successfully with a group of fishers in Bolinao, Pangasinan. However, this initiative encountered legal obstacles when the government regulatory agency prohibited the export of cultured clams, regarding this as a threat to the conservation of wild individuals. The long experience in culturing and restocking giant clams in the Philippines provides many lessons for other countries wishing to restore stocks of these large bivalves. Particular care needs to be given to selection of release sites, negotiations with participating groups to safeguard the released clams, adequate transfer of technology to collaborators, and transport of large clams from nursery areas to release sites.

Stock enhancement of the Japanese scallop *Patinopecten yessoensis* in Hokkaido*N. Uki***Source:** Fisheries Research 80(1):62–66. August 2006.

Prior to the early 1940s, harvests of scallops from Japan fluctuated from ~10,000–80,000 tonnes per annum. However, the fishery collapsed in 1945 and production remained at chronically low levels (<100 tonnes p.a.) in key areas. A breakthrough in methods for catching juvenile scallops (spat) for grow-out in hanging culture paved the way for the restoration, and eventual stock enhancement, of the major scallop fisheries in Hokkaido Prefecture. Following this breakthrough, scallop fisheries were managed using a system based mainly on: (1) mass-release of cultured juveniles, (2) removal of predators, and (3) rotational fishing, i.e. partitioning fishing grounds into four areas, releasing one-year-old juveniles into one area each year, then harvesting them three years later. This management system was pioneered largely by the fisheries cooperative at Sarufutsu, Hokkaido, and catches there improved from <100 tonnes to consistent harvests of 40,000 tonnes p.a. Similar management systems have been adopted by neighbouring fisheries cooperatives, resulting in current total harvests of scallops from stock enhancement in Hokkaido of ~300,000 tonnes p.a. The success of scallop stock enhancement in Hokkaido is attributed to a good supply of larvae, development of simple and effective methods for catching and rearing spat, ideal habitat for growth of scallops, removal of predators, and devolution of management to fisheries cooperatives. The management system developed in Hokkaido should be transferable to other locations where there is a good natural supply of spat, low levels of predation, currents that retain larvae, and incentives for fishermen to invest in the capture, rearing and release of spat and the implementation of rotational fishing.

Abundance and distribution of queen conch (*Strombus gigas*, Linné 1758) veligers of Alacranes Reef, Yucatan, Mexico*D. Aldana Aranda, M. Perez Perez***Source:** Journal of Shellfish Research 26(1):59–63. April 2007.

Distribution and abundance of *Strombus gigas* (Linné 1758) larvae were studied in Alacranes reef to identify if this marine protected area could be a basin site for recruitment of this species. Duplicate samples were collected every month from November 1999 to October 2000. Plankton tows were made with a conical net of 302- μ m mesh-size. During the sample period, 1,864 veligers were collected. Larvae were more abundant during June through August, with 1,288 larvae (69.10%), September through February with 367 larvae (19.69%), and 209 larvae were counted in March through May (11.21%). Larval density varied from 0.31 veligers 10 m⁻³ in March to 5.24 veligers 10 m⁻³ in June; 86.42% of larvae were less than 350 μ m, and 2.35% were between 450 and 950 μ m. A high abundance of small sizes suggests that Alacranes reef is a very important basin site for the recruitment of *Strombus gigas* larvae. Moreover surface marine current in Alacranes reef is northeast and crossing the lagoon reef, thus Alacranes could supply *S. gigas* larvae to Florida.

Isolation and characterization of eight polymorphic microsatellite markers from pink conch (*Strombus gigas*)*R. Zamora-Bustillos, R. Rodríguez-Canul, F.J. García De León***Source:** Molecular Ecology Notes 7(4):597–599. July 2007.

Many marine organisms have pelagic larvae, and these are often important agents of dispersal. The larval phase and the multiple paternity that occur in marine gastropods such as *Strombus gigas* are crucial for the success of this species throughout the Caribbean Sea. To analyse these factors, we developed eight microsatellite loci specific to *S. gigas*. On the same set of individuals, the microsatellite loci exhibited a greater level of polymorphism than previously studied allozyme markers and thus, will permit fine-scale analysis and larval pool studies.

Interactions between translocated and native queen conch *Strombus gigas*: evaluating a restoration strategy*G.A. Delgado, R.A. Glazer***Source:** Endangered Species Research 3:259–266. December 2007.

The proactive strategy for restoring Florida's depleted queen conch *Strombus gigas* population includes increasing the spawning stock by translocating reproductively deficient individuals into existing spawning aggregations where our previous research has shown that the translocated conch will develop normally. However, there may be unintended and potentially negative ecological ramifications if the translocated

conch displaces the native conch. To examine this issue, we translocated non-reproductive adult conch into two offshore spawning aggregations and used acoustic telemetry to track them relative to similarly tagged native conch. At one aggregation, the home range sizes of native conch were significantly smaller than those of the translocated conch, which led to a significant reduction in the static interaction (i.e. home-range overlap) between the two groups of conch. However, the dynamic interaction (i.e. sociality coefficient) among the translocated conch was significantly higher. We hypothesize that these results were driven by reproduction: the translocations took place in July during the breeding season, and because the translocated conch were not yet in reproductive condition they moved into forage habitats, while the natives occupied the breeding habitats. At the other aggregation, there were no significant differences in the movements or interactions between native and translocated conch, a result probably due to the mosaic of habitats at this site, where breeding and forage areas are in close proximity. Our results indicate that displacement of natives did not occur at either site, and that translocating conch into spawning aggregations does not have adverse consequences relative to the interactions among conspecifics.

Integrating customary management into marine conservation

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Source: Biological Conservation 140(3–4): 201–216, December 2007.

In many parts of the world, there is increasing interest among scientists, managers and communities in merging long-enduring customary practices such as taboos that limit resource use with contemporary resource management initiatives. Here, we synthesize the literature on the customary management of coral reefs emerging from diverse disciplines including anthropology, common property economics, and ecology. First, we review various customary management strategies and draw parallels with Western fisheries management. Secondly, we examine customary resource management and conservation. We argue that, while resource conservation often appears to be an unintended by-product of other social processes, customary management can, in fact, conserve marine resources. In the third section, we examine the resilience of customary management institutions to socioeconomic transformations. We suggest that in conditions of high population and commercialization of marine resources, property rights may become strengthened but arrangements that rely on self-restraint become weakened. Finally, we examine the commensurability of customary management and conservation. We emphasize that practical and conceptual differences exist between customary management and contemporary conservation, which have often led to failed attempts to hybridize these systems. However, when these differences are understood and acknowledged there exists a potential to develop adaptive management systems that are: (1) highly flexible; (2) able to conserve resources; and (3) able to meet community goals. In each section, we provide research priorities. We conclude by developing six key features of successful hybrid management systems.

Growth and differentiation during delayed metamorphosis of feeding gastropod larvae: signatures of ancestry and innovation

M.P. Lesoway, L.R. Page

Source: Marine Biology 153(4):723–734. February 2008.

Extent of larval growth among marine invertebrates has potentially profound implications for performance by benthic recruits because body size influences many biological processes. Among gastropods, feeding larvae often attain larger size at metamorphic competence than non-feeding larvae of basal gastropod clades. Delay of metamorphosis can further influence size at recruitment if larvae continue to grow during the delay. Some caenogastropod larvae grow during delayed metamorphosis, but opisthobranch larvae do not. Data on larval growth of neritimorph gastropods are needed to help determine which of these growth patterns for planktotrophic gastropod larvae is more derived. We cultured planktotrophic larvae from all three major gastropod clades with feeding larvae through delays of metamorphosis of 3–10 weeks. Larvae of the caenogastropod *Euspira lewisii* and the euthyneurans *Haminoea vesicula* (Opisthobranchia) and *Siphonaria denticulata* (Pulmonata) conformed to previously described growth patterns for their respective major clades. Furthermore, the caenogastropod continued to lengthen the prototroch (ciliary band for swimming and feeding) and to differentiate prospective post-metamorphic structures (gill filaments and radular teeth) during delayed metamorphosis. Larvae of the neritimorph *Nerita atramentosa* arrested shell growth during delayed metamorphosis but the radula continued to elongate, a pattern most similar to that of non-feeding larvae of *Haliotis*, a vetigastropod genus. Character mapping on a phylogenetic hypothesis suggests that large larval size and capacity for continued growth during delayed metamorphosis, as exhibited by some caenogastropods, is a derived innovation among feeding gastropod larvae. This novelty may have facilitated post-metamorphic evolution of predatory feeding using a long proboscis.

The presence of GABA in gastropod mucus and its role in inducing larval settlement

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Source: Journal of Experimental Marine Biology and Ecology 354(2):182–191. January 2008.

Chemical substances that induce larval settlement have been the focus of many gastropod studies due to the importance of wild stock recruitment and production within aquaculture facilities. Gamma-aminobutyric acid (GABA), GABA analogs, and GABA-mimetics associated with certain crustose coralline algae (CCA), are known to induce larval settlement in commercial abalone (*Haliotis*) species, and other gastropods. Furthermore, mucus secreted from these gastropods has been shown to induce larval settlement, but the stimulatory components of mucus have not been thoroughly investigated. We now present data confirming that GABA is the settlement-inducing effector molecule contained within abalone mucus. To do this, we initially generated anti-GABA for use in immunoenzyme and immunofluorescent microscopy. Using these techniques GABA was identified in the nerves and epithelial cells of the foot, including mucus. Dried mucus samples subject to HPLC analysis revealed a mean concentration of 0.68 mM GABA after sample rehydration. The presence of GABA in these samples was confirmed by time-of-flight mass spectroscopy (TOF-MS). In addition, GABA was detected in the mucus of several abalone species and other gastropods by immunocytochemistry. Subsequent bioassays using both dry and fresh mucus strongly promoted induction of larval settlement.

Distribution of large benthic gastropods in the Uruguayan continental shelf and Río de la Plata estuary

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Source: Journal of Coastal Research 24(1):161–168. January 2008.

We analyzed the distribution and ecology of large gastropods inhabiting the continental shelf of Uruguay and the Río de la Plata estuary, in depths ranging from 4 to 62 m. Seven species belonging to Tonnidae, Ranelidae, Muricidae, Nassariidae, and Volutidae were collected. While the seven species recorded in this study have been previously reported for the Uruguayan coast, here we provide the first detailed description of its habitat preferences in terms of depth, salinity, and sea bottom temperatures. Clustering analysis of stations based on biological data (presence/absence of species) indicated a spatial segregation of the large gastropods assemblages in three areas: estuarine, low specific richness, dominated by *Rapana venosa*; inshore (10 to 36 m), high richness, co-dominated by *Zidona dufresnei* and *Pachycymbiola brasiliana*; and offshore (21 to 62 m), intermediate richness, characterized by *Z. dufresnei*. Mean values for environmental parameters showed significant differences among clusters of stations. Direct developers were more ubiquitous than planktotrophic developers. On the other hand, the exotic planktotrophic species *R. venosa* dominated the estuarine area. This pattern is not coincident with predictions based on life history traits, such as dispersal capabilities; this suggests that generalizations in this respect are complicated and scale and species dependent.

Further twists in gastropod shell evolution

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Source: Biology Letters 4(2):179–182. April 2008.

The manner in which a gastropod shell coils has long intrigued lay people and scientists alike. In evolutionary biology, gastropod shells are among the best studied palaeontological and neontological objects. A gastropod shell generally exhibits logarithmic spiral growth, right-handedness and coils tightly around a single axis. Atypical shell-coiling patterns (e.g. sinistroid growth, uncoiled whorls and multiple coiling axes), however, continue to be uncovered in nature. Here, we report another coiling strategy that is not only puzzling from an evolutionary perspective, but also hitherto unknown among shelled gastropods. The terrestrial gastropod *Opisthostoma vermiculum* sp. nov. generates a shell with (i) four discernible coiling axes, (ii) body whorls that thrice detach and twice reattach to preceding whorls without any reference support, and (iii) detached whorls that coil around three secondary axes in addition to their primary teleoconch axis. As the coiling strategies of individuals were found to be generally consistent throughout, this species appears to possess an unorthodox but rigorously defined set of developmental instructions. Although the evolutionary origins of *O. vermiculum* and its shell's functional significance can be elucidated only when fossil intermediates and live individuals are found, its bewildering morphology suggests that we still lack an understanding of relationships between form and function in certain taxonomic groups.

Copulation behaviour of *Neptunea arthritica*: baseline considerations on broodstocks as the first step for seed production technology development

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Source: Aquaculture Research 39(3): 283–290. February 2008.

Copulation trials under three different scenarios were performed aiming to study the copulation behaviour of *Neptunea arthritica* and determine whether broodstock maintenance is required for artificial seed production. *Neptunea arthritica* showed polygamy, copulating at least three times with different partners. From all males and females used in this study, 43% of them copulated at least once. Female whelks showed rejection behaviour, which generated significant difference in copulation time between rejected (13.7 ± 10.7 min) and non-rejected (49.7 ± 44.7 min) males. The effect of body size on copula duration appeared to be superficial, while its effect on accumulative copulas played an important role as an indicator of copulation capacity because whelks varied in size. After first copula, males showed a contrasting tendency to mate copulated females over non-copulated females ($X^2 = 6.23$, d.f. = 1, $P = 0.01$). Broodstock maintenance as the first step in seed production is possible but considering low mating percentage and female rejection, it would be not economically reasonable due to the considerable number of whelks required and related logistical factors.

Do mussel patches provide a refuge for algae from grazing gastropods?

N.E. O'Connor, T.P. Crowe

Source: Journal of Molluscan Studies 74(1):75–78. February 2008.

On rocky shores, cover of macroalgae is often greater growing epibiotically on mussels compared to algae growing directly attached to rock. A survey of two shores on the east coast of Ireland confirmed that mussel beds contained greater percentage algal cover and more diverse algal assemblages compared to those on rock. The reasons for this difference are not clear. It has been suggested that mussel beds provide a refuge for algae from grazing gastropods. Surprisingly, we found no evidence to support this. Using wax discs, gastropod grazing patterns were found to be similar within the mussel beds as on rock. The mussel beds do not appear to provide a refuge for algae from grazing activity at this scale and we suggest other possible mechanisms for the prevalence of epibiotic algal cover on mussels. Intertidal grazers may in fact affect the epibiotic algae on mussels and thereby affect indirectly the persistence of mussel beds.

Molecular systematics of Vetigastropoda: Trochidae, Turbinidae and Trochoidea redefined

S.T. Williams, S. Karube, T. Ozawa

Source: Zoologica Scripta, OnlineEarly Articles, June 2008 (to be adjusted).

Trochoidea are a large superfamily of morphologically and ecologically diverse marine gastropods. We present here an appraisal of the composition and relationships among *trochoidean* families based on molecular data, with an especial focus on the family Trochidae. Bayesian analyses of sequences from three genes (18S rRNA, 28S rRNA and COI), including data from 162 vetigastropod species, show that the gastropod family Trochidae (*sensu* Hickman & McLean (1990), *Natural History Museum Los Angeles County Science Series*, 35, 1–169) is not monophyletic. Recognition of Chilodontidae, Solariellidae and Calliostomatidae at the family level is supported. Our new, more limited, definition of Trochidae includes the subfamilies Stomatellinae, Lirulariinae and Umboniinae and redefined Trochinae, Cantharidinae and Monodontinae. Halistylinae are provisionally retained in the Trochidae based on previous morphological studies. As redefined, Trochidae are a predominantly shallow-water radiation in the tropics and subtropics. Some subfamilies and genera previously included in Trochidae have been moved to an enlarged family Turbinidae. The family Turbinidae has been redefined to include Turbininae, Skeneinae, Margaritinae, Tegulinae, Prisogasterinae and most surprisingly the commercially important genus *Tectus* Montfort, 1810. The new definition of Turbinidae means that the family includes both predominantly shallow and deep-water clades as well as genera that are distributed across the globe from the poles to the tropics. A greater range of habitat is now seen in Turbinidae than in Trochidae. The redefined Trochidae and Turbinidae, together with Solariellidae, Calliostomatidae and Liotiidae, make up the superfamily Trochoidea. Phasianellidae and Colloniidae are recognized as belonging in a new superfamily, Phasianelloidea, and *Angaria* Röding, 1798 is recognized as belonging to a new superfamily, Angarioidea. Placement of Areneidae into a superfamily awaits further work.

Evolution of ecological specialization and venom of a predatory marine gastropod*E.A. Remigio, T.F. Duda Jr.***Source:** Molecular Ecology 17(4):1156–1162. February 2008.

Understanding the evolution of ecological specialization is important for making inferences about the origins of biodiversity. Members of the predatory, marine gastropod genus *Conus* exhibit a variety of diets and the ability to capture prey is linked to a venom comprised of peptide neurotoxins, termed conotoxins. We identified conotoxin transcripts from *Conus leopardus*, a species of *Conus* that uniquely preys exclusively on hemichordates, and compared its venom duct transcriptome to that of four other *Conus* species to determine whether a shift to a specialized diet is associated with changes in the venom composition of this species. We also examined the secondary structure of predicted amino acid sequences of conotoxin transcripts of *C. leopardus* to identify substitutions that may be linked to specialization on hemichordates. We identified seven distinct conotoxin sequences from *C. leopardus* that appear to represent transcripts of seven distinct loci. Expression levels and the diversity of conotoxins expressed by *C. leopardus* are considerably less than those of other *Conus*. Moreover, gene products of two transcripts exhibited unique secondary structures that have not been previously observed from other *Conus*. These results suggest that transition to a specialist diet is associated with reduction in the number of components expressed in venoms of *Conus* and that diverse venoms of *Conus* are maintained in species with a broad dietary range.

Prolonged exposure to low dissolved oxygen affects early development and swimming behaviour in the gastropod *Nassarius festivus* (Nassariidae)*H.Y. Chan, W.Z. Xu, P.K.S. Shin, S.G. Cheung***Source:** Marine Biology 153(4):735–743. February 2008.

Effects of low dissolved oxygen on early development and swimming behaviour of veliger larvae of the scavenging gastropod *Nassarius festivus* were studied. Embryonic development was significantly delayed when dissolved oxygen level was reduced to 3.0 mg O₂ L⁻¹ and no embryo hatched successfully at 0.5 mg O₂ L⁻¹. Veliger larvae hatched at 4.5 mg O₂ L⁻¹ had significantly smaller velar lobe, shell length and shell width. Median 48-h LC₅₀ value of the veliger larvae was estimated at 1.25 mg O₂ L⁻¹ with lower swimming speed (swimming velocity and dispersal velocity) being recorded for the survivors exposed to reduced oxygen levels. The percentage of veliger larvae that developed into crawling juveniles was significantly reduced and metamorphosis was delayed at 4.5 mg O₂ L⁻¹ whereas all larvae at 3.5 mg O₂ L⁻¹ died before they underwent metamorphosis. Juveniles developed at 4.5 mg O₂ L⁻¹ were also smaller than those at 6.0 mg O₂ L⁻¹. Results indicated that dissolved oxygen levels well above hypoxia levels (2.8 mg O₂ L⁻¹) have significant impact on the hatching success and larval development in gastropods, which may lead to long-term decreases in population growth.

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