

Abstracts & publications

Annual cycle of reproduction in *Turbo brunneus*, from Tuticorin south east coast of India

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This research work mainly focus on the reproductive and spawning season of *Turbo brunneus* a mollusk in the south east coast of India. Random samples from *Turbo brunneus* were collected from littoral tidal pools in Tuticorin coast, during May 2002 to April 2003. The number of male and females in the monthly samples was counted to determine the male: female ratio in the population and chi-square test was applied to test whether the population adheres to 1:1 ratio. The overall male and female ratio is found to be 1: 0.96 indicating only a slight variation in the evenness of male and female in the population. Both sexes of *T. brunneus* attain sexual maturity between 23 and 27mm. The mean gonadal index (G.I) was high (21.82%) in males during May, 2002 and then it decreased gradually and reached 15.52% during October 2002, which showed the low mean GI value in males for the whole study period. While for females it was high during May 2002 (23.09%) and low during September 2002(14.83%). The GI values for both the sexes were generally low until December 2002. The limited percentage of matured oocytes which exists even after spawning indicates the high possibility for partial spawning in *T. brunneus*. It was concluded that the reproductive behavior of *T. brunneus* is highly influenced by the seasonal factors.

Predation on juveniles of *Crepidula fornicata* by two crustaceans and two gastropods

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Crepidula fornicata, the slippershell snail, while native to New England, has now become a successful invasive species along coastlines in many other parts of the world. This study considers the possible control of native populations by several common predators: the invasive shore crab *Hemigrapsus sanguineus*, one species of pagurid hermit crab (*Pagurus longicarpus*), and juveniles of the drilling gastropods *Nucella lapillus* and *Urosalpinx cinerea*. In the laboratory, juveniles of *C. fornicata* were especially vulnerable to the two crustacean predators tested, and to a lesser extent vulnerable as well to predation by the oyster drill *U. cinerea*; in choice tests, young oyster drills ate barnacles and mussels rather than slippershell snails, but ate *C. fornicata* when offered no other choice. Juveniles of two other *Crepidula* species (*C. plana* and *C. convexa*) were less susceptible to predation by hermit crabs, probably due to differences in juvenile shell morphology and growth trajectories. Remarkably, juvenile dogwhelks (*N. lapillus*) ate no *Crepidula* prey over several months in the laboratory, even in the absence of alternative food and although they readily consumed blue mussels. Additional work is needed to determine the role of crustacean and other predators in regulating the growth of native populations of *C. fornicata* in the field and to determine the extent to which the explosive growth of at least some invasive *Crepidula* populations reflects escape of juveniles from native predators.

Coral reef associated gastropods in Tuticorin coast of Gulf of Mannar Biosphere Reserve, India

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Coral reef associated gastropods diversity study was undertaken in Tuticorin group of islands (Hare, Vaan and Koswari). Underwater survey was made in three quadrants (10 sq.m) in each site. A sum of 40 species of gastropods were recorded from the study area. Most of the species are commonly found in three islands. Twelve were rare viz., *Ficus ficus*, *Colubraria muricata*, *Casmaria erinaceus*, *Natica didyma*, *Nerita polita*, *Rapana bulbosa*, *Purpura rudolphi*, *Strombus* sp., *Architectonica perspectiva*, *Cypraea tigris*, *Cymatium lotorium* and *Haustellum haustellum* were reported from the study area. Species diversity and richness were found to be higher in the Vaan island.

Temporal patterns of arrival of beachcast green-lipped mussel (*Perna canaliculus*) spat harvested for aquaculture in New Zealand and its relationship with hydrodynamic and meteorological conditions

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Aquaculture (2010) Volume 302(3–4):208–218

The substantial Greenshell mussel aquaculture industry in New Zealand is heavily reliant on one major source of wild spat at Ninety Mile Beach, at the northern end of the country. The spat of *Perna canaliculus* arrives intermittently at the beach attached to seaweed and other debris whereupon it is harvested for seeding mussel farms around the country. Periods of low or non-existent spat arrival at the beach have caused major disruption to the aquaculture production of this species. In an attempt to better understand the daily, monthly, and inter-annual patterns in the arrival of spat at Ninety Mile Beach, the harvesting records of spat harvesters for 1990 to 1999 were analyzed in relation to historical records of wind speed and direction, tidal range, water temperature, and modeled swell height and direction. For the long-term data set, spatfall events and the amount of spatfall increased markedly with strong offshore winds. On days with high tidal range, there tended to be an increase in the amount of spatfall, but this trend was not significant statistically. Daily and seasonal water temperature records did not show a significant effect on the timing or the scale of spatfall events. However, low swell height in the onshore direction was associated with a significant increase in spatfall events and amounts. Within the 9 year data set, storm events (wind speeds $> 20 \text{ m s}^{-1}$) were most frequent during May to October. An average lag time of 4 months was found between peak storm events and the subsequent peak in spatfall events and amounts of spatfall occurring in September to October. Years with a greater number of storm events were also associated with significantly higher number of spatfall events and amounts of spatfall. Storminess and water temperature are associated with El Niño/La Niña episodes, which greatly influence the wind climate of New Zealand. During El Niño periods mussel farm managers could greatly reduce their risk of a shortfall in natural spat supply interrupting mussel production by securing sufficient spat to stock their farms from the large but less frequent spatfall events. Overall, the results provide valuable insight into possible ecological and oceanographic processes involved in spat arrival and will help with better utilization of the spat resource for this major mussel aquaculture industry.

Batch-tagging blacklip abalone (*Haliotis rubra*) for identification of hatchery-reared individuals on natural coastal reefs in New South Wales, Australia

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The identification of hatchery-reared larvae and juveniles is fundamental to assessing the success of their release when restocking. Hatchery-reared *Haliotis rubra* larvae and juveniles were successfully batch-tagged with distinct and persistent marks, enabling unambiguous differentiation from wild conspecifics when recaptured. Larvae were batch-tagged with the epifluorescent dye calcein. Experiments demonstrated that the batch-tagged larval shell was clearly visible in the spire of juvenile shells after 260 days. The recapture of batch-tagged and released larvae from natural reefs after 533 days at liberty also confirmed the persistence of this tag. A reliable and cost-effective method for batch-tagging juveniles was achieved with the use of an artificial diet that resulted in a distinctive blue-green coloration of the shell. This coloration differentiated released juveniles from wild conspecifics, was easily observed with the naked eye, and persisted on the spire of individuals for 777 days at liberty. These batch-tagging protocols allow large numbers of *H. rubra* larvae and juveniles to be distinctly tagged for long periods of time, enabling reliable estimation of survival after release and individual growth. It is likely that these techniques could also be applied to other abalone species.

Bivalves and gastropods of the Gulf of Tehuantepec, Mexico: A checklist of species with notes on their habitat and local distribution

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Journal of Marine Biology (2009) Volume 2009:1–12

The taxonomic composition of 160 species of bivalves and gastropods recorded in the Gulf of Tehuantepec is presented with information on their habitat and distribution along 10 different localities of the shoreline and 42 stations of the continental shelf. The species were on sandy and rocky beaches, coastal lagoons, estuaries, mangroves, rocky breakwaters of ports, and shallow subtidal areas (14–47 m depth). A total of 78 bivalve species and 82 gastropod species were recorded. Most of these were associated with sandy and rocky beaches and breakwaters of ports. The estuaries host 30 species and the coastal lagoons only two. In the shallow subtidal there were 18 gastropod species and 40 bivalve species representing 36.3% of all. This study adds 24 bivalve species and 29 gastropod species not recorded in previous studies for a total count of 213 species (102 bivalves and 111 gastropods) for Gulf of Tehuantepec.

Spatial patterns of wild oysters in the Hawkesbury River, NSW, Australia

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The native Sydney rock oyster, *Saccostrea glomerata*, is under increasing threat from QX disease, competition with nonnative *Crassostrea gigas* and coastal development. Knowledge of the distribution and population structure of *S. glomerata* and *C. gigas* is essential if oysters and their ecosystem services are to be successfully managed. We determined spatial patterns of abundance, condition, and size-structure of *S. glomerata* and *C. gigas*, across two key habitats, mangroves, and rocky shores of the Hawkesbury River, a highly modified estuary 50 km north of Sydney. Sampling of five sites per habitat, spanning a 15 km stretch of river, revealed abundant populations of *S. glomerata*, averaging $514 \pm 185 \text{ m}^{-2}$, in mangroves and on rocky shores. The native oyster accounted for 99% of all oysters sampled, with *C. gigas* found only at two of the five sites sampled within each habitat. Overall, rocky shores supported over eight times the oyster cover as mangroves. Among rock sites, live oyster cover and condition generally decreased with distance upstream. Although, at present, the Hawkesbury River estuary supports abundant wild oyster populations, ongoing monitoring of oyster populations is required to ensure that appropriate management strategies are established to ensure the persistence of this important component of the ecosystem. Our sampling of two key oyster habitats provides an important baseline against which future studies can assess change.

Growth of cultured pearl oyster (*Pinctada martensii*) in Li'an Lagoon, Hainan Island, China

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Growth of pearl oysters, *Pinctada martensii* was studied from June 2003 to March 2005 in Li'an Lagoon of Hainan Island in China. Shell height (SH) and total weight (TW) were measured monthly and temperature was recorded daily. The growth of oysters is characterized by fast initial growth of SH in the first year, followed by rapid increase of TW in the second year. Growth of SH was influenced by temperature, showing reduced growth rate in summer, fitting the extended Von Bertalanffy model:

$$y = 92.99(1 - e^{(-0.002070(t-13.63)+0.04164 \sin(2\pi/365.25)(t-193.03))}) \quad (y: \text{SH in mm, } t: \text{time in day}).$$

Growth rate of total weight increased steadily, except during typhoons or spawning, fitting the logistic model:

$$y = 53.63 / (1 + e^{-0.009770(t-463.33)+0.1938 \sin(2\pi/365.25)(t-564.73)}) \quad (y: \text{TW in g, } t: \text{time in day}).$$

It is also established that in Hainan, most oysters were mature and suitable for pearl nucleus insertion after 16–20 mo of farming; hence to meet the implantation season in April to June, it is more advisable to conduct hatchery operation in autumn than in spring.

Annual reproductive effort of Pacific winged pearl oyster *Pteria sterna* and its relation with the timing for planning pearl seeding operation

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Journal of Shellfish Research (2009), Volume 28(3):471–476

Using a combination of stereological and calorimetric methods, we studied reproductive effort of Pacific winged pearl oyster *Pteria sterna* during an annual cycle in Bahía de La Paz, B.C.S., Mexico. The relationship between changes in the volumetric fraction of germinal and somatic tissues (gonad, digestive gland, adductor muscle, and mantle tissue) and changes in their energy content was analyzed. These data were also correlated with changes in water temperature and availability of food (seston). Because *P. sterna* spawns several

times a year, reproductive effort was estimated ~ 400% in terms of energy increase from early development in October 2006 to the spawning occurring in January to February 2007. During this period, when water temperature was decreasing and seston concentration was increasing, *P. sterna* followed a conservative strategy for allocating energy from reserves previously stored in somatic tissues. In contrast, when productivity dropped in spring, the species followed an opportunistic strategy for sustaining gametogenesis from food energy. In decreasing order, total energy channeled for reproduction came from the digestive gland (23 KJ g⁻¹), adductor muscle (19 KJ g⁻¹), and mantle tissue (16 KJ g⁻¹). Based on these results, we recommend that commercial pearl culture practices be conducted from mid-autumn (October) through early spring (April), when *P. sterna* is energetically more resistant to manipulation. An additional recommendation is to avoid grafting during the summer (June through September), when the species is energetically exhausted and highly vulnerable to manipulation.

Studies on glycosaminoglycans isolated from bivalves molluscs *Tridacna maxima* and *Perna viridis*

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Our Nature (2009) Volume 7:10–17

The glycosaminoglycans (GAGs) in two marine invertebrate molluscs such as *Tridacna maxima* and *Perna viridis* were analyzed. Both the species was found to contain variable amounts of GAGs in the form of heparin biomolecules as identified by metachromatic activity and agarose gel electrophoresis analysis. Anticoagulant property of the biomolecules was assessed by anti factor Xa activity. Their molecular weight was estimated as 15000 and 9000 Daltons through GPC-HPLC. The ¹H NMR analysis of heparin was used to predict binding sites of the heparin. Structural characterization studies clearly demonstrated that heparin is the major GAGs constituents in the test animals.

Exotic *Perkinsus* sp. protozoa in an imported Vietnamese ornamental clam (*Tridacna crocea*) maintained in a home aquarium

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Journal of Zoo and Wildlife Medicine (2009) Volume 40(1):140–146

An adult, hermaphroditic *Tridacna crocea* ornamental clam imported from Vietnam into the USA became terminally moribund with sloughed byssal tissue and incomplete extension of the poorly responsive mantle and was necropsied. Necropsy findings included emaciation, visceral mass edema, and rare multifocal, 1-mm diameter, off-white to light tan gill nodules. Histopathology revealed marked inflammation and necrosis within the visceral mass and gills, with interstitial edema and atrophy of glandular, gonadal, and muscular tissues. Inflamed tissues contained large numbers of 10–15 µm extracellular, spherical organisms with a signet-ring morphology consistent with *Perkinsus* spp. trophozoites. The organisms often formed clusters of two to four cells and were surrounded by a host reaction consisting of a 1–4 µm rim of amorphous eosinophilic material and two to four host hemocytes. Incubation of infected host tissues in alternative Ray's fluid thioglycollate medium (ARFTM) confirmed the presence of *Perkinsus* sp. hypnospores that stained blue-black with Lugol's iodine. Polymerase chain reaction assays with sequencing of products revealed a high level of nucleotide similarity, but no exact match, to known *P. olseni* isolates. *Perkinsus* sp. organisms, including *P. olseni* and *P. marinus*, which are internationally reportable, are highly pathogenic destructive protozoa capable of disrupting ecosystems populated by naïve mollusks within the USA and negatively affecting both domestic and international shellfish industries. This is the first report of an exotic *Perkinsus* sp. pathogen in an imported ornamental clam maintained long term in a home aquarium. However, ongoing research indicates that *T. crocea* from Vietnam are commonly infected by such organisms. Veterinarians, aquarium facility managers, and veterinary clients with hobby aquariums should use appropriate caution and responsible disposal practices for clam carcasses and for water in which imported ornamental clams have been housed. Such practices will reduce the possibility of dispersing viable, exotic *Perkinsus* sp. organisms into domestic waters.

Can artificial substrates enriched with crustose coralline algae enhance larval settlement and recruitment in the fluted giant clam (*Tridacna squamosa*)?

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Hydrobiologia (2009) Volume 625(1): 83–90

Habitat recognition and selection can greatly increase the early-life survival of sessile reef organisms. This study describes the settlement and recruitment responses of the fluted giant clam, *Tridacna squamosa*, to concrete tablets and tiles containing different concentrations of crustose coralline algae covered coral rubble (CCACR). Crustose coralline algae is known to induce settlement in a variety of benthic animals, but it has

not been used previously as an aggregate in concrete—potentially a way of encouraging colonization of man-made structures erected on or near coral reefs. After being given the choice of small tablets made with 0%, 30% or 60% CCACR for 4 days, 11 days old larvae preferred the substrate containing the most CCACR. Recruitment responses of juvenile clams to larger tiles made with the same three CCACR concentrations were also tested. These tiles were further divided into rough and smooth surface textures. After 6 weeks, more juvenile clams had recruited to the rough surfaced tiles than the smooth ones, but no significant differences among the CCACR treatments were found. Thus, even though concrete made with CCACR is initially attractive to larvae, it has no effect on recruitment of juvenile *T. squamosa*.

***Trochus kotschy*, the first Indian Ocean record of the genus *Osilinus* (Mollusca: Gastropoda: Trochidae)**

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Journal of Zoology (2009) Volume 233(3):345–357

The species *Trochus kotschy* Philippi, 1849, and *Priotrochus obscurus* (Wood, 1828) have been much confused in the past. Consistent differences between these taxa in respect of shell morphology, external anatomy and radular and opercular form are demonstrated. The distribution of *T. kotschy* and the extent to which it and *P. obscurus* are sympatric are discussed. *T. kotschy* is referred to the genus *Osilinus* Philippi, 1847, a new combination and the first record of the genus from the Indo-West Pacific. The species is thought to be a pre-Miocene relict reflecting a mid-Tethyan origin of the genus. A note on the type species designation of *Osilinus* is provided.

Strong genetic population structure in the boring giant clam, *Tridacna crocea*, across the Indo-Malay archipelago: implications related to evolutionary processes and connectivity

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Molecular Ecology (2008) Volume 17:3775–3787

Even though the Indo-Malay Archipelago hosts the world's greatest diversity of marine species, studies on the genetic population structure and gene flow of marine organisms within this area are rather rare. Consequently, not much is known about connectivity of marine populations in the Indo-Malay Archipelago, despite the fact that such information is important to understand evolutionary and ecological processes in the centre of marine biodiversity. This study aims to investigate the genetic population structure of the boring giant clam, *Tridacna crocea*. The analysis is based on a 456-bp fragment of the cytochrome oxidase I gene from 300 individuals collected from 15 localities across the Indo-Malay Archipelago. *Tridacna crocea* shows a very strong genetic population structure and isolation by distance, indicating restricted gene flow between almost all sample sites. The observed F_{ST} -value of 0.28 is very high compared to other studies on giant clams. According to the pronounced genetic differences, the sample sites can be divided into four groups from West to East: (i) Eastern Indian Ocean, (ii) Java Sea, (iii) South China Sea, Indonesian throughflow, as well as seas in the East of Sulawesi, and (iv) Western Pacific. This complex genetic population structure and pattern of connectivity, characterised by restricted gene flow between some sites and panmixing between others can be attributed to the geological history and prevailing current regimes in the Indo-Malay Archipelago.

Energy storage and allocation during reproduction of Pacific winged pearl oyster *Pteria sterna* at Bahía de la Paz, Baja California Sur, Mexico

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Journal of Shellfish Research (2008) Volume 27(2):375–383

Seasonal variations in storage, partitioning, and allocation of energy reserves (proteins, carbohydrates, lipids, and triglycerides) between germinal and somatic tissues (gonad, digestive gland, mantle tissue, and adductor muscle), were investigated related to reproduction of Pacific winged pearl oyster *Pteria sterna*. Tissue samples were collected every three months and analyzed with histological and biochemical techniques. Energy coefficients were also calculated with data from chemical composition of tissues. Gonad samples in almost all developmental stages occurred throughout the year, suggesting that *P. sterna* is a multispawning species. The evidence indicates that the main reproductive season runs from January through April (21°C to 22°C) and was identified by higher frequency of ripe gonads, more and larger postvitellogenic oocytes and higher protein, lipid, and triglyceride levels in gonad tissue. Within this study period, there were two spawning peaks, July 2003 and January 2004. Gametogenesis was sustained from energy mainly obtained from the digestive gland and secondly from the adductor muscle. Only proteins from these two tissues were mobilized to the gonad for maturation of sex organs, because carbohydrates were stored despite the progress of gametogenesis. The role of mantle tissue was negligible. *P. sterna* appears to use a combination of stored reserves (conservative

strategy) and food supply (opportunistic strategy) as an overall strategy to regulate reproduction.

Seasonal variations in reproductive activity and biochemical composition of the cockle *Fulvia mutica* (reeve) from the eastern coast of China

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Journal of Shellfish Research (2008) Volume 27(2):405–411

Seasonal variations in condition index and biochemical composition of the cockle *Fulvia mutica* (Reeve) were studied from March 2004 to February 2005 in eastern coast of China in relation to reproductive cycle. The condition index declined during gametogenesis and spawning, recovered when the gonad was in resting phase. Histological analysis and measurements of protein, glycogen and lipid levels and RNA:DNA ratio from gonad-visceral mass, mantle, adductor muscle, and foot of *F. mutica* were performed. Gametogenesis took place during winter and spring at the expense of reserves (glycogen in various organs, protein in the foot, lipid in the adductor muscle), which were accumulated previously during summer and autumn. Spawning occurred in May to June when water temperature was higher and food availability was abundant. The RNA:DNA ratio is a good indicator of sexual maturity in the gonad-visceral mass; the increasing RNA:DNA ratio in the gonad-visceral mass appears to show the rising synthetic activity of vitellin within the gonad. The results demonstrated that *F. mutica* may be considered a conservative species in gametogenic pattern. The useful information obtained in this study can be applied for management of populations and to initiate aquaculture activities in this species.

Volutid snails as an alternative resource for artisanal fisheries in northern patagonic gulfs: availability and first suggestions for diving catches

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Journal of Shellfish Research (2008) Volume 27(2):417–421

Volutid snails have been identified as a potential resource for artisanal fisheries in northern patagonic gulfs. We explored their availability in two gulfs of Chubut Province (Patagonia, Argentina) by means of SCUBA diving and baited traps. CPUE and biomass were estimated from visual counting densities. CPUE of all the volutes was 65.85 kg·diver⁻¹·h⁻¹ and 59.5 kg·diver⁻¹·h⁻¹ in San Matías (SMG) and San Jorge (SJG) Gulfs, respectively. Estimated biomass was 89.7 (±28.9) and 44.4 (±19.2) tons in SMG and SJG. The species *Adelomelon ancilla* and *Odontocymbiola magellanica* could supplement the potential clam fishery existent at SJG. In SMG *Zidona* followed by *O. magellanica* could be the main commercial target. We suggest minimum catch sizes of 16 cm for *Z. dufresnei*, 9 cm for *O. magellanica*, and 12 cm for *A. ancilla*. Protection of the egg capsules and females would help the protection of the resource. These measures could ensure the sustainability of a small-scale multispecific fishery.

Suminoe oyster (*Crassostrea ariakensis*) culture in Korea

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Journal of Shellfish Research (2008) Volume 27(3):505–508

The Suminoe oyster *Crassostrea ariakensis* is considered a potential aquaculture species in Korea, potentially supplementing or supplanting culture of the Pacific oyster *Crassostrea gigas*, currently the focus of commercial production and research. Production of cultured Suminoe oysters in Korea is limited, in part because of limited information on its biology and ecology. Commercial production is presently restricted to two rivers (Seomjin and Kawha). Here we describe the current status of *C. ariakensis* in Korea, focusing on its ecology and factors affecting development of aquaculture for this species. Preliminary investigations suggest that the Suminoe oyster shows excellent potential for expanded cultivation. A comprehensive monitoring program is needed to detect natural and anthropogenic ecosystem changes affecting production of the Suminoe oyster.

Establishing a baseline for management of the rock scallop, *Spondylus calcifer* (Carpenter 1857): growth and reproduction in the upper gulf of California, Mexico

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Journal of Shellfish Research (2008) Volume 27(4):625–632

The rock scallop (also known as “donkey thorny oyster,” “spiny oyster,” and “thorny oyster”), *Spondylus calcifer*, is the largest member of any Panamic Province *Spondylus* and has played important economic, political, and cultural roles in coastal communities of the Eastern Tropical Pacific for thousands of years. Despite its importance, knowledge of its biology is scant. We assessed seasonal variations in shell and

adductor muscle growth, longevity, reproductive age and period, and population sex ratios in the upper Gulf of California, Mexico, the northernmost area within the geographic distribution of this species. Information on shell growth and age was obtained *via* the use of stable oxygen isotope profiles of shell aragonite cross-referenced with mark recapture data. *Spondylus calcifer* forms white growth bands during winter and spring months. Shell growth accelerates during warmer months and diminishes during colder months. Likewise, the adductor muscle increases in size and weight during colder months, affecting fishermen's distribution of fishing effort. These seasonal variations in growth are likely a result of energetic shifts related to resource allocation pre and post reproduction, which takes place in July–August as water temperatures reach 28°C to 30°C. The species reaches sexual maturity between 2.5–4 y of age and can live to at least 12 y. Overall sex ratios consisted of 1:1 male:female, a population structure in accordance with previous reports for the southern Gulf of California. We discuss our findings in the context of management and conservation of the species.

Prospective culture of the Cortez oyster *Crassostrea corteziensis* from northwestern Mexico: growth, gametogenic activity, and condition index

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Journal of Shellfish Research (2008) Volume 27(4):711–720

This study examined growth, gametogenic activity, condition index, as well as the relationship of the life cycle to environmental parameters of the Cortez oyster *Crassostrea corteziensis*, which was cultured for 25 mo in the lagoon of Las Guásimas (Sonora, Mexico). We used oocyte diameter and cytological characteristics of the gonad to determine reproductive stages in females and males. The condition index was used to describe the oyster's physiological health. Temperature, salinity, seston, and chlorophyll *a*, *b*, and *c* were recorded at the study site. The Cortez oyster had isometric shell growth, reaching 103.2 ± 1.82 mm height and 150.3 ± 4.98 g total weight. Data were adjusted to the von Bertalanffy growth equation ($L_{\infty} = 132.2$ mm and $K = 1.08 \text{ y}^{-1}$), and survival was about 70%. This native species exhibited a distinctive gametogenic cycle, with the beginning and end of the cycle controlled by seawater temperature fluctuation (15–33°C), which once started, is continuous over a 9-mo period (March to November). Elevated temperature (>25°C) produced high gametogenic activity, exhibiting primary, growing, and mature oocytes, and partial spawning in April, September, and November. The peak spawning event occurred in August, when seawater reached peak temperatures of 31°C to 33°C, which was followed by a significant reduction of the condition index. During winter, storage of nutrients took place, and this appears to be used in the following season for gametogenesis. In general, the condition index was high throughout the study period. Energy for growth and reproduction came from phytoplankton blooms in summer and high concentration throughout the year of nonchlorophyll particulate organic matter. Observations show that this oyster is a protandrous species. High survival, elevated yields, and a long, continuous gametogenic cycle indicate that *C. corteziensis* has importance in aquaculture in Gulf of California.

Assessment of genetic diversity of the eastern oyster *Crassostrea virginica* in Veracruz, Mexico using microsatellite markers

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Journal of Shellfish Research (2008) Volume 27(4):721–727

Genetic variation was evaluated in populations of the eastern oyster *Crassostrea virginica* (Gmelin) from the coast of Veracruz, eastern Gulf of Mexico. We sampled six lagoons and analyzed variation at five microsatellite loci. Significant Hardy-Weinberg deviations occurred at all loci and were attributed to the presence of null alleles. We found no isolation by distance among the populations in these lagoons, but significant heterogeneity was observed among some adjacent lagoons, possibly reflections of geographical factors and local reductions in population size. Certain extreme north and south localities were not genetically different in terms of nonsignificant pairwise F_{ST} values. Gene flow is attributed to seasonal shifts in coastal currents, larval production throughout the year, human interference with the natural lagoon processes, and restocking efforts. The observed pattern of variation could be another example of chaotic genetic patchiness in marine organisms.

Prospect of oyster culture in Pakistan: pathology assessment of two commercially important oyster species

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Nine different species of oysters belonging to the genera *Crassostrea*, *Saccostrea*, and *Ostrea* occur naturally along Pakistan's coastline in the northern Arabian Sea. At the present time, no commercial harvesting or hatchery culture of oysters exists in Pakistan. The world's oyster aquaculture industry is seriously affected by diseases caused by parasites, such as *Bonamia ostrea* in the European flat oyster *Ostrea edulis*, and *Haplosporidium nelsoni* or *Perkinsus marinus* in the Eastern oyster *Crassostrea virginica*. Pathogens may be endemic or recently introduced and may cause epizootic mortalities and catastrophic economic losses. To evaluate if there are parasites or diseases in Pakistan's oysters that could limit prospective aquaculture development, histopathological analyses were performed on two oyster species, *Ostrea nomades* and *Crassostrea belcheri*. Oysters were sampled year-around, and fixed and processed for histology. Slides (217 cases for *O. nomades* and 76 cases for *C. belcheri*) were examined for the presence of parasites or pathological changes. *Ostrea nomades* was infected by a protozoan parasite, *Nematopsis* sp. Sneider, 1892 (Apicomplexa, Porosporidae), at 67% prevalence, and *C. belcheri* at 1.3% prevalence. *Nematopsis* spp. did not induce pathological changes in the oysters. *Stegotricha*-like ciliates (Thigmotrichida, Ancistrocomidae) were present in the stomachs of *O. nomades* with a prevalence of 1%, and 25% of *C. belcheri* presented ceroid deposits in their tissues. Historically, *Ostrea* and *Crassostrea* genera have been associated with epizootic diseases, but in the present samples, no known, economically important parasites or diseases were found. Absence of any pathology in these samples projects a positive future for oyster aquaculture in Pakistan. These oyster populations should be protected from nonendemic bivalve importations, which could transmit new parasites to these potentially susceptible, previously unexposed, native oysters.

Survival, growth and recruitment of abalone *Haliotis diversicolor* in Sagami Bay, Japan

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The occurrence of newly settled postlarvae (<500 µm of shell length [SL]) and subsequent growth and survival of the abalone, *Haliotis diversicolor*, were observed from 2001–2004 at two stations in the rocky shore of Nagai on the coast of Sagami Bay, Japan. Seawater temperature, current velocity, and distance of the weekly stone movement were monitored at both stations to determine factors affecting survival and growth of postlarvae. There were newly settled postlarvae in August and September of 2001, October 2002, August 2003, and September 2004. A total of 6 cohorts were identified between 2001 and 2004. Initial density of each cohort was generally higher at Station 1 than Station 2, but recruits at Station 1 had greater mortality than Station 2. Results from measurements of the physical environmental factors suggested that higher mortality rate of postlarval and juvenile *H. diversicolor* at Station 1 were produced by greater water turbulence and stone movement caused by storms. Growth rates in the first month after settlement varied between cohorts (35–62 µm SL day⁻¹), and growth rates were slower for cohorts settling later in the spawning season and experiencing lower water temperature. The timing of typhoon-triggered spawning in *H. diversicolor* population was also suggested to be an important factor affecting growth and survival of postlarvae and early juveniles, along with their subsequent recruitment. The cohorts from 2001–2004 attained 17–40 mm SL in about one year after settlement. To estimate the size and age at the first stage of maturation, the increase in shell length and gonad development of a single cohort from 2001 were measured. This cohort attained 30–55 mm SL and showed high gonad index at 22 mo after settlement, indicating the first stage of maturation of *H. diversicolor* is achieved at age 2.

Analysis of the decline of the abalone fishery (*Haliotis fulgens* and *H. corrugata*) along the west-central coast of the Baja California Peninsula, Mexico

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We analyzed the decline in the abalone harvest of two species *Haliotis fulgens* and *H. corrugata*, from one region composed of six study zones along the Baja California peninsula, Mexico. Survey data from 1991 to 2001 were used and density estimations with a χ^2 -distribution were computed. The results showed a dramatic decline in density (kg/10 m²) for both species. The decline in densities of *H. fulgens* and *H. corrugata* is consistent with a pattern observed since 1975. The current condition of the abalone stock is an example

of an uncontrolled fishery. An increase in fishing effort or harvest rate must be avoided because we do not know the equilibrium density of these populations.

Population assessment of the conch *Strombus galeatus* (Gastropoda, Strombidae) in Pacific Panama

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Populations of *Strombus galeatus* Swainson 1823 have been severely overfished in Pacific Panama. In this study, we assessed the status of the *S. galeatus* population in Las Perlas and Coiba Archipelagos. Average densities per site were dismal: 0.45 ± 3.8 ind ha⁻¹ and 6.0 ± 18 ind ha⁻¹ in Las Perlas and Coiba, respectively. In Las Perlas, low densities occurred on the southwest coast of Del Rey, the south coast of Chaperas, and Bolaños, whereas intermediate densities were found on the eastern coast of Saboga. In Coiba, high relative densities occurred only on the west coast of Coiba Island and at the north and south of Bahía Damas. Environmental variability and depth did not explain the differences found between densities nor the low abundances in the archipelagos. Shell length of *S. galeatus* from Coiba ranged from 91.0–213.3 mm (156 ± 22.2 mm). We fitted a von Bertalanffy growth model to juvenile data using the following parameters: $L_{\infty} = 315$ mm, $K = 0.029$ mo⁻¹, and $t_0 = 0.5$ mo. The model suggests that 27–28 mo are required (on average) before the outer lip begins to form. Two years after the enactment of Decree No. 159 in September 2004, which banned the *Strombus* fisheries in Panama for five years, the conch populations in Las Perlas and Coiba have not recovered. The Las Perlas population is recruitment limited and we recommend that a program of law enforcement and monitoring should be implemented immediately to protect this species, conducive to increase spawning and settlement in nursery grounds.

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