

Marine Science Review - 168

Introduced species



In this review:

A. Recent articles with abstracts

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Johnson, D.R., Perry, H.M., and Graham, W.M. **Using nowcast model currents to explore transport of non-indigenous jellyfish into the Gulf of Mexico.** *Marine Ecology Progress Series* 305: 139-146, 2005.

Notes: In the spring of 2000, millions of the non-endemic jellyfish *Phyllorhiza punctata* were found in coastal regions of the Mississippi Bight in the northern Gulf of Mexico. The aggregations were large enough to seriously impact local fisheries by clogging shrimp nets and damaging gear. More importantly perhaps, the impact on plankton biomass and hence on fishery resources were potentially large, since *P. punctata* is a voracious filter feeder. In this study, we examine a hypothesis for their sudden appearance which involves advection from the Caribbean in an intruding Loop Current and subsequent flux onto the Mississippi Shelf through eddy-shedding processes which interact with the continental shelf/slope. Surface current data were obtained from an archived finite difference model of the Gulf of Mexico which used altimeter data assimilation and real wind forcing covering the time of the invasion. Model and satellite data showed that an exchange event occurred in late April at a time appropriate for the invasion. The results from tracing transport pathways suggest that mass redistribution of Caribbean populations into the northern Gulf of Mexico can be accomplished via Loop Current intrusion and flux of deep basin water onto the shelf. As such, the occurrence of the invasive species *P. punctata* in the northern Gulf in 2000 can be explained by a natural, but not necessarily common, sequence of events. This hypothesis is discussed as a means of redistribution of a species by invasion as opposed to redistribution by diffusive spreading.

Ruiz-Carus, R., Matheson, R.E., Roberts, D.E., and Whitfield, P.E. **The western Pacific red lionfish, *Pterois volitans* (Scorpaenidae), in Florida: Evidence for reproduction and parasitism in the first exotic marine fish established in state waters.** *Biological Conservation* 128(3): 384-390, 2006.

Notes: Many exotic fresh-water and brackish-water fish species have become established in Florida waters, but the red lionfish is the first entirely marine species that appears to have become established here. We give a detailed account of the initial collections of adult specimens from off St. Augustine and Jacksonville, including data on morphometrics, meristics, and gonad histology. Our review of historical sightings on Florida reefs and of the specimens reported herein suggests that the most plausible vector for the introduction of this fish was aquarium releases. We discuss our reasons for concluding that this species has probably become established in Florida, summarize the potential danger that these venomous fishes pose to the public, and examine the effect of a parasite hosted by the male lionfish. We also consider the potential effect of the red lionfish on marine communities in Florida, but limited information on its biology precludes a detailed assessment.

Smith, D.G., Shiinoki, E.K., and VanderWerf, E.A. **Recovery of native species following rat eradication on Mokoli'i Island, O'ahu, Hawai'i.** *Pacific Science* 60(2): 299-303, 2006.

Notes: Rats were eradicated from Mokoli'i, a 1.6-ha island off the east shore of O'ahu, using snap traps, cage traps, and diphacinone bait stations. A total of 18 black rats (*Rattus rattus*) were caught, and 354 bait blocks were used. There was no sign of rats on the island after 27 May 2002. Wedge-tailed Shearwaters (*Puffinus pacificus*) nest on Mokoli'i, but only a single chick survived during 1999-2001; the number of surviving chicks increased to 126 in 2002 and 185 in 2003. The number of intertidal invertebrates and native plants, including the endangered Carter's panic grass (*Panicum fauriei* var. *carteri*), also appeared to

increase after rat eradication. Rats had a devastating impact on the flora and fauna of Mokoli'i, and their eradication has allowed a dramatic recovery of native species. The majority of the labor for the eradication effort was provided by the local community, demonstrating what can be achieved with dedicated volunteers and community support.

Seuront, L. **First record of the calanoid copepod *Acartia omorii* (Copepoda: Calanoida: Acartiidae) in the Southern bight of the North Sea.** *Journal of Plankton Research* 27(12): 1301-1306, 2005.

Notes: The occurrence of the calanoid copepod, *Acartia omorii*, is reported for the first time in the coastal waters of the Southern bight of the North Sea, off Calais harbour. *Acartia omorii* males and females were consistently found in four plankton samples. The collected specimens were compared with *A. omorii* individuals collected from the type locality (Tokyo Bay, Japan). The capture of *A. omorii*, a species native to Japanese coastal waters, is in agreement with the recent observation of the Japanese macroalgae *Undaria pinnatifida* within Calais harbor and the hypothesis of passive transport in ship's ballast water.

Doblin, M.A. and Dobbs, F.C. **Setting a size-exclusion limit to remove toxic dinoflagellate cysts from ships' ballast water.** *Marine Pollution Bulletin* 52(3): 259-263, 2006.

Notes: Dinoflagellate cysts are well-recognized biological constituents of ships' ballast tanks. They are present in ballast water, sediments and residual water in drained tanks, and in biofilms formed on interior tank surfaces. Therefore, cysts have the potential to be released during ballast discharge. The International Maritime Organization's (IMO) Ballast Water Management Convention (promulgated February 2004) stipulates a performance standard (Annex, Regulation D2) requiring discharged ballast water contain < 10 viable organisms between 10 and 50 µm per ml and < 10 viable organisms ≥ 50 µm per m³. The proposed size limit has potential to exclude both the smallest toxic and the largest toxic and non-toxic dinoflagellate (and other microalgal) cysts from discharged ballast water. Despite the appropriateness of size cutoffs however, ballast water containing predominantly small cysts (< 50 µm) could be deemed in compliance with the performance standard, even without treatment, while ballast water having the same concentration of larger cysts (> 50 µm) could require a multiple-log reduction in abundance before its permissible discharge. Also of concern, it remains uncertain whether ballast-water treatment can remove sufficient organisms, including dinoflagellate cysts, to meet the performance standard.

Golani, D. and Sonin, O. **The Japanese threadfin bream *Nemipterus japonicus*, a new Indo-Pacific fish in the Mediterranean Sea.** *Journal of Fish Biology* 68(3): 940-943, 2006.

Notes: A specimen of the Japanese threadfin bream *Nemipterus japonicus* was recorded for the first time from the Mediterranean Sea. The presence of this Indo-Pacific fish in the Mediterranean is evidently due to migration from the Red Sea via the Suez Canal.

Chelossi, E. and Faimali, M. **Comparative assessment of antimicrobial efficacy of new potential biocides for treatment of cooling and ballast waters.** *The Science of the Total Environment* 356(1-3): 1-10, 2006.

Notes: The comparative in vitro antibacterial activity of five non-oxidizing biocides was investigated by laboratory standard test procedures. Minimum Inhibitory Concentrations (MIC) of two alkylated naphthoquinone derivative molecules (MNB and MPB) and three commercial biocide formulations (MACROTROL (R) MT200, MICROTREAT (R) AQZ2010 and MICROBIOCIDE (R) 2594) were determined against a total of 23 non-pathogenic bacterial strains. This investigation demonstrated a broad-spectrum bactericidal efficacy of three of the assayed biocides (MT200 and both naphthoquinone derivatives) at low use levels, also against naturally tolerant species, such as *Pseudomonas* spp. MT200 was the most effective, inhibiting bacterial growth of both Gram-positive (MIC < 4 mg/l) and Gram-negative bacteria (MIC < 16 mg/l), whereas effectiveness of naphthoquinones was highly variable (MIC ranging from 1 to 64 mg/l). The findings show the ability of the tested products to reduce bacterial populations under laboratory conditions. These products could provide an efficient bacterial growth control, for treatment of both fresh and salt waters used for various industrial purposes.

Strauss, S.Y., Webb, C.O., and Salamin, N. **Exotic taxa less related to native species are more invasive.** *Proceedings of the National Academy of Sciences [USA]* 103(15): 5841-5845, 2006.

Notes: Some species introduced into new geographical areas from their native ranges wreak ecological and economic havoc in their new environment. Although many studies have searched for either species or habitat characteristics that predict invasiveness of exotic species, the match between characteristics of the invader and those of members of the existing native community may be essential to understanding invasiveness. Here, we find that one metric, the phylogenetic relatedness of an invader to the native community, provides a predictive tool for invasiveness. Using a phylogenetic supertree of all grass species in California, we show that highly invasive grass species are, on average, significantly less related to native grasses than are introduced but noninvasive grasses. The match between the invader and the existing native community may explain why exotic pest species are not uniformly noxious in all novel habitats. Relatedness of invaders to the native biota may be one useful criterion for prioritizing management efforts of exotic species.

Gordon, D.P., Ramalho, L.V., and Taylor, P.D. **An unreported invasive bryozoan that can affect livelihoods - *Membraniporopsis tubigera* in New Zealand and Brazil.** *Bulletin of Marine Science* 78(2): 331-342, 2006.

Notes: *Membraniporopsis tubigerum* (Osburn, 1940) (Cheilostomata) is added to the list of known invasive bryozoans. Originally described from Puerto Rico, Texas, and Florida, it has been found at several localities in southern Brazil since October 1997 and in Kaipara Harbour, New Zealand since December 2001. At the latter location, its irruption in the austral summer-autumn of 2001-02 resulted in such massive numbers of erect colony fragments as to clog set nets for flounder and wash up on local beaches in stinking 20-cm-thick drifts. Since then, its frequency of occurrence has declined and it was not definitely seen in the harbor in 2003 and 2004. Neither the manner of reproduction nor agency of dispersal is known. It is even possible that the original description may have been based on invasive material inasmuch as the only certain congeners, *Membraniporopsis bifloris* (Wang and Tung, 1976) and *Membraniporopsis serrilamelloides* (Liu and Li, 1987) are east Asian species. New characters are identified that are diagnostic of the genus *Membraniporopsis*, which is provisionally included in the Flustridae in the absence of knowledge about larval type. A full redescription of *M. tubigera* is provided, along with information on skeletal mineralogy; it is noted that *M. tubigera* has exceptionally high-magnesium calcite.

Simon-Bouhet, B., Garcia-Meunier, P., and Viard, F. **Multiple introductions promote range expansion of the mollusc *Cyclope neritea* (Nassariidae) in France: evidence from mitochondrial sequence data.** *Molecular Ecology* 15(6): 1699-1711, 2006.

Notes: Since the 1970s, the nassariid gastropod *Cyclope neritea* has been extending its range north along the French Atlantic coasts from the Iberian Peninsula. This may be due to natural spread because of the recent warming of the northeastern Atlantic. However, human-mediated introductions related to shellfish culture may also be a probable explanation for this sudden range expansion. To examine these two hypotheses, we carried out a comprehensive study based on mitochondrial gene sequences (cytochrome oxidase I) of the five recently colonized French bays as well as 14 populations located in the recognized native range of the species. From a total of 594 individuals, we observed 29 haplotypes to split into three divergent clades. In the native range, we observed a low molecular diversity, strong genetic structure and agreement between geography and gene genealogies. Along the French coasts, we observed the opposite: high genetic diversity and low genetic structure. Our results show that recurrent human-mediated introductions from several geographical areas in the native range may be a source for the French Atlantic populations. However, despite the low dispersal ability of *C. neritea*, the isolation-by-distance pattern in France suggested that this gastropod may have been present (although unnoticed) on the French Atlantic coasts before the 1970s. As *C. neritea* shows characteristics of a cryptogenic species, the classification of Atlantic populations as either native or introduced is not straightforward. Cryptogenic species should be studied further to determine the status of new populations close to their recognized native range.

Levin, L.A., Neira, C., and Grosholz, E.D. **Invasive cordgrass modifies wetland trophic function.** *Ecology* 87(2): 419-432, 2006.

Notes: Vascular plants strongly control belowground environments in most ecosystems. Invasion by vascular plants in coastal wetlands, and by cordgrasses (*Spartina* spp.) in particular, are increasing in incidence globally, with dramatic ecosystem-level consequences. We examined the trophic consequences of invasion by a *Spartina* hybrid (*S. alterniflora* X *S. foliosa*) in San Francisco Bay (USA) by documenting differences in biomass and trophic structure of benthic communities between sediments invaded by *Spartina* and uninvaded sediments. We found the invaded system shifted from all algae-based to a detritus-based food web. We then tested for a relationship between diet and tolerance to invasion, hypothesizing that species that consume *Spartina* detritus are more likely to inhabit invaded sediments than those that consume surface algae. Infaunal diets were initially examined with natural abundance stable isotope analyses and application of mixing models, but these yielded an ambiguous picture of food sources. Therefore, we conducted isotopic enrichment experiments by providing N-15-labeled *Spartina* detritus both on and below the sediment surface in areas that either contained *Spartina* or were unvegetated. Capitellid and nereid polychaetes, and oligochaetes, groups shown to persist following *Spartina* invasion of San Francisco Bay tidal flats, took up N-15 from labeled native and invasive *Spartina* detritus. In contrast, we found that amphipods, bivalves, and other taxa less tolerant to invasion consumed primarily surficial algae, based on C-13 enrichment experiments. Habitat (*Spartina* vs. unvegetated patches) and location of detritus (on or within sediments) did not affect N-15 uptake from detritus. Our investigations support a "trophic shift" model for ecosystem response to wetland plant invasion and preview loss of key trophic support for fishes and migratory birds by shifting dominance to species not widely consumed by species at higher trophic levels.

Maron, J.L., Estes, J.A., Croll, D.A., Danner, E.M., Elmendorf, S.C., and Buckelew, S.L. **An introduced predator alters Aleutian island plant communities by thwarting nutrient subsidies.** *Ecological Monographs* 76(1): 3-24, 2006.

Notes: The ramifying effects of top predators on food webs traditionally have been studied within the framework of trophic cascades. Trophic cascades are compelling because they embody powerful indirect effects of predators on primary production. Although less studied, indirect effects of predators may occur via routes that are not exclusively trophic. We quantified how the introduction of foxes onto the Aleutian Islands transformed plant communities by reducing abundant seabird populations, thereby disrupting nutrient subsidies vectored by seabirds from sea to land. We compared soil and plant fertility, plant biomass and community composition, and stable isotopes of nitrogen in soil, plants, and other organisms on nine fox-infested and nine historically fox-free islands across the Aleutians. Additionally, we experimentally augmented nutrients on a fox-infested island to test whether differences in plant productivity and composition between fox-infested and fox-free islands could have arisen from differences in nutrient inputs between island types. Islands with historical fox infestations had soils low in phosphorus and nitrogen and plants low in tissue nitrogen. Soils, plants, slugs, flies, spiders, and bird droppings on these islands had low dN-15 values indicating that these organisms obtained nitrogen from internally derived sources. In contrast, soils, plants, and higher trophic level organisms on fox-free islands had elevated dN-15 signatures indicating that they utilized nutrients derived from the marine environment. Furthermore, soil phosphorus (but not nitrogen) and plant tissue nitrogen were higher on fox-free than fox-infested islands. Nutrient subsidized fox-free islands supported lush, high biomass plant communities dominated by graminoids. Fox-infested islands were less graminoid dominated and had higher cover and biomass of low-lying forbs and dwarf shrubs. While dN-15 profiles of soils and plants and graminoid biomass varied with island size and distance from shore, after accounting for these effects differences between fox-infested and fox-free islands still existed. Fertilization over four years caused a 24-fold increase in graminoid biomass and a shift toward a more graminoid dominated plant community typical of fox-free islands. These results indicate that apex predators can influence plant productivity and composition through complex interaction web pathways involving both top-down forcing and bottom-up nutrient exchanges across systems.

Facon, B., Genton, B.J., Shykoff, J., Jarne, P., Estoup, A., and David, P. **A general eco-evolutionary framework for understanding bioinvasions.** *Trends in Ecology and Evolution* 21(3): 130-135, 2006.

Notes: Studies of bioinvasions have revealed various strategies of invasion, depending on the ecosystem invaded and the alien species concerned. Here, we consider how migration (as a demographic factor), as well as ecological and evolutionary changes, affect invasion success. We propose three main theoretical scenarios that depend on how these factors generate the match between an invader and its new environment. Our framework highlights the features that are common to, or differ among, observed invasion cases, and clarifies some general trends that have been previously highlighted in bioinvasions. We also

suggest some new directions of research, such as the assessment of the time sequence of demographic, genetic and environmental changes, using detailed temporal surveys.

Walters, L.J., Brown, K.R., Stam, W.T., and Olsen, J.L. **E-commerce and *Caulerpa*: unregulated dispersal of invasive species.** *Frontiers in Ecology and Environment* 4(2): 75-79, 2006.

Notes: Professional aquarists and hobbyists are thought to be the source of invasions of the aquarium strain of the green macroalga *Caulerpa taxifolia* in the Mediterranean, southern California, and Australia. The US Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) restricted interstate commerce and importation of the Mediterranean clone of *C. taxifolia* prior to the California invasion and is currently deciding if it should strengthen regulation of this genus as more species of *Caulerpa* are being described as invasive. Here we document the importance of e-commerce as a mode of dispersal for many species of *Caulerpa* in the United States. We purchased *Caulerpa* from 30 internet retailers and 60 internet auction sites representing 25 states and Great Britain. Twelve different *Caulerpa* species were confirmed using DNA sequencing. Only 10.6% of sellers provided the correct genus and species names with their shipments. Thirty purchases of "live rock" provided four species of *Caulerpa*, as well as 53 additional marine species. Our results confirm the extensive e-commerce availability of this invasive genus and its high dispersal potential via postal services and hobbyists. We recommend that both eBay and the USDA maximize regulation of *Caulerpa*.

Messing, R.H. and Wright, M.G. **Biological control of invasive species: solution or pollution?** *Frontiers in Ecology and Environment* 4(3): 132-140, 2006.

Notes: Biological control of invasive species using co-evolved natural enemies has long been considered a safe, cost effective, and environmentally benign tool for pest management. However, recent work has questioned the extent to which these imported natural enemies have negative impacts on populations of non-target species. The result has been a vociferous debate about the safety and proper role of biological control, often without convincing evidence on either side. The issues are particularly well focused in Hawaii, with its high numbers of both endemics and invasive pest species. We review the data concerning environmental impacts from past biocontrol projects, discuss the patterns and generalizations that emerge from retrospective analyses, and consider some new techniques for risk assessment. We then emphasize the need for a federal regulatory framework that is rational, efficient, transparent, and ecologically meaningful.

Diederich, S. **High survival and growth rates of introduced Pacific oysters may cause restrictions on habitat use by native mussels in the Wadden Sea.** *Journal of Experimental Marine Biology and Ecology* 328(2): 211-227, 2006.

Notes: Pacific oysters *Crassostrea gigas* (Thunberg, 1793) were introduced to the northern Wadden Sea (North Sea, Germany) by aquaculture in 1986 and finally became established. Even though at first recruitment success was rare, three consecutive warm summers led to a massive increase in oyster abundances and to the overgrowth of native mussel beds (*Mytilus edulis* L.). These mussels constitute biogenic reefs on the sand and mud flats in this area. Survival and growth of the invading *C. gigas* were investigated and compared with the native mussels in order to predict the further development of the oyster population and the scope for coexistence of both species. Field experiments revealed high survival of juvenile *C. gigas* (approximately 70%) during the first three months after settlement. Survival during the first winter varied between > 90% during a mild and 25% during a cold winter and was independent of substrate (i.e., mussels or oysters) and tide level. Within their first year *C. gigas* reached a mean length of 35-53 mm, and within two years they grew to 68-82 mm, which is about twice the size native mussels would attain during that time. Growth of juvenile oysters was not affected by substrate (i.e., sand, mussels, and other oysters), barnacle epibionts and tide level, but was facilitated by fucoid algae. By contrast, growth of juvenile mussels was significantly higher on sand flats than on mussel or oyster beds and higher in the subtidal compared to intertidal locations. Cover with fucoid algae increased mussel growth but decreased their condition expressed as dry flesh weight versus shell weight. High survival and growth rates may compensate for years with low recruitment, and may therefore allow a fast population increase. This may lead to restrictions on habitat use by native mussels in the Wadden Sea.

Williams, P.J., Floyd, T.A., and Rosson, M.A. **Agonistic interactions between invasive green crabs, *Carcinus maenas* (Linnaeus), and sub-adult American lobsters, *Homarus americanus* (Milne Edwards).** *Journal of Experimental Marine Biology and Ecology* 329(1): 66-74, 2006.

Notes: The invasive green crab, *Carcinus maenas*, has recently expanded its range into the Southern Gulf of St. Lawrence, where there is potential for substantial niche overlap with juvenile American lobsters, *Homarus americanus*. We used two experiments to elicit, record and analyze the agonistic interactions of adult green crabs (carapace width of 63-75 mm) and sub-adult (carapace length of 55-70 mm) lobsters. The first experiment gave each animal equal access to a limited food resource. The green crabs were first to the food in significantly more trials, spent a significantly greater proportion of time with the food, and were able to successfully defend the food from attacks by the heavier lobsters. In the second experiment, we allowed the lobsters to gain possession and initiate feeding on the food before releasing the green crabs. In these trials, the lobsters spent significantly more time with the food, and were able to defend the food from the green crabs. The results of both experiments are discussed in the context of game theory. The different behaviour of the crustaceans in the two experiments is consistent with the "bourgeois" strategy in a hawk and dove game simulation. With this strategy, an animal acts like a hawk if in possession of a resource, but acts like a dove if the other animal is in possession of the resource. The fact that the green crabs were able to physically compete with, and in many cases dominate the larger, heavier lobsters supports the potential for competitive impacts of green crabs on sub-adult lobsters.

Olden, J.D. and Rooney, T.P. **On defining and quantifying biotic homogenization.** *Global Ecology and Biogeography* 15(2): 113-120, 2006.

Notes: Ongoing species invasions and extinctions are changing biological diversity in different ways at different spatial scales. Biotic homogenization (or BH) refers to the process by which the genetic, taxonomic or functional similarities of regional biotas increase over time. It is a multifaceted process that encompasses species invasions, extinctions and environmental alterations, focusing on how the identities of species (or their genetic or functional attributes) change over space and time. Despite the increasing use of the term BH in conservation biology, it is often used erroneously as a synonym for patterns of species invasions, loss of native species or changes in species richness through time. This reflects the absence of an agreed-upon, cogent definition of BH. Here, we offer an operational definition for BH and review the various methodologies used to study this process. We identify the strengths and weaknesses of these approaches, and make explicit recommendations for future studies. We conclude by citing the need for researchers to: (1) consider carefully the definition of BH by recognizing the genetic, taxonomic and functional realms of this process; (2) recognize that documenting taxonomic homogenization requires tracking the identity of species (not species richness) comprising biotas through space and time; and (3) employ more rigorous methods for quantifying BH.

Barnes, D.K.A., Hodgson, D.A., Convey, P., Allen, C.S., and Clarke, A. **Incursion and excursion of Antarctic biota: past, present and future.** *Global Ecology and Biogeography* 15(2): 121-142, 2006.

Notes: *Aim* To investigate the major paradigms of intense isolation and little anthropogenic influence around Antarctica and to examine the timings and scales of the modification of the southern polar biota. *Location* Antarctica and surrounding regions. *Methods* First, mechanisms of and evidence for long-term isolation are reviewed. These include continental drift, the development of a surrounding deep-water channel and the Antarctic Circumpolar Current (ACC). They also include levels of endemism, richness and distinctiveness of assemblages. Secondly, evidence for past and modern opportunities for species transport are investigated. Comparative levels of alien establishments are also examined around the Southern Ocean. *Discussion* On a Cenozoic time-scale, it is clear that Gondwana's fragmentation led to increasing geographical isolation of Antarctica and the initiation of the ACC, which restricted biota exchange to low levels while still permitting some movement of biota. On a shorter Quaternary time-scale, the continental ice-sheet, influenced by solar (Milankovitch) cycles, has expanded and contracted periodically, covering and exposing terrestrial and continental shelf habitats. There were probably refugia for organisms during each glacial maxima. It is also likely that new taxa were introduced into Antarctica during cycles of ice sheet and oceanic front movement. The current situation (a glacial minimum) is not 'normal'; full interglacials represent only 10% of the last 430 ka. On short (ecological) time-scales, many natural dispersal processes (airborne, oceanic eddy, rafting and hitchhiking on migrants) enable the passage of biota to and from Antarctica. In recent years, humans have become influential both directly by transporting organisms and indirectly by increasing survival and establishment prospects via climate change. *Main conclusions* Patterns of endemism and alien establishment are very different across taxa, land and sea, and north vs. south of the

Polar Frontal Zone. Establishment conditions, as much as transport, are important in limiting alien establishment. Three time-scales emerge as important in the modification of Antarctica's biota. The natural 'interglacial' process of reinvasion of Antarctica is being influenced strongly by humans.

Buschbaum, C., Chapman, A.S., and Saier, B. **How an introduced seaweed can affect epibiota diversity in different coastal systems.** *Marine Biology* 148(4): 743-754, 2006.

Notes: Invasions by non-indigenous species have the potential to alter the biodiversity of recipient systems. The magnitude of this effect often depends on the nature of the invaded communities and the ecology of the invader. We investigated the impacts of the Japanese seaweed *Sargassum muticum* (Phaeophyceae, Fucales) on biodiversity in a rocky and sedimentary environment on two islands in the North Sea. In each case, we compared the epibiota of non-indigenous *S. muticum* with epibiota communities on taxonomically related and structurally similar native seaweed hosts. Total and average species richness on *S. muticum* were similar on the rocky shore (60 species and 22 +/- 6 species, respectively) and the sandy shore (64 species and 20 +/- 3 species, respectively). However, community structure and species composition differed significantly between the environments. On the rocky shore, another native furoid seaweed, *Halidrys siliquosa*, supported an epibiota community very similar to that of the invader. On the sandy shore, the only other abundant native habitat-providing algal species was *Fucus vesiculosus*. This species supported a different and less diverse assemblage of associated taxa. We conclude that *S. muticum* enhances epibiota diversity in the sedimentary environment, probably by increasing the substratum availability and habitat heterogeneity. In contrast, it has negligible impacts on epibiota diversity in the rocky shore environment, where it does not represent a fundamentally new habitat component. We conclude that even within the same region, the consequences of non-indigenous species on biodiversity cannot be generalised but depend on the composition and structural complexity of the species in the recipient community.

Bulleri, F., Airoidi, L., Branca, G.M., and Abbiati, M. **Positive effects of the introduced green alga, *Codium fragile* ssp. *tomentosoides*, on recruitment and survival of mussels.** *Marine Biology* 148(6): 1213-1220, 2006.

Notes: The green macroalga, *Codium fragile* ssp. *tomentosoides*, is an important component of sheltered low-shore assemblages on breakwaters along sandy shores in the northern Adriatic Sea. Macroscopic thalli of *C. fragile* are not perennial, but develop from propagules and/or undifferentiated forms in early spring, when the dominant native space-occupier, the mussel *Mytilus galloprovincialis*, recruits. By mid-summer, rapid growth of *C. fragile* leads to the formation of a dense canopy. We investigated the effects of juvenile and adult thalli of *C. fragile* on recruitment, survival and growth of mussels. Two experiments tested the hypotheses: (1) that recruitment of mussels is greater within patches of juvenile thalli (primordia) of *C. fragile* than on adjacent bare surfaces; (2) that the presence of a canopy of *C. fragile* affects the survival and growth of mussel recruits. The number of recruits of mussels was significantly larger within clumps of primordia of *C. fragile* than on bare surfaces. The removal of the canopy of *C. fragile* affected negatively the density of mussels after 2 months from the start of the experiment, but there were no effects on the mean size of individuals, nor on the size-frequency distribution. The same trend persisted after 4 months from the start of the experiment. These results show that re-colonisation of space by mussels is enhanced by *C. fragile*. Given that mussels, in turn, have the potential to reduce recruitment rates of *C. fragile*, quick recovery of mussel beds after disturbances could be crucial for controlling the abundance of this alga on breakwaters. Results also suggest that the effects of introduced species on native assemblages can be explained only through studies encompassing different life-stages of interacting organisms.

Braby, C.E. and Somero, G.N. **Ecological gradients and relative abundance of native (*Mytilus trossulus*) and invasive (*Mytilus galloprovincialis*) blue mussels in the California hybrid zone.** *Marine Biology* 148(6): 1249-1262, 2006.

Notes: Marine communities are experiencing unprecedented rates of species homogenization due to the increasing success of invasive species, but little is known about the mechanisms that allow a species to invade and persist in a new habitat. In central California, native (*Mytilus trossulus* Gould 1850) and invasive (*Mytilus galloprovincialis* Lamarck 1819) blue mussels and their hybrids co-exist, providing an opportunity to analyze the mechanisms that determine the distributions of these taxa. Spatial and temporal variation in temperature and salinity and the relative frequencies of these mussel taxa were examined between 2000 and 2004 at four sites in San Francisco Bay and four in Monterey Bay, which were chosen for their different positions

along inferred estuarine/oceanic gradients in the hybrid zone. Mussels were genetically identified as the parent species or hybrids by amplifying regions of two species-specific loci: the adhesive byssal thread protein (Glu-5') and the internal transcribed spacer region of ribosomal DNA (ITS 1). The proportion of *M. trossulus* at the eight hybrid zone sites correlated negatively with average salinity ($R^2=0.60$) and positively with maximal temperature ($R^2 \geq 0.72$), a somewhat unexpected result given what is known about the phylogeography of this species. The proportion of *M. galloprovincialis* showed the opposite pattern. The proportion of hybrids was correlated neither with habitat temperature nor salinity. Genotypes of mussel populations at an additional 13 sites from Coos Bay, Oregon (latitude 43.35°N) to Long Beach, California (latitude 33.72°N), sampled at various intervals between 2000 and 2004, were also determined. This survey confirmed previous reports that the hybrid zone lies between Monterey and the Cape Mendocino region (latitudes 36.63°N-40.5°N). Within Monterey and San Francisco Bays, however, the temporal comparisons (1990s vs. 2000s) revealed abrupt changes in the proportions of the two parent species and their hybrids on annual and decadal time scales. These changes indicate that the blue mussel populations are in a highly dynamic state. The survey also showed that, regardless of habitat, *M. trossulus* is consistently of smaller average size than either *M. galloprovincialis* or hybrids.

Reise, K., Olenin, S., and Thielges, D.W. **Are aliens threatening European aquatic coastal ecosystems?** *Helgoland Marine Research* 60(2): 77-83, 2006.

Notes: Inshore waters of European coasts have accumulated a high share of non-indigenous species, where a changeable palaeoenvironment has caused low diversity in indigenous biota. Also strongly transformed modern coastal ecosystems seem to assimilate whatever species have been introduced and tolerate the physical regime. Adding non-native species does not have any directional predetermined effects on recipient coastal ecosystems. The status of being a non-native rather refers to a position in evolutionary history than qualify as an ecological category with distinct and consistent properties. Effects of invaders vary between habitats and with the phase of invasion and also with shifting ambient conditions. Although aliens accelerate change in European coastal biota, we found no evidence that they generally impair biodiversity and ecosystem functioning. More often, invaders expand ecosystem functioning by adding new ecological traits, intensifying existing ones and increasing functional redundancy.

Gollasch, S. **Overview on introduced aquatic species in European navigational and adjacent waters.** *Helgoland Marine Research* 60(2): 84-89, 2006.

Notes: More than 1,000 non-indigenous aquatic species have been recorded, in total, from coastal Europe, i.e. navigational inland waterways for ocean-going vessels and adjacent water bodies in close proximity. Regions considered in this overview range from European Arctic waters to the Mediterranean Sea and Irish waters to the Black Sea. The majority of introduced taxa have been first recorded since the 1950s. Approximately 600 taxa (ranging from unicellular algae to vertebrates) are established with self-sustaining populations. The dominating group of exotic species across all seas is zoobenthos organisms. Introduction vectors are predominantly shipping (ballast water and hull fouling) and species movements for aquaculture or stocking purposes.

Orlova, M.I., Telesh, I.V., Berezina, N.A., Antsulevich, A.E., Maximov, A.A., and Litvinchuk, L.F. **Effects of nonindigenous species on diversity and community functioning in the eastern Gulf of Finland (Baltic Sea).** *Helgoland Marine Research* 60(2): 98-105, 2006.

Notes: An increase of xenodiversity in plankton and benthos in the eastern Gulf of Finland was observed from 1998 to 2004. Nonindigenous species account for 4.8% of all species found and up to 96% of total biomass. Invasive benthic omnivores, the alien amphipods *Gmelinoides fasciatus* and *Pontogammarus robustoides* and the predaceous fish *Perccottus glenii* with their versatile diets strongly affect the community structure. Invasive sessile seston-feeders that directly (through grazing and water clearance) and indirectly (through recycling of nutrients) interact with other ecosystem components, are mainly represented by the zebra mussel *Dreissena polymorpha*, which affect the structure of benthic and planktonic communities as well as benthic-pelagic coupling. The invasive predatory cladocerans *Cercopagis pengoi* and *Evadne anonyx* and larvae of *D. polymorpha* are only temporary components in the zooplankton, which is limiting their overall effect. Alien benthic bioturbators, the polychaetes

Marenzelleria neglecta and the oligochaete *Tubificoides pseudogaster* account for a high proportion of total abundance and biomass but their effects on native species need further research.

Kotta, J., Kotta, I., Simm, M., Lankov, A., Lauringson, V., Pollumae, A., and Ojaveer, H. **Ecological consequences of biological invasions: three invertebrate case studies in the north-eastern Baltic Sea.** *Helgoland Marine Research* 60(2): 106-112, 2006.

Notes: Population dynamics and ecological impacts of the cirriped *Balanus improvisus*, the polychaete *Marenzelleria neglecta* and the cladoceran *Cercopagis pengoi* were investigated in the north-eastern Baltic Sea. After an increase during the first decade of invasion, the density of *M. neglecta* and *C. pengoi* declined afterwards. The studied abiotic environmental variables did not explain the interannual variability in the seasonal cycles of *M. neglecta* and *C. pengoi* indicating that the species are at their initial phase of invasion. The population dynamics of *B. improvisus* was best described by water temperature. *B. improvisus* promoted the growth of the green alga *Enteromorpha intestinalis*. *M. neglecta* enhanced the content of sediment chlorophyll *a* and reduced growth and survival of the polychaete *Hediste diversicolor* and growth of the amphipod *Monoporeia affinis*. Concurrent with the invasion of *C. pengoi* the abundance of small-sized cladocerans declined, especially above the thermocline. *C. pengoi* had become an important food for nine-spined stickleback, bleak, herring and smelt.

Nehring, S. **Four arguments why so many alien species settle into estuaries, with special reference to the German river Elbe.** *Helgoland Marine Research* 60(2): 127-134, 2006.

Notes: In one of the largest European rivers, the Elbe, from its source in the Czech Republic to the German North Sea, 31 alien macrozoobenthic species have been recorded in total. Most of these species have been introduced by shipping activities. With a total number of 21 species, many of the established aliens occur - partly exclusively - in the brackish area of the Elbe estuary. In order to explain this observed settlement characteristic, four main arguments come into consideration: (1) estuaries with intensive international shipping have a higher potential infection rate than other aquatic zones; (2) brackish water species have, due to specific physiological characteristics, a better chance of being transported alive than euhaline or freshwater species and they also probably have a higher perennation and establishment potential after release; (3) brackish waters have the greatest natural 'indigenous species minimum', so that more alien species can potentially establish; and (4) salt-tolerant limnetic alien species introduced into inland water reached the coast at first in the estuaries. It seems that the combination of brackish water with its unsaturated ecological niches and intensive international ship traffic has the highest potential infection rate for aquatic systems with alien macrozoobenthic species. And, estuaries are subjected to a two-sided invasion pressure by alien species, via the ocean (mainly shipping) and via inland waters (mainly shipping canal construction). The identification of such patterns is an important prerequisite for the development of a forward-looking alien monitoring and management strategy.

Nehls, G., Diederich, S., Thieltges, D.W., and Strasser, M. **Wadden Sea mussel beds invaded by oysters and slipper limpets: competition or climate control?** *Helgoland Marine Research* 60(2): 135-143, 2006.

Notes: Introduced species are often considered to be a threat to residents, but not all reciprocal trends may reflect species interaction. In the northern German Wadden Sea, native mussel *Mytilus edulis* beds are declining and overgrown by introduced Pacific oysters *Crassostrea gigas* and slipper limpets *Crepidula fornicata*. We review the population development of the three species and analyse whether the invading species may be responsible for the decline of native mussels. The Pacific oyster predominately settles on mussel beds in the intertidal and the slipper limpet dominates around low water line. We compare the development of mussels and invaders in two subregions: mussel beds near the islands of Sylt and Amrum decreased both in the presence (Sylt) and absence (Amrum) of the two invading species and more detailed investigations could not confirm a causal relationship between the increasing invaders and decreasing mussel beds. There is evidence that the decline of mussel beds is mainly caused by failing spatfall possibly due to mild winters, whereas the increase in slipper limpets and oysters is facilitated by mild winters and warm summers, respectively. We conclude that changing species composition is a result of the climatic conditions in the last decade and that there is no evidence yet that the exotic species caused the decline of the natives. It remains an open question whether the species shift will continue and what the consequences for the native ecosystem will be.

Viard, F., Ellien, C., and Dupont, L. **Dispersal ability and invasion success of *Crepidula fornicata* in a single gulf: insights from genetic markers and larval-dispersal model.** *Helgoland Marine Research* 60(2): 144-152, 2006.

Notes: The success of an exotic species relies on many factors including dispersal capabilities and adaptation to novel environments. In particular, rapid spread from an initial point of introduction favours long-term establishment of exotic species, especially when large genetic diversity is maintained during the colonization phase. We here focused on the slipper limpet, *Crepidula fornicata*, a species native to the western Atlantic that has successfully invaded European bays and estuaries since the end of the nineteenth century following repeated introductions. Its settlement at high densities has major consequences on the macro-benthic fauna and flora. The aim of the present study was to analyse the ability of *C. fornicata* for rapid diffusion and long-distance dispersal, at the level of a large French gulf, namely the Gulf of St-Malo (covering 120 km in latitude and 40 km in longitude) in the English Channel. The genetic architecture of 16 populations distributed all over this gulf was investigated using five microsatellite loci. Genetic diversity was found to be high and did not vary significantly with population density, population age or geographic location. Moreover, despite potential isolation among populations due to a strong tidal regime and the action of wind-induced currents, only weak barriers to gene flow were found across the gulf. These results were in agreement with results obtained from a simple 2D larval dispersal model. Both genetic data and the simulation model highlighted the potential for rapid and efficient spread of *C. fornicata* at a regional level.

Savini, D. and Occhipinti-Ambrogi, A. **Consumption rates and prey preference of the invasive gastropod *Rapana venosa* in the Northern Adriatic Sea.** *Helgoland Marine Research* 60(2): 153-159, 2006.

Notes: The alien Asian gastropod *Rapana venosa* (Valenciennes 1846) was first recorded in 1973 along the Italian coast of the Northern Adriatic Sea. Recently, this predator of bivalves has been spreading all around the world oceans, probably helped by ship traffic and aquaculture trade. A caging experiment in natural environment was performed during the summer of 2002 in Cesenatico (Emilia-Romagna, Italy) in order to estimate consumption rates and prey preference of *R. venosa*. The prey items chosen were the Mediterranean mussel *Mytilus galloprovincialis* (Lamarck 1819), the introduced carpet clam *Tapes philippinarum* (Adams and Reeve 1850), both supporting the local fisheries, and the Indo-Pacific invasive clam *Anadara* (*Scapharca*) *inaequivalvis* (Bruguier 1789). Results showed an average consumption of about 1 bivalve prey per day (or 1.2 g wet weight per day). Predation was species and size selective towards small specimens of *A. inaequivalvis* consumption of the two commercial species was lower. These results might reduce the concern about the economical impact on the local bivalve fishery due to the presence of the predatory gastropod. On the other hand, selective predation might probably alter local community structure, influencing competition amongst filter feeder/suspension feeder bivalve species and causing long-term ecological impact. The large availability of food resource and the habitat characteristics of the Emilia-Romagna littoral makes this area an important breeding ground for *R. venosa* in the Mediterranean Sea, thus worthy of consideration in order to understand the bioinvasion ecology of this species and to control its likely further dispersal.

Cardigos, F., Tempera, F., Avila, S., Goncalves, J., Colaco, A., and Santos, R.S. **Non-indigenous marine species of the Azores.** *Helgoland Marine Research* 60(2): 160-169, 2006.

Notes: Marine benthic species introduced to the Azores are collated from scientific publications, internal reports and own data. Twelve algae and 21 invertebrates are classified as non-indigenous species, 18 as cryptogenic. Two species of algae and two ascidians are regarded as particularly invasive along the shores of this oceanic archipelago.