

### In this review:

#### A. Recent articles with abstracts

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Soto, D., Arismendi, I., DiPrinzio, C., and Jara, F. **Establishment of Chinook salmon (*Oncorhynchus tshawytscha*) in Pacific basins of southern South America and its potential ecosystem implications.** *Revista Chilena de Historia Natural* 80(1): 81-98, 2007.

**Notes:** Salmon and trout species are not native to the southern hemisphere, however rainbow and brown trout have been established a century in southern South America. Yet most attempts to introduce anadromous salmon failed until the onset of aquaculture by 1980. Escapes of *Oncorhynchus tshawytscha* (Chinook salmon) from aquaculture after 1990 have apparently produced increasingly important reproductive returns "naturalized" to upper basins in Chile and Argentina south of 39°S. In this paper we show data on the historic and spatial occurrence of chinook salmon in four Pacific basins during the past decade. Our objective is to establish the progress of the settlement forecasting some ecosystem disruptions in order to project and manage potential impacts. In Chile, sampling took place from 1995 to 2005 including rivers Petrohue, Poicas, and Rio Negro-Hornopiren, and Lake Puyehue, in the X Region. In Argentina sampled rivers were Futaleufu, Carrenleufu and Pico. In Chile and Argentina reproductive Chinooks ranged in size between 73 and 130 cm total length, being the smallest sizes those of Lake Puyehue where the population is apparently landlocked. In Rio Petrohue, the size of the runs varied from year to year reaching in the peak season of 1996 and 2004 up to 500 kg of fish along 100 m of riverbank. Temporal distribution of juvenile Chinooks suggested mainly a typical ocean type as they are gone to sea within the first year of age. As seen in Petrohue, reproductive populations could import significant quantities of marine derived nutrients as they do in their original habitats thus disturbing natural cycles and balances. Chinook establishment in these pristine watersheds in southern South America poses new challenges for decision makers and fishermen since they may develop a fishery in the Pacific Ocean with consequences to other fishery resources. Additionally they also become a resource for sport fishing. Therefore there is the need of developing management tools and approaches to control the populations avoiding irreversible ecosystem disruptions and social conflicts.

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McCann, L.D., Hitchcock, N.G., Winston, J.E., and Ruiz, G.M. **Non-native bryozoans in coastal embayments of the Southern United States: New records for the western Atlantic.** *Bulletin of Marine Science* 80(2): 319-342, 2007.

**Notes:** Bryozoans are among the most common fouling organisms in coastal marine environments around the world, yet their distribution in many coastal areas is not well known. We surveyed the bryozoans in shallow coastal estuaries in the southern United States, focusing on Texas and Florida. We deployed settlement plates across six different estuaries at 61 sites. Thirty-five species of bryozoans were identified, including four non-native species described here for the first time from the United States: *Hippoporina indica* (Pillai, 1978), *Electra bengalensis* (Stoliczka, 1869), *Sinoflustra annae* (Osburn, 1953), and *Celleporaria pilaefera* (Canu and Bassler, 1929). At all six estuaries, non-native species were among the most common bryozoans. *Hippoporina indica* was the most abundant bryozoan, occurring in all estuaries sampled. In Jacksonville, Florida, *E. bengalensis* and *S. annae* dominated both the numbers and biomass of bryozoans. All four species have probable Indo-West Pacific origins. A literature-based analysis identified 39 additional non-native species of marine invertebrates and algae already established in the region, and over half are considered to have an Indo-West Pacific origin. Ships from Asia are regular visitors to Florida and the Gulf of Mexico, providing a possible mechanism of introduction for the non-native bryozoans.

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D'Archino, R., Nelson, W.A., and Zuccarello, G.C. **Invasive marine red alga introduced to New Zealand waters: first record of *Grateloupia turuturu* (Halymeniaceae, Rhodophyta).** *New Zealand Journal of Marine and Freshwater Research* 41(1): 35-42, 2007.

**Notes:** The red alga *Grateloupia turuturu* is recorded from New Zealand waters for the first time. This species, native to Japan, is considered to be invasive in western Europe, North America, and Tasmania. The occurrence of *G. turuturu* is confirmed by molecular analysis of chloroplast-encoded *rbcL* and mitochondrial *cox2-3* spacer sequences as well as the vegetative and reproductive anatomy of both tetrasporophyte and gametophyte specimens.

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Glasby, T.M., Connell, S.D., Holloway, M.G., and Hewitt, C.L. **Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions?** *Marine Biology* 151(3): 887-895, 2007.

**Notes:** We identified different distributions of marine nonindigenous species (NIS) and native species on some artificial structures versus natural reefs and using experimental manipulations, revealed some possible causal mechanisms. In well-established subtidal assemblages, numbers of NIS were 1.5-2.5 times greater on pontoons or pilings than on rocky reefs, despite the local species pool of natives being up to 2.5 times greater than that of NIS. Conversely, on reefs and seawalls, numbers of native species were up to three times greater than numbers of NIS. Differential recruitment to different positions and types of surfaces appeared to influence distribution patterns. NIS recruited well to most surfaces, particularly concrete surfaces near the surface of the water, whilst natives occurred infrequently on wooden surfaces. The position of rocky reefs and seawalls close to the shore and to the seabed appeared to make them favourable for the recruitment of natives, but this positioning alone does not hinder the recruitment of NIS. We argue that pontoons and pilings represent beachheads (i.e. entry points for invasion) for many nonindigenous epibiota and so enhance the spread and establishment of NIS in estuaries. Habitat creation in estuaries may, therefore, be a serious threat to native biodiversity.

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Thomsen, M.S., Wernberg, T., Staehr, P., Krause-Jensen, D., Risgaard-Petersen, N., and Silliman, B.R. **Alien macroalgae in Denmark - a broad-scale national perspective.** *Marine Biology Research* 3(2): 61-72, 2007.

**Notes:** Most studies documenting the importance of alien macroalgae relative to native species are based on smaller-scale sampling programmes. Between 1989 and 2003, a Danish monitoring programme collected data on the percentage cover of macroalgae at more than 600 locations throughout the country. We examined this data set to estimate the relative abundance of alien species in the algal flora on large spatiotemporal scales, i.e. across depth ranges, regions and years. Of the 10 alien macroalgal species known to inhabit Danish coastal waters, nine were found in the survey. Most of the alien species were only present in low quantities (<1% of the entire flora). In contrast, the two most common alien species, *Sargassum muticum* and *Bonnemaisonia hamifera*, constituted 2-7% of the assemblages, depending on depth, region and year. *Sargassum muticum* was abundant from 0 to 5 m in the northwestern region, where salinity and species richness are highest, whereas *B. hamifera* was abundant in several regions in deeper waters, where the native flora is species-poor. Based on their relatively high abundance, we hypothesize that these two aliens have had the largest impact on the native communities. Of some concern is the recent introduction of *Gracilaria vermiculophylla*. This species has traits that match the conditions of Danish estuaries and may become widespread with potential negative impacts on native biota.

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Cordell, J.R., Rasmussen, M., and Bollens, S.M. **Biology of the introduced copepod *Pseudodiaptomus inopinus* in a northeast Pacific estuary.** *Marine Ecology Progress Series* 333: 213-227, 2007.

**Notes:** Compared to other regions, estuaries and coastal bays along the west coast of North America have experienced the largest number of invasions by nonindigenous planktonic copepods. Eight species of copepods from Asia, including 2 species of the genus *Pseudodiaptomus*, have been reported in coastal bays of northern California, and a third species of Asian *Pseudodiaptomus* (*P. inopinus*) has become established in the Columbia River estuary and many smaller estuaries in the northeast Pacific Ocean. It can dominate the plankton in fresh and oligohaline tidal waters of estuaries that are utilized as rearing grounds for a variety of larger invertebrates and fishes. In July 1998 we initiated a 16 mo study of *P. inopinus* in the Chehalis

River estuary, Washington State, USA, to document its biology, ecological relationships with other holoplankton, and importance as prey for fish and invertebrate planktivores. In 1998 *P. inopinus* reached peak densities in the late summer/early autumn period of low river flow but a similar peak was not seen in the same period in 1999, when densities of the copepod were significantly lower. These interannual density differences did not appear to be caused by between-year differences in predation or river flooding, but could have resulted from cooler temperatures and higher river flows that occurred in the Chehalis River in 1999. Other abundant planktonic copepods were separated from *P. inopinus* either temporally (*Eurytemora affinis*) or spatially (*Acartia* spp., *Eurytemora americana*) within the estuary, over a relatively short segment of the estuary spanning salinities of 0 to 10 psu. This separation may imply that *P. inopinus* experienced little competition when it was introduced; alternatively, it may have altered the distribution of other copepods in the estuary. *P. inopinus* was rare in the diets of estuarine fishes, but comprised an important and sometimes dominant prey for mysid shrimp *Neomysis mercedis* and juvenile caridean shrimp *Crangon franciscorum*. In turn, *N. mercedis* was an important prey item for estuarine fishes, and thus the main impact of *P. inopinus* on the estuarine food web was via this pathway.

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Fridley, J.D., Stachowicz, J.J., Naeem, S., Sax, D.F., Seabloom, E.W., Smith, M.D., Stohlgren, T.J., Tilman, D., and Von Holle, B. **The invasion paradox: Reconciling pattern and process in species invasions.** *Ecology* 88(1): 3-17, 2007.

**Notes:** The invasion paradox describes the co-occurrence of independent lines of support for both a negative and a positive relationship between native biodiversity and the invasions of exotic species. The paradox leaves the implications of native-exotic species richness relationships open to debate: Are rich native communities more or less susceptible to invasion by exotic species? We reviewed the considerable observational, experimental, and theoretical evidence describing the paradox and sought generalizations concerning where and why the paradox occurs, its implications for community ecology and assembly processes, and its relevance for restoration, management, and policy associated with species invasions. The crux of the paradox concerns positive associations between native and exotic species richness at broad spatial scales, and negative associations at fine scales, especially in experiments in which diversity was directly manipulated. We identified eight processes that can generate either negative or positive native-exotic richness relationships, but none can generate both. As all eight processes have been shown to be important in some systems, a simple general theory of the paradox, and thus of the relationship between diversity and invasibility, is probably unrealistic. Nonetheless, we outline several key issues that help resolve the paradox, discuss the difficult juxtaposition of experimental and observational data (which often ask subtly different questions), and identify important themes for additional study. We conclude that natively rich ecosystems are likely to be hotspots for exotic species, but that reduction of local species richness can further accelerate the invasion of these and other vulnerable habitats.

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Saltonstall, K. and Stevenson, J.C. **The effect of nutrients on seedling growth of native and introduced *Phragmites australis*.** *Aquatic Botany* 86(4): 331-336, 2007.

**Notes:** Differing responses to abiotic stresses and increased nutrient availability may play a role in the invasion and spread of introduced *Phragmites australis* Cav. (Trin.) ex. Steud. and the decline of native *P.a. americanus* Saltonstall, P.M. Peterson & Soreng in North America. We present results from an outdoor experiment where native and introduced *P. Australis* seedlings were grown under two nutrient treatments. Both subspecies responded positively to increased nutrients but introduced plants clearly outperformed natives, growing taller, producing more stems, and had three to four times higher biomass. The biomass of introduced *P. australis* growing in low nutrients was similar to that of the native in high nutrients. Aboveground: belowground biomass ratios were nearly 1.25 for both native and introduced plants across treatments and reflect the high investment *P. australis* seedlings place on shoot production in their first year of growth. Our results also demonstrate that introduced *P. australis* can have explosive growth over a single growing season, even when established from seed. This implies that management of young, newly established populations may be prudent where introduced *P. australis* is considered undesirable, irregardless of whether eutrophication is an issue.

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Ballesteros, E., Cebrian, E., and Alcoverro, T. **Mortality of shoots of *Posidonia oceanica* following meadow invasion by the red alga *Lophocladia lallemandii*.** *Botanica Marina* 50(1): 8-13, 2007.

**Notes:** *Lophocladia lallemandii*, an Indo-Pacific alga that is currently invading several Mediterranean areas, is especially aggressive when colonizing meadows of *Posidonia oceanica* in Formentera (Balearic Islands). *L. lallemandii* settles on rhizomes and old leaves situated mainly at meadow edges and in low density *Posidonia* patches, growing rapidly, producing disc-like holdfasts along the thalli that allow formation of a mat of the red algal filaments intermingled with *P. oceanica* leaves. This mat can get so thick and dense that now leaves become confined inside the web of red algal filaments. The seagrass leaves display chlorosis and sometimes die. Invasion by *L. lallemandii* significantly reduces seagrass shoot size, leaf biomass, and percentage of living shoots. A lower content of sucrose in shoots from invaded plots points to a reduction of photosynthetic activity. However, other causes such as enhanced sediment trapping, organic and nutrient enrichment inside the algal carpet, and increased oxygen consumption may jointly or individually contribute to observed seagrass shoot demise.

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Finnoff, D., Shogren, J.F., Leung, B., and Lodge, D. **Take a risk: Preferring prevention over control of biological invaders.** *Ecological Economics* 62(2): 216-222, 2007.

**Notes:** Scientists have argued that invasive species can be managed most cost effectively with greater investments in prevention. Further, under ideas like the precautionary principle it is reasonable to expect that a cautious manager would use more prevention relative to control because it keeps more invaders out. Yet, this is not typically done. In many cases, private and public resources are invested primarily to control existing invaders rather than to prevent new invasions. Managers frequently wait until after invaders have arrived and then scramble to limit the damages. We believe these paradoxical decisions can be understood by recognizing the link between typical human preferences for risk bearing and the technology of risk reduction. We demonstrate quantitatively how managers perceived to be cautious or averse to risk tend to shy away from prevention relative to control. This counterintuitive result arises because control is a safer choice than prevention because its productivity is relatively less risky: it works to remove existing invaders from the system. In contrast, the productivity of prevention is more uncertain because prevention only reduces the chance of invasion, it does not eliminate it, and invasion may not occur even in the absence of prevention. Managers' averse to risk will inherently avoid as much uncertainty as possible, whether the source of uncertainty regards ecological outcomes or economic productivity. Implications for environmental decision making are clear. In invasive species management, if managers act as though they are risk averse, their caution can backfire when it leads to more control rather than prevention. The social consequences of this choice are a greater probability of future invasions and lower social welfare. Our results suggest that social welfare is highest when managers were willing to "take a risk" with prevention.

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Blanchet, S., Loot, G., Bernatchez, L., and Dodson, J.J. **The disruption of dominance hierarchies by a non-native species: an individual-based analysis.** *Oecologia* 152(3): 569-581, 2007.

**Notes:** We studied the effects of the exotic rainbow trout (*Oncorhynchus mykiss*) on the performance and the dominance hierarchy of native Atlantic salmon (*Salmo salar*) at the group and individual level using laboratory and semi-natural experiments. At the group level, we compared the effects of interspecific and intraspecific competition (substitutive and additive design) on behavioural responses and growth of young-of-the-year Atlantic salmon. At the individual level, the same design was used to evaluate: (1) the temporal consistency of behavioural responses, dominance hierarchy and growth rate of Atlantic salmon; (2) the pattern of correlations between behaviours; and (3) the relationship between individual growth rate and behaviour. In the laboratory, group-level analyses revealed a weak but similar effect of rainbow trout and intraspecific competition on the behaviour and growth of Atlantic salmon. In contrast, individual-based analyses demonstrated that rainbow trout (but not intraspecific competition) strongly affected behavioural strategy, dominance hierarchy and growth trajectory of individual Atlantic salmon. Specifically, behaviours, dominance status and growth rate of salmon were temporally consistent in the intraspecific environment, while these patterns were disrupted when rainbow trout were present. Similarly, we found that rainbow trout strongly affected behavioural correlations and the relationships between individual growth rate and behaviour. The semi-natural experiments confirmed these results as interspecific competition affected relationships between individual growth rate of salmon, initial weight and activity index. Overall, individual-based analyses highlighted important mechanisms that were concealed at the group level, and that may be crucial to understand ecological and evolutionary consequences of exotic species. Moreover, these results demonstrated that competition with an exotic species disrupts the hierarchical relationship among native individuals and may therefore represent a potential for a shift in selective pressure.

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Boersma, M., Malzahn, A.M., Greve, W., and Javidpour, J. **The first occurrence of the ctenophore *Mnemiopsis leidyi* in the North Sea.** *Helgolander Meeresunters* 61(2): 153-155, 2007.

**Notes:** After the discovery of large densities of *Mnemiopsis leidyi* in the Baltic Sea near Kiel by Javidpour et al. (First record of *Mnemiopsis leidyi* A. Agassiz 1865 in the Baltic Sea, 2006) in October 2006, we investigated the gelatinous zooplankton in the North Sea near Helgoland and recorded *Mnemiopsis leidyi* for the first time in the North Sea, albeit in much lower densities than those recorded in the Baltic Sea.

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Bailey, S.A., Duggan, I. C., Nandakumar, K., and MacIsaac, H.J. **Sediments in ships: Biota as biological contaminants.** *Aquatic Ecosystem Health and Management* 10(1): 93-100, 2007.

**Notes:** Global ports are hubs for industrial activities and trade. In consequence, sediments and water in these areas are often contaminated by an array of chemicals. Sediments also harbour both living, active stages and various diapausing or resting stages of biota. International shipping activities move sediments containing these biotic stages around the world, possibly resulting in biological contamination of port areas. In this study we assess active and resting stages of invertebrates contained in ballast sediment of transoceanic vessels operating on the North American Great Lakes to determine if ballast sediments could serve as a vector of nonindigenous species. A cumulative total of 160 species were identified, including 22 freshwater species not recorded from the Great Lakes' basin. Hatch rates of resting stages are affected by thermal conditions, thereby affecting invasion success. Total abundance and species diversity of freshwater invertebrate animals hatched from resting stages were negatively related to salinity of residual water in ballast tanks from which the sediments were obtained, suggesting that ballasting a shallow lens of saltwater may provide some degree of risk reduction from freshwater species invasions.

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Meyerson, L.A. and Mooney, H.A. **Invasive alien species in an era of globalization.** *Frontiers in Ecology and Environment* 5(4): 199-208, 2007.

**Notes:** Globalization facilitates the spread of invasive alien species (IAS) as international commerce develops new trade routes, markets, and products. New technologies increase the pace at which humans and commodities can move around the world. Recent research on IAS at the global scale has examined commerce and travel in order to inform predictions, risk analyses, and policy. Due to limited data, regional-scale studies have primarily focused on invasion patterns rather than impacts. Local-scale experimental research can identify mechanisms and impacts of biological invasions, but the results may not be applicable at larger spatial scales. However, the number of information networks devoted to IAS is increasing globally and may help integrate IAS research at all scales, particularly if data sharing and compatibility can be improved. Integrating ecological and economic factors with trade analysis to explore the effectiveness of different approaches for preventing invasions is a promising approach at the global scale.

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Mack, R.N., Von Holle, B., and Meyerson, L.A. **Assessing invasive alien species across multiple spatial scales: working globally and locally.** *Frontiers in Ecology and Environment* 5(4): 217-220, 2007.

**Notes:** Quantitative investigations on invasive alien species (IAS) across multiple spatial scales are needed because biological invasions often encompass enormous expanses in both donor and invaded ranges and because the immigrants may be carried great distances between these ranges. Although invasion biology is rich in anecdotes, translation of this information into generalizations remains limited by technical shortcomings in data acquisition, inconsistent data assembly, and the continuing search for meaningful indices of the impact of IAS. Much better justification of and greater opportunities to combat IAS could be achieved by distilling all information for IAS into spatially explicit case histories and synthetic predictions on the epidemiology and consequences of biological invasions for public review, discussion, and action.

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Eastwood, M.M., Donahue, M.J., and Fowler, A.E. **Reconstructing past biological invasions: niche shifts in response to invasive predators and competitors.** *Biological Invasions* 9(4): 397-407, 2007.

**Notes:** Studying historic invasions can provide insight into the ongoing invasions that threaten global biodiversity. In this study, we reconsider the impacts of *Littorina littorea* and *Carcinus maenas* on the rocky intertidal community of the Gulf of Maine. Past research using invader-removal experiments demonstrated strong top-down effects of *L. littorea* on algal community structure; however, such removal experiments may overlook the long-term effects of niche shifts and local extinctions caused by invasive species. We considered how a niche-shift in the native littorine, *Littorina saxatilis*, may change the interpretation of *L. littorea* impacts. Using a factorial experiment crossing predator presence/absence with *L. littorea* presence/absence, we found that *L. saxatilis* is able to exert top-down control on ephemeral algae similar to that exerted by *L. littorea* and that both competition by *L. littorea* and predation by *C. maenas* have strong, negative impacts on *L. saxatilis*. We also found higher predation rates on protected shores and at lower tidal heights and preferential predation on *L. saxatilis* compared to *L. littorea*. While movement experiments demonstrate that behavioral response to tidal height is the proximate cause of *L. saxatilis* exclusion from the lower intertidal, our study suggests that the ultimate causes are the additive effects of competition from and predation by invasive species.

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Ojaveer, H., Gollasch, S., Jaanus, A., Kotta, J., Laine, A.O., Minde, A., Normant, M., and Panov, V.E. **Chinese mitten crab *Eriocheir sinensis* in the Baltic Sea - a supply-side invader?** *Biological Invasions* 9(4): 409-418, 2007.

**Notes:** Although the Chinese mitten crab *Eriocheir sinensis* (H. Milne- Edwards, 1853) (Crustacea, Decapoda, Varunidae) invaded the Baltic Sea about 80 years ago, published information on its present distribution and abundance in this region is lacking. We provide here information on its Baltic-wide distribution and long-term population dynamics. The species has been found all over the coastal Baltic Sea and also in some adjacent rivers and lakes. The Chinese mitten crab appears to have increased in abundance in recent years in the northeastern part of the Baltic Sea (Gulf of Finland, Gulf of Riga, northern Baltic Proper). Higher catch rates were observed in spring (April-June) and autumn (September-November). The size variation of crabs in different samples was low (mean carapace width 6.1-6.3 cm). Despite findings of gravid females, the reproduction of the mitten crab in the central, northern and eastern Baltic region is considered unlikely due to low salinity and the individuals caught are assumed to actively migrate into the region from the species' main European distribution area (southeastern North Sea), certainly over 1500 km migration distance. Thus, the dynamics of the North Sea population is probably regulating, at least in part, the occurrence of the Chinese mitten crab in the Baltic Sea area.

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Bolch, C.J.S. and de Salas, M.F. **A review of the molecular evidence for ballast water introduction of the toxic dinoflagellates *Gymnodinium catenatum* and the *Alexandrium "tamarensis" complex* to Australasia.** *Harmful Algae* 6(4): 465-485, 2007.

**Notes:** The potential of ballast water to act as a major introduction vector for toxic dinoflagellates and other phytoplankton is beyond doubt; however, evidence that links the suspected introduced species with a source population is less convincing, especially without supporting historical and biochemical data, or consideration of palaeobiogeographical scenarios that may explain current species distributions. This paper presents new molecular data based on LSU- rDNA and rDNA-ITS sequences that demonstrate an unequivocal and recent link between temperate Asian and Australasian populations of the toxic dinoflagellates *Gymnodinium catenatum* and toxic strains of the *Alexandrium "tamarensis" complex*". We integrate our data with supporting evidence from historical distribution records, sediment dating studies, toxin profiles, mating studies and previous molecular studies. We contrast the observed patterns of genetic and biochemical variation with those expected from various palaeobiogeographical scenarios explaining the evolution and natural dispersal of both species. While definitive proof is impossible, the total evidence indicates that these toxic dinoflagellates were introduced to Australasia during the past 100 years, most probably via ballast water from bulk-cargo shipping from Japan and/or south-east Asia.

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Burkholder, J.M., Hallegraeff, G.M., Melia, G., Cohen, A., Bowers, H.A., Oldach, D.W., Parrow, M.W., Sullivan, M.J., Zimba, P.V., Allen, E.H., Kinder, C.A., and Mallin, M.A. **Phytoplankton and bacterial assemblages in ballast water of US military ships as a function of port of origin, voyage time, and ocean exchange practices.** *Harmful Algae* 6(4): 486-518, 2007.

**Notes:** We characterized the physical/chemical conditions and the algal and bacterial assemblages in ballast water from 62 ballast tanks aboard 28 ships operated by the U.S. Military Sealift Command and the Maritime Administration, sampled at 9

ports on the U.S. West Coast and 4 ports on the U.S. East Coast. The ballast tank waters had been held for 2-176 days, and 90% of the tanks had undergone ballast exchange with open ocean waters. Phytoplankton abundance was highly variable (grand mean for all tanks,  $3.21 \times 10^4$  viable cells  $m^{-3}$ ; median,  $7.9 \times 10^3$  cells  $m^{-3}$ ) and was unrelated to physical/chemical parameters, except for a positive relationship between centric diatom abundance and nitrate concentration. A total of 100 phytoplankton species were identified from the ballast tanks, including 23 potentially harmful taxa (e.g. *Chaetoceros concavicornis*, *Dinophysis acuminata*, *Gambierdiscus toxicus*, *Heterosigma akashiwo*, *Karlodinium veneficum*, *Prorocentrum minimum*, *Pseudo-nitzschia multiseries*). Assemblages were dominated by chain-forming diatoms and dinoflagellates, and viable organisms comprised about half of the total cells. Species richness was higher in ballast tanks with coastal water, and in tanks containing Atlantic or Pacific Ocean source waters rather than Indian Ocean water. Total and viable phytoplankton numbers decreased with age of water in the tanks. Diversity also generally decreased with water age, and tanks with ballast water age >33 days did not produce culturable phytoplankton. Abundance was significantly higher in tanks with recently added coastal water than in tanks without coastal sources, but highly variable in waters held less than 30 days. Bacterial abundance was significantly lower in ballast tanks with Atlantic than Pacific Ocean source water, but otherwise was surprisingly consistent among ballast tanks (overall mean across all tanks,  $3.13 \pm 1.27 \times 10^{11}$  cells  $m^{-3}$ ; median,  $2.79 \times 10^{11}$  cells  $m^{-3}$ ) and was unrelated to vessel type, exchange status, age of water, environmental conditions measured, or phytoplankton abundance. At least one of four pathogenic eubacteria (*Listeria monocytogenes*, *Escherichia coli*, *Mycobacterium* spp., *Pseudomonas aeruginosa*) was detected in 48% of the ballast tanks, but toxigenic strains of *Vibrio cholerae* were not detected. For ships with tanks of similar ballasting history, the largest source of variation in phytoplankton and bacteria abundance was among ships; for ships with tanks of differing ballasting histories, and for all ships/tanks considered collectively, the largest source of variation was within ships. Significant differences in phytoplankton abundance, but not bacterial abundance, sometimes occurred between paired tanks with similar ballasting history; hence, for regulatory purposes phytoplankton abundance cannot be estimated from single tanks only. Most tanks (94%) had adequate records to determine the source locations and age of the ballast water and, as mentioned, 90% had had ballast exchange with open-ocean waters. Although additional data are needed from sediments that can accumulate at the bottom of ballast tanks, the data from this water-column study indicate that in general, U.S. Department of Defense (DoD) ships are well managed to minimize the risk for introduction of harmful microbiota. Nevertheless, abundances of viable phytoplankton with maximum dimension >50  $\mu m$  exceeded proposed International Maritime Organization standards in 47% of the ballast tanks sampled. The data suggest that further treatment technologies and/or alternative management strategies will be necessary to enable DoD vessels to comply with proposed standards.

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McCollin, T., Shanks, A.M., and Dunn, J. **The efficiency of regional ballast water exchange: Changes in phytoplankton abundance and diversity.** *Harmful Algae* 6(4): 531-546, 2007.

**Notes:** Ballast water was sampled on 12 occasions before and after an exchange process carried out in regional seas in order to assess the efficiency of this type of ballast water management at reducing the abundance and diversity of phytoplankton. Although there was an overall reduction in the average abundance and number of taxa after exchange this was not consistent between tanks and voyages. On some occasions there were changes in species composition after exchange and, in some cases, there were increases in potentially harmful species after the exchange process. Factors such as the depth of the water during the exchange process, the season and the method of exchange influenced the efficacy of the exchange process. The variability in the results after exchange mean that this is unlikely to be a ballast water management method that would give consistent results and careful consideration would have to be given to the suitability of using this method in regional seas as a means of reducing the risk of introducing non-native species.

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Gollasch, S., David, M., Voigt, M., Dragsund, E., Hewitt, C., and Fukuyo, Y. **Critical review of the IMO international convention on the management of ships' ballast water and sediments.** *Harmful Algae* 6(4): 585-600, 2007.

**Notes:** The International Maritime Organization (IMO), the United Nations body which administers the international regulatory regime for shipping, noted the negative impact of non-indigenous organisms transported in the ballast water of ships already in the early 1970s. Consequently, measures were taken with the aim to minimize ballast water mediated species invasions through IMO Marine Environmental Protection Committee (MEPC) Resolutions. As a result of long-term IMO efforts, it was determined that an international convention would best meet the needs of the global community, hence the International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted in a Diplomatic Conference in 2004 and is now open for signature by IMO Member States. This very complex (and by no means "simple") Convention aims to reduce the transfer and subsequent impact of aquatic organisms in the ballast water and

sediment of ships by acting to reduce the load of these organisms in discharged ballast water. A set of 15 guidelines provides technical guidance for the implementation of the Convention principles. This review considers critical aspects of this Convention and selected guidelines seen from perspectives, of biological, shipping and regulatory concerns.

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Smayda, T.J. **Reflections on the ballast water dispersal - harmful algal bloom paradigm.** *Harmful Algae* 6(4): 601-622, 2007.

**Notes:** The ballast water dispersal-HAB paradigm, increasingly invoked circumstantially to explain puzzling and unaccountable HAB species outbreaks when lacking the multiple tests of confirmation recommended by Bolch and de Salas (2007), is evaluated. The types and examples of natural dispersions and taxon cycles are compared to exotic species bloom behavior linked to ballast water vectoring. The regional spreading, bloom behavior and disjunct distributions of the brown tide pelagophyte *Aureococcus anophagefferens* and the toxic dinoflagellate *Gymnodinium catenatum*, attributed to ballast water vectoring, are used as representative examples to evaluate the general application of the ballast water-HAB paradigm and associated interpretative problems. Human-aided emigration has a seeding and colonization ecology that differs from bloom ecology. For self-sustaining blooms to occur, these two ecologies must be accommodated by habitat growth conditions. The three stages that a non-native species must pass through (pioneering, persistence, community entry) to achieve colonization, community maintenance, and to bloom, and the niche-related factors and role of habitat disturbance are discussed. The relevance of cryptic occurrences, cyst deposits, dormancy periods and bloom rhythms of HAB species to their blooms attributed to ballast water-assisted introductions is also sketched. The different forms of HAB species rarity, their impact on the ballast water dispersal-HAB paradigm, and the dispersion and blooms of specialist and generalist HAB species are discussed. The remarkable novel and, often, monospecific blooms of dinoflagellate HAB species are being paralleled by similar eruptive bloom behavior cutting across phylogenetic lines, and being found also in raphidophytes, haptophytes, diatoms, silicoflagellates, etc. These blooms cannot be explained only as seeding events. An ecological release of 'old barriers' appears to be occurring generally at coastal bloom sites, i.e. something significant is happening ecologically and embedded within the ballast water-HAB paradigm. There may be a relationship between Life Form type [Smayda, T.J., Reynolds, C.S., 2001. Community assembly in marine phytoplankton: application of recent models to harmful dinoflagellate blooms. *J. Plankton Res.* 23, 447-461] and mode of expatriation; HAB dinoflagellate species commonly reported to produce ballast water-assisted toxic blooms invariably are members of cyst-producing Life Forms IV, V, VI. Ballast water vectoring of Life Forms I, II, III is rarely reported, even though many produce cysts, and where their novel introductions do occur they are more likely to be ichthyotoxic, and vectored in shellfish stock consignments. The relevance of, and need to distinguish between morphospecies and their geographic/ribotype clades are discussed based on the *Alexandrium tamarense/catenella/fundyense* complex. Morphospecies-level ballast water dispersions are probably minor compared to the dispersal of the different ribotypes (toxic/non-toxic clades) making up HAB morphospecies; the redistribution and admixture of genotypes should be the focus. Ballast water-assisted expatriations impact the global occurrence of HABs through the direct transfer of previously absent species or introduction of genetic strains from the donor habitat that are ecologically favored over resident strains. The hybridization of species may be of potentially greater impact, resulting from the (1) mating of individuals from the donor and recipient habitats, or (2) through the interbreeding of strains introduced from to different donor sites into the recipient site, and whose progeny have greater ecological fitness than indigenous strains. Exceptional ecological changes of some sort appear to be occurring globally which, in combination with the genetically altered ecophysiological behavior of HAB species linked to ballast water dispersion and admixture, underpins the global HAB phenomenon. The impact of ballast water and shellfish transplantation on HABs and phytoplankton community ecology, generally, is considerably greater than the current focus on HAB species distributions, vectoring, and blooms. The methodological, investigative and conceptual potential of the ballast water-HAB paradigm should be exploited by developing a GEOHAB type initiative to advance quantification of global HAB ecology.

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Wallentinus, I. and Nyberg, C.D. **Introduced marine organisms as habitat modifiers.** *Marine Pollution Bulletin* 55(7-9): 323-332, 2007.

**Notes:** Introductions of non-indigenous species (NIS) are mostly discussed through their impact on biodiversity. However, NIS can also act as ecosystem engineers, influencing the habitat itself, positively or negatively, directly or indirectly, which should be included when making risk assessments. Special concern should be given to changes in ecological services provided by the ecosystem. Physically, NIS may affect the substrate itself, or alter habitat architecture, indirectly influencing water movements, sediment accumulation, and light conditions. Chemical changes brought upon by NIS occur both on small and

large scales, some having positive effects on ecosystem services, others can perturb epibionts. Furthermore, NIS may negatively affect natural resources, aquaculture or create fouling communities, all resulting in a negative impact on economics. However, if removed, already established NIS can be used as bioremediators, having a positive effect on different ecosystems. Using NIS for habitat management may be economically profitable, but could affect the habitat adversely.

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Drake, L.A., Doblin, M.A., and Dobbs, F.C. **Potential microbial bioinvasions via ships' ballast water, sediment, and biofilm.** *Marine Pollution Bulletin* 55(7-9): 333-341, 2007.

**Notes:** A prominent vector of aquatic invasive species to coastal regions is the discharge of water, sediments, and biofilm from ships' ballast-water tanks. During eight years of studying ships arriving to the lower Chesapeake Bay, we developed an understanding of the mechanisms by which invasive microorganisms might arrive to the region via ships. Within a given ship, habitats included ballast water, unpumpable water and sediment (collectively known as residuals), and biofilms formed on internal surfaces of ballast-water tanks. We sampled 69 vessels arriving from foreign and domestic ports, largely from Western Europe, the Mediterranean region, and the US East and Gulf coasts. All habitats contained bacteria and viruses. By extrapolating the measured concentration of a microbial metric to the estimated volume of ballast water, biofilm, or residual sediment and water within an average vessel, we calculated the potential total number of microorganisms contained by each habitat, thus creating a hierarchy of risk of delivery. The estimated concentration of microorganisms was greatest in ballast water >> sediment and water residuals >> biofilms. From these results, it is clear microorganisms may be transported within ships in a variety of ways. Using temperature tolerance as a measure of survivability and the temperature difference between ballast-water samples and the water into which the ballast water was discharged, we estimated 56% of microorganisms could survive in the lower Bay. Extrapolated delivery and survival of microorganisms to the Port of Hampton Roads in lower Chesapeake Bay shows on the order of  $10^{20}$  microorganisms ( $6.8 \times 10^{19}$  viruses and  $3.9 \times 10^{18}$  bacteria cells) are discharged annually to the region.

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Gollasch, S. **International collaboration on marine bioinvasions - The ICES response.** *Marine Pollution Bulletin* 55(7-9): 353-359, 2007.

**Notes:** The International Council for the Exploration of the Sea (ICES) noted the risks associated with uncontrolled species introductions and transfers more than 40 years ago and launched two working groups to address the issue, i.e. the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) to deal with the movement of non-indigenous species for e.g. aquaculture purposes and the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors which focuses on species movements with ships. Both groups are actively working until today and the key achievements of the groups are outlined.

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Hewitt, C.L. and Campbell, M.L. **Mechanisms for the prevention of marine bioinvasions for better biosecurity.** *Marine Pollution Bulletin* 55(7-9): 395-401, 2007.

**Notes:** Biosecurity management allows countries to meet a number of international obligations and provides some protection from potential degradation of environmental, economic, social and cultural values. Ocean governance relies on the precepts of ecologically sustainable development to manage the multiple uses in the coastal zone. The increasing reliance on aquaculture to provide food security and economic development has led to an increase in the use of non-native target species grown as food sources. Increased economic activity has led to shifting trade patterns and increased efficiencies in vessels with the resulting increase in the number of introduced marine species via ballast water and hull fouling. Herein we review the different marine biosecurity strategies and legislation that have been implemented internationally and locally that aid in preventing and managing introduced marine species, with some attention to Australia and New Zealand as examples. Typical tools being used include quarantine, Import Health Standards, voluntary cleaning guidelines, and risk assessment, all of which aim to prevent introductions.

Galil, B.S. **Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea.** *Marine Pollution Bulletin* 55(7-9): 314-322, 2007.

**Notes:** More than 500 alien species were listed from the Mediterranean Sea. Though no extinction of a native species is known, sudden decline in abundance, and even local extirpations, concurrent with proliferation of aliens, had been recorded. Examination of the profound ecological impacts of some of the most conspicuous invasive alien species underscores their role, among multiple anthropogenic stressors, in altering the infralittoral communities. Local population losses and niche contraction of native species may not induce immediate extirpation, but they augur reduction of genetic diversity, loss of functions, processes, and habitat structure, increase the risk of decline and extinction, and lead to biotic homogenization. The relevant environmental policy and management framework is discussed.

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Occhipinti-Ambrogi, A. **Global change and marine communities: Alien species and climate change.** *Marine Pollution Bulletin* 55(7-9): 342-352, 2007.

**Notes:** Anthropogenic influences on the biosphere since the advent of the industrial age are increasingly causing global changes. Climatic change and the rising concentration of greenhouse gases in the atmosphere are ranking high in scientific and public agendas, and other components of global change are also frequently addressed, among which are the introductions of non indigenous species (NIS) in biogeographic regions well separated from the donor region, often followed by spectacular invasions. In the marine environment, both climatic change and spread of alien species have been studied extensively; this review is aimed at examining the main responses of ecosystems to climatic change, taking into account the increasing importance of biological invasions. Some general principles on NIS introductions in the marine environment are recalled, such as the importance of propagule pressure and of development stages during the time course of an invasion. Climatic change is known to affect many ecological properties; it interacts also with NIS in many possible ways. Direct (proximate) effects on individuals and populations of altered physical-chemical conditions are distinguished from indirect effects on emergent properties (species distribution, diversity, and production). Climatically driven changes may affect both local dispersal mechanisms, due to the alteration of current patterns, and competitive interactions between NIS and native species, due to the onset of new thermal optima and/or different carbonate chemistry. As well as latitudinal range expansions of species correlated with changing temperature conditions, and effects on species richness and the correlated extinction of native species, some invasions may provoke multiple effects which involve overall ecosystem functioning (material flow between trophic groups, primary production, relative extent of organic material decomposition, extent of benthic-pelagic coupling). Some examples are given, including a special mention of the situation of the Mediterranean Sea, where so many species have been introduced recently, and where some have spread in very large quantities. An increasing effort by marine scientists is required, not only to monitor the state of the environment, but also to help predicting future changes and finding ways to mitigate or manage them.

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Campbell, M.L., Gould, B., and Hewitt, C.L. **Survey evaluations to assess marine bioinvasions.** *Marine Pollution Bulletin* 55(7-9): 360-378, 2007.

**Notes:** Countries need to know what species are present within their waters to effectively manage the issue of non-indigenous marine species. Five survey methods are currently employed to detect introduced marine species: the Hewitt and Martin protocols (66% of effort; 73 ports, 12 countries); Rapid Assessment Surveys (7% of effort; 8 regions, 4 countries); the Bishop Museum protocols (7% of effort; 8 ports, 3 countries); the Chilean aquaculture surveys (1% of effort; numerous regions; 1 country); and Passive Sampling protocols (18% of effort; 20 ports, 2 countries). These methods use either quantitative, qualitative, or a mixture of the two sampling techniques and tend to target locations that are potential inoculation sites (i.e., such as ports, marinas and aquaculture facilities). To date, introduced marine species surveys have been implemented in 19 countries and have detected more than 1185 non-indigenous, 735 cryptogenic and 15,315 native species.

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