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Invasive Marine and Estuarine Animals of the Gulf of Mexico

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PURPOSE: New species of estuarine and marine animals are inadvertently or intentionally introduced into the waters of the United States every year (Figure 1). Variously referred to as introduced, nonindigenous (NIS), alien, nonnative, or exotic species, most pose little or no threat; however, a few have the potential to disrupt local ecosystems, fisheries, and human infrastructure. Such invasions directly impact the mission of the U.S. Army Corps of Engineers (USACE) through its responsibilities for construction and maintenance of harbors, ports, and waterways; erosion control; management of water resources; and wetland and coastal habitat restoration. The general biology and ecology of invasive estuarine and marine animals have been described in previous reports (Carlton 2001, Ray 2005). This report is part of a series describing the biology and ecology of known invasive estuarine and marine animals in the major geographic regions of the United States. Invasive animals of the Gulf of Mexico are described and examples of species posing a specific threat to USACE activities are identified.

BACKGROUND: Invasive species are officially defined as "alien species whose introduction does or is likely to cause economic or environmental harm to human health" (Executive Order 13112, Federal Register (1999)). Any species removed from its native range has the potential to become invasive. This is because within its normal range, predation, disease, parasites, competition, and other natural controls act to keep population levels in check (Torchin et al. 2003, Wolfe 2002). Once released from these controls species abundances have the potential to reach levels that interfere with or displace local fauna. Such effects may occur immediately, after some period of delay, or never be realized at all depending on the characteristics of the individual species and the conditions into which it is introduced.

Figure 1. Example of an invasive species, the green-lipped mussel, *Perna viridis* (image courtesy of U.S. Geological Survey (USGS))

Lists of estuarine and marine nonindigenous species are often dominated by mollusks, crustaceans, and polychaete worms; however, this may reflect their ease of identification and detection rather than the degree to which they are representative. Ultimately it is an issue of an organism's biological characteristics (e.g., reproductive capacity, growth rate) and not its taxonomic affinities that determine if it becomes invasive. Successful invaders tend to be abundant over a large range in their native region, have broad feeding and habitat preferences, wide physiological tolerances, short generation times, and high genetic variability (Erlich 1989, Williams and Meffe 1999). Despite the fact that we can identify these characteristics, predicting which species pose the greatest threat remains problematic since many species possess these characters, most are not obvious in their native range, and the opportunities for introduction and subsequent likelihood of survival are difficult to assess. The situation is further complicated by difficulty in distinguishing invaders from species with naturally wide distributions and those that are cryptogenic, that is, species whose original distributions are uncertain.

Predicting which habitats are likely to be invaded is much simpler. Invaded habitats tend to have low natural diversity, relatively simple (low-connectance) food webs, and a history of recent natural or anthropogenic disturbance (Williams and Meffe 1999). Estuaries and sheltered coastal areas are among the most invaded habitats, presumably due to the fact that they are naturally disturbed, low-diversity systems and are historically centers of anthropogenic disturbance associated with navigation, industrial development, and urbanization.

Species are introduced by a variety of different mechanisms; however, most estuarine and marine species introductions are associated with shipping (Ruiz et al. 2000). Species capable of attaching to hard surfaces may be transported on ship hulls, navigational buoys, floatation devices, anchors, chains, ropes, and flotsam or jetsam (Carlton 2001). During the heyday of wooden-hulled ships, wood-borers (e.g., shipworms) and species associated with "dry" ballast such as stones, rock, sand, or other materials were frequently introduced (Carlton and Hodder 1995). Presently, the largest single source of shipping-related introductions is ballast water (Carlton 1985, Lavoie et al. 1999). Ballast water is taken on board vessels for a variety of purposes related to ship maneuverability and control (Carlton et al. 1995). Animals suspended in the water column or present in bottom sediments are taken in and then introduced to a new location when the ballast is pumped out.

Recently, concerns have also been raised regarding introductions of fish, invertebrates, and "live" rock from the aquarium trade (Padilla and Williams 2004, Weigle et al. 2005). The lionfish *Pterois volitans* may have been introduced to Atlantic waters when a private aquarium was demolished in the Miami area in 1992 during Hurricane Andrew (Hare and Whitfield 2003). Other introductions may result from accidental release of animals, inappropriate disposal of packing material by restaurants serving live seafood, and by the live bait industry. Many species have been deliberately introduced to develop new fisheries. For example, the Atlantic striped bass *Morone saxatilis* has been introduced both outside its normal geographic range and in nonnative habitats (e.g., reservoirs) in much of the United States.

METHODS: As indicated in the official definition, invasive species are nonindigenous or alien to the region in which they are found. This does not mean that all NIS are invasive but rather that invasives constitute a subset of NIS. A list of known invasive species within the Gulf of Mexico was created by querying NISBase, a national database of nonindigenous species (NIS) listings maintained by the Smithsonian Institution (*http://www.nisbase.org/nisbase/index.jsp*). Part of the National Exotic Marine and Estuarine Species Information System (NEMESIS), this database permits simultaneous searches of multiple NIS listings. Searches return up to 300 species and include links to individual species' fact sheets and collection data. Queries were performed by state and included searches of the United States Geological Survey's Nuisance Aquatic Species (NAS) database (*http://nas.er.usgs.gov/*), the Chesapeake Bay Exotic Marine and Estuarine Species Information System database, and the Nonindigenous Species in the Gulf of Mexico database (*http://nis.gsmfc.org/*). The resulting lists were amended as necessary after comparison with individual state NIS listings and other reports (Table 1), then edited to include only estuarine and marine species (Appendix A). Cryptogenic species were not included in the list. Species known to be invasive or suspected of having the potential to become invasive are discussed.

Table 1
State NIS Listings and Other Sources Utilized in This Report

Benson et al. 2001
Gossett and Lester 2004
Louisiana Aquatic Invasive Species Task Force 2004
Texas Parks and Wildlife 2004
USEPA 2000
U.S. Geological Survey (USGS) 2003

Additional NIS information specific to the Gulf of Mexico can be found in U.S. Environmental Protection Agency (USEPA) (2000), Gossett and Lester (2004), as well as the management plan for the state of Louisiana (Louisiana Aquatic Invasive Species Task Force 2004).

RESULTS: Listings for the Gulf of Mexico include 74 nonindigenous estuarine and marine animal species (Table 2). Fishes dominated these lists with 25 species. At least 10 of these species represent deliberate introductions associated with sport fisheries or mariculture operations including herring and shad (*Alosa* spp. and *Dorosoma* spp.), salmon (*Onchorhynchus* spp. and *Salmo salar*), and four-spined stickleback (*Apeltes quadricus*), Atlantic needlefish (*Strongylura marina*), spotted seatrout (*Cynoscion nebulosus*) and Atlantic striped bass. In the case of the spotted seatrout, introduction represents stocking of a nonindigenous habitat (e.g., lakes and reservoirs) rather than placement outside of its native geographical range. An additional 15 fish species represent unintentional releases from aquaria including six species of angelfish (*Pomacanthus* spp.), five species of tang (*Zebrasoma* spp.), the spotted scat (*Scatophgus argus*), the blackbelly triggerfish (*Rhinecanthus verrucosus)*, the humpback grouper (*Cromileptes altivelis*), the lionfish (*Pterios volitan*), and the

Table 2
Numbers of South Atlantic NIS by State

Species	FL	AL	MS	LA	TX	Total for Region
Scyphozoans	2	1	1	1		2
Anthozoans	2	2				2
Polychaetes	3	3				3
Bivalves	7				1	8
Gastropods	4			1	1	4
Nudibranchs	2	2				2
Copepods	1			1	3	3
Barnacles	3				1	3
Amphipods	1					1
Isopods	3					3
Tanaids	1					1
Crabs	5	1	1	1	1	7
Shrimp	4				1	4
Bryozoans	2					2
Entoprocts		1				1
Tunicates	2				1	3
Fish	18	4	3	2	7	25
Total	60	14	5	6	16	74

Asian swamp eel (*Monopterus albus*). Only the lionfish and the swamp eel are recognized as species of concern at this time.

Geographical distribution of NIS varies widely among states. Florida has the greatest number of reported NIS, probably reflecting the length of coastline, intensity of human influence (e.g., shipping and industrialization), and the extent of NIS monitoring efforts in this state. Texas has the next-longest coastline and the second largest number of NIS.

DISCUSSION: Species most commonly identified as invasive or listed as of concern in the Gulf of Mexico include Australian spotted jellyfish, *Phylloriza punctata*, green or green-lipped mussel *Perna viridis*, brown mussel *Perna perna*, shipworms, green porcelain crab *Petrolisthes armatus*, lionfish, and Asian swamp eel. Of these species, the biology and ecology of all but shipworms and the swamp eel have been previously described in Ray (2005). In the following sections these results will be briefly summarized.

Potential Threats to Infrastructure.

***Perna viridis*.** *Perna viridis* (Figure 1), a native of the tropical Indo-pacific, has been collected from Tampa Bay to Charlotte Harbor, Florida and in Kingston Harbor, Jamaica (Buddo et al. 2003). Initially discovered clogging water intake pipes at Tampa Bay power plants (Gulf States Marine Commission 2003a), its planktonic larvae are capable of settling on almost any hard surface. It can foul navigation buoys and ship hulls, interfere with shellfish culture, and displace local fauna. This species could also potentially harbor algal species that produce toxic shellfish poisoning (Buddo et al. 2003). The Brown mussel, *P. perna*, a close relative, is also a potential fouling threat. Native to South Africa, it has successfully invaded South America from Uruguay to the Caribbean (Gulf States Marine Commission 2003b) and is now found in the Gulf of Mexico from Freeport, Texas to Veracruz, Mexico (Hicks and Tunnel 1993, 1995). Slightly smaller than its congener, the brown mussel shares most of its biological characteristics. Its planktonic larvae reside in the water column for up to three weeks, potentially allowing it to invade much of the Gulf of Mexico and the Florida Keys. Like *P. viridis*, it can settle on almost any hard surface and has been reported at jetties, navigational buoys, oil platforms, and natural hard-bottom substrates (Hicks and Tunnell 1995). There are an additional 11 NIS species that can be considered fouling species. Probably introduced on ships' hulls or in ballast water, they include two anthozoans (anemones), three barnacles, two bryozoans, one entoproct, and three tunicates.

Chinese mitten crab. The Chinese mitten crab *Eriocheir sinensis* first appeared as an invasive species in Germany during the early 1900's and has since spread through most of Europe (Clark et al. 1998). It is reported in the United States from Lake Erie, San Francisco Bay, the Columbia River, and the Mississippi Sound. The crabs are catadromous, spending most of their adult life in freshwater, then returning to the sea only to reproduce. They form extensive burrows in riverbanks and levees, thus posing a direct threat to earthen water control structures. Further information on the life history of mitten crabs can be found in Veldhuizen and Stanish (2002), an ANS fact sheet (*http://el.erdc.usace.army.mil/ansrp/eriocheir_sinensis.htm*), and in Ray (2005).

Shipworm. *Lyrodus medilobatus,* a wood-boring bivalve mollusc commonly called a shipworm, is native to the Indo-Pacific. First detected at Cape Canaveral in 1995, it was probably introduced on a fouled ship hull (USGS 2005). Shipworms are tolerant of a wide range of salinities, temperatures, flow conditions, and oxygen concentrations. Dispersed by planktonic larvae, the larvae settle and construct extensive burrow systems in wooden structures (e.g., boat hulls, marinas, docks, and pilings). Cohen and Carlton (1995) report that shipworms caused $615 million in damage in San Francisco Bay during a 1920's outbreak. Likewise, severe damage was reported in Barnegat Bay, New Jersey and Long Island Sound, New York, after outbreaks of *Teredo. bartschi* associated with increased water temperatures and salinities in power station effluents (Hoagland 1983). Effective control of these pests can be accomplished by chemical treatment (e.g., creosote) or use of alternative materials (Highley 1999).

Potential Threats to Habitat Restoration.

Green porcelain crab. The Green porcelain crab *Petrolisthes armatus* (Figure 2) is a South American and Caribbean species distributed as far north as Georgia and South Carolina. Found in rocky intertidal and tidal creek oyster bar habitats, it is presently undergoing large changes both in its distribution and abundance. This species has reached densities as high as 10,000/m^2 in South Carolina salt marshes (Lohrer 2001). It is unclear whether this represents a natural range expansion or an inadvertent introduction. Hartman et al. (2001) and Hollebone and Hay (2003) suggest that high abundances of *P. armatus* provide an alternative prey for predators of xanthid crabs. Xanthids are important predators of newly settled oysters; therefore, the increase in porcelain crab abundance may indirectly result in a negative impact on oyster populations. Such an effect obviously has important implications for oyster habitat restoration efforts.

Figure 2. Green porcelain crab, *Petrolisthes armatus* (image courtesy of Southeast Regional Taxonomic Center)

Australian spotted jellyfish. Australian spotted jellyfish *Phylloriza punctata* is presently found in abundance only in the northern Gulf of Mexico, but has been reported as far afield as Brevard County, Florida. This large jellyfish (average adult bell width is 35 cm) can be found in swarms of up to 500,000 in a 150-km^2 area. Feeding intensively on zooplankton and fish larvae, they may represent a threat to fisheries and fisheries restoration operations. For more information on this species see Fuller (2005a).

Asian swamp eel. The Asian swamp eel *Monopterus albus* is actually not a true eel, but a member of the fish family Synbranchidae. Nocturnal in habit, it burrows as deep as 1.5 m in the bottoms of ponds, streams, rivers, and other freshwater habitats. It can also tolerate both saline and brackish waters. The swamp eel feeds on fishes, worms, crustaceans and other aquatic species.

Marketed as an aquarium species, it may have been introduced accidentally by aquarium release. It is presently found in drainages in South Florida as well as the Tampa Bay region. It may interfere with USACE operations by displacing native species and its extensive burrow systems may contribute to accelerated drying of shallow water bodies. For more information on this species see either the ANSRP website (listed above) or the Gulf States Marine Fisheries Commission NIS fact sheet at *http://nis.gsmfc.org*.

Wood-boring isopods. Two wood-boring isopods reported in the Gulf of Mexico (*Sphaeroma terebrans* and *S. walkeri*) may also affect habitat restoration. The first of these species was probably introduced on the hulls of wooden ships. Now found from Brazil to South Carolina and from Liberia to the Congo (Carlton and Ruckelshaus 1997), it burrows into hard substrates including hard packed sand, and decaying or living wood. There is considerable concern over its potential impact on restoration of mangrove habitat. The isopod burrows into the prop roots of red mangrove (*Rhizophora mangle*), weakening and ultimately destroying them (Rehm and Humm 1973). This not only damages the individual mangrove plant, but leads to undercutting and erosion of exposed sediments. Impact of the introduction of the Southwestern Pacific *S. walkeri* is unknown (Fuller 2005b).

Asian date mussel. Although not presently reported from the Gulf of Mexico, the Asian date mussel *Musculista senhousia* is also of concern in this region. Native from Siberia to the Red Sea, it is now found in Australia, New Zealand, the eastern Mediterranean, and southern France (Crooks 1996). Probably arriving in the United States during introduction of Japanese oysters to the state of Washington in the 1920's, it has since spread to southern California. Its planktonic larvae can remain in the water column as long as 55 days making it a likely candidate for secondary introduction via ballast water. The mussel settles on intertidal or subtidal sand and mud, forming dense beds that can alter both sediment composition and native benthic assemblages (Crooks 1998, Crooks and Khim 1999). Success of seagrass restoration projects can be compromised in heavily infested areas (Reutsch and Williams 1998). Additional information on this species can be found in Ray (2005).

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APPENDIX A: NIS LISTINGS BY STATE FOR THE GULF OF MEXICO

Species	Group	FL	AL	MS	LA	TX
Drymonema dalmatina	Scyphozoan	FL				
Phyllorhiza punctata	Scyphozoan	FL	AL		LA	
Diadumene lineata	Anemone	FL				
Haliplanella lineata	Anemone	FL				
Argulus japonicus	Copepod	FL				
Centrophages typicus	Copepod					TX
Eurytemora affinis	Copepod				LA	TX
Balanus amphitrite	Barnacle	FL				TX
Balanus reticularis	Barnacle	FL				
Balanus trigonus	Barnacle	FL				
Chelura terebrans	Amphipod	FL				
Ligia exotica	Isopod	FL				
Sphaeroma terebrans	Isopod	FL				
Sphaeroma walkeri	Isopod	FL				
Zeuxo maledivensis	Tanaid	FL				
Callinectes bocourti	Crab	FL	AL	MS		
Charybdis helleri	Crab	FL				
Eriocheir sinensis	Crab				LA	
Petrolisthes armatus	Crab	FL				
Platychirograpsus spectabilis	Crab	FL				
Rhithropanopeus herbstii	Crab					TX
Scylla serrata	Crab	FL				
Macrobrachium olfersi	Shrimp	FL				
Penaeus monodon	Shrimp	FL				
Penaeus stylirostris	Shrimp	FL				
Penaeus vannanmei	Shrimp	FL				TX
Lyrodus medilobatus	Bivalve	FL				
Mytella charruana	Bivalve	FL				
Perna viridis	Bivalve	FL				
Perna perna	Bivalve					TX
Pinctada margaritfera	Bivalve	FL				
Rangia cuneata	Bivalve	FL				
Tridacna crocera	Bivalve	FL				
Tridacna maxima	Bivalve	FL				
Littorina littorea	Gastropod	FL				
Melanoides tuberculatus	Gastropod	FL			LA	TX
Myostella myosotis	Gastropod	FL				
Truncatella subcylindrica	Gastropod	FL				
Cuthona oerca	Nudibranch	FL				
Ercolania fuscovittata	Nudibranch	FL				
Boccardiella ligerica	Polychaete	FL				
Hydroides elegans	Polychaete	FL				
Polydora cornuta	Polychaete	FL				

Species	**Group**	**FL**	**AL**	**MS**	**LA**	**TX**
Sunanella sbogae	Bryozoan	FL				
Victorella pavida	Bryozoan	FL				
Schizoporella unnicornis	Ectoproct		AL			
Botryllus schosseri	Tunicate	FL				
Styela plicata	Tunicate	FL				
Didemnum perlucidum	Tunicate					TX
Alosa aesitvalis	Fish					TX
Alosa sapidissima	Fish	FL	AL	MS	LA	TX
Apeltes quadricus	Fish		AL			
Cromileptes altivelis	Fish	FL				
Cynscion nebulosa	Fish					TX
Dorosoma petenense	Fish	FL	AL			TX
Monopterus albus	Fish	FL				
Morone saxatilis	Fish	FL		MS		TX
Oncorhynchus kisutch	Fish					TX
Oncorhynchus tshawytscha	Fish				LA	TX
Pomacanthus annularis	Fish	FL				
Pomacanthus asfur	Fish	FL				
Pomacanthus imperator	Fish	FL				
Pomacanthus maculosus	Fish	FL				
Pomacanthus semicircularis	Fish	FL				
Pomacanthus xanthometopon	Fish	FL				
Pterois volitans	Fish	FL				
Rhinecanthus verrucosus	Fish	FL				
Salmo salar	Fish			MS		TX
Scatophagus argus	Fish	FL				
Strongylura marina	Fish		AL			
Zebrasoma desjardinii	Fish	FL				
Zebrasoma flavescens	Fish	FL				
Zebrasoma veliferum	Fish	FL				
Zebrasoma xanthurum	Fish	FL				