

# Hawaiian Marine Bioinvasions: A Preliminary Assessment<sup>1</sup>

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THROUGH THE Hawaii Biological Survey at Bishop Museum, a count of the total numbers of species in the Hawaiian Archipelago has been accumulated, with the latest listing (1999) totalling 23,150, of which 5047 are nonindigenous species (Eldredge 2000). For the nonindigenous marine and estuarine species, we have been accumulating information from the literature, museum specimens, and through field collections. This preliminary assessment is an extended abstract of a much longer review still in preparation (J.T.C. and L.G.E., unpubl. data). Using the criteria of Chapman and Carlton (1991), we have calculated that the total number of marine and brackish-water species in the Hawaiian Islands is 343: 287 invertebrates, 24 algae, 20 fish, and 12 flowering plants. Of a total of 4099 marine invertebrate species, 71 species are introduced arthropods and 53 species are mollusks (Eldredge and DeFelice 2001).

The greatest number of introduced species arrived through hull fouling, with solid ballast and ballast water following (Table 1). Two hundred and one species (70%) are considered introduced and 86 species (30%) cryptogenic (that is, not demonstratively native or introduced). Two hundred forty-eight species (87%) have become established, 15 (5%) failed, 6 (2%) were intercepted, and 18 (6%) unknown.

The nonindigenous species have their origins primarily in the Indo-Pacific/Philippine Islands region (Table 2).

Historically the numbers of introductions have peaked at several different times: during the 1920s, probably through the effort of Charles Howard Edmondson, then recently arrived invertebrate zoologist at the University of Hawai'i and Bishop Museum; during the 1940s, probably through wartime activities and development; during the 1970s, through surveys conducted by the U.S. Navy; and during the 1990s and the current series of biological inventories of intensity.

TABLE 1

Marine Invertebrates: Probable Mechanisms of Transport to the Hawaiian Islands

Mechanism	Species	% Established
Hull fouling	212	90
Solid ballast	21	90
Ballast water	18	89
Intentional release: fishery	18	28
Parasites on nonindigenous species	8	88
With commercial oysters: unintentional	7	100
Aquarium release	3	67

TABLE 2

Biogeography of Marine Nonindigenous Species in the Hawaiian Islands

Origin	%
Indo-Pacific, Philippines	21.3
Unknown	19.9
Unknown, worldwide	16.4
Tropical western Atlantic (Caribbean)	10.5
Japan-Asia	7.0
NW Atlantic (Europe and Mediterranean)	6.6
West coast North America	6.3
Southern Hemisphere	2.8
Australia and New Zealand	2.4
Tropical eastern Pacific	2.4
Oceania	2.1
Other	2.3

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In harbors and embayments in Hawai'i the percentage of nonindigenous species increases greatly: 23% for Pearl Harbor, 17% for Honolulu Harbor, but 1.5% and 1.0% for Midway Island and Kaho'olawe, respectively (Coles and Eldredge 2002). As information becomes available it suggests that a gradient in the diversity of introduced species exists from intensive to less intensive regions of both shipping traffic and estuarine modification and urbanization.

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