

APPENDIX 1(A). INTRODUCED TERRESTRIAL PLANTS, BIRDS AND MAMMALS REPORTED FROM THE SAN FRANCISCO ESTUARY.

Native Range:	N - North S - South	n - northern s - southern	e - eastern w - western
Listed in:	D1 Madrone Assoc. (1980), reported in the Sacramento-San Joaquin Delta D2 Herbold & Moyle (1989), Appendix A: Vascular Plants of the Sacramento-San Joaquin Delta TM Atwater et al. (1979), Table 3: Common Introductions in Tidal Marshes of the San Francisco Bay Area GL Mills et al. (1993), nonindigenous aquatic plants and algae of the Great Lakes HR Mills et al. (1995), nonindigenous organisms in the Hudson River		

Species	Common Name	Native Range	Listed in:
PLANTS			
Vascular Plants			
<u>Dicotyledones</u>			
<i>Apium graveolens</i>	celery	Eurasia	TM
<i>Atriplex semibaccata</i>	Australian salt bush	Australia	D2, TM
<i>Carpobrotus edulis</i>	iceplant	s Africa	D2
<i>Chenopodium album</i>	lambs' quarters	Europe	TM
<i>Cirsium vulgare</i>	bull thistle	Europe	D1, D2, TM
<i>Conium maculatum</i>	poison hemlock	Europe	D1, D2, TM (GL)
<i>Cotula australis</i>		Australia	TM
<i>Dipsacus fullonum</i>	wild teasel	Europe	TM
<i>Foeniculum vulgare</i>	fenel	s Europe	D1, D2, TM
<i>Melilotus alba</i>	white sweetclover	Eurasia	D1, D2, TM
<i>Mentha arvensis</i>		Europe? e N America?	
<i>Mentha x piperita</i>	peppermint	Europe	TM (GL, HR)
<i>Phyla nodiflora</i>	mat-grass	S America	D1, D2, TM
<i>Plantago major</i>	common plantain	Europe	TM
<i>Rumex crispus</i>	curly dock	Eurasia	D1, D2, TM (HR)
<i>Solanum dulcamara</i>	bittersweet	n Eurasia	TM (GL, HR)
<i>Solanum nigrum</i> or <i>americanum</i>	nightshade	Eurasia or S America	D2, TM (HR)
<i>Tamarix</i> sp.	tamarisk	Europe, Asia or Africa	D2
<i>Tetragonia tetragonioides</i>	New Zealand spinach	New Zealand, Australia	
<i>Veronica anagallis-aquatica</i>	water speedwell	Europe	D2
<u>Monocotyledones</u>			
<i>Arundo donax</i>	giant reed	Europe	D1, D2
<i>Bromus diandrus</i>	ripgut grass	Eurasia	D1, D2, TM
<i>Bromus hordeaceus</i>	soft chess	Eurasia	TM
<i>Cortaderia selloana</i>	pampas grass	e S America	D1, D2, TM
<i>Echinochloa crus-galli</i>	barnyard grass	Eurasia and Africa	D1 (GL, HR)
<i>Festuca pratensis</i>	meadow fescue	Europe	TM
<i>Hordeum murinum</i>	hare barley	Europe	TM
<i>Polypogon monspeliensis</i>	rabbit's-foot grass	s & w Europe	D1, D2, TM

Species	Common Name	Native Range
VERTEBRATES		
Birds		
<i>Columba livia</i>	pigeon, rock dove	Eurasia
<i>Passer domesticus</i>	house sparrow	Eurasia
<i>Phasianus colchicus</i>	ring-necked pheasant	Asia
<i>Sturnus vulgaris</i>	starling	Eurasia
Mammals		
<i>Felis felis</i>	cat	Eurasia
<i>Mus musculus</i>	house mouse	Eurasia
<i>Rattus norvegicus</i>	Norway rat	Eurasia
<i>Vulpes vulpes</i>	red fox	e & midw N America

APPENDIX 1(B). DESCRIPTIONS OF INTRODUCED TERRESTRIAL PLANTS REPORTED FROM THE SAN FRANCISCO ESTUARY

Dicotyledones

Apium graveolens Linnaeus [APIACEAE]

CELERY

Celery is a native of Eurasia, widely cultivated and commonly naturalized in wet places at low elevations in California (Jepson, 1951; Munz 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary.

Atriplex semibaccata R. Br. [CHENOPODIACEAE]

AUSTRALIAN SALT BUSH

Australian saltbush, drought-resistant and adapted to alkaline soils, was introduced to the United States as a forage plant according to Robbins et al. (1941), although Spicher & Josselyn (1985) say that it was introduced in ships' ballast. It is commonly found in waste places, shrubland and woodland throughout most of California (except for parts of the Cascade Range and Sierra Nevada), to Utah, Texas and northern Mexico (Hickman, 1993). Atwater et al. (1979) list it as common in tidal marshes in all parts of the San Francisco Estuary, and it is reported as occasional in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989). We've observed it just above and occasionally below the highest tidemarks in San Francisco Bay saltmarshes, on dikes and on riprapped banks.

Carpobrotus edulis (Linnaeus) N. E. Br. [AIZOACEAE]

SYNONYMS: *Mesembryanthemum edule*

ICEPLANT, SEA FIG

Native to South Africa, iceplant was introduced into the United States in the early 1900s for erosion control along railroad tracks and has been extensively planted along highways, on sand dunes and in high fire-risk areas. Its fruits have been widely dispersed from planted areas by several native mammals, and it is now common and naturalized along much of the California and Mexican coasts, where it may compete with native species, including several threatened or endangered plants (Jepson, 1951; Munz, 1959; D'Antonio, 1993; Hickman, 1993; Albert, 1995). We

have often seen it at the margins of salt marshes, with some plants occasionally below the level of the highest tides.

Chenopodium album Linnaeus, 1753 [CHENOPODIACEAE]

LAMB'S QUARTERS, PIGWEED

A native of Europe, lamb's quarters is a common weed in waste and fallow places and along roadsides, widely distributed over North America and other temperate regions of the world (Munz, 1959; Hickman, 1993), and reported in California by Robbins et al. (1941) as an important host plant of the beet leafhopper. In Suisun Marsh it was found at 8 of 48 sites in a 1989 survey. In 1987, pickleweed, saltgrass and lamb's quarters comprised the principal vegetation at one site in the marsh (Herrgesell, 1990). Atwater et al. (1979) listed it as a common introduction in the tidal marshes of the San Francisco Estuary.

Cirsium vulgare (Savi) Ten. [ASTERACEAE]

BULL THISTLE, COMMON THISTLE

Bull thistle is native to Europe, and is an aggressive weed in North America common in waste places (Munz, 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary, and is reported as common in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989).

Conium maculatum Linnaeus [APIACEAE]

POISON HEMLOCK

Poison hemlock is a native of Europe and was established in North America by 1818 (Nuttall, 1818). It is common in moist, disturbed ground at low elevations in California (Jepson, 1951; Munz 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary, and is reported as occasional in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989).

Cotula australis (Sieber) Hook. f. [ASTERACEAE]

This Australian plant was initially reported in California as occurring "along the streets of many of our towns and cities" including Berkeley, Oakland and San Francisco (Robbins et al., 1941; Jepson, 1951). Munz (1959) describes it as a "very common and troublesome weed about gardens, city lots, etc." Hickman (1993) reports it as a common weed at low elevations "in urban coastal areas." Atwater et al. (1979) list it as common in tidal marshes of the San Francisco Estuary.

Dipsacus fullonum Linnaeus [DIPSACACEAE]

WILD TEASEL, FULLER'S TEASEL

A native of Europe, wild teasel is commonly found at roadsides and in pastures, old fields and other waste places, and occasionally at moist sites, more-or-less throughout cismontane California including the San Francisco Bay Area (Jepson, 1951; Munz, 1959; Hickman, 1993). Atwater et al. (1979) list it as common in tidal marshes of the San Francisco Estuary.

Foeniculum vulgare Miller [APIACEAE]

FENNEL, SWEET FENNEL

Fennel is native to southern Europe and widely escaped from cultivation in the western hemisphere. It is commonly found on roadsides and in waste places at low elevations (Jepson, 1951; Munz, 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary, and is reported as common in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989).

Melilotus alba Medikus [FABACEAE]

WHITE SWEETCLOVER

SYNONYMS: *Melilotus albus*

This native of Eurasia is abundantly naturalized in disturbed sites in the northern United States and southern Canada. It is locally abundant in damp places in much of California (Jepson, 1951; Munz, 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary, and is reported as common in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989).

Mentha arvensis Linnaeus [LAMIACEAE]

Munz (1959) reported this plant as occurring in California in "several forms that are questionable as to whether native here," Hickman (1993) states "some plants sterile; some plants naturalized from Europe," while Mills et al. (1995) describe it as a native North American mint. Jepson (1951) called *Mentha arvensis* the "tule-mint," common in marshes and meadows, and Hickman (1993) reports it from moist areas, stream banks and lake shores through much of California. Atwater (1980) reported it from the bank of an islet at Sand Mound Slough in the Delta.

Mentha x piperita Linnaeus [LAMIACEAE]

PEPPERMINT

SYNONYMS: *Mentha piperita*
Mentha citrata

Hickman (1993) describes this plant as a generally sterile hybrid of *M. aquatica* and *M. spicata*, which propagates asexually via underground shoots (Mills et al., 1993). A native of Europe, peppermint was reported in New York by 1843 (Torrey, 1843). It is widely cultivated for its oil and is commonly escaped in Canada, the eastern United States, and California, where it is found in fields and wet places (Jepson, 1951; Mason, 1957; Munz, 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary.

Phyla nodiflora (Linnaeus) Greene var. *nodiflora* [VERBENACEAE]

MAT-GRASS, GARDEN LIPPIA

SYNONYMS: *Phyla nodiflora* var. *reptans*
Lippia nodiflora var. *rosea*
Lippia nodiflora var. *canescens*
Lippia nodiflora var. *reptans*
Lippia filiformis
Zappania nodiflora var. *reptans*

Naturalized from South America, mat-grass has been planted as groundcover and to resist erosion on levees. It is well established in low elevation wet places, ditches and fields in many parts of California including the Central Valley and the Bay Area (Jepson, 1951; Mason, 1957; Munz, 1959; Hickman, 1993). In the Delta it has been variously listed as especially common in the region (Robbins et al., 1941), common in tidal marshes (Atwater et al., 1979), and uncommon (Madrone Assoc., 1980; Herbold & Moyle, 1989).

Plantago major Linnaeus [PLANTAGINACEAE]

COMMON PLANTAIN, WHITE MAN'S FOOT

Naturalized from Europe, common plantain is a weed of damp waste places (Jepson, 1951; Munz, 1959; Hickman, 1993). Atwater et al. (1979) list it as common in tidal marshes of the San Francisco Estuary.

Rumex crispus Linnaeus [POLYGONACEAE]

CURLY DOCK, YELLOW DOCK

Native to Eurasia, curly dock was reported from New York by 1843 (Torrey, 1843) and is now an abundant weed throughout North America including California (Jepson, 1951; Munz, 1959; Hickman, 1993). It was apparently introduced to California prior to 1769, as it is found embedded in the adobe bricks of buildings of that age (Crosby, 1986, p. 152). Atwater et al. (1979) list it as common in San Pablo and Suisun Bay tidal marshes in 1975 but not in 1977. Madrone Assoc. (1980) list it as common in most moist or seasonally ponded habitats in the Delta, and Herbold & Moyle (1989) list it as common in the Delta.

Solanum dulcamara Linnaeus [SOLANACEAE]

BITTERSWEET, CLIMBING NIGHTSHADE

This member of the nightshade genus is native to northern Eurasia and was imported to North America from Europe as a remedy for rheumatism and scurvy (Torrey, 1843). It escaped and become established by 1818 (Nuttall, 1818) and is now found through much of the United States and Canada. In California it grows in moist places and marshes at low elevations along the central coast and in the Bay Area (Munz, 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in tidal marshes of the San Francisco Estuary.

Solanum americanum or *Solanum nigrum* Miller [SOLANACEAE]

SMALL-FLOWERED NIGHTSHADE or BLACK NIGHTSHADE

SYNONYMS: see below

The plant listed by Herbold & Moyle (1989) as *Solanum nodiflorum*, present in the Delta, and by Atwater et al. (1979) as *Solanum nodifolium* (possibly a typographic error), common in tidal marshes of the San Francisco Estuary, might refer to either or both of *S. americanum* or *S. nigrum*. Munz (1959) lists *S. nigrum* of authors as a synonym of *S. nodifolium*. Hickman (1993) lists *S. nigrum* as a native of Eurasia, found in low elevation disturbed sites and damp fields in cismontane California, including the Bay Area, and "expected elsewhere." It was reported from New York by 1843 (Torrey, 1843), where it may have either escaped from cultivation or been transported in solid ballast, as it was found on ballast dumping grounds in New York City (Brown, 1880). It is now reported as common in the eastern United States and from California to Washington.

Although treating *S. americanum* as a native, Hickman (1993) states that it might be an early introduction from South America, listing *S. nodiflorum* Jacq. as a synonym.

Tamarix spp. [TAMARICACEAE]

TAMARISK, SALT CEDAR

Jepson (1951) lists one species of tamarisk in California, Mason (1957) lists three, Munz (1959) lists four, Munz (1968) lists seven, and Hickman (1993) lists five. All of these are native to Europe, Asia or Africa. Jepson (1951) reported French tamarisk, *Tamarix gallica*, from White Sulphur Creek in the Napa Valley; Mason (1957) and Munz (1959) reported African athel, *Tamarix aphylla*, planted and occasionally escaped in the Sacramento and San Joaquin valleys; and Herbold & Moyle (1989) reported *Tamarix* sp. from the Delta. Dudley & Collins (1995) describe an infestation of tamarisk covering several thousand acres of riparian and upland areas near the Kern National Wildlife Refuge in the Central Valley, and note *T. chilensis*, *T. ramosissima*, *T. gallica* and *T. parviflora* as introduced species posing a serious, documented threat to sensitive species or ecosystems in California.

Tetragonia tetragonioides (Pallas) Kuntze [AIZOACEAE]

SYNONYMS: *Tetragonia expansa* Murray

NEW ZEALAND SPINACH

Kozloff (1983) reported this plant as well established in California and southern Oregon, "found at the edges of salt marshes and bay shores, but decidedly above the high-tide mark." We have found it at and above the high-tide line in San Francisco Bay, often growing in among riprap, and rarely on bare soil below the high-tide line. Hickman (1993) reports it common on sand dunes, bluffs and the margins of coastal wetlands throughout coastal California. It's native range includes New Zealand, Australia and possibly other locations in Southeast Asia. It reportedly can be cooked & eaten like spinach.

Veronica anagallis-aquatica Linnaeus [SCROPHULARIACEAE]

WATER SPEEDWELL

A native of Europe and widely naturalized in North and South America, water speedwell is occasionally found in wet meadows, on stream banks or in slow streams in California (Munz, 1959; Hickman, 1993). Herbold & Moyle (1989) report it

from the Delta. Sterile hybrids with chain speedwell, *Veronica catenata*, have been found in some mixed populations (Hickman, 1993).

Monocotyledones

Arundo donax Linnaeus [POACEAE]

GIANT REED, CARRIZO

Giant reed is native to Europe (it is the reed from which reed instruments are made) and is found at moist sites, such as ditches, streams or seeps, at low elevations in cismontane and desert California (Munz, 1959; Hickman, 1993). Jepson (1951) reported it "escaped along irrigation ditches" in central and southern California. It is reported as occasional on herbaceous banks in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989), and Atwater (1980) recorded it from the bank of an islet at Sand Mound Slough in the Delta. Although it has been planted along river banks for erosion control, it is an invasive weed in some riparian areas in California and the Nature Conservancy has organized a pilot project to control it with herbicides in Riverside County (Sullivan, 1994).

Bromus diandrus Roth [POACEAE]

SYNONYMS: *Bromus rigidus* Roth.
Bromus diandrus var. *gussonei*

RIPGUT GRASS

Ripgut grass is native to Eurasia. It is widely distributed in open, generally disturbed places and fields in California, and is also known from British Columbia and South America (Hickman, 1993). Atwater et al. (1979) list Gussone's ripgut grass as common in the landward fringes of tidal marshes around San Pablo and Suisun bays, and Madrone Assoc. (1980) and Herbold & Moyle (1989) report it as from the Delta.

Bromus hordeaceus Linnaeus [POACEAE]

SYNONYMS: *Bromus mollis* Linnaeus

SOFT CHESS

Soft chess is native to Eurasia, and widely distributed in the western hemisphere in open, often disturbed places (Hickman, 1993). It is listed by Atwater et al. (1979) as common in the landward fringes of tidal marshes around San Pablo and Suisun bays.

Cortaderia selloana (Schultes) Asch. & Graebner [POACEAE]

PAMPAS GRASS

Pampas grass is a native of eastern South America, escaped from cultivation in coastal California and the southern U. S. and common in disturbed places at low elevation, including the Bay Area (Munz, 1959; Hickman, 1993). Atwater et al. (1979) list it as common in tidal marshes, mainly in the Delta, and others report it as common in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989). The somewhat similar *C. jubata*, also reported from the Bay Area, is highly invasive.

Echinochloa crusgalli (Linnaeus) Beauv. [POACEAE]

BARNYARD GRASS, WATER GRASS

Native to Eurasia and Africa, this plant is now found worldwide in fields, on roadsides and in wet sites (Munz, 1959; Hickman, 1993). It was reported from New York by 1803, possibly having escaped from cultivation as livestock fodder and grain (Mills et al., 1993). Robbins et al. (1941) reported it as "the most troublesome weed in California rice fields," present since the start of the rice industry, and found in all agricultural sections of the state and along streams and ditches. Madrone Assoc. (1980) described it as a typical member of the nontidal freshwater marsh community in the Delta, and Atwater (1990) found it on the banks of 4 out of 6 islets surveyed in the Delta. A single plant may produce as many as 40,000 seeds (Robbins et al., 1941).

Festuca pratensis Hudson [POACEAE]

SYNONYMS: *Festuca elatior* Linnaeus

MEADOW FESCUE

Native to Europe, meadow fescue is grown for forage and is found escaped from cultivation in fields and waste places in the eastern U. S. and most of California. (Munz, 1959; Hickman, 1993). Atwater et al. (1979) list it as common in the landward fringes of tidal marshes around San Pablo and Suisun bays.

Hordeum murinum Linnaeus ssp. *lepinorum* (Link) Arcang. [POACEAE]

SYNONYMS: *Hordeum lepinorum* Link

HARE BARLEY

Hare barley is native to Europe and is found in moist, generally disturbed sites in eastern U. S., northern Mexico, British Columbia, and California (Munz, 1959; Hickman, 1993). Atwater et al. (1979) list it as common in the landward fringes of tidal marshes around San Pablo and Suisun bays.

Polypogon monspeliensis (Linnaeus) Desf. [POACEAE]

RABBIT'S-FOOT GRASS, ANNUAL BEARD GRASS

Rabbit's-foot grass is native to southern and western Europe and widespread and common in North America including California, along streams and ditches and in other moist places (Munz, 1959; Hickman, 1993). It is listed by Atwater et al. (1979) as common in the landward fringes of tidal marshes around San Pablo and Suisun bays, and it is reported as common in the Delta (Madrone Assoc., 1980; Herbold & Moyle, 1989).

APPENDIX 1(C). DESCRIPTIONS OF INTRODUCED TERRESTRIAL MAMMALS REPORTED FROM THE SAN FRANCISCO ESTUARY

Felis felis

HOUSE CAT

In the South Bay, feral cats have frequently been observed foraging in salt marshes, along salt pond levees, and wading at the edge of tidal sloughs (Foerster & Takekawa, 1991). Feral cats may be a major predator of small birds and mammals. An analysis of stomach contents of feral cats in the Sacramento Valley found occasional remains of waterfowl including pintail ducks, mallard or closely related ducks, coot, and a green heron (Hubbs, 1951). They have killed adult light-footed clapper rails (Foerster & Takekawa, 1991) and at least one California clapper rail (Takekawa, 1993).

The San Francisco Bay National Wildlife Refuge in the South Bay began a predator management program in May, 1991 that includes the removal of feral cats. (Takekawa, 1993).

Mus musculus

HOUSE MOUSE

The house mouse is native to Europe. It is common in the Delta in riparian habitats (Herbold & Moyle, 1989), and in salt and brackish marsh in San Francisco Bay (Josselyn, 1983; Harvey et al., 1992; BDOC, 1994).

Rattus norvegicus

NORWAY RAT

The Norway rat is native to Europe, and was established in many areas in California by the mid-1880s (BDOC, 1994). It is common in the Delta in riparian and marsh areas (Herbold & Moyle, 1989), and in San Francisco Bay in salt and brackish marsh and diked areas (de Groot, 1927; Foerster & Takekawa, 1991; Harvey et al., 1992). Norway rats will feed in salt marshes, where they are often observed during the highest winter tides (Josselyn, 1983; Foerster & Takekawa, 1991).

De Groot (1927) listed the Norway rat as the third most important factor in the decline of the California clapper rail (after the destruction of marshes and hunting), stating that "the Clapper Rail has no more deadly enemy than this sinister fellow. No rail dares nest on a marsh area which has been dyked, for as surely as she does this vicious enemy will track her down and destroy the eggs. Many nests have I

found bearing mute evidence of the fact that some luckless rail had gambled her skill at nest-hiding against the cunning of the Norway rat, only to have her home destroyed." Foerster & Takekawa (1991) report that "rats have been identified as clapper rail egg predators by several investigators." Josselyn (1983) suggests that cordgrass may support higher densities of clapper rail in part because of the greater protection it provides against Norway rats, which is "probably the most significant predator" of rail chicks. Norway rats reportedly take about a third of the clapper rail eggs laid in the southern part of the Estuary (BDOC, 1994).

Vulpes vulpes regalis

RED FOX

SYNONYMS: *Vulpes fulva*

The red foxes in California are probably descended from Iowa or Minnesota stock. They were either intentionally introduced into California by hunters or they escaped from commercial fox farms in the Central Valley in the last half of the 19th century, with a population reported from the southern Sacramento Valley in the 1870s (BDOC, 1994). Red foxes subsequently spread to the coast, reaching the east Bay area by the early 1970s (Harvey et al., 1992), and are now common in the Central Valley and in coastal counties from Sonoma south. They were first observed at the San Francisco Bay National Wildlife Refuge in the South Bay in 1986, and have continued to expand their range around the Bay, invading Bair Island by 1992 (Harvey et al., 1992). They are regularly seen in the South Bay in all habitat types, and dens have been found in levee banks and salt marshes (Foerster & Takekawa, 1991).

Impacts from this predator could be substantial, as it has been estimated "that a family of two adults and five pups would require about 317 pounds of food during the 12-week whelping period" (Harvey et al., 1992). In San Francisco Bay the red fox has preyed on the eggs and sometimes the young or adults, and disrupted nests or colonies, of endangered California clapper rail, least tern and snowy plover, and of Caspian tern, black-necked stilt and avocet. It may also prey on endangered salt-marsh harvest mouse, the salt marsh wandering shrew, and California black rail in the Estuary. In southern California the red fox has preyed on endangered light-footed clapper rail and California least tern (Foerster & Takekawa, 1991; Harvey et al., 1992; Takekawa, 1993; BDOC, 1994).

The San Francisco Bay National Wildlife Refuge began a predator management program in May, 1991 that includes the trapping and killing of red foxes. Red foxes control has been practiced at Seal Beach National Wildlife Refuge to protect least tern and light-footed clapper rail since 1986 (Foerster & Takekawa, 1991, Takekawa, 1993).

APPENDIX 2. EARLIER INOCULATIONS INTO THE SAN FRANCISCO ESTUARY AND NEARBY WATERS

Species	Native Range	Date Planted or Collected	Comments (references)
INVERTEBRATES			
Porifera			
<i>Tetilla</i> sp.	n Atlantic	early 1950s	(C. Hand, pers. comm.; W. Hartman, pers. comm., 1977).
Cnidaria			
Hydrozoa			
<i>Campanularia gelatinosa</i>	?	1859-1912	(Agassiz, 1865; Torrey, 1902; unpublished NMNH records).
<i>Halocordyle disticha</i>	n Atlantic	<1925, 1944-47	Reported by Fraser in 1925 (as <i>Pennaria tiarella</i>) without giving a date of collection. Reported on fouling panel (as <i>Pennaria</i> sp.) at Mare Island Naval Base in 1944-47 (US Navy, 1951).
<i>Turritopsis nutircola</i>	n Atlantic	<1925	Reported by Fraser in 1925 without giving a date of collection. Undated material at NMNH labeled "probably from Oakland." Listing by Light (1941) and Rees & Hand (1975) probably based on these earlier, undated records.
Annelida			
Polychaeta			
<i>Sabellaria spinulosa</i>	n Atlantic	1932-37	Collected by Olga Hartman between Point Richmond and Alameda (Carlton, 1979a).
Mollusca: Bivalvia			
<i>Anadara transversa</i> , <i>Lunarca ovalis</i> , <i>Aequipecten irradians</i> , <i>Anomia simplex</i>	nw Atlantic		Dead shells of these bivalves collected in the Bay were probably brought in with Atlantic oysters either as dead shells or as living organisms that failed to become established.
<i>Crassostrea gigas</i> JAPANESE OYSTER	Japan	1932-39	Planted in large numbers in the Bay during this period but, despite occasional reproductive success, never became established. Some experimental plantings since the late 1950s. (Carlton, 1979a).
<i>Crassostrea virginica</i> ATLANTIC OYSTER	nw Atlantic	1869-1940s	Planted in large numbers in the Bay during this period but never became established. Some experimental plantings since. (Carlton, 1979a).
<i>Mercenaria mercenaria</i> QUAHOG	nw Atlantic	1901, 1968	Dead valves and living specimens collected in the Bay (Keep, 1901; Carlton, 1969).
<i>Ostrea angasi</i>	Australia New Zealand	about 1891, before 1963	On at least two occasions small quantities of this oyster were imported to and possibly planted in the Bay. (Carlton, 1979a).
<i>Ostrea chilensis</i>	Mexico	1868-70, 1897-99	This or another species of southern oyster was imported to and possibly planted in the Bay. (Skinner, 1962; Carlton, 1979a).
<i>Ostrea edulis</i> EUROPEAN OYSTER	Europe	1962	Experimental planting of less than 300 oysters from Milford, CT (Carlton, 1979a).

Species	Native Range	Date Planted or Collected	Comments (references)
Arthropoda: Crustacea			
Decapoda			
<i>Callinectes sapidus</i> BLUE CRAB	rw Atlantic	1897	162 crabs planted in the Bay (Vogelsang & Gould, 1900). Sporadic reports of blue crabs from Bay Area waters in recent decades. In 1994, one crab reported at the Tracy pumping plant in the Delta (S. Siegfried, pers. comm., 1994).
<i>Homarus americanus</i> AMERICAN LOBSTER	rw Atlantic	1874-88	1873 shipment lost in train wreck. In 1874 four egg-bearing females (of 150 shipped) from Massachusetts were planted in the Bay. Four other shipments planted from San Francisco to Monterey Bay; several lobsters later caught by Monterey fishermen (Shebley, 1917).
<i>Limulus polyphemus</i> HORSESHOE CRAB	rw Atlantic	1880s?, 1917	Single specimen collected from Bay in 1917. In 1995 we received a report of 2 crabs caught and released in the Central Bay whose description matched that of <i>L. polyphemus</i> (Scofield, 1917; Carlton, 1979a).
<i>Upogebia affinis</i> MUD SHRIMP	n Atlantic	1912	2 males and 2 females of this common Atlantic species were dredged by the <i>Albatross</i> in the Central Bay (Williams, 1986).
VERTEBRATES			
Fish			
<i>Ambloplites rupestris</i> ROCK BASS	e US	1874	Four adults from Vermont planted in Napa Creek (Shebley, 1917).
<i>Anguilla rostrata</i> COMMON EEL	rw Atlantic	1873, 1879, 1882	In 1873, 12 freshwater eels from Hudson River planted in Sacramento River, and 1500 saltwater eels from New York Harbor planted near Oakland. In 1879, 500 eels planted in Sacramento River. In 1882, 10 eels from Shrewsbury River, NY planted in Suisun Bay (Smith, 1895; Shebley, 1917). In 1964 and 1994, one specimen caught in Delta in each year (Skinner, 1971; S. Walker, pers. comm., 1994).
<i>Chanos cyprinella</i> AWA	Hawaii	1877	100 fish planted in tributary stream in Solano County (Shebley, 1917).
<i>Lucius masquinongy</i> MUSKELLUNGE	midw US	1893	93,000 fry from Chatauqua Lake, NY planted in Lake Merced, San Francisco to control carp (Shebley, 1917).
<i>Perca flavescens</i> YELLOW PERCH	midw US & Canada	1891-1950s	Fish planted in rivers tributary to the Delta in 1891 and 1908; were widely distributed by 1918; extinct in the Delta by 1950s; are today present in Klamath River and Tule Lake systems in northern California (Shebley, 1917; McGinnis, 1984; Herbold & Moyle, 1989).

Species	Native Range	Date Planted or Collected	Comments (references)
<i>Salmo salar</i> ATLANTIC SALMON	nw Atlantic	1874, 1891, 1931	In 1874, 305 fish from Penobscot River, ME planted in Sacramento River near Redding. In 1891, 194,000 fry planted in Trinity River. In 1931, 55,000 fish planted in Smith and Klamath Rivers (Anon., 1932).
<i>Stizostedion vitreum</i> WALLEYED PIKE	e US & Canada	1874	16 adult pike from Vermont planted in Sacramento River near Sacramento (Goodson, 1966).
<i>Tautoga onitis</i> TAUTOG	nw Atlantic	1874, 1897	A few hundred fish planted in the Bay (Shebley, 1917).
<i>Thymallus arcticus</i> ARCTIC GRAYLING	n central US & Canada	1904 and later	600 grayling from Montana washed into the Sacramento River when a pond wall at the Sisson Hatchery burst. Additional plants were made in the Sierra Nevada, but never became established (Shebley, 1917; McGinnis, 1984).

APPENDIX 3. DESCRIPTIONS OF INTRODUCED PLANTS AND INVERTEBRATES IN AREAS ADJACENT TO THE SAN FRANCISCO ESTUARY

PLANTS

VASCULAR PLANTS

Dicotyledones

Ludwigia peploides var. *montevidensis* (Spreng.) Raven [ONAGRACEAE]

WATER PRIMROSE, FALSE LOOSESTRIFE

SYNONYMS: *Jussiaea repens* var. *montevidensis*

Jussiaea montevidensis

Ludwigia uruguayensis

Native to southern South America and introduced to Europe, Australia and the southeastern U. S., water primrose is found on low elevation lake shores and stream banks in much of cismontane California including the Central Valley (Hickman, 1993).

Nymphaea mexicana Zucc. [NYMPHAEACEAE]

YELLOW WATERLILY, BANANA WATERLILLY

Native to the southeastern U. S. and Mexico, the yellow waterlily is found in lakes, ponds and slow streams in the San Joaquin Valley. It is officially listed as a noxious weed (Hickman, 1993).

Nymphaea odorata Aiton [NYMPHAEACEAE]

FRAGRANT WATERLILY, WHITE WATERLILY

The fragrant waterlily is native to the eastern United States and is found in quiet waters, in ponds and at the edges of lakes at widely scattered locations in California including Butte County in the Sacramento Valley, Lake Tahoe, and the San Bernardino Mountains area, and is "expected elsewhere." It is widely cultivated as an ornamental, and is officially listed as a noxious weed (Hickman, 1993).

Polygonum hydropiper Linnaeus [POLYGONACEAE]

COMMON SMARTWEED, MARSHPEPPER, WATERPEPPER

Native to Europe, common smartweed was reported from New York by 1843, where it was used to make a yellow dye (Torrey, 1843). It is uncommon in wet places from central and northern California to Washington (Munz (1959; Hickman, 1993).

Polygonum pennsylvanicum Linnaeus [POLYGONACEAE]

PINKWEED

Native to the eastern United States, where its flowers are an important waterfowl food, pinkweed is found in moist disturbed areas and drying ponds in the eastern Sacramento Valley, where it may be planted, and is "expected elsewhere" (Hickman, 1993).

Polygonum prolificum (Small) Robinson [POLYGONACEAE]

Native to the eastern United States, *Polygonum prolificum* is found in wet salty places in Napa County and in the Lake Tahoe area, and "expected elsewhere" (Hickman, 1993).

Tamarix spp. [TAMARICACEAE]

TAMARISK, SALT CEDAR

Jepson (1951) lists one species of tamarisk in California, Munz (1959) lists four species, Munz (1968) lists seven species, and Hickman (1993) lists five species. All of these are native to Europe, Asia or Africa. Jepson (1951) reported French tamarisk, *Tamarix gallica*, from White Sulphur Creek in the Napa Valley; Munz (1959) reported athel, *Tamarix aphylla*, planted in the Sacramento and San Joaquin valleys. Dudley & Collins (1995) describe an infestation of tamarisk covering several thousand acres of riparian and upland areas near the Kern National Wildlife Refuge in the Central Valley, and note *T. chilensis*, *T. ramosissima*, *T. gallica* and *T. parviflora* as introduced species posing a serious, documented threat to sensitive species or ecosystems in California.

Monocotyledones

Alisma lanceolatum With. [ALISMATACEAE]

Native to Eurasia and northern Africa, this member of the water plantain family has been introduced to Chile, Australia, Oregon and California. It is reported from ponds, rice fields, ditches and slow streams at low elevations in northwestern California, Sonoma and Marin counties, the northern Sierra Nevada Foothills, and the Sacramento Valley (Munz, 1968; Hickman, 1993).

Aponogeton distachyon Linne [APONOGETONACEAE]

SYNONYMS: *Aponogeton distachyus*

CAPE PONDWEED

Cape pondweed, native to southern Africa, is widely cultivated for aquaria, often escaping but rarely becoming established. It is reported from low elevation ponds in the southern Coast range and the Bay Area, and is "expected elsewhere" (Munz, 1968; Hickman, 1993).

Cyperus difformis Linnaeus [CYPERACEAE]

This plant is native to the Old World and has been introduced to Mexico and Virginia. It is found in low elevation ditches, rice fields (where it is a serious pest) and pond shores in southwestern California, in the Coast Range in Sonoma, Napa, Marin and San Francisco counties, and in the Central Valley (Munz, 1959, 1968; Hickman, 1993).

Echinochloa oryzoides (Ard.) Fritsch [POACEAE]

SYNONYMS: *Echinochloa oryzicola* var. *mutica*

Native to Eurasia, this plant is reported from rice fields in Butte County (Munz, 1968) and rice fields and wet places in the southern Sacramento Valley (Hickman, 1993).

Eleocharis pachycarpa Desv. [CYPERACEAE]

Native to Chile, this plant is found in Nevada, in coastal salt marsh in Humboldt County, and in vernal pools in Amador and El Dorado counties in the Sierra Nevada (Munz, 1959; Hickman, 1993).

Fimbristylis miliacea Linnaeus [CYPERACEAE]

This is a widespread alien that is native to the Old World tropics. It is found in low elevation rice fields in the Central Valley, and was collected in the Bay Area in 1866 (Hickman, 1993).

Heteranthera limosa (Schwartz) Willd. [PONTEDERIACEAE]

Native to central and eastern U. S. and tropical America, this plant is reported as uncommon in rice fields at low elevations in the Sacramento Valley. It is an annual, generally growing emergent in water or on wet ground, and submerged as a seedling (Hickman, 1993).

Hydrilla verticillata (Linne) Caspary [HYDROCHARITACEAE]

HYDRILLA

Native to Eurasia or central Africa, hydrilla is a highly invasive aquatic plant that clogs waterways, interferes with navigation, and displaces native plants. It was first observed in the U. S. in western Florida in 1958 or 1959, presumably introduced as discarded material from aquaria or escaped from cultivation for the aquarium trade (Joyce, 1992), became established in the southern United States and Central America, and has been found in Texas and Iowa. It was first collected in California in October 1976 at Lake Ellis in Marysville, and by 1977 was reported from two small ponds in Santa Barbara and Riverside counties, from Lake Murray near San Diego, and from the All American Canal in the Imperial Valley (Yeo & McHenry, 1977; IESP, 1991).

Only female hydrilla plants have been found in North America, which propagate by stem fragments, buds and tubers. Dormant propagules may survive in the water or mud for several years. Hydrilla's use in aquaria may account in part for its rapid spread, and it may also be spread by boat trailers and possibly by waterfowl (Yeo & McHenry, 1977).

Hickman (1993) reports hydrilla from ditches, canals, ponds, reservoirs and lakes at low elevations throughout much of cismontane California, including the Sacramento Valley and the Delta. Thomas (pers. comm., 1994), however, reports that hydrilla is not in the Delta waterways, and it was not found in the Delta in surveys conducted by the California Department of Water Resources and Department of Food and Agriculture (IESP, 1991).

In 1977, the California Department of Food and Agriculture classified hydrilla as a Class A noxious weed. Hydrilla may have been eradicated from Lake Ellis and Lake Murray, and there are current efforts to control it at Redding on the Sacramento River (Thomas, pers. comm., 1994). In the 1970s, the state of Florida spent \$6 to \$8 million a year on hydrilla control (Yeo & McHenry, 1977).

Najas gracillima (A. Braun) Magnus [HYDROCHARITACEAE]

THREAD-LEAVED WATER-NYMPH

Native to the northeastern U. S., this plant is reported as rare in low elevation rivers in the northern Sacramento Valley, but "expected elsewhere" (Hickman, 1993).

Najas graminea Del. [HYDROCHARITACEAE]

RICE-FIELD WATER-NYMPH

Native to tropical Asia, this plant is reported as very uncommon in low elevation irrigation ditches and rice fields in Butte and Colusa counties in the Sacramento Valley (Munz; 1959; Hickman, 1993).

Ottelia alismoides (Linnaeus) Pers. [HYDROCHARITACEAE]

Native to Africa, India and the southwestern Pacific, this plant is described as a potentially noxious weed. It was found in low elevation ditches and rice fields in Butte County in the eastern Sacramento Valley, and is presumed to be eradicated (Hickman, 1993).

Peltandra virginica (Linnaeus) Schott & Endl. [ARACEAE]

TUCKAHOE, GREEN ARROW ARUM

Tuckahoe is native to eastern North America, and is uncommon in low elevation ponds and reservoirs in southwestern San Joaquin Valley (Hickman, 1993).

Scirpus mucronatus Linnaeus [CYPERACEAE]

This plant is native to Eurasia and introduced to central and eastern U. S. and California, where it is a weed in rice fields and wet places at low elevations in the Sacramento Valley, the Bay Area and the Coast Ranges (Munz, 1959; Hickman, 1993).

Scirpus tuberosus Desf. [CYPERACEAE]

SYNONYMS: *Scirpus maritimus* var. *tuberosus*

Native to Europe, this plant is cultivated for waterfowl food and has been introduced to eastern North America and the Pacific coast from California to Oregon. In California it is reported from low elevation ditches, marshes and rice fields in the Central Valley and Bay Area (Munz, 1959; Hickman, 1993).

INVERTEBRATES

MOLLUSCA: GASTROPODA

Planorbella duryi (Wetherby, 1879) [PLANORBIDAE]

SEMINOLE RAMS-HORN

SYNONYMS: *Seminolina duryi*

This snail is native to Florida and has been spread by the aquarium trade, with the albino form sold as the "red ramshorn." It is common in southern California and north near the coast to Humboldt County, reported especially from artificial ponds, drainage and irrigation ditches, and the outflow from warm springs. The first California record is from San Bernardino County in 1931. It is unclear whether it occurs in the study zone (Taylor, 1981).

Pseudosuccinea columella (Say, 1817) [LYMNAEIDAE]

MIMIC LYMNAEA

SYNONYMS: *Lymnaea columella*

This snail, native to the eastern United States, is common in artificial and natural ponds, irrigation ditches, creeks and rivers in central and southern California. The earliest California record is from an irrigation ditch in Calaveras County in 1921. It is unclear whether it occurs within the study zone (Taylor, 1981).

Radix auricularia (Linnaeus, 1758) [LYMNAEIDAE]SYNONYMS: *Lymnaea auricularia*

Hanna (1966) reported this European snail, which is now widespread in the United States, from irrigation systems and natural bodies of water from Sacramento to Los Angeles counties, including Napa, Santa Clara and Alameda counties. It is unclear whether it occurs within the study zone. It apparently has spread from artificial ponds in metropolitan areas. The first California records are from ornamental ponds in Los Angeles, where Gregg (1923) first noticed them in 1922 and was told they first occurred about 1920, and from the Japanese tea garden in Golden Gate Park, San Francisco and the fountain pool at Byron Hot Springs, Contra Costa County in 1924 (Hanna & Clark, 1925). It has been suggested that it may have been introduced as snails or eggs on ornamental aquatic plants, or through the aquarium trade, where it was sold as the "African or Paper-shelled Snail" (Gregg, 1923; Hanna & Clark, 1925).

APPENDIX 4. INTRODUCED ORGANISMS IN THE NORTHEASTERN PACIFIC KNOWN ONLY FROM THE SAN FRANCISCO ESTUARY OR ITS WATERSHED

Dates are marked as in Table 1.

Species	Dates of First Records	Comments
PLANTS		
Seaweeds		
<i>Bryopsis</i> sp.	1951	
<i>Codium fragile tomentosoides</i>	1977	
Vascular Plants		
<i>Salsola soda</i>	1968	a few plants found in Bodega Bay in 1994, but none in 1995
PROTOZOANS		
<i>Ancistrum cyclidioides</i>	1946* [1894]	
<i>Boveria teredinidi</i>	1927* [1913]	
<i>Sphenophyra dosinia</i>	1946* [1894]	
<i>Mirofolliculina limnoriae</i>	1927* [1871]	
<i>Trochammina hadai</i>	1991*	
INVERTEBRATES		
Porifera		
<i>Prosuberites</i> sp.	1953*	
Cnidaria		
<i>Blackfordia virginica</i>	1970	Napa River only
<i>Cladonema uchidai</i>	1979	
<i>Clava multicornis</i>	1895	
<i>Corymorpha</i> sp.	1955-56	
<i>Garveia franciscana</i>	1901	
<i>Maeotias inexpectata</i>	1992	Napa & Petaluma rivers only
<i>Aurelia "aurita"</i>	1989?*	South Bay only?
Annelida		
<i>Branchiura sowerbyi</i>	1963* [1950*]	limited to watershed
<i>Potamothrix bavaricus</i>	≤1965	
<i>Tubificoides apectinatus</i>	1961-62*	
<i>Varichaetadrilus angustipenis</i>	1982	limited to watershed
<i>Ficopomatus enigmaticus</i>	1920	
<i>Marenzelleria viridis</i>	1991	
<i>Potamilla</i> sp.	1989	
<i>Sabaco elongatus</i>	1950s*	

Species	Dates of First Records	Comments
Mollusca: Gastropoda		
<i>Busycotypus canaliculatus</i>	1938	
<i>Crepidula convexa</i>	1898	
<i>Littorina saxatilis</i>	1993*	Emeryville Marina only
<i>Boonea bisuturalis</i>	1977*	
<i>Cuthona perca</i>	1979	Lake Merritt only
<i>Eubranchus misakiensis</i>	1962	
<i>Sakuraeolis enosimensis</i>	1972	
Mollusca: Bivalvia		
<i>Potamocorbula amurensis</i>	1986	
Arthropoda: Crustacea		
<i>Eusarsiella zostericola</i>	1953*	
<i>Acartiella sinensis</i>	1993	
<i>Limnoithona sinensis</i>	1979	
<i>Limnoithona tetraspina</i>	1993	
<i>Oithona davisae</i>	1979	
<i>Pseudodiaptomus forbesi</i>	1987	
<i>Sinocalanus doerrii</i>	1978	
<i>Tortanus</i> sp.	1993	
<i>Epinebalia</i> sp.	1992	
<i>Acanthomysis aspera</i>	1992	
<i>Acanthomysis</i> sp.	1992	
<i>Deltamysis holmquistae</i>	1977	
<i>Dynoides dentisinus</i>	1977	
<i>Eurylana arcuata</i>	1978	
<i>Paranthura</i> sp.	1993*	
<i>Gammarus daiberi</i>	1983	
<i>Leucothoe</i> sp.	1977*	
<i>Melita</i> sp.	1993*	
<i>Paradexamine</i> sp.	1993*	
<i>Transorchestia enigmatica</i>	1962*	Lake Merritt only
<i>Eriocheir sinensis</i>	1992	
<i>Orconectes virilis</i>	≤1959 [1939-41]	limited to watershed?
Arthropoda: Insecta		
<i>Anisolabis maritima</i>	1935 [1921] (1920)	reports elsewhere probably in error
<i>Neochetina bruchi</i>	1982	
<i>Neochetina eichhorniae</i>	1982-83	
<i>Trigonotylus uhleri</i>	1993*	
Entoprocta		
<i>Urnatella gracilis</i>	1982-84 [1972]	
Bryozoa		
<i>Victorella pavida</i>	1967*	Lake Merritt only?

APPENDIX 5. INTRODUCED MARINE, ESTUARINE AND AQUATIC ORGANISMS IN FOUR REGIONAL STUDIES

	Mills et al., 1993 Great Lakes	Jansson, 1994 ^a Baltic Sea & Swedish Coast	Mills et al., 1995 Hudson River	This Study ^b San Francisco Estuary
PLANTS				
Bacteria	1 (1%)	0 -	0 -	0 -
Phytoplankton	17 (12%)	9 (18%)	0 -	0 -
Seaweeds	7 (5%)	8 (16%)	0 -	5 (2%)
Vascular Plants	59 (42%)	2 (4%)	97 (63%)	49 (20%)
PROTOZOA				
	2 (1%)	0 -	0 -	8 (3%)
INVERTEBRATES				
Porifera	0 -	0 -	0 -	5 (2%)
Cnidaria	2 (1%)	2 (4%)	2 (1%)	17 (7%)
Platyhelminthes	1 (1%)	0 -	0 -	0 -
Nematoda	0 -	1 (2%)	0 -	0 -
Annelida	3 (2%)	2 (4%)	1 (1%)	21 (9%)
Mollusca	14 (0%)	6 (12%)	19 (12%)	30 (13%)
Arthropoda: Crustacea	6 (4%)	11 (22%)	6 (4%)	49 (20%)
Arthropoda: Insecta	2 (1%)	0 -	0 -	4 (2%)
Entoprocta	0 -	0 -	0 -	2 (1%)
Bryozoa	0 -	1 (2%)	0 -	11 (5%)
Chordata: Tunicata	0 -	0 -	0 -	8 (3%)
VERTEBRATES				
Fish	25 (18%)	4 (8%)	29 (19%)	28 (12%)
Amphibians	0 -	0 -	0 -	1 *
Reptiles	0 -	0 -	0 -	1 *
Birds	0 -	2 (4%)	0 -	0 -
Mammals	0 -	2 (4%)	0 -	1 *
SUBTOTAL: Plants	84 (60%)	19 (38%)	97 (63%)	54 (23%)
SUBTOTAL: Protozoa	2 (1%)	0 -	0 -	8 (3%)
SUBTOTAL: Invertebrates	28 (20%)	23 (46%)	28 (18%)	147 (61%)
SUBTOTAL: Fish	25 (18%)	8 (16%)	29 (19%)	31 (13%)
TOTAL	139 (100%)	50 (100%)	154 (100%)	240 (100%)

* Less than 0.5%.

^a Jansson did not report specific criteria for inclusion on the list of introduced species within her study zone, but reported only two vascular plants, both of them submersed aquatic plants.

^b Based on the expanded list, as explained in the "Taxonomic Groups" section of Chapter 5.