LOWER COLUMBIA RIVER AQUATIC NONINDIGENOUS SPECIES SURVEY 2001-2004

Final Technical Report

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Prepared for the
UNITED STATES COAST GUARD
and the
UNITED STATES FISH AND WILDLIFE SERVICE

October 2004

Executive Summary

The National Invasive Species Act of 1996 identified the need to conduct an ecological survey of aquatic nonindigenous species (ANS) in the Columbia River and authorized funding for this purpose. The Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS) was initiated to provide comprehensive information about the nonnative species present in the lower Columbia River. A comprehensive list of nonnative species distribution is the first step to understanding invasions, assessing impacts, and developing effective management actions. This investigation provides a baseline for evaluating the rate of species introductions to the river that will allow assessment of the efficacy of ballast water management regulations and contribute important new information to ongoing regional aquatic nonindigenous species (ANS) studies. Despite the considerable volume of shipping received by the five major freshwater and brackish ports on the lower Columbia River it had not been previously surveyed explicitly for nonnative species.

The objective of the LCRANS was to provide a comprehensive survey and analysis of all ANS present in the tidally influenced, 234-kilometer reach of the lower Columbia River from Bonneville Dam to the Pacific Ocean and the tidal portions of the major tributaries. The project included a review of literature, conducted in 2001-2002, and field surveys, conducted in 2002-2003.

Due to the size and diversity of habitats the taxonomic scope of the LCRANS, field surveys were limited to free-living plants and animals. The geographic area surveyed encompassed brackish and freshwater marshes, low salinity mudflats, polyhaline beaches, rocky shorelines, protected embayments, large river habitats, tidally influenced agricultural drainages, and urban sloughs.

We sampled at 134 stations and documented 269 aquatic species (and 55 other distinct organisms that we were unable to identify at the species level) in the lower Columbia River. Of the 269 species identified, 54 (21%) were introduced, 92 (34%) were native, and 123 (45%) were cryptogenic.

The literature review and field survey revealed that at least 81 organisms have been introduced into the lower Columbia River since the mid 1800s. The majority of these species were fish (28%), aquatic plants (23%) and crustacea (15 %). The remaining 18% was a combination of mollusks, annelids, bryozoans, cnidaria, amphibians, reptiles and an aquatic mammal. Due to the limitations of this survey, inadequate taxonomic resolution in prior studies, and the abundance of unresolved and cryptogenic taxa, our results are likely a conservative estimate of the ANS invasion of the lower Columbia River.

From the 1880s to the 1970s a new introduced species was discovered in the lower Columbia about every five years. The frequency of new discoveries ANS is increasing worldwide (OTA 1993, Ruiz et al. 2000), however, and the rate of discovery of introduced invertebrates in the lower Columbia River mirrors this trend. Over the past ten years a new invertebrate species was discovered about every five months. The increasing rate of new discovery is due to increasing frequency of introductions and to the number and type of surveys conducted. It is not possible to separate these effects from the available data.

In contrast to the increasing rate of invertebrate discovery, the rate of fish discovery peaked in the 1950s. This trend was likely due to a decline in intentional fish introductions by both individuals and fish and game agencies to increase the diversity of food and game fishes.

The majority of introduced species in the lower Columbia originated in North America. Introduced fish accounted for most of the species with North American origin, while Asia was the native region of 34 percent of the invertebrates introduced via shipping mechanisms in the Columbia River. The high proportion of Asian invertebrates in the Columbia River fauna may be related to shipping patterns. Asian ports are the last port of call for most arrivals to the Columbia River from outside the Exclusive Economic Zone (EEZ). These patterns, however, are based on estimates of both origin and vectors of dispersal. For many species precise vectors and origins remain uncertain.

The Columbia River receives more port calls from vessels from domestic ports (59 percent) than it does from international ports (Flynn and Sytsma 2004). About 25 percent of coastal vessel traffic entering Oregon estuaries originated in the highly invaded San Francisco Bay/Sacramento/San Joaquin Delta (Flynn and Sytsma 2004). Short transit times, established populations of introduced invertebrates possibly selected for dispersal by shipping vectors in several domestic ports on the West Coast, and abundant shipping traffic suggests that domestic shipping is a highly important vector for ANS introduction to the Columbia River.

This report establishes a baseline on ANS in lower Columbia River. Additional monitoring and sampling is necessary to detect new invasions and to document invasion rate, impacts, and efficacy of management efforts. We recommend a multiple-purpose sampling approach to maximize the potential of detecting additional species and new arrivals. Sampling should target habitats and taxa that are likely to contain new invaders every year; a synoptic survey of the lower Columbia River should be conducted every five years; and additional sampling should target data gaps and survey limitations of this project.

Acknowledgements

Funding of this project by the U.S. Coast Guard and U.S. Fish and Wildlife Service was stimulated by the Columbia River Aquatic Nuisance Species Initiative, a joint effort by the Ports of Portland and Astoria and the Columbia River Steamship Operators Association. Rich Everett, Denny Lassuy, Paul Heimowitz, and Stephen Phillips facilitated the project. The Technical Advisory Committee assisted with the literature review, reviewed draft reports, and provided sampling and analysis advice when needed. The project could not have been completed without the assistance of consulting taxonomists: Leslie Harris, Terry Frest, Jennifer Parsons, Jin Hwan Lee and Steve Fend. Selene O'Dell, April Fong, Laura Johnson, Mary Pfauth, Jeff Adams, Bruce Sutherland, Dennis Issacson, Chris Kodadek's summer 2002 aquatic science class, Christy McDonough, Dr. and Mrs. Richard Peterson, Diane Kightlinger, and Kurt Getsinger provided valuable volunteer assistance in the field.

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List of Abbreviations and Acronyms

ANS	Aquatic Nonindigenous Species
BSWQP	Bi-State Water Quality Program
CREDDP	Columbia River Estuary Data Development Project
CREST	Columbia River Estuary Studies Taskforce
IUCN	The World Conservation Union also known as the International Union For Conservation of Nature and Natural Resources
LCRANS	Lower Columbia River Aquatic Nonindigenous Species Survey
LCREP	Lower Columbia River Estuary Project
NAISA	National Aquatic Invasive Species Act, 1996
NMFS	National Marine Fisheries Service, also known as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University
OTA	Office of Technology and Assessment
SERC	Smithsonian Environmental Research Center
TAC	Technical Advisory Committee (part of LCRANS) (see Appendix A)
USACE	United States Army Corps of Engineers
USFC	United States Fish Commission (predecessor to USFWS and NOAA Fisheries) also known as United States Commission of Fish and Fisheries
USFWS	United States Fish and Wildlife Service
WEMAP	West Coast Environmental Monitoring and Assessment Program
WDE	Washington State Department of Ecology
WDFW	Washington Department of Fish and Wildlife

Chapter 1: Introduction

Overview

Rates of aquatic nonindigenous species (ANS) introductions and their social, economic, and ecological impacts are increasing (OTA 1993, Ruiz et al. 2000). Introductions of nonnative marine organisms have increased exponentially over the last two centuries and expenditures on outreach, control, and research exceed millions of dollars per species for several invaders of particular concern to the United States (Carlton 2001)[1]. These trends suggest that major changes are occurring in the freshwater, estuarine, and marine ecosystems of North America (OTA 1993, Cohen and Carlton 1995), but their magnitude is probably underestimated. For every well-documented impact of notorious invaders, such as intake-pipe fouling by the zebra mussel,*Dreissena polymorpha* (OTA 1993), water quality decline caused by hydrilla, *Hydrilla verticillata* (Langeland 1996), and mudflat conversion by the smooth cord grass, *Spartina alterniflora* (Daehler and Strong 1996), there are unknown numbers (likely thousands) of nonnative species with undocumented ecological and economic impacts.

Basic information on species presence is necessary for ecosystem management. A comprehensive list of nonnative species distribution is the first step to understanding invasions, assessing impacts, and developing effective management actions. Several estuaries, bays and other protected coastal habitats of the northeast Pacific have been the subject of rapid assessment surveys (Cohen and Carlton 1995, Cohen et al. 1998, Mills et al. 2000 and Cohen et. al. 2001). Studies of ANS and ballast water release on the West Coast of North America have focused on ports in higher salinity estuaries and bays such as San Francisco Bay and Coos Bay. Freshwater-dominated estuaries and large river systems have received little attention. Discharge of ballast water into marine and aquatic systems has become a significant pathway for ANS introductions worldwide as a result of a substantial increase in the speed and volume of global trade over the past century

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[1] Recent estimates place the cost of the introduction of *Driessna polymorpha* between $750 million and $1 billion from 1989 and 2000 (Carlton 2001); state and federal funding for understanding impacts and eradicating *Spartina alterniflora* in the Pacific Northwest total over $4.5 million in the past 5 years; $1 million of federal funding went to *Eriocheir sinensis* control and research efforts in California in 2000-2001; and control and monitoring of *Caulerpa taxifolia* in southern California cost $2.33 million.

(Cohen & Carlton 1995, Cohen 1998). Despite the considerable volume of shipping received by the five major freshwater and brackish ports on the lower Columbia River (LCR), it has never been surveyed explicitly for nonnative species.

The United States Congress remedied this disparity in 1996 when they re-authorized the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, renamed the National Invasive Species Act (NISA). The authors of NISA specifically identified the need to conduct an ecological survey of ANS in the Columbia River and authorized funding for this purpose. In the fall of 2001, the Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS) was initiated.

LCRANS was undertaken to provide comprehensive information about the ANS present in the lower Columbia River. The results of this investigation will serve as a baseline for evaluating the rate of species introductions to the river and the efficacy of ballast water management regulations, and contribute important new information to ongoing regional ANS studies. In addition, the data may be useful for determining where the lower Columbia River is vulnerable to invasion and for evaluating effects of introductions on important ecological processes.

The project was implemented in consultation with the LCRANS Technical Advisory Committee (TAC). The TAC consisted of local, regional, and national experts on biological invasions of aquatic systems, taxonomy, and regional resource management (see Appendix A for a complete list of TAC participants). The role of the TAC was not supervisory; rather the TAC reviewed, evaluated, and assisted LCRANS in achieving the following goals:

- Develop a database for relevant information including timeframe of introduction, native and source regions of introduced species, modes of introduction, etc.
- Review existing literature on ANS in the lower Columbia River.
- Perform field surveys for ANS to complete and/or extend existing records –i.e. focusing on habitats and taxa not well represented in literature.
- Design and implement replicable monitoring protocols for detecting new or expanding invasions.
- Complete a written report including at minimum 1) an examination of the attributes and patterns of invasions of ANS in the LCR, and 2) a discussion of the effectiveness of ballast water management in abating ANS invasions in LCR.

Structure and Scope

The objective of the LCRANS was to provide a comprehensive survey and analysis of all ANS present in the lower Columbia River - the tidally influenced 234-kilometer reach from Bonneville Dam to the Pacific Ocean, and the tidal portions of the major tributaries. This geographic area encompassed brackish and freshwater marshes, low salinity mudflats, polyhaline beaches, rocky shorelines, protected embayments, large river habitats, tidally influenced agricultural drainages, and urban sloughs. Due to the size and diversity of habitats the taxonomic scope of the LCRANS project was limited to free-living macrophytes and animals. The project included three components:

- A literature review of Columbia River ANS,
- Field surveys to characterize the ANS present
- A comprehensive analysis and summary of the results of the previous components.

The field survey focused on species and habitats that were not well studied previously. For example, nonnative fish were recorded when captured in the course of sampling but were not specifically targeted during the field surveys. Much of the information in this report about nonnative fishes comes from the initial literature review that, unlike many of the invertebrate taxa, have been well studied.[2]

This report summarizes the work performed by the LCRANS team between October 2000 and July 2004. Some sections reference previously released LCRANS reports. These reports are available upon request from the corresponding author or in Adobe PDF format from the website http://www.clr.pdx.edu under the link “LCRANS.” In order to further understand the ANS present in the lower Columbia River in a regional context, this report also describes the timeframe, source, vector, distribution, and impacts of invasion where possible. In the Conclusion, we discuss our major findings and their implications for regional ANS management, and identify data gaps and further research needs.

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[2] There are several types of fish such as gobies and blennies that have been documented as introduced unintentionally and are associated with habitats (such as rocky cervices) that are not typically targeted during routine fish sampling. These habitats may need to be specifically targeted in future ANS surveys (Andy Cohen, personal communication).

Chapter 2: The Lower Columbia River

The Columbia River is the largest river in the Pacific Northwest and the second largest in the United States (in terms of volume discharged). Its drainage basin covers 671,000 km^2 in seven states and one Canadian province. Tidal influence of the Pacific Ocean is evident 234 km upriver to Bonneville Dam, the lowest of many impoundments on the river (Figure 1). The tidal influence also extends 207 km from the Pacific Ocean to Willamette Falls on the Willamette River, the largest tributary entering the lower river. The lower Columbia, from Bonneville dam to the mouth, drains approximately 46,600 km^2. Although it represents only seven percent of the entire Columbia Basin, it is the most developed and urbanized portion of the watershed.

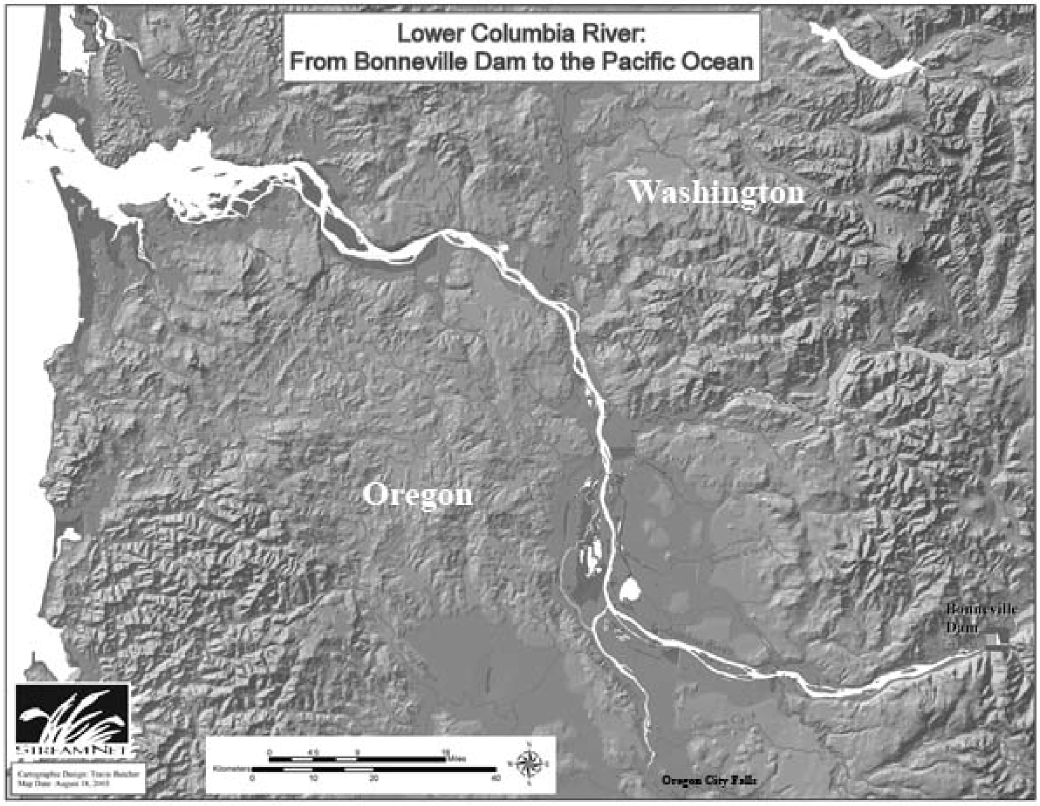

Figure 1. The LCRANS study area – the tidally influenced portions of the lower Columbia and Willamette Rivers (map created by StreamNet)

The Lower Columbia River Basin

For thousands of years the Columbia River has been central to the existence and cultures of numerous Native American tribes. Lewis and Clark’s exploration of the Columbia

River in the early 1800s ushered in two centuries of transformation. In 1825, the British Hudson's Bay Company established a post at Fort Vancouver. With the arrival of the first European American settlers in the 1840s, who reached the lower Columbia and Willamette river valleys via the Oregon Trail, the shape and character of Columbia River began to change. Like many other bays and estuaries along the West Coast, the lower Columbia River became a busy port, with ships arriving daily bearing supplies and immigrants, and leaving with timber, furs and fish. Since then, the population of the lower Columbia River basin has continued to grow, accompanied by increased demands on the river.

The lower Columbia River delineates the boundary between Oregon and Washington. Three major tributaries enter the Columbia River downstream of Bonneville Dam; the Willamette River on the Oregon side, and the Lewis and Cowlitz rivers from Washington. There are five major ports along the lower Columbia River: Astoria, Longview/Kelso, Kalama, Vancouver, and Portland. In 1998, the US Department of Commerce reported that these five deep-water ports support a shipping industry responsible for transporting 30 million tons of foreign trade worth $13 billion each year (LCREP 1999).

According to the Lower Columbia River Estuary Project (LCREP 1999) “historical evidence indicates that since 1870, more than half of estuarine wetlands have been lost as a result of diking, draining, filling, dredging, and flow regulation.” (Figure 2). In 1932, construction began on the first of many dams that altered the flow regime of the Columbia. In 1938, Bonneville Dam was completed. Located 233 kilometers from the mouth, Bonneville Dam marked the new upper boundary of tidal influence on the river. By the mid 1970s, 18 dams had been erected on the main stem of the Columbia and its main tributary, the Snake River. Today, the river supports numerous commercial and recreational activities including fishing, hydroelectric power generation, irrigation, aquaculture, shipping, and boating.

From the mouth to Skamokawa, WA (~ river km 56) the lower Columbia River is a coastal plain estuary[3]. Sand deposition in the middle reach of the estuary has formed vast areas of sand flats and shoals. Dredge disposal has built up some of these areas into islands. There are four large, shallow embayments in the estuary (Grays, Baker, Youngs and Cathlamet bays) (Holton 1984). Upstream of Skamokawa, from Puget Island to Longview, WA and the confluence of the Cowlitz River, the Columbia is primarily a single channel bordered by steep valley walls (Holton 1984). Further upstream, from Longview to the start of the Columbia River Gorge below Bonneville Dam, the river valley widens into a low-elevation flood plain.

The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 7,500 m^3/s, but may range from lows of 2,000-3,000 m^3/s to highs of 15,000 m^3/s (Hamilton 1990; Prahl *et al.* 1998; NOAA 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March with periodic peaks due to heavy winter rains (Holton 1984). The discharge during May-June has been reduced by more than 50 percent since impoundment for water storage, hydropower generation, and irrigation diversion in the middle and upper basin[4] (Ebel et al. 1989) (Figure 3).

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[3] This delineation of the estuary is a simplification. The boundaries of the Columbia River estuary can be viewed as fluctuating daily, seasonally, and annually. Further complicating any generalization is ongoing dredging for navigation, which creates a narrow, deep channel that restricts salt water penetration into the estuary. Simenstad et al. (1990) give a more detailed discussion of the physical and chemical characteristics of the Columbia River estuary.

[4] There are over 250 dams and reservoirs and 150 hydroelectric projects in the Columbia River watershed, including 18 main-stem dams on the Columbia and Snake rivers (USACE 2001). Extensive development has turned the main stem of the Columbia River into a series of slow-moving reservoirs impounded by 11 large dams, the lowest of which is Bonneville Dam (Sherwood et al. 1990, Prahl et al. 1998, USACE 1999).

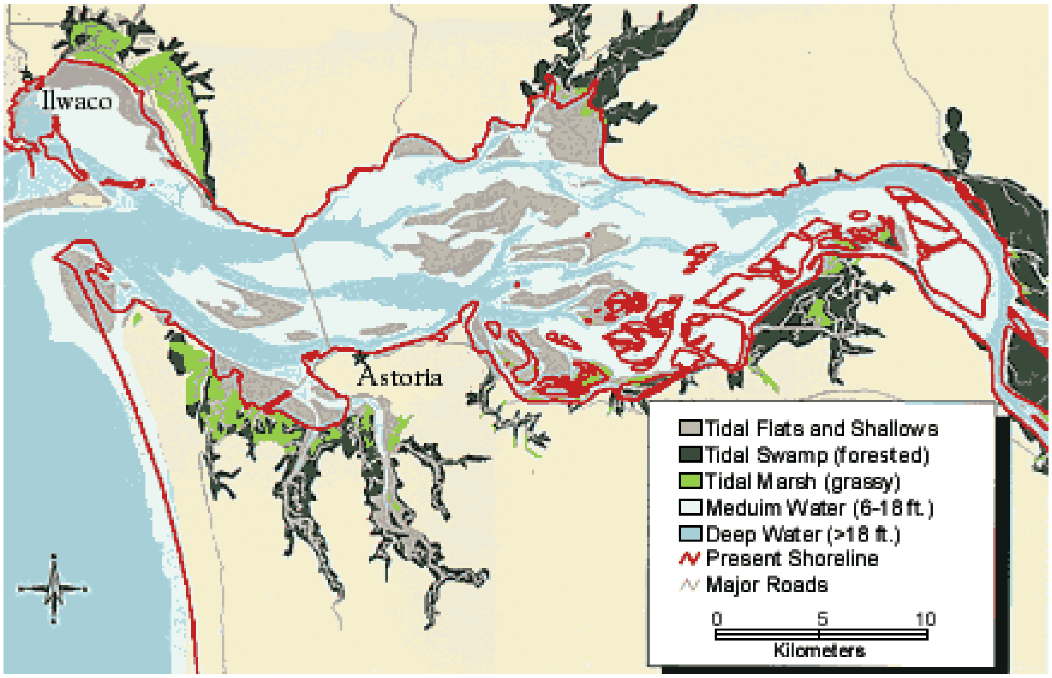

Figure 2. Habitat alteration along the Columbia River estuary contrasting the shoreline position in 1868-1875 with the present shoreline shown in outline. (Source: Lower Columbia River Bi-State Water Quality program http://www.ecotrust.org)

Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (USGS 2003). Historically, flooding has occurred primarily during the cool phase of ENSO. A major exception was the devastating 1948 Vanport flood that occurred when ENSO was in its neutral phase. Droughts have usually occurred during the warm phase of ENSO.

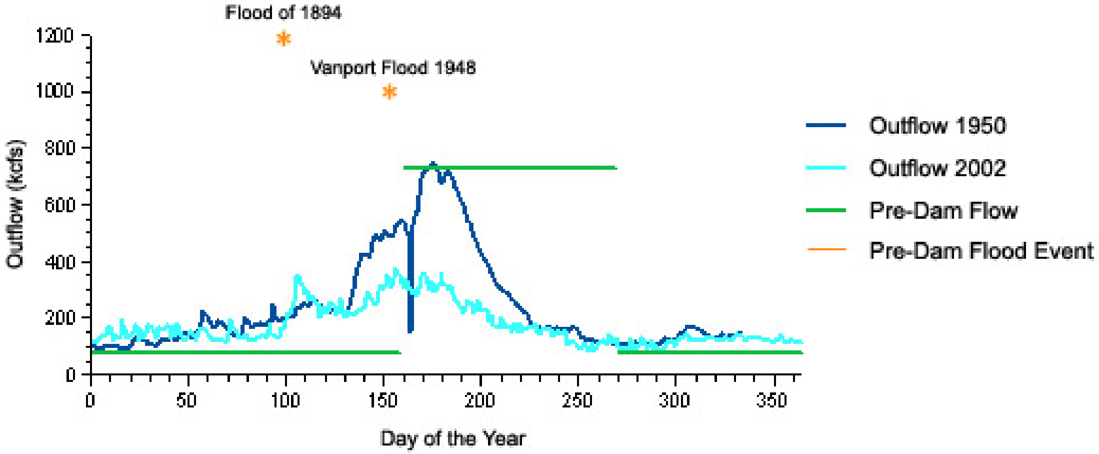

Figure 3. Past and present flow data for the lower Columbia River collected at the Bonneville Dam. (The straight line demonstrates average estimated flow of the Columbia River prior to the

construction of dams and other impoundments. Two extreme flood events are starred. Data from the Columbia Basin Research team at the University of Washington http://www.cbr.washington.edu/dart/riverclimate.html with additional pre-dam data from Pruter and Alverson (1972)).

Salinity intrusion is flow dependent but typically extends to around 50 km from the mouth and is largely confined to the two main channels; the southern one is the dredged shipping channel that extends from the mouth to Portland, OR (Hamilton 1990). Vertical stratification varies from fully mixed to salt wedge conditions depending on both the volume of flow and tidal heights (Hamilton 1990). At the river mouth the estuary is considered partially mixed except at extreme low flows when it can become vertically homogeneous at high tide (Neal 1972, Hamilton 1990). Further upstream at river kilometer 30 the estuary behaves as a partially mixed estuary except during high flows at low tide when it can become vertically stratified or completely freshwater (Neal 1972).

Historically the free-flowing Columbia River may have supported an “average to rich bottom fauna in which caddis fly and chironomid larvae, mayfly nymphs and mollusks predominated” (Roebeck et al. 1954 in Ebel et al 1989). Aside from catch data of commercially important species, however, few biological records exist for the lower Columbia Basin that pre-date the construction of the dams (Weitkamp 1994). Today the main stem of the lower Columbia River is considered depauperate in species (Ebel et al 1989). The biological integrity of the river may be further degraded by pollution, destruction of wetlands, and other impacts related to industrialization, navigation improvement, and urbanization. While many adjustments to the impoundment of a river happen very quickly (Petts 1984), geophysical changes may require more than 100 years to adjust to major alterations of flow (Sherwood and Creager 1990). The strong linkage between biological communities and the physical characteristics of riverine systems may mean that the lower Columbia River biota is still adjusting to anthropogenic changes. This adjustment period may have benefited ANS (Weitkamp 1994).

The Changing Nature of Invasions

Human beings, unlike other species, often bring their favorite food, sport, and ornamental species with them when they colonize new locations (Minns and Cooley 1999). This pattern held true for the new arrivals to the Columbia River Basin. It is ironic to note that, while the early settlers rapidly took advantage of the abundance of salmon in the region and made it the basis of a multi-mullion dollar industry, they soon “tired” of its pink flesh and yearned for the game fishes of their childhoods (Lampman 1946). Today, the region faces the rapid decline of native salmon stocks.

> “They could catch a salmon whenever they wanted it. They measured their cutthroat trout, *Salmo clarkii*, by the bushel… [but], by Godfrey, what they really wanted was a big mess of catfish.” (Lampman 1946)

In the late 1800s, the United States Fish Commission (the precursor to the US Fish and Wildlife Service) became active in the transport and stocking of Atlantic/Eastern fish species on the West Coast to “increase the quality and variety of food and game fishes” and supplement the “worthless and unpalatable fish” (Smith 1896). Today, more than 20 species of non-native, popular, game fish have been successfully introduced to the lower Willamette and Columbia rivers.

One early fish introduction to the lower Columbia River Basin was the carp, *Cyprinus carpio* (Smith 1896, Lampman 1946). Lauded as a European delicacy as easy to raise as “pigs in your back yard” – the first shipments of carp arrived in the Willamette Valley in 1879 and 1880. A great number of the carp thrived and reproduced in the pond of Captain John Harlow and, with the arrival of a vigorous spring freshet that swelled the waters of the Sandy River and freed the fish, they made their way into the lower Columbia River system in May 1881 (Lampman 1946). The US Fisheries Commission supplied additional shipments of carp to the Pacific Northwest from stock raised in California (Smith 1896) and by 1892 the populations of carp had grown so vast and become such a nuisance that the Oregonian newspaper reported that fishermen were “offering to supply farmers with any desired quantity [for use as fertilizer] at $5 a ton” (Lampman 1946).

American shad, *Alosa sapidissima*, were released in California in 1871. They rapidly dispersed along the Pacific Coast and were caught in the Columbia River as early as 1876 (Smith 1896), ten years prior to the intentional stocking of shad fry in the Columbia Basin. Recently, measures were enacted by the National Marine Fisheries Service (NMFS) to reduce American shad populations in the Columbia River because they are believed to prey on, and compete with, juvenile salmon (Rishi Sharma, personal communication 2002; NMFS 1995). American shad appear to have benefited from the construction of dams and impoundments that threaten many native fish (Weitkamp 1994).

In 1914, the Oregon Fish and Game Commission granted permission to a private individual to introduce bullfrogs, *Rana catesbeiana,* into the mid-Columbia River basin below John Day (Lampman 1946). In 1924 or 1925 bullfrogs resulting from the above planting were shipped to Portland for further distribution (Lampman 1946). Today, mature bullfrogs are responsible for significant levels of predation on native aquatic species, particularly the Western pond turtle and the spotted frog (Crayon 2002).

While many of the earliest non-native species introductions to the lower Columbia River were the result of intentional plantings, more recent arrivals appear to be the result of unintentional introductions[5]. It has been hypothesized that the physical and biological changes to the lower Columbia River promote the establishment of new ANS (Cordell et al 1992, Weitkamp 1994).

Three of the most recent ANS that have become established in the lower Columbia River the New Zealand mudsnail, *Potamopyrgus antipodarum*, a Siberian freshwater prawn, *Exopalaemon modestus*, and an Asian calanoid copepod, *Pseudodiaptomus inopinus*, differ from earlier invaders in that they are invertebrates with little or no food or recreational value. As such, none of these species were likely to have been intentionally introduced and no clear documentation of the dates and vectors of introduction exists. *P. inopinus* is believed to have been introduced between 1980 and 1990 via ballast water released from ships arriving from Asia (Cordell et al. 1992). When first captured in 1995, *E. modestus* was immediately recognized as an invasive species because there are no true freshwater shrimp native to the Columbia River (Emmett et al. 2002). This prawn may also have arrived in ballast water (Emmett et al. 2002). The arrival of *P.*

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[5] This does not exclude the possibility that several species now present in the lower Columbia River were the result of early unintentional introductions facilitated by shipping traffic. These early wooden sailing ships transported numerous wood boring and fouling organisms (see Carlton and Hodder 1995 for a discussion of wooden ships and the dispersal potential of fouling organisms), and at least one species, the barnacle *Balanus improvisus,* is thought to have arrived in the Columbia via this vector. Cohen and Carlton (1995) estimate that 26% of introductions into San Francisco Bay are the result of hull fouling. In addition, throughout the 1800s many vessels carried solid ballast made up of sand or rock dredged from the nearby shoreline, and solid ballast has been implicated in the introduction of several marine species on the West Coast, e.g. Cohen and Carlton (1995) link 3% of invasions into San Francisco Bay to this vector.

antipodarum[6], was initially misidentified as the native snail *Fluminicola virens* in benthic surveys. When its abundance increased significantly it was correctly identified as an invasive species (Rod Litton personal communication). It is not known how this snail arrived in the lower Columbia River, but the lower Columbia population has the same genotype as those in the Snake River and other western aquatic systems (Mark Dybdahl personal communication).

Introductions

Part of the global trend of increasing rates of introductions (see Ruiz et al. 2001, Cohen 2002) may be the result of increasing awareness of, and efforts to find and report, introductions, particularly among the lesser-studied taxa. The trend may also reflect increasing opportunities for, and success of, introductions. For example the increasing speed and geographic range of global trade may facilitate the survival of species being transported (intentionally or unintentionally) as well as the volume and variety of potential colonists. It has yet to be determined whether changes in vector management (such as the US ballast water guidelines for international shipping) have had an effect on the rate of introductions.

While management regulations aimed at reducing the threat of ANS invasions in the United States have improved, the Pacific Northwest is nevertheless an at-risk region for further introductions. Many long-established pathways and vectors are unregulated or remain open due to a lack of enforcement of existing rules. Also, increased efficiency of trade and transportation, new trade opportunities, and new trade dimensions (e.g. internet trade) may have opened new pathways for ANS introduction. As the region experiences ecological alterations from global climate change, increased use of natural resources such as water and timber, and urbanization, modifications in the aquatic biological communities are likely. Effects of these changes on ANS introductions in the region are unknown but probably significant.

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[6] Recorded in the benthic sampling reports of the Clatsop Economic Development Council's salmon net pen operation in Youngs Bay (See Litton 2000).

Vectors

A vector is the vehicle or activity by which a nonnative species is transported (intentionally or unintentionally) and introduced to a new habitat. A fundamental understanding of the diversity and patterns of vectors operating in a region is essential to reducing new introductions.

There may be a wide range of vectors operating at many spatial scales (i.e., between watersheds, estuaries, oceans, etc.) that impact a given system and result in substantial transfer of biological material. Tens of thousands of species are in transit globally on a daily basis (Carlton 2001). Some introductions may be the result of numerous vectors while others may be limited to one specific mechanism or action. The success of some vectors may be limited by environmental factors like climate or seasonality. The wide diversity of potential vectors makes them a complex management issue, and identifying them is an essential step in managing invasions. It is important to note that the vectors listed for each species should be considered merely best estimates of the means of dispersal. For many species the precise vectors of dispersal are unknown. Facing a lack of unequivocal evidence regarding which species came in via which vector, the vectors assigned to each species represent “possible” vectors based primarily on life history characteristics of species. In the following section we detail several categories of vectors that may play a significant role in the introduction of aquatic nonindigenous species into the lower Columbia River.

Commercial Shipping and Maritime Vessels

The introduction of nonnative organisms into the lower Columbia River by sailing vessels has been possible since the European discovery of the river by Capt. Robert Gray in 1792 - the first known arrival of a foreign sailing ship, but the imposing bar at the mouth of the Columbia River deterred numerous large vessels from entering the river. In 1875, however, the U.S. Army Corps of Engineers began construction of a jetty that, along with dredging, turned the lower Columbia River into a major port system.

In the early 1800s sailing ships entering the lower river arrived bearing supplies and immigrants and leaving with timber, furs, and fish. These ships may have introduced new species in the form of fouling and wood boring invertebrate and plants. Other organisms may have been introduced from anchor chains, sea chests, solid ballast, and later, water ballast. With the advent of metal-hulled ships wood boring aquatic invertebrates were no longer transported on the hulls of commercial vessels. The introduction of anti-fouling paint and other hull-coating efforts has further reduced hull-fouling communities but the contribution of hull-fouling communities to nonnative species introductions is not well known.[7]

Although numerous aspects of commercial shipping have been implicated in the introduction of ANS, ballast water, because of its sheer volume, remains the primary method by which ANS are believed to be transported globally (Carlton 2001)[8]. . As ships continue to get bigger and faster the total volume of ballast transported will continue to increase as travel times decrease, thus increasing the probability that potential invaders will survive their journey.

In addition to trans-oceanic ballast transport, transport of organisms in ballast water from domestic, coastal ports is also a threat. Ships in-ballast from heavily invaded locations, such as San Francisco Bay, may spread nonnative species along the West Coast. These introductions may have a high probability of establishment because transit times are short and they have already been challenged by transport in ballast tanks and local factors such as climate and competition.

The commercial shipping industry is an important component of the Oregon economy. Exports from Oregon to Asian-Pacific markets alone amounted to $5.1 billion in 2001 (Oregon Bluebook Website 2004). Major exports include wheat and cereal, vehicles, soda ash and pot ash, (Oregon Economic and Community Development Department 2004, Port of Portland 2004). The Portland metro region is the leader in export sales for the

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[7] On January 1, 2003 the International Convention Convention on the Control of Harmful Anti-Fouling Systems went into effect prohibiting the use of harmful organo-tins (which act as biocides and over time leach into surrounding water) in anti-fouling paints used on ships. It also established a mechanism to prevent the future use of other harmful substances and pollutants in anti-fouling systems. By January 1, 2008 all organo-tin anti-fouling compounds must be removed from vessels and platforms or coated with an approved sealant to prevent further leaching. (see http://www.imo.org for more information).

[8] Detailed investigation throughout the US has shown that ballast water transfer has acted as a major vector of ANS but, by comparison, much less research has been conducted on ships' hulls and their potential to act as vectors of ANS in coastal waterways. On going research at SERC and elsewhere is beginning to suggest that the threat of ANS dispersal posed by ships hulls could be greater than previously attributed.

state, and ranks 11th of 253 in sales for U.S. metropolitan regions (U.S. Department of Commerce 2001). In 2000, the shipping industry produced a total earnings and consumption impact in Oregon of about $1.7 billion (Port of Portland 2004).

A sustainable economy requires effective and efficient management of pathways of invasive species introduction that are associated with shipping. To protect Oregon water resources from the risk of ballast water-related introductions the legislature enacted SB 895 during the 2001 session., revising it with HB 3620 in 2003. The bills regulate ballast water discharge into Oregon waters, prohibiting all transoceanic and coastal vessels from discharging unexchanged ballast water with a few exceptions. Oregon law allows discharges of unexchanged ballast water from vessels traveling within defined common waters. Common waters are defined as waters between the parallel 40 degrees north latitude and the parallel 50 degrees north latitude (ORS 783.630). Currently, Oregon law only allows the discharge of ballast water treated in a manner approved of by the U.S. Coast Guard, which creates potential problems for vessels with Washington-approved treatment technology that visit both Washington and Oregon ports on the Columbia River. Ballast water regulatory changes have occurred at international, federal, and regional levels and necessitate changes in Oregon regulations to ensure compatibility with new federal regulations, proposed regulations in California, and existing Washington regulations.

Vessels entering the Columbia River discharge ballast water in three locations (Monaca Noble personal communication). Some might dump a portion of their ballast while at anchorage outside of Astoria, Oregon to adjust their draft before coming upriver. This anchorage area runs approximately three km alongside the main shipping channel. Vessels sometimes dump ballast while traveling up the lower river to port, again to adjust their draft as necessary. The majority of vessels, however, appear to dump their ballast while in port (Monaca Noble personal communication). Ballast water release sites likely differ by both vessel type and draft requirements. Ballast water uptake for vessels off loading cargo at ports along the Columbia River likely mirrors this pattern in reverse.

Fishery Enhancement

Intentional legal and illegal introductions of nonnative species to enhance local fishing opportunities have occurred in the lower Columbia River for nearly 150 years. In addition, several fishery enhancement actions may have led to unintentional species introductions in the region. The late 1800s and early 1900s were characterized by many intentional plantings by the USFC, local fishery managers, and private citizens to improve commercial, recreational and sustenance fishing in the region (see Lampman 1946). Legal and illegal releases of sport fish into public and private ponds (and their subsequent escape) still occur, but the state wildlife agencies are becoming more reluctant to stock nonnative species in the region (Dailey 2003). Fish stocking activities in the middle and upper Columbia River also may have contributed species to the system that subsequently spread down-stream.

Mariculture, especially of oysters, is associated with numerous detrimental ANS introductions on the West Coast[9] (Cohen and Carlton 1995). However, there are no records of shellfish mariculture in the lower Columbia River. The low salinity of the estuary is unsuitable for most commercially desirable shellfish, with the exception of the soft-shell clam *Mya arenaria*. This species rapidly spread up the West Coast from San Francisco Bay (1874) to Puget Sound (by 1889). The arrival of *M. arenaria* to the lower Columbia may have been the result of intentional introduction or it may have spread unintentionally in hull fouling communities (see Cohen and Carlton 1995).

Other fishery enhancement activities associated with ANS introductions include freshwater aquaculture and hatchery stocking both on the lower river and upstream of the Bonneville Dam. There are no aquaculture activities on the lower Columbia River that involve nonnative species.

Fishing and Recreational Water Use

Recreational anglers and other water users may unintentionally transport ANS (primarily aquatic weeds, snails and other small invertebrate species) as they move from watershed to watershed. Some organisms may move as “hitchhikers”, in damp gear or boat wells,

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[9] It has been proposed that the arrival of the Asian clam *Corbicula fluminea* may have been the result of an intentional introduction to establish a food source in the Columbia River but McMahon (1982) argues that this species spread naturally down the coast from Vancouver Island.

others may be transported as fouling organisms on boat hulls or as weeds trapped in boat propellers. The spread of zebra mussel, *Driessenia polymorpha,* throughout much of the United States has been attributed to movement by recreational boaters, etc. Although the practice of dumping left-over live bait has not been implicated in ANS introductions in the lower Columbia River, it is a potential vector for ANS introductions. The bait itself may be an ANS, as could be its packing material or other associated "hitchhiking" organisms (see live aquatics industry below). The risk of bait as ANS may increase with the availability of exotic bait species available for purchase on the internet (e.g. the Vietnamese "nuclear" worm)[10].

Live Aquatics Industry

The commercial transport of live aquatic species (for aquaculture, mariculture, bait, aquaria trade, water gardens, fisheries, scientific supply, etc.) is a vector for both intentional and accidental introductions of aquatic organisms. Plant and animal shipments may also include "hitchhikers", species that are accidentally included with the shipment as parasites or pathogens and in shipping water and packaging (Olson and Linen 1997). Organisms in the live aquatics industry have the potential to be dispersed across broad geographical areas and thus can be released or escape to many different habitats (Chapman et al. 2003). In spite of this risk, the live aquatics industry (especially trade in live seafood) receives less attention than other activities that introduce nonindigenous species, such as ballast water (Chapman et al 2003).

Ornamentals – the Nursery and Aquarium Trades

Within the live aquatics trade ornamental species, defined here as those species sold for use in ponds and aquariums, pose additional risks. Numerous nonnative aquatic plants, fish, and aquatic invertebrates are offered by nurseries and aquarium stores for use in indoor and outdoor displays. Intentional introductions into the wild may be the result of releases by individuals to "enhance" a natural area, to develop a harvestable population for resale, to humanely dispose of/or "free" species, or to conveniently dispose of unwanted organisms. According to the Southwest Florida Watershed Council, aquarium

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[10] The 2004 Oregon Fishing Regulations ban the import and transport of live bait fish 1) It is unlawful to transport live (fish) bait between bodies of water, 2) Live fish may not be used or held for use as bait, except live nongame fish may be used in the ocean, bays and tidewaters when taken from the waterbody in which they will be used. http://www.dfw.state.or.us/ODFWhtml/Regulations/2004_fishregs.pdf

dumping is the leading cause of ANS introductions into the state of Florida. While many ornamental species may be unable to overwinter in the lower Columbia River (such as fish in the family Characidae – including piranhas – which have been repeatedly released into the system, see Farr and Ward 1993) there are several established species that are the result of intentional releases. These include popular aquarium and pond species such as oriental weatherfish *Misgurnus anguillacaudatus*, and goldfish *Carassius auratus*, aquatic plants like *Cabomba caroliniana* and *Egeria densa*, and the Chinese mystery snail *Cipangopaludina chinensis malleatus*. Unintentional introductions also result from flooding or other escapes from outdoor ponds, failure of commercial rearing operations, or improper disposal of species (especially via flow-through drainage system sometimes found in research labs, hatcheries, etc.). One examples of an accidental introductions into the lower Columbia River is the escape of nutria, *Myocaster coypus* from a fur farm in Tillamook, Oregon during a flood (ODFW 2001).

Biological Control

There is little information on early efforts at biological control but the practice likely originated with the observation that predation by some animals and/or insects led to the reduction of unwanted species. Certainly the domestication of small felines by the Egyptians to reduce the presence of small rodents is such an example. By 900 AD the Chinese had begun successfully introducing predatory ants into their citrus groves to protect against worm-infested oranges. Official attempts at biological control in North American aquatic systems range from the failed introduction of muskellunge, *Esox masquinongy*, into a drinking water reservoir in San Francisco in the 1880s to rid the lake of introduced carp, *Cyprinus carpio* (which were later successfully removed after the introduction of sea lions, Smith 1896), to the release of nutria in Louisiana in the late 1930s by state and federal agencies to control unwanted nonnative aquatic plants such as water hyacinth, *Eichhornia crassipes*, and alligator weed, *Alternanthera philoxeroides* (USGS 2000).

Grass carp, *Ctenopharygodon idella*, and mosquito fish, *Gambusia affinis*, are still in use as aquatic biological control organisms and are found throughout the lower Columbia River. Purple loosestrife, *Lythrum salicari,* is currently the target of a biological control in the lower Columbia using insects (see http://www.oda.state.or.us for more information on this project).

Pathways

A pathway is the geographic pattern of an invasion. Some pathways may be more successful than others (Chapman 2000). Due to climate compatibility and life history ranges of potential invaders the temperate shorelines of continents are more likely to be invaded by species from less temperate climates. Pathway analysis may also reflect long-established trade routes or patterns of repeated, high-volume inoculations from particular locations. Such information could be vital to making management decisions about which vectors presented the greatest risks to a region. For example, if introduced species populations are dominated by species transported by a particular vector from a particular location, management actions could be taken to target that pathway rather than the entire vector.

The lower Columbia River is part of an established trade route between eastern Asia and western North America. Commercial shipping traffic routinely arrives at the five major deep-water ports in the lower river from destinations such as Korea, China, Taiwan and Japan. This pathway encompasses the high-risk transport of species from less temperate climates to the temperate western coast of North America.

Occasional events may increase risk of transportation of nonindigenous species. One example that is relevant to the lower Columbia River is the observance of the bicentennial of the Lewis and Clark Expedition. As part of the observance boaters are encouraged and expected to re-create the journey of Lewis and Clark from the Midwest to the Pacific Ocean. This activity is a potential conduit for transporting zebra mussels, *Dreissena polymorpha,* and other ANS from infested waters to the Columbia. More frequently occurring events such as conventions and fairs where live aquatics may be displayed, sold or bartered, etc. may also be events that sporadically increase the risk of introductions.

Chapter 3: Literature Review

Methods

Publications, reports, and collection records referring to projects conducted on the lower Columbia River were reviewed to compile a list of nonnative species reported in the study area and to identify gaps in the taxa and/or habitats studied. The goals of the literature review were to: 1) compile a list of non-native species already reported from the Columbia River, 2) identify taxa that have been poorly studied or represented in previous studies, and 3) identify areas of potential ANS hot-spots such as habitats associated with previously reported ANS and cryptogenic species, as well as habitats that have been under studied. All results were entered into a database.

Due to a dearth of information on ANS in the lower Columbia River the literature review was expanded to include all species collections in the study area. The expansion of the review encompassed many reports that do not discern between native and nonnative species. The compiled species list was distributed to the TAC and other taxonomic experts for review.

Personal contacts and electronic database searches were conducted for information on ANS in the lower Columbia. Two electronic databases were searched for journal articles: BIOSIS Previews and ASFA (Aquatic Science and Fisheries Abstracts). The online catalog ORBIS (Orbis Cascade Alliance) allowed a search of participating Pacific Northwest academic libraries including but not limited to Portland State University, Oregon State University and the University of Washington. In addition the libraries and references published by the following organizations were searched: Columbia River Estuary Studies Task Force (CREST), Lower Columbia River Estuary Project (LCREP), Portland General Electric, National Marine Fisheries Service (NMFS), Army Corps of Engineers, and the Oregon Department of Fish and Wildlife (ODFW). Informal interviews of natural resource personnel were conducted at many of the above organizations. Other reports were retrieved from a variety of sources using the Interlibrary Loan Program at Portland State University.

Results

The complete results of the LCRANS Literature Review were published previously and are available at the Center for Lakes and Reservoirs website (http://clr/pdx/edu). Copies of the LCRANS database are available upon request from the authors.

Database

The format of the database was developed in coordination with SERC. The LCRANS database includes all of the relevant categories proposed by SERC including: timeframe of introductions, native and source regions, modes of introduction, taxonomy and synonymy, etc. The LCRANS database differs from the SERC database in two major ways - the database includes fields for information collected on native species in the lower Columbia River and several fields that appear in the SERC database were omitted or renamed because they were not applicable to the freshwater ANS present in the LCRANS survey (e.g. biogeographic ocean provinces). All data entered into the database is cross-referenced with a full list of bibliographic sources.

Literature Review

With the exception of fishes, there is little historical information available on the flora and fauna of the Columbia River. Many of the invertebrate taxa, such as oligochaetes and epibenthic meiofauna were poorly studied. Information on species present in the literature was complicated by potential misidentifications (Leslie Harris personal communication). Such errors can result in false conclusions on their origins (e.g., Carlton 1979, Rotramel 1972, Chapman 1988, Chapman and Carlton 1991, 1994). The nonindigenous status of a species occurring in the Columbia River or elsewhere in northeast Pacific may not be apparent until the organism is discovered and described as indigenous in its native habitat, or until the synonymies of the local species with populations in other parts of the world are resolved (a time consuming undertaking that is outside the scope of most parochial biological surveys)[11].

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[11] Published information associated with a species is only accessible under the scientific name of that species. The names of species change as errors in taxonomy are corrected. Few species that have been recognized for long periods or are widely distributed have been static in their nomenclature; most species bear many epithets. Widely distributed species are often misidentified as new species when they are found far away from the localities where they were originally described. Tracking the synonymies and name changes is complicated but necessary to allow for searches for information on a species under its previous

Three projects have comprehensively surveyed the fauna of the lower Columbia River. In 1984 the results of the Columbia River Estuary Data Development Program (CREDDP) were published to augment the Atlas of Physical and Biological Characteristics of the Columbia River Estuary. In the early 1990s the Bi-State Water Quality Program published its findings on the state of the lower Columbia River. Lastly, in 1999, the Environmental Protection Agency conducted a two-year sampling effort in the lower Columbia River as part of its Environmental Monitoring and Assessment Program West Coast Project (EMAP).

Using these three comprehensive surveys and several site-specific studies (Table 1), we compiled an inventory of the flora and fauna of the lower Columbia River. Many of the previous studies were limited in taxonomic and geographic scope.

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names. Each error in the taxonomy of a species prevents access to information under the correct names. Without continuous revisions, local taxonomic literature does not include information on new discoveries elsewhere in the world. The taxonomy of ANS therefore requires continuous reevaluation, based on the world taxonomic developments.

Table 1. Principal biological surveys of the lower Columbia River consulted by the literature review.

Sampling Period	Organisms Targeted	Sites	Agency or Program (Published References)
1962-1963	Fish	Lower Willamette	(Hutchinson and Aney 1964)
1963-1964	Fish	freshwater tributaries of the lower Columbia	(Reimers 1964, Reimers and Bond 1967)
1963-65	fish, benthic invertebrates, zooplankton	sites on the mainstem to Harrington Point	(Osterberg 165, Haertel & Osterberg 1967, Haertel 1970)
1971-1972	Zooplankton	Columbia River estuary	NMFS (Misitano 1974)
1973	fish, benthic invertebrates, zooplankton	Lower Columbia River	NMFS & USACE (McConnell *et al.* 1973; Durkin 1973; Durkin & McConnell 1973; McConnell et al. 1973; Misitano 1973; Sanborn 1973)
1973-75	fish, benthic infauna	Youngs Bay and tributaries	OSU (Higley & Holton 1975; CREDDP 1980a,b)
1975-1977	fish, benthic invertebrates, plants	Miller Sands	USACE (Clairain et al. 1977)
1975-77?	fish, benthic invertebrates	Estuarine beaches of Columbia River	NMFS (Durkin *et al.* 1977)
1975-78	Benthos	Alder Creek in Youngs Bay	(Montagne & Assoc. 1977, in CREDDP 1980a)
1975-78	benthos	lower estuary	OSU (Higley *et al.* 1976; Higley & Holton 1978); CREDDP 1980a)
1978-80	tidal marsh plants	Columbia River estuary	CREDDP (MacDonald & Winfield 1984)
1980-81	Fish	primarily in the main stem of the Columbia River estuary	CREDDP, NMFS & ODFW (Bottom *et al.* 1984, Bottom and Jones 1990)
1980s	Mammals	lower Columbia River	CREDDP (Howerton 1984)
1978-80	benthic infauna	lower Columbia River	CREDDP (Holton 1984)
1978-80	epibenthic organisms	lower Columbia River	CREDDP (Simenstad 1984)
1980-81	benthic invertebrates	Baker Bay near Ilwaco	NMFS (Furota & Emmett 1993)
1980s	benthic invertebrates	Cathlamet Bay	NMFS & USFWS (Emmett *et al.* 1986; Durkin *et al.* 1982)
1987-1992	benthic invertebrates, demersal fishes	freshwater mainstem of the lower Columbia River	NMFS (McCabe and Hinton 1990, McCabe et al. 1990, McCabe and Hinton 1993, McCabe et al. 1993, McCabe et al. 1997)
1990-92	benthic invertebrates	mouth to Bonneville Dam	BSWQP (Ellis & DeGasperi 1994)
1991-1994	fish, benthic invertebrates	Rice Island, Miller Sands	NMFS (Hinton et al. 1992a, Hinton et al. 1992b, McCabe et al. 1993, McCabe et al. 1996)
1990-1992	Fish	lower Willamette River	ODFW (Ward and Nigro 1992)
1995	fish, benthic invertebrates	Trestle Bay	USACE (Hinton & Emmett 2000)
1998	freshwater bryozoans	Willamette River	(Marsh and Wood 2002)
1999-2000	benthic invertebrates	mouth to Bonneville Dam	WEMAP[12], WDE & ODEQ
2001-2002	fish, benthic invertebrates	lower Willamette River	ODFW, City of Portland (North et al. 2002)
2002	Plants	lower Columbia River	LCREP
2003	Plants	Astoria shoreline	CREST (CREST 2003)

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[12] Portions of the 1999-2000 WEMAP Survey data from the did not become available until the literature review was completed and are not reflected in the previous LCRANS Literature Review release.

The literature review revealed uneven coverage of taxa. Nonnative fishes and aquatic plants (submersed, floating, emergent and marsh) were the most abundant introduced taxa of the lower Columbia (Table 2). Native and non-native fishes of the lower Columbia River and its tributaries have been well described (Hutchinson and Aney 1964, Reimers and Bond 1967, McConnell et al. 1973, Bottom et al. 1984, Ward and Nigro 1992, North et al. 2002, but there was little information on nonnative and cryptogenic invertebrates. These species were poorly-studied and rarely identified as introduced or potentially introduced species. A complete species list is available in Appendix B.

Intentionally and unintentionally introduced species are present in the lower Columbia River. The non-native fishes were dominated by intentionally introduced species. The invertebrates were considered primarily unintentional introductions.

Table 2. Summary of nonindigenous and cryptogenic species compiled during the literature review,listed by major taxonomic category.

Taxon	Nonindigenous Species	Cryptogenic Species
* Indicates species counts that include introductions that failed or are thought to have failed to become established, for example: *Homerus americanus* has been introduced intentionally with no known surviving populations. # May include native species that were misidentified.		
Plants	23	5
Mammals	1	0
Herptiles	3	0
Fishes	36*	1
Annelids	6	37#
Amphipods	1	3
Copepods	6	12#
Decapods	4*	0
Isopods	1	1
Bivalves	2	0
Gastropods	2	0

The cryptogenic species list compiled during the literature review includes species, that have been identified as non-native, but for which the validity of the identifications is uncertain and unverifiable. This is principally suspected of species in poorly studied taxonomic groups (e.g., polychaete worms, aquatic insects, oligochaetes). Consulting taxonomists concluded that many of these species were not correctly identified in the papers and reports surveyed. Mis-identifications could have resulted from the use of inaccurate local keys, inexperienced taxonomists, or attempts to fit unrecognized non native species into local species keys.

From the literature review we concluded that there are biological communities and habitats within the lower Columbia River that are poorly studied. Patchy habitats and poorly characterized areas exist in the estuary as well as further upriver. Several ANS such as the anthozoa, *Nematostella vectensis*, and Japanese eelgrass, *Zostera japonica*, have been reported from the two relatively high salinity bays at the mouth of the Columbia; Trestle Bay and Baker Bay (Furota and Emmett 1993, Hinton and Emmett 2000, EMAP unpublished data) but no follow up information exists on these populations. Although common along the main-stem, tidal freshwater sloughs are also poorly characterized and many exist adjacent to major deep-water ports, features that made them of special interest to this survey. We hypothesized that such areas may provide protection from strong flushing events and could therefore provide non-native aquatic macrophytes, insects and epibenthic invertebrates opportunities to establish. Other sites of interest to us had records where a variety of poorly characterized organisms, i.e. oligochaetes, were collected but not identified to species.

Chapter 4: Field Sampling

Methods

The 2002 and 2003 field surveys were guided by sampling plans built on prior knowledge and reviewed by the TAC. The literature review was integral to the development of a stratified and adaptive sampling plan. Limited resources and the relatively large area required that we identify areas of interest such as locations closely associated with ballast water release, habitats with previously reported ANS and cryptogenic species, and areas that have been understudied previously. It was also deemed important to avoid duplication of new and ongoing projects, (i.e. the EMAP survey conducted by the EPA, ODEQ and WDOE); we wanted to conduct sampling complementary to these efforts.

The 2002 survey focused on taxa and habitats that were poorly represented in the literature, sites that could be re-sampled at regular intervals in a long-term monitoring program, and/or sites that had a reliable historical record to permit evaluation of invasion rates. In 2003, we re-sampled those stations identified as potential long-term monitoring stations, and some additional new stations. Whenever appropriate, members of the TAC were asked to comment on the targeted sampling efforts, species identifications, and regional ANS information. When sampling was limited by access and weather we either arranged to return to those stations or attempted to sample as near to those locations as possible.

The taxonomic scope of the LCRANS project was limited to free-living macrophytes and animals, except in unmistakable cases of disease causing organisms and parasites, which were noted when they were observed. Taxa that have not been well studied by previous investigators were the primary focus of these surveys. We did not conduct surveys of the fishes, which are the most studied fauna of the lower Columbia River, or the insects, which we could not identify to species reliably.

Locations

Seventy-two stations were sampled from the Bonneville Dam to the Pacific Ocean between April 2002 and October 2002 (Figure 4). Fifty-three sites were sampled by invertebrate and aquatic macrophyte experts. The remaining nineteen stations were sampled specifically for nonindigenous aquatic macrophytes (although the presence of nonnative mollusks was also noted when apparent at these sites). In 2003, 62 stations were sampled (Figure 4). Invertebrate communities were sampled at 36 stations and plant surveys conducted at more than 30 stations between May and September. In 2003, phytoplankton surveys were conducted at seven stations in the lower river. Gaps in the spatial distribution of 2002 sampling were also addressed, including the Willamette River and parts of the mainstem of the lower Columbia that had not been adequately sampled in 2002. In 2003 we devoted more sampling effort to the mainstem of the Columbia in the estuary, between Portland and Bonneville Dam, and on the Willamette River. In addition, special effort was made to sample and identify soft-bodied benthic organisms such as polychaete worms. A more thorough aquatic macrophyte survey was also conducted that noted macroinvertebrate communities associated with both native and nonnative aquatic plants (Figure 5). At some locations only nonnative species of aquatic plants were noted.

Techniques

The major substrates and microhabitats sampled included intertidal and subtidal mud, sand, gravel, cobbles, rocks, banks, artificial substrates such as floats and pilings, and aquatic plants. Every accessible habitat at each sampling station was sampled. Sampling was conducted at various lengths of time at each location, depending on the number of habitats present; sampling usually occurred during low tide. Estuary sampling was scheduled to coincide with negative low tides during daylight hours to increase access to hard substrates. Tidal amplitudes in the freshwater reach of Columbia River above Longview did not affect access to substrates. A variety of sampling methods were employed including collection by hand, scraping substrata using a 2-mm mesh stainless steel mesh sieve attached to a long pole developed specifically for sampling vertical fouling communities, a 0.0225-m2 Petite Ponar grab sampler, 700-µm epibenthic sled, a 250-µm mesh zooplankton net, a 80-µm mesh phytoplankton net, a plant rake, several types of kick and dip nets. Sampling was conducted to obtain the best qualitative coverage possible. Quantitative sampling protocols and precise species counts were not deemed necessary in order to develop a comprehensive list of species present.

Benthic organisms were collected by vigorously agitating mud, sand, gravel and rock samples in water to suspend organic material and small invertebrates. The suspensions were decanted through a series of mesh sieves (2-mm, 1-mm mesh, and 0.5-mm) to retain suspended organisms. The washing and decanting procedure was repeated until the majority of organisms in the samples were removed. Sub-samples were made only when the total volume of organisms retained on the sieves exceeded the volume of the largest sample containers.

In 2003 many samples were collected specifically for oligochaete analysis by Steve Fend. Depending on field conditions these samples were either picked live and un-sieved or preserved un-sieved for later sorting with 200-µm sieves. Live specimens were preserved by first anaesthetizing the sample in dilute alcohol for 10 minutes, then fixing by slowly adding a formalin-alcohol-acetic acid (FAA) solution.

Bulky samples of aquatic plants, peat, rocks or gravel or other similarly course substratums, were washed on a 4-mm or 2-mm mesh sieve in a 20-liter dishpan. Large organisms and unique organisms were removed directly to sample containers. Smaller organisms were captured by decanting the wash water through 0.5-mm and 1-mm mesh sieves. This procedure was repeated until most of the invertebrates in the sample were acquired

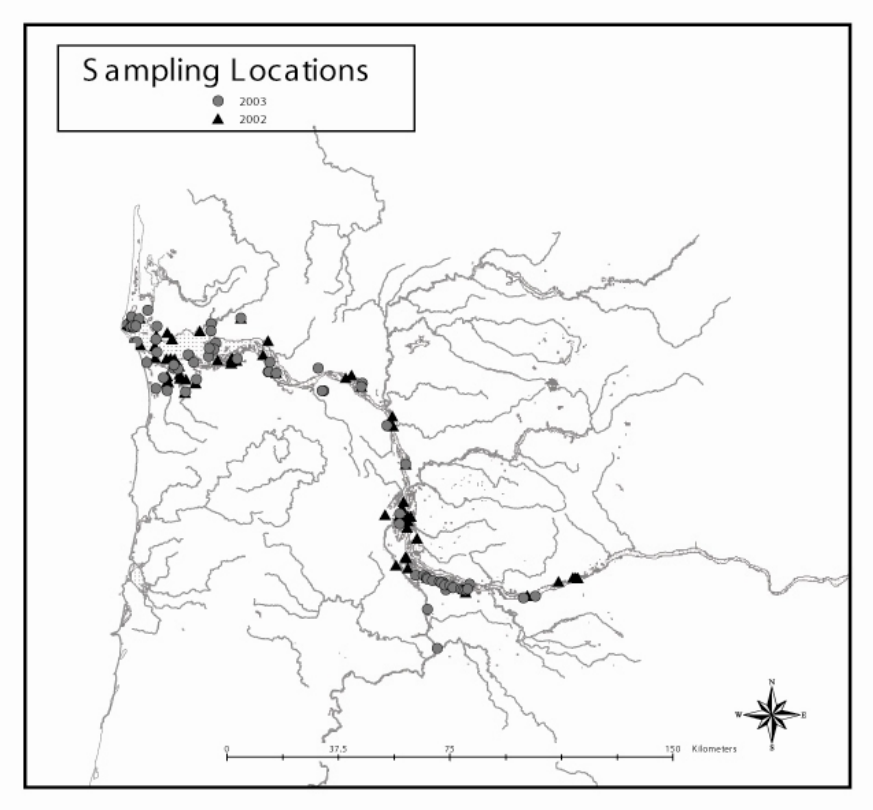

Figure 4. LCRANS sampling locations 2002, 2003

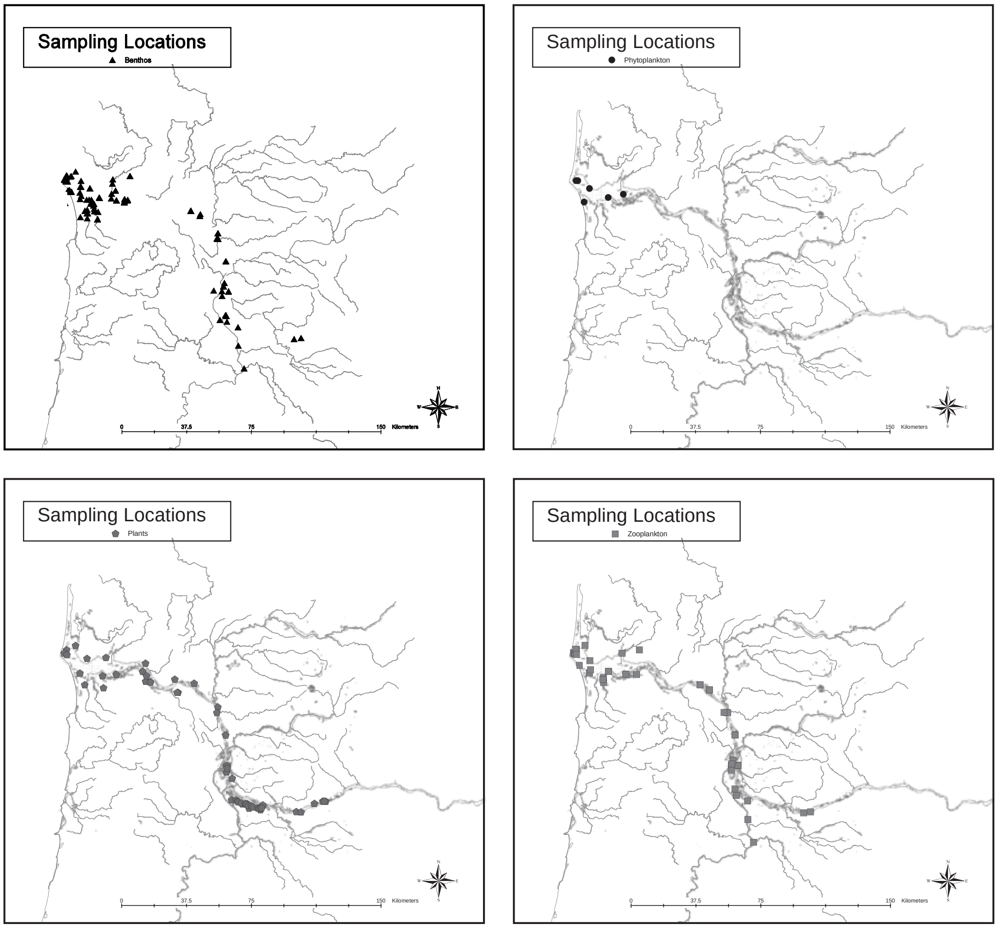

Figure 5. Distribution of LCRANS sample types 2002-2003

Organisms retained on the sieves or picked out of samples were placed into plastic bags or jars of water from the sample location for later examination and sorting in the laboratory. Live samples were kept on ice and processed on the same day they were collected. These collection methods usually produced large numbers of undamaged invertebrates suitable for taxonomic identifications.

Zooplankton and phytoplankton were collected with water column plankton hauls made either off a dock or from a boat with a 0.25-m diameter, 250-µm mesh plankton net (zooplankton) and an 80-µm mesh plankton net (phytoplankton). The net was lowered to the bottom, and after several minutes was slowly pulled to the surface. In the laboratory, each plankton sample was examined under a dissecting microscope, and representatives of each species were removed. If necessary for identification, diagnostic parts (e.g., fifth legs of copepods) were removed and examined under a compound microscope.

Sorting thousands of specimens collected in some of the fouling and benthic samples was impractical and unnecessary for the purposes of the survey. Therefore, in the final sorting, abundant and highly visible species were collected only during the first 40-60 minutes and then an additional 40-60 minutes of sorting was performed under a stereomicroscope to collect rarer or inconspicuous species. Live sorting of the samples allowed identification of species that were unique in behavior or coloration, and that might have been overlooked in fixed samples. The large size of the benthic samples greatly increased the probabilities of collecting all species present.

Classification of species

Distinctions between nonindigenous, cryptogenic and native species were based on criteria for introduced species developed by Lindroth (1957), Carlton (1979), Webb (1985), Chapman (1988), and Chapman and Carlton (1991, 1994) (Table 3). Application of these criteria to each species required detailed information on their taxonomy, biogeography, ecology, and life histories. Therefore, taxa for which this information did not exist (e.g., non-commercial species, poorly known groups) were difficult to assess.

Species were considered native when most of the criteria were not met and introduced when most of the criteria were met. The degree of certainty of the classification of each species was assessed from the number of criteria that applied, and the quality of the data used to assess the criteria. Satisfaction of a single criterion was rarely sufficient evidence that a species is introduced. Satisfaction of multiple criteria, however, was considered definitive for the nonindigenous or native origins of species even though the criteria are largely subjective. Species for which evidence of these criteria was mixed or unclear were defined as cryptogenic (Carlton 1996). All specimens that were identified to species level were classified according to the native vs. nonnative criteria. Species that could not be identified to species were classified as cryptogenic. Application of the criteria relied on the quality of associated systematic, ecological, and historical data. Pertinent information was often lacking, and species were included in these analyses only when they were confidently identified.

Table 3. Criteria for introduced species modified from Chapman and Carlton (1991, 1994) and Lindroth (1957), Carlton (1979), Webb (1985), Chapman (1988).

(1) Historical records of introduction. (Game, aquaculture, agriculture or otherwise intentionally introduced species are commonly recorded upon entry.)

(2) Association with human mechanisms of introduction. (Species are associated with particular mechanisms of introduction by timing and location of arrival and direct observations of association such as organisms that occur in the fouling communities on the hulls of ships or oysters or in ballast water discharged from ships, aquarium pets.)

(3) The absence from fossil deposits or from Native American shell middens in regions where the species is present. (Species with hard parts, such as angiosperms, diatoms, sponges, mollusks, bryozoans, echinoderms, and vertebrates leave fossil remains that can be of sufficient quality for species identifications. Their presence in prehuman fossil deposits is evidence of native origins. Therefore, their absence in fossil assemblages of communities in where they presently occur is evidence of their recent appearance. Fossils are not as useful for species of genera such as the bivalves *Mytilus* and *Ennucula* that are extremely difficult to distinguish by morphologically and peracaridan fossils are all but unknown.)

(4) Insufficient natural dispersal mechanisms to create the entire global distribution of a species. (Many species do not have specialized adult or larval dispersal stages or associations with natural dispersal mechanisms that could transport them across major geographic barriers. The occurrence on both sides of dispersal barriers by such species is evidence of their nonindigenous status.)

(5) Appearance in regions where not found previously. (Recent appearances of conspicuous species such as the green crab and the Chinese mitten crab in the northeast Pacific or a charismatic species such as the cholera bacterium, *Vibrio cholerae* in the southeast Pacific where they would not be overlooked previously are evidence that they were introduced by human activities.)

(6) Discontinuous or otherwise incomplete local distributions relative to those of ecologically similar endemic species. (Incomplete dispersal by the mechanism of introduction, poor adaptation to the range of local conditions, and early stages of invasion within new geographic ranges create disjunct distributions that are uncommon among native species.)

(7) Recent spread from one or a few locations to broad geographical areas. (Introductions invariably begin in isolated areas due to the uneven occurrences of the mechanisms of dispersal. Thus, ballast water introductions spread from shipping ports and aquaculture introductions spread from areas where aquaculture activities occur.)

(8) Close associations with other introduced species. (Spatial associations of introduced species result, in small part, from their common mechanisms of dispersal and possibly in greater part from the patchy, aggregated distributions of introductions due to poorly understood ecological and biological factors. The fouling communities of floats in San Francisco Bay are dominated by ANS that are identified by other criteria. Additionally, the specialization of some parasites and predators on a single introduced species can reveal their nonindigenous origins.)

(9) Restriction to new or artificial environments. (Introduced aquatic species commonly are restricted to substratums or habitats, such as cement or styrofoam floats, pilings, rip-rap over mudflats, and boat hulls, that were absent, uncommon or ephemeral before European settlement. A complete dependence on such artificial substratums is unlikely among native species.)

(10) Conspecific with geographically isolated populations. (All recent introductions are geographically isolated from their native populations and therefore, all recently introduced species are conspecific with geographically isolated native populations.)

(11) Non-endemic evolutionary origins apparent from membership in a non-indigenous taxonomic group. (Introduced species are often morphologically or genetically most similar to geographically isolated taxonomic groups rather than local groups.)

(12) Non-endemic evolutionary origins apparent from ecological or physiological adaptations. (Many introduced species are from climates were temperature ranges exceed those in the new location or where they escape parasites or diseases. Some introduced species tolerate temperatures, for instance, that do no exist in the new locations. Other ANS are vulnerable to nonindigenous parasites, such as the green crab to the parasitic barnacle *Sacculina carcini*, to which the native northeast Pacific species are not vulnerable.

Transportation vectors, dates of discovery and the definition of native range relied heavily on available ecological and historical data and may not represent the definitive pattern of introduction (i.e. when it arrived, how it arrived, and where it came directly from), information which remains unknown for many species. When more than one vector was found in the literature or determined from species' life history characteristics all of them were included in the results. The following vectors were assigned to each introduced species where appropriate.

- Aquarium - intentional aquarium disposal by an individual into waters of the basin
- Ornamental - ornamental species escape (e.g. flooding of a private pond), release, or improper disposal by an individual
- Release by individual - other types of release by individuals (i.e. does not include aquarium or ornamental species or actions taken by state or federal agencies) release my be intentional or accidental (e.g. dumping of bait or bait packing material into water, unintentional transport of species in recreational gear, release of live food species for religious or humane purposes, etc.
- Accidental - accidental introduction accompanying intentional introduction of a different species by a state or federal agency (does not include introductions associated with oyster planting;
- Escape - escape from commercial cultivation
- Fishery enhancement - intentionally introduced for fishery or wildlife enhancement by an agency rather than an individual
- Solid ballast - entrained with solid ballast used by ships in the 1800s before ballast water became prevalent
- Ballast water – collected and transported in ballast water taken on to stabilize commercial, military and other vessels
- Ship fouling - transported as part of the fouling community on the hulls of ships, anchor chains, etc.
- Gradual spread – species arrived via natural mechanisms of spread from introduced populations outside of the lower Columbia River (i.e. transported by birds, wind, water, etc.) often associated with Japanese or Atlantic Oyster introductions in other estuaries
- Biological control – species introduced intentionally by an agency or an individual for biological control purposes

Chapter 5: Results and Discussion

Field Survey Results

Samples were collected from the field at the 134 sampling stations. We documented 269 aquatic species (and 55 other distinct organisms that we were unable to identify at the species level and are labeled as "unknown" in the following figures) in the lower Columbia River. Of the 269 species identified, 54 (21%) were introduced, 92 (34%) were native, and 123 (45%) were cryptogenic. It is important to note that vertebrates were not intentionally targeted in our sampling and not all native plants (especially emergent and marsh species) were recorded during plant surveys.

The introduced, native, and unknown species collected from the lower Columbia River were mostly invertebrates (Figure 6). There were slightly more cryptogenic phytoplankton than cryptogenic invertebrates. The cryptogenic phytoplankton and invertebrates accounted for nearly half of all the species collected. The low number of vertebrates collected can be attributed to sampling methods and does not reflect the actual number of vertebrates (especially fish) present in the lower river. In addition, these data do not reflect all of the native plants present (primarily emergent and marsh species) because those species were not recorded during plant surveys.

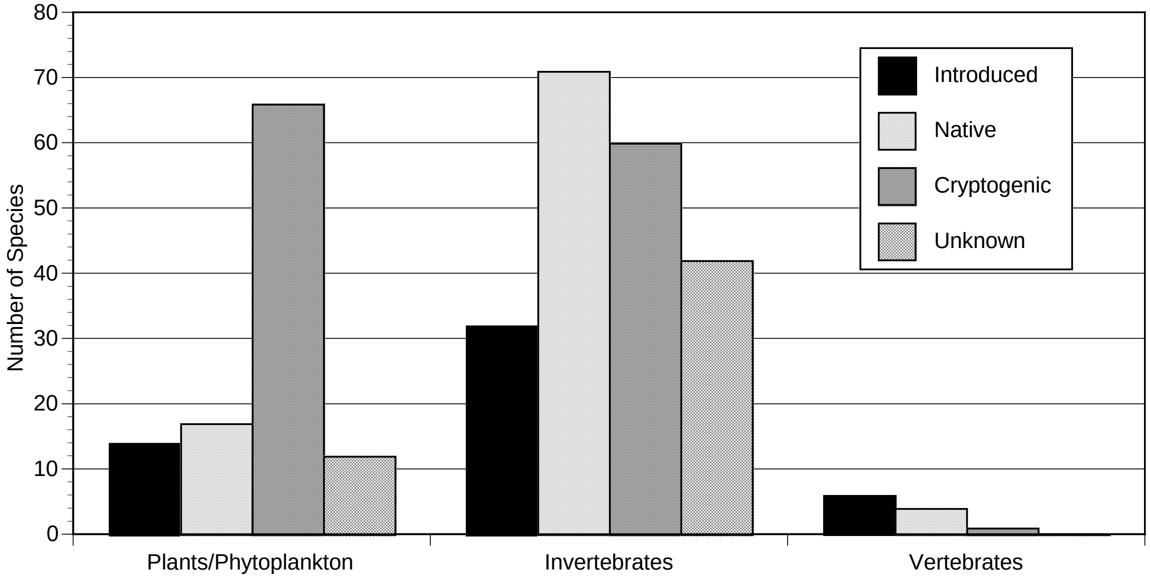

Figure 6. LCRANS field survey species collections broken down by major taxonomic group and origin.

Crustaceans were the most abundant introduced invertebrates (42%) followed by annelids (30%) (Figure 7). The introduced invertebrates were dominated by benthic organisms. Benthic invertebrates accounted for 61% of all introduced invertebrates collected and 36% of the total number of introduced species. Fouling organisms (organisms capable of attaching to surfaces like stone, concrete, wood, piers, docks, and boat hulls) comprised 23% of the introduced invertebrates. Pelagic organisms accounted for the remaining invertebrates.

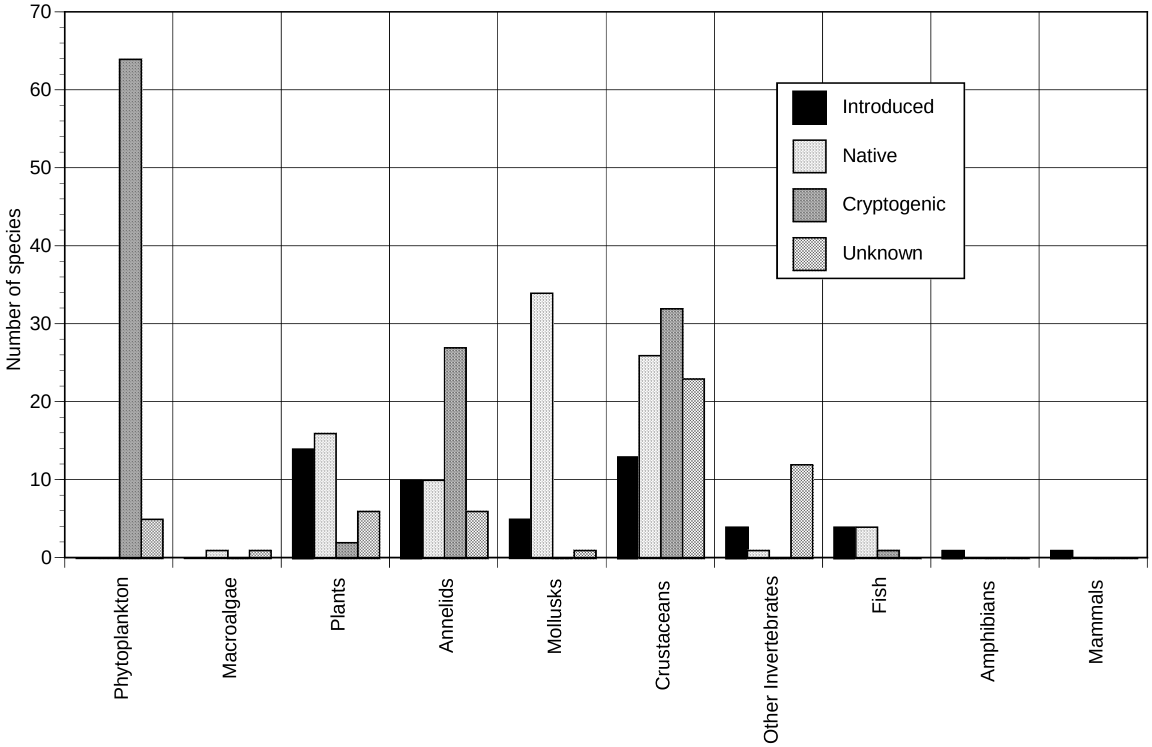

Figure 7. LCRANS field survey species collections broken down by minor taxonomic group and origin

Although vertebrates were not specifically targeted by this effort five introduced fishes and one mammal were documented (Figure 7). The single introduced mammal was the nutria, *Myocaster coypus*, a semi-aquatic rodent that was seen at numerous stations along the Willamette River.

Cryptogenic species numbers were dominated by phytoplankton, oligochaetes and many types of zooplankton (Figure 7) for which little information is available on native range. All of diatoms, dinoflagellates, and other phytoplankton collected were classified as cryptogenic in this study. In addition, several of the species collected, such as *Gasterosteus aculeatus* or *Branchiura sowerbyi*, are subject to changing expert opinions on origin.

Eight of the 54 introduced species collected were new records for the lower Columbia River. One of these species, the oligochaete *Eukerria saltensis*, appears to be a new record for the West Coast. The other seven species, the oligochaetes *Branchiura sowerbyi, Chaetogaster diaphanous, Paranais frici,* and *Stylodrilus heringianus*, the purple varnish clam, *Nuttallia obscurata*, the Chinese mystery snail, *Cipangopaludina chinensis malleatus*, and the crustaceans *Limnoithona tetraspina* and *Melita cf. nitida* have been reported previously at other West Coast locations.

Literature Review and Field Survey Results

Combing the results from both the field surveys conducted in 2002 and 2003 with the results of the earlier literature review (complete literature review results available at http://www.clr.pdx.edu/) we determined that at least 81 new organisms have been introduced into the lower Columbia River since the mid 1800s (Figure 8, Table 4).[13] The majority of these species were fish (28%), aquatic plants (23%) and crustacea (15%). The remaining 18% was a combination of mollusks, annelids, bryozoans, cnidaria, amphibians, reptiles and an aquatic mammal.

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[13] Those species not collected by LCRANS in 2002 or 2003 are species collected either by WEMAP in the lower Columbia in 1999 and 2000 and validated by the same team of taxonomists as used by LCRANS, or species noted in the LCRANS literature review and confirmed by regional taxonomists or our team of experts.

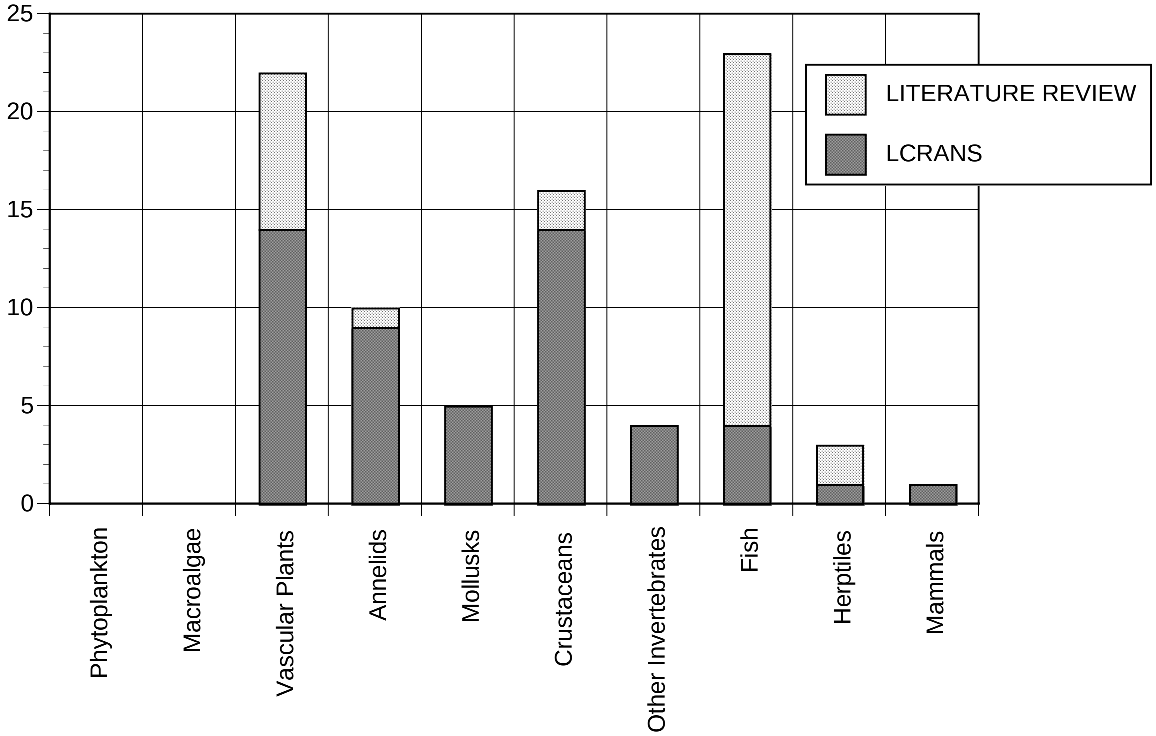

Figure 8. Number of introduced species in various taxa in the lower Columbia River from the literature review and field survey.

Table 4. Invasion dates and mechanisms of introduction for all introduced species present in the lower Columbia River. This table does not include one-time unsuccessful introductions or seasonally limited introductions such as piranha, lobster, etc. reported from the literature review. All species included on this list as a result of the literature review appear without bold lettering and were reviewed for inclusion on this list by field and taxonomic experts before labeling them as present in the lower Columbia River basin.

Mechanism abbreviations: AQ = aquarium disposal, OR = ornamental species (escape, release, disposal), RI = release by individual (not considered an aquarium or ornamental species nor released by a state or federal agency), AX = accidental introduction accompanying intentional introduction, ES = escape from commercial cultivation, FS = fisheries or wildlife enhancement, intentional by a state or federal agency, SB = solid ballast, BW = ballast water, SF = ship fouling, GS = gradual spread from other introduction locations outside of the river, and BC = biological control organism

Species	Common Name	Native Range	1st Western Collection	1st LCR Collection	Vector	Record
PLANTS						
Vascular						
Cabomba caroliniana	Carolina fanwort	NA, SA		?	AQ	LCRANS
Callitriche stagnalis	pondwater starwort	EUR-ASIA	1871, 1902	?	BW,SB	LCRANS
Cotula coronopifolia	brass buttons	AF	1878	?	SB	LCRANS
Egeria densa	elodea	SA	?	1944	OR	LCRANS
Iris pseudocorus	yellow flag iris	EUR	1860s	?	OR	LCRANS
Lythrum salicaria	purple loosestrife	EUR	1880s	?	OR, GS, SB	LCRANS
Myriophyllum aquaticum	parrot's feather	SA	<1957	?	OR	LCRANS
Myriophyllum spicatum	Eurasian milfoil	EUR, AF	1976	?	AQ	LCRANS
Mentha aquatica	water mint	EUR	?	?	GS, OR, RI	LIT REV
Mentha aquatica x spicata	peppermint	EUR	?	?	GS, RI	LIT REV
Ludwigia uruguayensis	water primrose	SA	?	1956	OR	LIT REV
Nymphaea odorata	fragrant water lily	NA	?	?	OR, RI	LCRANS
Phalaris arundinacea	reed canary grass	NA	?	?	GS	LCRANS
Phragmites australis	common reed	NA	?	?	GS	LCRANS
Potamogeton crispus	curly leaf pondweed	EUR-ASIA	?	1947	RI, OR, AX, ES	LCRANS
Sagittaria subulata	awl-leaf arrowhead	NA	?	?	AQ	LCRANS
Typha angustifolia	narrow-leaf cattail	EUR-ASIA	1951	?	OR	LCRANS
Vallisneria Americana	water celery	NA	1900s	?	FS	LCRANS
Zostera japonica	Japanese eelgrass	NW Pacific	?	?	GS	LCRANS

Table 4. cont.

Mechanism abbreviations: AQ = aquarium disposal, OR = ornamental species (escape, release, disposal), RI = release by individual (not considered an aquarium or ornamental species nor released by a state or federal agency), AX = accidental introduction accompanying intentional introduction, ES = escape from commercial cultivation, FS = fisheries or wildlife enhancement, intentional by a state or federal agency, SB = solid ballast, BW = ballast water, SF = ship fouling, GS = gradual spread from other introduction locations outside of the river, and BC = biological control organism

	Species	Common Name	Native Range	1st Western Collection	1st LCR Collection	Mechanism of Introduction	Record
INVERTEBRATES							
Bryozoa							
	Fredericella indica		NA	?	1999	GS, AX, RI	LCRANS
	Pectinatella magnifica		NA	?	1999	GS, AX, RI	LCRANS
Anthozoa							
	Nematostella vectensis		NW Atlantic	1946	1994	SB, BW	LCRANS
Hydrozoa							
	Cordylophora lacustris		EUR	ca 1920	1965	BW, SF	LCRANS
Oligochaeta							
	Branchiura sowerbyi		Black-Caspian Sea	1950	2002	SB, BW, RI	LCRANS
	Chaetogaster diaphanous		not known	2002	2003	SB, BW, RI	LCRANS
	Eukerria saltensis		SA	?	2003	SB, ?	LCRANS
	Paranais frici		EUR	1961	2003	SB, BW, RI	LCRANS
	Stylodrilus heringianus		EUR	?	2003	SB, BW, RI	LCRANS
Polychaeta							
	Hobsonia florida		NA	1940	1975	BW, AX	LCRANS
	Manayunkia aesturina		NA	?	1981	BW	LCRANS
	Manayunkia speciosa		NA	1961	1999	AX, BW	LCRANS
	Polydora cornuta		N. Atlantic	1932	1981	BW, SF, GS	LCRANS
	Pseudopolydora kempi		NW Pacific	1951	1991	BW, SF, GS	LIT REV
	Streblospio benedicti		N Atlantic	1932	1999	BW, SF, GS	LCRANS
Gastropoda							
	Cipangopaludina chinesis malleatus	Chinese mystery snail	ASIA	1950s	2002*	OR, AQ	LCRANS

Table 4. cont.

	Species	Common Name	Native Range	1st Western Collection	1st LCR Collection	Mechanism of Introduction	Record
Mechanism abbreviations: AQ = aquarium disposal, OR = ornamental species (escape, release, disposal), RI = release by individual (not considered an aquarium or ornamental species nor released by a state or federal agency), AX = accidental introduction accompanying intentional introduction, ES = escape from commercial cultivation, FS = fisheries or wildlife enhancement, intentional by a state or federal agency, SB = solid ballast, BW = ballast water, SF = ship fouling, GS = gradual spread from other introduction locations outside of the river, and BC = biological control organism							
	Potamopyrgus antipodarum	New Zealand mudsnail	AUS-NZ	1980s	<1995	AX, GS	LCRANS
Bivalvia							
	Corbicula fluminea	Asian clam	ASIA	1924	1932	RI	LCRANS
	Mya arenaria	soft-shell clam	NA, EUR	1874	<1900	SB, BW, GS	LCRANS
	Nuttallia obscurata	purple varnish clam	ASIA	1990	2003	BW, RI	LCRANS
Crustacea							
	Balanus improvisus	bay barnacle	NA, EUR	1853	<1900	SF, SB, BW	LCRANS
	Acartiella sinensis		ASIA	1979	1997	BW	LIT REV
	Limnoithona sinensis		ASIA	?	1979	BW	LIT REV
	Limnoithona tetraspina		ASIA	1993	2003	BW	LCRANS
	Pseudodiaptomus forbesi		ASIA	?	1999	BW	LCRANS
	Pseudodiaptomus inopinus		ASIA	?	1990	BW	LCRANS
	Sinocalanus doerri		ASIA	1978	1999	BW	LCRANS
	Tachidius (Neotachidius) triangulari		ASIA	?	1990s	BW	LCRANS
	Nippoleucon hinumensis		ASIA	1979	1999	BW	LCRANS
	Caecidotea racovitzai racovitzai		EUR	1972	1999	BW	LCRANS
	Crangonyx pseudogracilis		EUR	1998	1999	BW	LCRANS
	Grandidierella japonica		ASIA	1966	1999	BW, SF	LCRANS
	Exopalaemon modestus	Siberian prawn	EUR-ASIA	1995	1995	BW, RI	LCRANS
	Sinelobus cf. stanfordi		not known	1943	1943	BW, SF	LCRANS
	Melita cf. nitida		NA	1941	2003	BW, SF	LCRANS

Table 4. cont.

Mechanism abbreviations: AQ = aquarium disposal, OR = ornamental species (escape, release, disposal), RI = release by individual (not considered an aquarium or ornamental species nor released by a state or federal agency), AX = accidental introduction accompanying intentional introduction, ES = escape from commercial cultivation, FS = fisheries or wildlife enhancement, intentional by a state or federal agency, SB = solid ballast, BW = ballast water, SF = ship fouling, GS = gradual spread from other introduction locations outside of the river, and BC = biological control organism

Species	Common Name	Native Range	1st Western Collection	1st LCR Collection	Mechanism of Introduction	Record
VERTEBRATES						
Fish						
Lepomis gibbosus	pumpkinseed	NA	?	1893	FS	LIT REV
Lepomis gulosus	warmouth	NA	?	1893	FS	LIT REV
Lepomis macrochirus	bluegill	NA	?	1893	FS	LIT REV
Micropterus dolomieu	smallmouth bass	NA	1874	1923	FS	LIT REV
Micropterus salmoides	largemouth bass	NA	?	1888	FS	LIT REV
Pomoxis annularis	white crappie	NA	?	1893	FS	LCRANS
Pomoxis nigromaculatus	black crappie	NA	?	1893	FS	LIT REV
Alosa sapidissima	American shad	NA	1871	1880s	FS	LIT REV
Misgurnus anguillicaudatus	Oriental weatherfish	ASIA	?	1980s	AQ	LIT REV
Carassius auratus	goldfish	ASIA	?	1933	AQ, RI, OR	LCRANS
Ctenopharygodon idella	grass carp	ASIA	1960s	1960s	BC	LIT REV
Cyprinus carpio	common carp	EUR-ASIA	1872	1880	ES, FS	LIT REV
Fundulus diaphanous	banded killifish	NA	?	1971	RI, AQ	LIT REV
Ameiurus catus	white catfish	NA	1874	1880s	FS, RI	LIT REV
Ameiurus melas	black bullhead	NA	1874	1894	RI	LIT REV
Ameiurus natalis	yellow bullheard	NA	1874	1905	FS	LIT REV
Ameiurus nebulosus	brown bullhead	NA	1874	1880s	RI	LIT REV
Ictalurus punctatus	channel cat	NA	?	1920s	RI, FS	LIT REV
Morone chrysops	white bass	NA	1895	?	RI	LIT REV
Morone saxatilis	stripped bass	NA	1879	1900s	FS,RI	LIT REV
Perca flavescens	yellow perch	NA	?	1894, 1905	FS	LCRANS
Sander vitreus	walleye	NA	1874	1940s	FS	LIT REV
Gambusia affinis	mosquitofish	NA		1960s	BC, OR	LCRANS
Herptiles						
Chelydra serpentina serpentina	Eastern snapping turtle	NA	?	?	RI, AQ, OR	LIT REV
Rana catesbeiana	bullfrog	NA	?	1914, 1924	RI	LCRANS
Trachemys scripta elegans	red eared slider	NA	?	?	RI, AQ, OR	LIT REV
Mammals						
Myocaster coypus	nutria	SA	?	1937	ES	LCRANS

Due to the limitations of this survey, inadequate taxonomic resolution in prior studies, and the abundance of unresolved or cryptogenic taxa, our results are likely to represent a conservative estimate of the ANS invasion. Some areas or habitat types in the lower Columbia were not well-sampled previously or in this study. Because our surveys were shore-based or conducted using small boats, the deep, main channel of the river and the salt wedge at the mouth of the estuary were not sampled. We sampled riverbanks, sandy islands, and the benthos adjacent to industrial and port facilities, but these areas should be subjected to more intensive sampling to better characterize these habitats.

Some taxa were either under-sampled or were not identified to species. The Nemertea, Porifera, Ostracoda, Acarina, Kamptozoa, and aquatic insects were collected but not identified to species in most cases. Other data gaps were revealed during analysis of the results. We concluded that oligochaetes were under-sampled because 46% (18 of the 39) (including native, cryptogenic and introduced species) were collected at only one of the 134 sampling locations visited over two years. Such a large number of rare species suggests that we undersampled a patchy oligochaete habitat (Steve Fend, personal communication). In addition, several native oligochaete species reported in our literature survey (including one described from the lower Columbia River) were not found in any of our samples.

Other species previously reported in the Columbia but not recorded in our surveys included the mysid *Alienacanthomysis macropsis* (McCabe et al. 1993*);* a copepod, *Hansenulus trebax*, which is parasitic in the brood chamber of the native mysid *Neomysis mercedis* and described from the Columbia River by Daly and Damkaer (1986)*;* and several endemic mollusk species (Appendix B). Experts who evaluated our species lists also concluded that some taxa lists may be incomplete because they included few mesohaline and marine species, particularly phytoplankton and polychaetes, which should be found near the mouth of the river. Our survey results are supplemented by the results of the literature review, but some poorly resolved taxa (such as the oligochaetes) are still not well-documented in the lower Columbia River.

The large percentage of cryptogenic species (45%) complicates evaluation of the magnitude of aquatic bioinvasion of the lower Columbia River, but it is a consequence of our strict adherence to precise protocols for assigning organisms to classes. The majority of the cryptogenic species were found to belong to taxa that are poorly resolved in the Columbia River and elsewhere. The distribution of many species is reported as widespread or cosmopolitan without discussion of the possibility that these species were spread by human activity. Clarifying the status of cryptogenic species in the Columbia River will be difficult until their worldwide distributions are known and evaluations are made about where they are native and where they are introduced. For example, prior to the publication of Kathman and Brinkhurst (1998) that first described a distribution throughout North America, the oligochaete, *Amphichaeta sannio*, was considered by some to be a European estuarine species. In addition, its taxonomy remains in doubt (some consider *A. sannio*, to be synonymous with *A. raptisae)*, which further complicates resolution of the classification of this species. As a species with unknown origin and a holarctic distribution, we considered it cryptogenic.

Patterns of Introduction

Most invertebrates reported from the Columbia River also occur in San Francisco Bay but not all of these species are distributed throughout other major West Coast estuaries (Table 5)[14]. San Francisco Bay has the highest recorded number of nonindigenous species in the region (Cohen and Carlton 1995) and nearly all ANS reported elsewhere in the eastern Pacific occur in San Francisco Bay (Chapman 2000); however, the importance of dispersal of introduced species from San Francisco Bay to other West Coast estuaries is unclear (Wasson et al. 2001). Twenty-eight of the 35 introduced invertebrates in the lower Columbia River have not been reported in other major bays and estuaries on the West Coast. This distinctive assemblage could be the result of unique hydrological and physical characteristics of the lower Columbia River. Alternatively, it could be a result of differences in sampling effort. For example, rapid assessments surveys – those surveys that are conducted over a limited period of time (usually less than a week) by a team of species experts to identify both native and introduced species found

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[14] These data were assembled from several major introduced species surveys undertaken in the past 10 years but may not reflect the current, largely unpublished, state of knowledge on species distributions.

at selected sites - have produced much of the information on introduced species in other estuaries, and oligochaetes are rarely identified during rapid assessment surveys.

Table 5. West Coast distributions of all introduced invertebrates found in the lower Columbia River. (Additional data compiled from Cohen and Carlton 1995, Cohen et al. 1998, Ruiz et al. 2000, Cohen et al. 2001, CDFG 2004, and NAS 2004.)

Location abbreviations: SFB = San Francisco Bay CA, CB = Coos Bay OR,
LCR = Lower Columbia River, WB = Willapa Bay WA, and PS = Puget Sound WA
Table abbreviations: Lit = in literature review but not collected by LCRANS
1 = Found in Humboldt Bay and San Diego Harbor, 2 = Found along the northern California coast, 3 = Found in other Northwest freshwater sites, Bold species names indicates species distributed throughout all listed estuaries

Invertebrate Species	SFB	CB	LCR	WB	PS
Fredericella indica[3]			x		
Pectinatella magnifica[3]			x		
Nematostella vectensis	x	X	x		x
Cordylophora lacustris	x	X	x	x	x
Branchiura sowerbyi	x		x		
Chaetogaster diaphanus	x		x		
Eukerria saltensis			x		
Paranais frici	x		x		
Stylodrilus heringianus	x		x		
Hobsonia florida			x	x	x
Manayunkia aestuarina			x		x
Manayunkia speciosa	x		x		
Polydora cornuta	x		x	x	
Pseudopolydora kempi	x	X	Lit	x	x
Streblospio benedicti	x	X	x	x	x
Cipangopaludina chinesis malleatus	x		x		
Potamopyrgus antipodarum	(drainage)		x		
Corbicula fluminea	x	X	x		x
Mya arenaria	x	X	x	x	x
Nuttallia obscurata		X	x		x
Balanus improvisus	x	X	x	x	
Acartiella sinensis	x		Lit		
Limnoithona sinensis	x		Lit		
Limnoithona tetraspina	x		x		
Pseudodiaptomus forbesi	x		x		
Pseudodiaptomus inopinus		X	x		
Sinocalanus doerri	x		x		
Tachidius (Neotachidius) triangulari			x		
Nippoleucon hinumensis	x	X	x	x	x
Caecidotea racovitzai racovitzai [1]			x		
Crangonyx pseudogracilis			x		
Grandidierella japonica	x	X	x	x	x
Exopalaemon modestus	x		x		
Sinelobus stanfordi [2]			x		x
Melita nitida	x	X	x	x	x

Comparisons between the Columbia River, San Francisco Bay and other invaded aquatic systems are difficult but inevitable. While they have similar habitat types, it is problematic to compare these systems because they differ considerably in their physical, chemical, and biological characteristics. Depending upon the taxonomic group considered, the lower Columbia River is more invaded than some systems and less than others (Figure 9). Unlike the lower Columbia, the Hudson River is dominated by introduced plants and mollusks. Except for a smaller number of introduced mollusks, the Columbia River appears to be "more invaded" than Puget Sound. These differences could result from differences in sampling methods, introduction vectors, invasion pressure, habitat types, climates, disturbance regimes, etc. For example, the comparatively large number of introduced vascular plants in the Great Lakes and Hudson River systems may be a result of longer histories of solid ballast discharge; the success of introduced invertebrates in San Francisco Bay could be facilitated by the temperate waters of the Eastern Pacific in (Chapman 1997); and the bathymetry of Puget Sound could decrease the success of benthic invertebrate establishment.

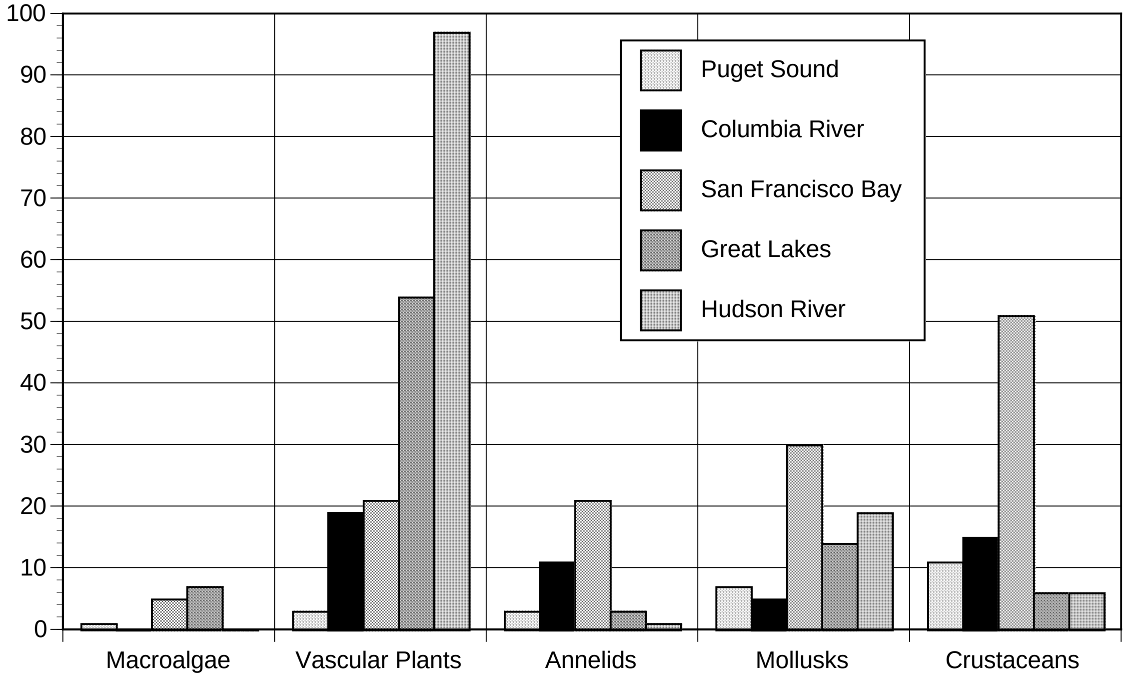

Figure 9. Comparison of invasive species in several North American systems (Mills et al. 1993, Cohen and Carlton 1995, Mills et al. 1995, Cohen et al. 1998, and Cohen at al. 2001).

Rates of Invasion

The number of introduced species found in the lower Columbia River is increasing (Figure 12), and mirrors similar trends observed elsewhere (Ruiz et al. 2001); however, the rate of introduced invertebrate discovery and reporting probably does not represent the actual introduction rates. The lower Columbia invertebrate community was poorly studied in the past and the presence of nonnative species may have been overlooked. Furthermore, some of the introduced species found in our survey were undoubtedly in the Columbia River for several years prior to recent reports. For example, the New Zealand mudsnail, *Potamopyrgus antipodarum,* was present in the Snake River since the mid 1980s and was almost certainly transported downstream from the Snake River at some earlier date than its first discovery near Astoria in 1995 (Wonham and Carlton unpublished). The Chinese mystery snail, *Cipangopaludina chinesis malletus,* has been a popular aquarium/pet species for well over 50 years (Cohen and Carlton 1995) and anecdotal evidence supports a presence in protected waters of the Columbia River basin long before our sighting in 2002. It is also probable that the invertebrate curve reflects sampling effort, in part, which has increased in the last 20 years.

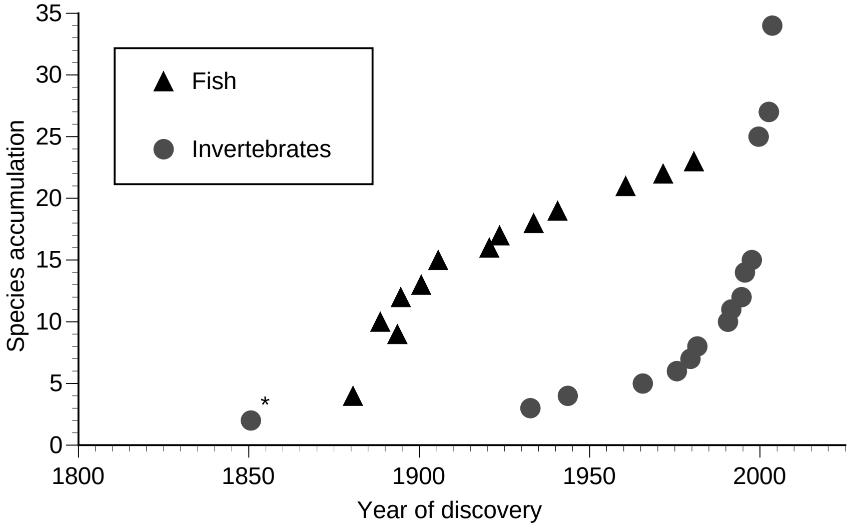

Figure 10. Accumulation of non-indigenous species in the lower Columbia by year of discovery.

In contrast to the rate of nonative invertebrate discovery, the rate of nonnative fish introductions in the river may approximate the actual in introduction rate. Prior to 1955, the majority of fish introductions were intentional, often conducted by the U.S. Fish

Commission, and well-documented (Smith 1896, Lampman 1946). After 1955, intentional sport fish introductions declined but new introductions for biological control, e.g., the mosquito fish, *Gambusia affinis* (Bond 1994), or illegal aquarium disposal, e.g., the oriental weather loach, *Misgurnus anguillicaudatus* (Logan et al 1996), continue to be reported. Furthermore, new and unusual species (e.g. piranha which cannot survive over winter in cold water and are not considered successful introductions) caught by anglers often receive media attention and are reported as novelties (Quinn 2002).

Vectors and Pathways

Nonnative species have been introduced into the lower Columbia River intentionally and unintentionally through a variety of vectors (Figure 10). Although vector determination is not precise, shipping-related vectors accounted for the largest number of introduced species. Ballast water alone was considered to be a possible mechanism of introduction for 29 out of 35 invertebrate species and one plant into the Columbia River. All shipping mechanisms together (fouling, solid ballast, and ballast water) accounted for 30 invertebrates and two aquatic plants. Intentional releases for wildlife enhancement by individuals and fisheries agencies accounted for 19 out of 23 fish introductions to the lower Columbia River. Similarly, many aquatic plant introductions could be attributed to intentional introduction but could also have escaped from ornamental cultivation (Figure 11, Table 4). Many species are associated with multiple mechanisms. For example, the population of the common goldfish, *Carassius auratus*, in the lower Columbia River may be the result of aquarium dumping, escape from ornamental ponds, and/or release by an individual for wildlife enhancement. Intentional introduction and escape from culture ponds were documented for the common carp, *Cyprinus carpio* (Lampman 1949).

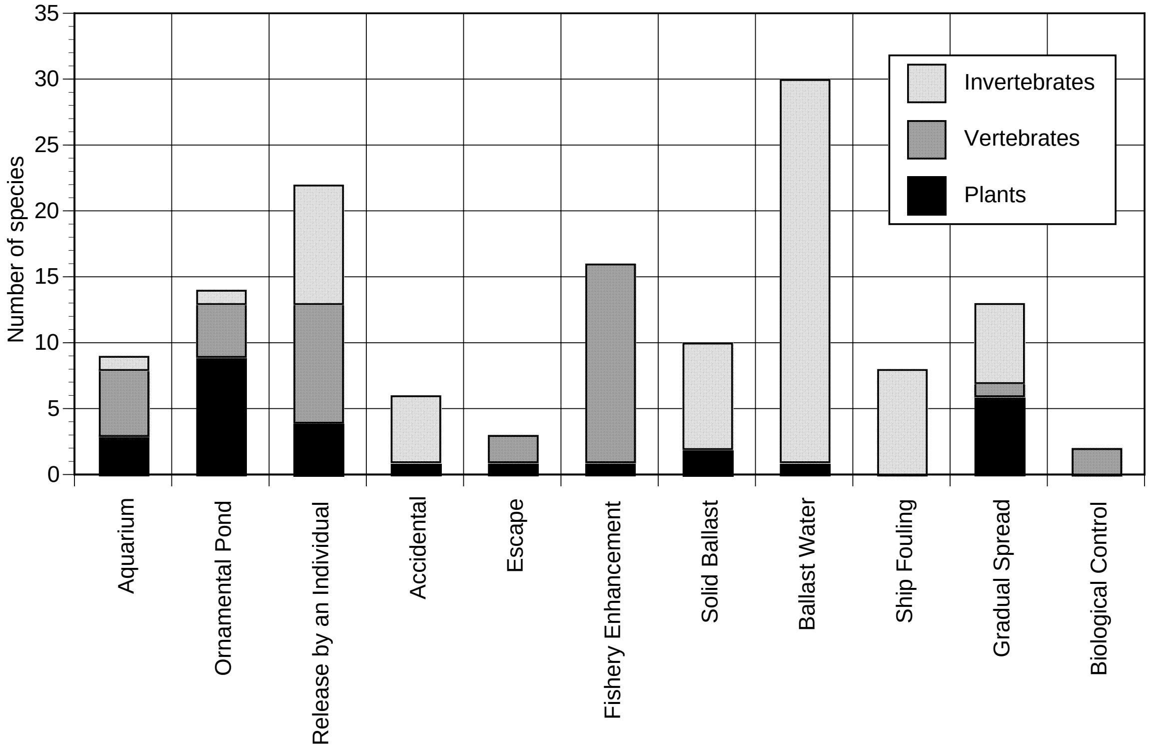

Figure 10. Invasions by type of introduction mechanism.

The importance of various vectors for introduction of invertebrates has changed over time (Figure 11). Shipping-related vectors have increased in importance since 1950. The increase in introductions associated with shipping corresponds with an increase in the volume and speed of shipping in the Columbia. Invertebrate introductions that could be attributed to aquarium dumping and individual release occurred only after 1999, although anecdotal evidence suggests that this vector was active earlier as well.

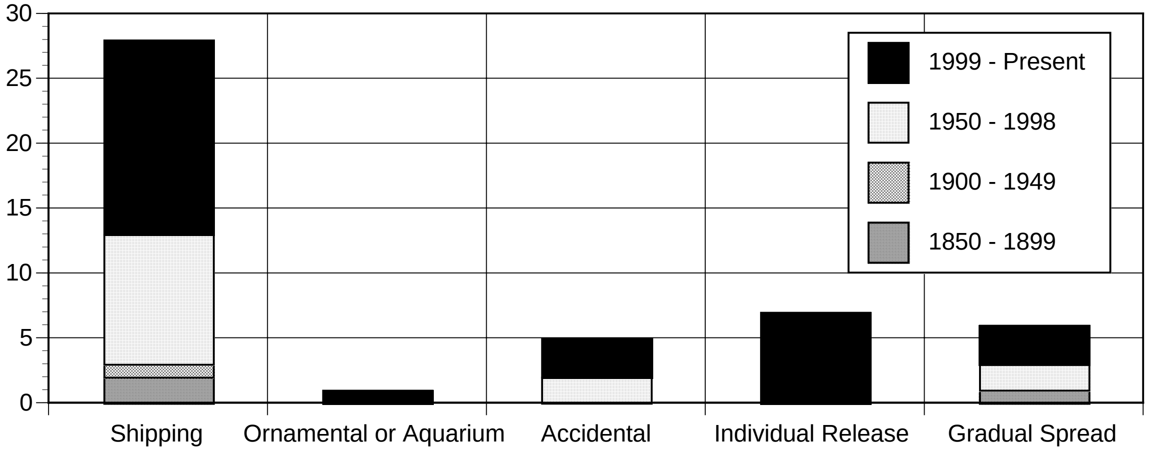

Figure 11 Changes in invertebrate introduction vectors over time.

The majority of introduced species in the lower Columbia originated in North America (Figure 12). Introduced fish accounted for most of the species with North American origin. Europe, Asia, and South America supplied similar numbers of plants as North America. Europe and Asia provided similar numbers of invertebrates as North America. No fish or invertebrates originated in Africa, and no fish or plants originated in New Zealand/Australia.

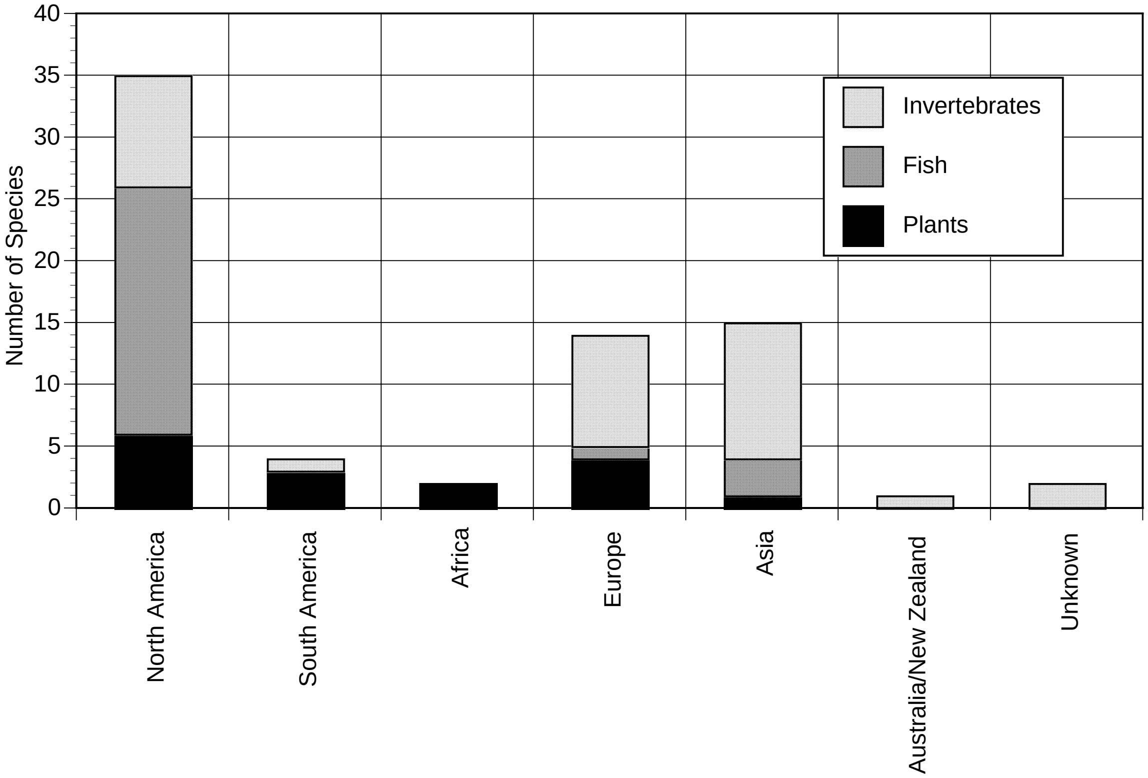

Figure 12. Invasions by region. This figure contains species collected by LCRANS as well as those species from the WEMAP study and the literature review that are considered valid.

Asia was the native region of 34% of the invertebrates introduced via shipping vectors in the Columbia River (Figure 13). The role of shipping in these introductions was supported by data on shipping traffic in the Columbia River. Ninety-four percent of all transoceanic voyages to Oregon ports originate in Asia, i.e., Japan, Korea, China and Taiwan (Flynn and Sytsma 2004).

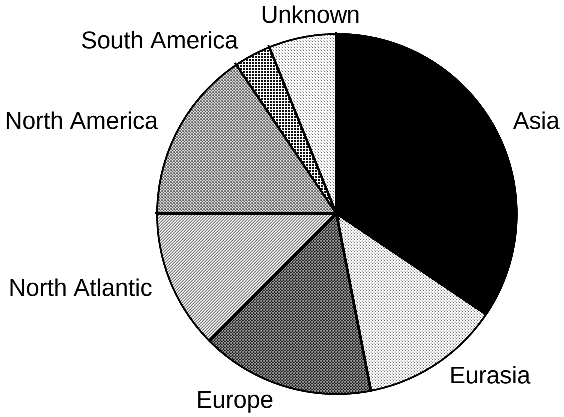

Figure 13. Origins of ballast water introduced invertebrate species in the lower Columbia River.

Despite an apparent correlation between volume of shipping from Asia and the preponderance of Asian species in the invertebrate community in the lower Columbia River, the source of these populations may not be their native ranges in Asia. Many recent ballast water introductions were previously established elsewhere on the West Coast (Table 5). The Columbia River receives more port calls from vessels from these domestic ports (59%) than it does from international ports (Flynn and Sytsma 2004). About 25 percent of coastal vessel traffic coming into Oregon estuaries originated in the highly invaded San Francisco Bay/Sacramento/San Joaquin Delta (Flynn and Sytsma 2004). Short transit times, established populations of introduced invertebrates possibly selected for dispersal by shipping vectors in several domestic ports on the West Coast, and abundant shipping traffic suggests that domestic shipping is a highly important vector for ANS introduction to the Columbia River. According to the dates of first discovery, most ANS in the lower Columbia River were reported earlier from other locations on the West Coast. Discovery dates, however, represent detection rather than arrival and are heavily influenced by sampling effort and regional ANS awareness.

The Columbia River is probably a net importer of ballast water and associated organisms. Columbia River ports are primarily bulk shipping ports, bulkers contain more ballast water than other ship types, and bulkers typically enter the Columbia River without cargo and in-ballast (Flynn and Sytsma 2004). Still, ships do take on ballast water in the Columbia. The role of the Columbia River in regional and global dispersal of ANS requires further investigation.

Chapter 6: Conclusions and Recommendations

We determined that 81 aquatic species were introduced into the lower Columbia River since the 1880s. The majority of these species were fish (28%), aquatic plants (23%) and crustacea (15 %). The remaining 18% was a combination of mollusks, annelids, bryozoans, cnidaria, amphibians, reptiles and an aquatic mammal. These results were likely a conservative estimate of the number of ANS in the river because of limitations of the survey, inadequate taxonomic resolution in prior studies, and the abundance of unresolved and cryptogenic taxa.

Over the course of our field survey we documented 269 aquatic species (and 55 other distinct organisms that we were unable to identify at the species level) in the lower Columbia River. Of the 269 species identified, 54 (21%) were introduced, 92 (34%) were native, and 123 (45%) were cryptogenic. From the 1880s to the 1970s a new introduced species was discovered in the lower Columbia about every five years. The frequency of new discoveries ANS is increasing worldwide (OTA 1993, Ruiz et al. 2000), however, and the rate of discovery of introduced invertebrates in the lower Columbia River mirrors this trend. Over the past ten years a new invertebrate species was discovered about every five months. The increasing rate of new discovery is due to increasing frequency of introductions and to the number and type of surveys conducted. It is not possible to separate these effects from the available data

In contrast to the invertebrates, the rate of fish discoveries in the lower Columbia declined after the 1950s. For fish, the rate of discovery may parallel introduction rates because many introductions were well-documented. The reduction in fish introductions was likely due to a decline in intentional fish stocking by individuals and fish and game agencies to increase the diversity of food and game fishes.

The majority of introduced species in the lower Columbia originated in North America. Introduced fish accounted for most of the species with North American origin, while Asia was the native region of 34 percent of the invertebrates introduced via shipping vectors.

Ballast water was the probable vector responsible for introducing 29 of 35 nonnative invertebrates. Most invertebrates reported from the Columbia River also occur in San Francisco Bay. Seven of the 35 invertebrates introduced into the lower Columbia River are widespread in major bays and estuaries of the West Coast. Additional surveys may increase this number.

The Columbia River receives more port calls from vessels from domestic ports (59 percent) than it does from international ports (Flynn and Sytsma 2004). About 25 percent of coastal vessel traffic coming into Oregon estuaries originated in the highly invaded San Francisco Bay/Sacramento/San Joaquin Delta (Flynn and Sytsma 2004). Short transit times, established populations of introduced invertebrates possibly selected for dispersal by shipping vectors in several domestic ports on the West Coast, and abundant shipping traffic suggests that domestic shipping is a highly important vector for ANS introduction to the Columbia River.

Additional surveys

This report establishes a baseline on ANS in lower Columbia River. Additional monitoring and sampling is necessary to detect new invasions and to document invasion rate, impacts, and efficacy of management efforts. We recommend a multiple purpose sampling approach to maximize the potential of detecting additional species and new arrivals. Sampling should target habitats and taxa that are likely to contain new invaders every year; a synoptic survey of the lower Columbia River should be conducted every five years; and additional sampling should target data gaps and survey limitations of this project. Regular comprehensive sampling of incoming ballast water is also needed to evaluate the probability of new introductions deriving from this vector.

Targeted sampling

Targeted sampling should focus on tracking changes in habitats that are highly invaded and are considered hot spots for detecting new arrivals. Targeted taxa include benthic crustaceans, mollusks, polychaetes, hydroids, zooplankton, and aquatic vascular plants. Sampling should replicate the protocols followed by in this survey. The locations in Table 9 are hot spots of invasion and/or have good, long-term records of species composition. These locations are recommended for targeted sampling.

Table 6. Suggested sampling locations proposed for targeted sampling.

Location	Sites	Prior Research	Comments
Youngs Bay	CEDC Net Pens	CREDDP, benthic surveys by CEDC, LCRANS, nearby surveys by NMFS, EMAP	Brackish water, benthic surveys demonstrate interactions between mudsnail invaders and native crustacean community.
	Youngs River Mouth	CREDDP, LCRANS, EMAP, Cordell et al.	Changes in freshwater and low salinity zooplankton community
Trestle Bay	Interior	NMFS, LCRANS	Protected embayment with soft sediment, salt marsh and rocky intertidal community along jetty.
Baker Bay	Sand Island	LCRANS	High salinity site, close to mouth but partially protected, several ANS found in island pools
	Eastern mud flats	LCRANS, EMAP	Extensive exposed meso-polyhaline mud flats, unique benthic invertebrate community vs. other mud flats in estuary
Miller Sands	Interior	NMFS, ACE, LCRANS	Artificially established freshwater sand habitat, interior is shallow, protected and adjacent to main shipping channel
Cathlamet Bay	Russian Island	NMFS, EMAP, LCRANS	Protected tidally influenced freshwater mudflats upstream of primary anchorage site for commercial vessels.
Port of Longview			Potential site for ANS introductions via ballast water
Port of Portland			Potential site for ANS introductions via ballast water
Sloughs	Wallace, Westport, Skamania, Fisher Island etc.	LCRANS	Slow, protected waters in the transition zone between the Willamette confluence and the estuary may retain species released at the Ports of Portand, Vancouver and Longview/Kelso
Sauvie Island	Multnomah Channel Side	LCRANS	Potential hot spot for aquarium and ornamental plant disposal, warm water area
Columbia Slough		ODFW, LCRANS	Potential hot spot for aquarium and ornamental plant disposal, high nutrient, warm water area with limited seasonal flushing, hot spot for *Exopalaemon modestus*, etc.

Discrete sampling

The goal of the discrete sampling should be to use intensive surveys resolve the data gaps and sampling limitations encountered in this survey. Sampling should focus on under-sampled taxa and areas such as the mouth and main channel of the estuary where LCRANS was unable to sample. Discrete sampling results should be used to modify targeted sampling if new hot spots or species are discovered.

Synoptic surveys

A repeat of the synoptic survey reported on here, should be conducted every five years. The goals of the survey should be to investigate potential new hotspots of invasion and to update the database on ANS developed through review of the literature. The synoptic survey should be used to fine-tune sampling methods and protocols to ensure complete coverage of taxa and habitats in the river.

Research Needs

Understanding the ecology, biology, dispersal of ANS is critical to management of invasions and protection of native plant and animal communities. Some research recommendations include investigation of:

- Facilitation – Major anthropogenic alteration of the physical, chemical, and hydrological characteristics of the lower Columbia River have occurred in the last century. Additional changes in these characteristics, as well as climate change, can be anticipated. The importance of various vectors of dispersal, human and natural, may also vary. Do these changes enhance establishment of ANS?
- Impacts – While economic and ecological impacts of ANS that are ecological engineers, like zebra mussels, are readily apparent, impacts of other species may be less obvious but still have significant ecological consequences. What are the economic and ecological effects of ANS? Do invaders at some trophic levels or in specific guilds have greater impacts than others?
- Taxonomy and biogeography– Taxonomic resolution of many species is poor, which limits conclusions about the number and rate of introduction of ANS. Biogeography of many species is also poorly documented. Taxonomic expertise on many taxa is limited. Are the large numbers of cryptogenic species found in the lower Columbia introduced or native? What is the number and importance of introduced disease organisms, parasites (plant and animal) and aquatic insects in the lower Columbia?
- Disperal of ANS – Movement of ANS in ballast water transferred between domestic ports is a particular threat to the Columbia River. Other vectors may be equally important, but are not well documented. What is the role of coastal shipping in dispersal of ANS on the West Coast? What is the role of shipping-related vectors other than ballast water, e.g., hull fouling, in dispersal of ANS?
- Management of ANS Prevention of new invasions requires interdiction of pathways through regulation of vectors. What methods can be used to manage populations of potential ANS in ballast water, hull fouling, live aquatics, ornamental and aquarium, and other vectors?

Management Needs

Invasive species management targets introduction, establishment, further spread and impacts of ANS. While the tools to control populations at the latter three stages include chemical, biological, and mechanical options – preventing introductions is the best and most cost effective way to limit the negative impacts of invasive species Eradication and often control of ANS in open systems has proved nearly impossible and many ANS management options are simply aimed at lessening the impacts of these species, usually by buffering the affected resource, without reducing overall population densities (i.e. retrofitting water-intake pipes to diminish zebra mussel fouling). In order to better focus ANS management of the lower Columbia River we have identified the following needs:

- Evaluation of vectors and pathways - While ballast water and other shipping activities appear to dominate recent ANS introductions into the lower Columbia River, other vectors, especially intentional releases, remain poorly quantified. New ballast water regulations (Flynn and Sytsma 2004) should reduce the frequency of ballast water introductions, which will lead to an increase in the relative importance of escape, release, and disposal of ANS by individuals will increase. We also need policies or guidelines that that address those individual behaviors that contribute to both intentional and unintentional introductions of ANS. .
- Compliance data - Without compliance numbers it is difficult to estimate the current effectiveness of ballast water management and other vessel management guidelines. Our study demonstrates the prominent role ballast water has played recently in the introduction of ANS into the lower Columbia River but because this represents the first comprehensive survey of ANS in the area it is difficult to determine if federal guidelines or state ballast water management legislation has had an effect on ANS introductions.
- Export risk evaluation - It is important that we view the lower Columbia River as a source of invaders and develop management actions aimed at preventing export as well as import. This includes not only native species that may be exported to other continents, but also nonnative species established in the lower Columbia River that may be transported to other nearby coastal waters
- Facilitation activity evaluation - As part of a comprehensive ANS management plan for the lower Columbia River it is vital that future and ongoing environmental modifications of the region be evaluated as actions that may enhance existing or facilitate new ANS invasions. This includes projects such as dredging, diking, flow alteration, water impoundment and removal, and even habitat restoration activities. Along with dramatic habitat disturbance, restoration, dredging and other ventures may require bringing in equipment and personnel that act as transportation vectors for hitchhiking ANS. In other instances the removal of pest species such as emergent aquatic

plants may just open up new habitat for other invasive species. An important step in the management of ANS is the evaluation of such projects in light of potential ANS impacts. This may require incorporating ANS into impact statements as well as monitoring plans. The more we know about how modifications to the Columbia River effect existing ANS populations the more tools we will have to manage future introductions.

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LOWER COLUMBIA RIVER AQUATIC NONINDIGENOUS SPECIES SURVEY 2001-2004

Final Technical Report: Appendices

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Prepared for the
UNITED STATES COAST GUARD
and the
UNITED STATES FISH AND WILDLIFE SERVICE

October 2004

Appendices: Contents

APPENDIX A: TAC

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APPENDIX B: SPECIES LIST

Guide to the format of this section

- Species arranged by Phylum/Division, then Class and/or other relevant taxonomic breakdown

- List of all species compiled from literature review and the field surveys

Family
Species Name LCRANS = present in survey, LIT= present in literature review Origin

- Species Descriptions
  Species Name, Author
  Synonyms (if applicable)
  Source of Information (LCRANS, LIT)
  Origin (i.e. Introduced, Cryptogenic or Native)
  Descriptive paragraph

Kingdom: Monera

Division: Cyanophycota

Cyanobacteria

There are 124 freshwater genera of cyanobacteria or blue-green algae reported from North America, however this division is in a state of taxonomic flux (Sheath and Wehr 2003). Cyanobacteria can be important in surface blooms, often toxic, in nutrient rich waters. All three genera below are widely distributed (Komarek 2003).

Nostocaceae	
Anabaena sp.	LCRANS, LIT
Aphanizomenon flosaquae	LIT
Aphanizomenon sp.	LIT
Oscillatoriaceae	
Lyngbya sp.	LIT
Oscillatoria sp.	LCRANS
Phormidium sp.	LCRANS
Spirulina sp.	LIT

Kingdom: Plantae

Division: Bacillariophyta

Phytoplankton species are the most common of all groups found in ballast water entering eastern Pacific ports (Carlton and Geller 1993, Levings et al. 2004, Cohen 1998).

Achnanthaceae	
Achnanthes deflexa	LIT
Achnanthes lemmermannii	LIT
Achnanthes suchlandtii	LIT
Achnanthes sp.	LIT
Karayevia clevei	LIT
Planothidium hauckianum	LIT
Planothidium lanceolatum	LIT
Planothidium peragalli	LIT
Rossithidium linearis	LIT
Achnanthidiaceae	
Achnanthidium minutissimum	LIT
Amphipleuraceae	
Frustulia rhomboids	LIT
Asterolampraceae	
Asteromphalus heptactis	LIT
Aulacoseiraceae	
Aulacoseira ambigua	LIT
Aulacoseira distans	LIT
Aulacoseira granulata	LCRANS, LIT
Aulacoseira granulata f. spiralis	LCRANS
Aulacoseira islandica	LIT
Aulacoseira italica	LCRANS
Bacillariaceae	
Bacillaria paxillifer	LCRANS
Cyclindrotheca closterium	LCRANS, LIT
Cylindrotheca gracilis	LIT
Cymbellonitzschia diluviana	LIT
Hantzschia amphioxys	LCRANS
Hantzschia distinctepunctata	LIT
Hantzschia marina	LIT
Nitzschia accuminata	LIT
Nitzschia acicularis	LIT
Nitzschia amphibian	LIT
Nitzschia capitellata	LIT
Nitzschia dissipata	LIT
Nitzschia frustulum	LIT
Nitzschia holsatica	LIT
Nitzschia linearis	LIT

Nitzschia longissima	LCRANS
Nitzschia palea	LIT
Nitzschia paleacea	LIT
Nitzschia parvula	LIT
Nitzschia pungens	LCRANS
Nitzschia recta	LIT
Nitzschia seriata	LIT
Nitzschia sigma	LCRANS, LIT
Nitzschia sigmoidea	LIT
Nitzschia subhybrida	LIT
Nitzschia sublinearis	LIT
Nitzschia vermicularis	LCRANS
Nitzschia vitrea	LCRANS
Nitzschia sp.	LIT
Tryblionella angustata	LIT
Tryblionella apiculata	LIT
Tryblionella hungarica	LIT
Tryblionella victoriae	LIT
Berkeleyaceae	
Berkeleya rutilans	LIT
Biddulphiaceae	
*Eucampia zodiacu*s	LCRANS
Catenulaceae	
Amphora angusta	LIT
Amphora coffaeiformis	LIT
Amphora micrometra	LIT
Amphora ovalis	LCRANS, LIT
Amphora perpusilla	LIT
Amphora sabyii	LIT
Amphora tenerrima	LIT
Amphora sp.	LCRANS
Chaetocerotaceae	
Bacteriastrum delicatulum	LIT
Bacteriastrum hyalinum	LCRANS
Chaetoceros convolutes	LIT
Chaetoceros decipiens	LCRANS, LIT
Chaetoceros didymus	LIT
Chaetoceros radicans	LIT
Chaetoceros sp.	LCRANS, LIT
Cocconeidaceae	
Cocconeis klamathenis	LIT
Cocconeis placentula	LCRANS, LIT
Coscinodiscaceae	
Coscinodiscus apiculatus	LIT
Coscinodiscus centralis	LIT
Coscinodiscus curvatulus	LIT

Coscinodiscus excentricus	LIT
Coscinodiscus hantzschii	LCRANS
Coscinodiscus perforatus	LIT
Coscinodiscus radiatus	LCRANS
Coscinodiscus sp.	LIT
Cymbellaceae	
Cymbella affinia	LIT
Cymbella cuspidate	LIT
Cymbella elginsis	LCRANS, LIT
Cymbella sp.	LIT
Encyonema minutum	LIT
Placoneis gastrum	LIT
Placoneis placentula	LIT
Diploneidaceae	
Diploneis fasca var. *pelagica*	LCRANS
Diploneis puella	LIT
Diploneis smithii	LIT
Diploneis subovalis	LIT
Diploneis sp.	LCRANS
Eupodiscaceae	
Odontella longicruris	LCRANS, LIT
Odontella aurita	LIT
Fragilariaceae	
Asterionella formosa	LCRANS, LIT
Asterionella gracillima	LCRANS
Asterionella japonica	LIT
Asterionellopsis glacialis	LCRANS
Diatoma hiemale var. *mesodon*	LIT
Diatoma tenue	LIT
Diatoma tenue var. *elongatum*	LIT
Diatoma vulgare	LCRANS, LIT
Diatoma vulgare var. *breve*	LIT
Fragilaria capucina	LCRANS, LIT
Fragilaria crotonensis	LCRANS, LIT
Fragilaria oceanica	LIT
Meridion circulare	LIT
Staurosira contruens	LIT
Synedra ulna	LCRANS, LIT
*Synedra delicatissim*a	LCRANS
Gomphonemataceae	
Gomphonema acuminatum	LCRANS
Gomphonema sp.	LCRANS
Reimeria sinuata	LIT
Heliopeltaceae	
Actinoptychus senarius	LCRANS
Actinoptychus splendens	LCRANS

Kingdom: Plantae
Division: Bacillariophyta

Hemidiscaceae		
	Actinocyclus ehrenbergii	LCRANS
Lauderiaceae		
	Lauderia annulata	LCRANS
Lithodesmiaceae		
	Ditylum brightwellii	LCRANS
Melosiraceae		
	Melosira italica	LCRANS
	Melosira nummuloides	LCRANS
	Melosira varians	LCRANS
Naviculaceae		
	Amphiprora gigantea var *sulcata*	LCRANS
	Navicula elegans	LCRANS
	Navicula sp.	LCRANS
Pinnulariaceae		
	Pinnularia sp.	LCRANS
Pleurosigmataceae		
	Gyrosigma sp.	LCRANS
	Pleurosigma fasciola	LCRANS
	Pleurosigma sp.	LCRANS
Rhizosoleniaceae		
	Proboscia alata	LCRANS
	Rhizosoleria setigera	LCRANS
Skeletonemaceae		
	Skeletonema costatum	LCRANS
	Skeletonema tropicum	LCRANS
Stephanodiscaceae		
	Cyclotella comta	LCRANS
	Cyclotella meneghiniana	LCRANS
	Stephanodiscus hantzschii	LCRANS
Surirellaceae		
	Surirella caproni	LCRANS
	Surirella linearis	LCRANS
Tabellariaceae		
	Tabellaria fenestrata	LCRANS
Thalassionemataceae		
	Thalassionema nitzschioides	LCRANS
Thalassiosiraceae		
	Thalassiosira lineatus	LCRANS
	Thalassiosira pacficia	LCRANS
	Thalassiosira punctigera	LCRANS

Kingdom: Monera
Phylum: Cyanophycota

Division: Chlorophyta

Green Algae

The division Chlorophyta includes both plankonic forms and macroalgal species as well as marine, estuarine and freshwater species. Filamentous green alage can often form free-floating mats or may be intertwined with other algal masses attached to hard surfaces (Shubert 2003). Macroalgae were not actively collected and identified during the LCRANS survey.

Chlorococcaceae		
Schroederia setigera	LCRANS	Cryptogenic
Dictyosphaeriaceae		
Dictyosphaerium pulchellum	LCRANS	Cryptogenic
Hydrodictyaceae		
Pediastrum integrum	LCRANS	Cryptogenic
Pediastrum sp.	LCRANS	
Scenedesmaceae		
Actinastrum hantzschii	LCRANS	Cryptogenic
Scenedesmus longispina	LCRANS	Cryptogenic
Scenedesmus sp.	LCRANS	
Ulvaceae		
Enteromorpha intestinalis	LIT	Native
Ulva	LCRANS, LIT	
Volvocaceae		
Eudorina elegans	LCRANS	Cryptogenic
Eudorina sp.	LIT	

CHLOROCOCCACEAE

Schroederia setigera (Schroeder) Lemmermann
Synonyms: *Ankistrodesmus setigurus, Reinschiella setigera*
LCRANS
Origin Crypotgenic

Freshwater planktonic alga. Widely reported and common in the plankton of North America (Shubert 2003). Also found in Europe and Asia.

DICTYOSPHAERIACEAE

Dictyosphaerium pulchellum Wood, 1872
LCRANS
Origin Crypotgenic

Colonial form. This genus is common but not considered abundant in North America (Shubert 2003).

HYDRODICTYACEAE

Pediastrum integrum Naeg.
LCRANS
Origin Crypotgenic

The genus is found in all regions of North America (Shubert 2003).S

SCENEDESMACEAE

Actinastrum hantzschii Lagerheim, 1882
LCRANS
Origin Crypotgenic

Colonial alga. Genus is widely reported from North America, common in ditches, ponds, bogs and lakes (Shubert 2003).

Scenedesmus longispina Meyen
LCRANS
Origin Crypotgenic

The most commonly reported genus of coccoid green algae worldwide (Shubert 2003).

ULVACEAE

Enteromorpha intestinalis (L.) Link
Synonyms: *Ulva intestinalis*
LIT
Origin: Native

Found on rocks in the high to mid tidal zone in protected bays and estuaries from Alaska to Mexico (Abbott and Hollenberg 1976). The genus *Enteromorpha* is cosmopolitan.

VOLVOCACEAE

Eudorina elegans
LCRANS

According to Shubert (2003) *Eudorina elegans* is among the most frequently encountered species of green alage.

Division: Phaeophycophyta

The brown algae

Macroalgae were not actively collected and identified during the LCRANS survey but *Fucus distichus* was noted because of its abundance at Trestle Bay and Baker Bay sites.

Fucaceae		
Fucus distichus	LCRANS, LIT	Native

FUCACEAE

Fucus distichus Linnaeus 1767
LCRANS, LIT
Native

Found attached to rocks in the upper to mid-intertidal zone from northern Washington State to Point Conception, California (Abbott and Hollenberg 1976). Dominant macrophyte in the intertidal zone in Trestle Bay and Baker Bay.

Division: Chrysophyta

Silicaflagellates

There are 72 genera of silicaflagellates known from inland habitats in North America, freshwater species are typically associated with standing bodies of water (Sheath and Wehr 2003). The skeletons of silicoflagellates usually comprise 1-2% of the siliceous component of marine sediments; making them much less abundant than diatoms. Marine species can contribute to blooms and are widely distributed throughout the world’s oceans (McCartney 1993).

Dictyochaceae		
Dictyocha fibula	LCRANS	Cryptogenic

DICTYOCHACEAE
Dictyocha fibula Ehrenb.
LCRANS
Origin: Cryptogenic

Marine species, also known from the eastern Atlantic.

Division: Pyrrophycophyta

The dinoflagellates

Dinoflagellates are typically a minor compenent of the phytoplankton and at times form dense blooms – usually in the presence of high levels of nitrates and phosphates (Sheath and Wehr 2003).

Ceratiaceae		
Ceratium hirundiella	LCRANS	Cryptogenic
Protoperidinaceae		
Protoperidinium depressum	LCRANS	Cryptogenic

CERATIACEAE
Ceratium hirundiella
LCRANS
Cryptogenic

Freshwater dinoflagellate, found throughout North America, distributed worldwide.

PROTOPERIDINACEAE
Protoperidinium depressum
LCRANS
Cryptogenic

Marine dinoflagellate, distributed worldwide

Subkingdom: Tracheobionta

Division: Magnoliophyta

Aquatic vascular plants include a variety of lifeforms including submersed and emergent, free-floating and rooted species. Submersed speices are restricted to shallow water, low current-velocity sites due to light and scouring effects. Emergent species occur are common on islands in the lower Columbia River. Emergent species are typically included in wetland deliniation work, however, submersed species are often overlooked. LCRANS sampling focused on cataloging introduced submersed species, although introduced emergent species were noted when observed. Submersed and emergent species were included in the literature review.

Kingdom: Plantae
Division: Magnoliophyta

Alismataceae			
	Alisma spp.	LCRANS	
	Alisma triviale	LIT	Native
	Sagittaria cuneata	LIT	Native
	Sagittaria latifolia	LIT	Native#
	Sagittaria spp.	LIT	
Apiaceae			
	Angelica lucida	LIT	Native
	Heracleum maximum	LIT	Native
	Hydrocotyle ranunculoides	LCRANS, LIT	Native
	Lilaeopsis occidentalis	LIT	Native
	Oenanthe sarmentosa	LIT	Native
	Sium suave	LIT	Native
Araceae			
	Lysichiton americanus	LIT	Native
Asteraceae			
	Achillea millefolium	LIT	Cryptogenic
	Aster spp.	LIT	
	Aster subspicatus	LIT	Native
	Bidens cernua	LIT	Native
	Boltonia asteroides	LIT	Cryptogenic
	Canadanthus modestus	LIT	Native
	Cotula coronopifolia	LCRANS, LIT	Introduced
	Helenium autumnale	LIT	Native
	Senecio triangularis	LIT	Native
Azollaceae			
	Azolla mexicana	LCRANS	Native
Boraginaceae			
	Myosotis laxa	LIT	Native
Cabombaceae			
	Cabomba caroliniana	LCRANS, LIT	Introduced
Callitrichaceae			
	Callitriche stagnalis	LCRANS, LIT	Introduced
	Callitriche verna	LCRANS, LIT	Native
	Callitriche spp.	LIT	
Ceratophyllaceae			
	Ceratophyllum demersum	LCRANS, LIT	Native
Chenopodiaceae			
	Salicornia depressa	LIT	Native
Clusiaceae			
	Hypericum scouleri	LIT	Native
Commelinaceae			
	Murdannia keisak	LIT	Introduced*
Crassulaceae			
	Crassula aquatica	LIT	Native

Cyperaceae		
Carex lyngbyei	LIT	Native
Carex obnupta	LIT	Native
Carex spp.	LCRANS, LIT	
Eleocharis minima	LIT	Native$^{\#}$
Eleocharis palustris	LIT	Native
Eleocharis spp.	LCRANS, LIT	
Schoenoplectus americanus	LIT	Native
Schoenoplectus tabernaemontani	LIT	Native
Schoenoplectus maritimus	LIT	Native
Schoenoplectus robsutus	LIT	Native$^{\#}$
Scirpus microcarpus	LIT	Native
Scirpus spp.	LIT	
Dictyosphaeriaceae		
Dictyosphaerium sp	LIT	
Equisetaceae		
Equisetum fluviatile	LIT	Native
Fabaceae		
Lathyrus palustris	LIT	
Lupinus sp.	LIT	
Trifolium spp.	LIT	
Vicia nigricans ssp. *gigantea*	LIT	Native
Haloragaceae		
Myriophyllum aquaticum	LCRANS, LIT	Introduced
Myriophyllum sibiricum	LCRANS	Native
Myriophyllum spicatum	LCRANS, LIT	Introduced
Hydrocharitaceae		
Egeria densa	LCRANS, LIT	Introduced
Elodea canadensis	LCRANS, LIT	Native
Elodea nuttallii	LCRANS, LIT	Native
Vallisneria americana	LCRANS, LIT	Introduced
Iridaceae		
Iris pseudacorus	LCRANS, LIT	Introduced
Isoetaceae		
Isoetes tenella	LIT	Native
Juncaceae		
Juncus balticus	LIT	Native
Juncus effusus	LIT	Native
Juncus filiformis	LIT	Native
Juncus nevadensis	LIT	Native
Juncus oxymeris	LIT	Native
Juncaginaceae		
Triglochin maritimum	LIT	Native
Lamiaceae		
Mentha arvensis	LIT	Native
Mentha aquatica	LIT	Introduced

Mentha aquatica x spicata	LIT	Introduced
Mentha spp.	LIT	
Prunella vulgaris	LIT	Native
Lemnaceae		
Lemna minor	LCRANS, LIT	Native
Liliaceae		
Veratrum californicum	LIT	Native
Lythraceae		
Lythrum salicaria	LCRANS, LIT	Introduced
Menyanthaceae		
Nephrophyllidium crista-galli	LIT	Native
Najadaceae		
Najas sp.	LIT	
Nymphaeaceae		
Nymphaea odorata spp. *odorata*	LCRANS, LIT	Introduced
Onagraceae		
Epilobium ciliatum ssp. *watsonii*	LIT	Native
Ludwigia uruguayensis	LIT	Introduced
Orchidaceae		
Platanthera dilatata var. dilatata	LIT	Native
Plantaginaceae		
Littorella sp.	LIT	
Plantago lanceolata	LIT	Introduced
Poaceae		
Beckmannia syzigachne	LIT	Cryptogenic
Deschampsia caespitosa	LIT	Cryptogenic
Distichlis spicata	LIT	Native
Elymus glaucus	LIT	Native
Glyceria striata	LIT	Native
Hordeum brachyantherum	LIT	Native
Lolium arundinacea	LIT	Introduced
Phalaris arundinacea	LCRANS, LIT	Introduced
Spartina spp.	LIT	Introduced*
Polygonaceae		
Polygonum hydropiperoides	LIT	Native
Polygonum spp.	LCRANS, LIT	
Pontederiaceae		
Eichhornia crassipes	LIT	Introduced*
Potamogetonaceae		
Potamogeton crispus	LCRANS, LIT	Introduced
Potamogeton epihydrus	LCRANS	Native
Potamogeton foliosus	LIT	Native
Potamogeton friesii	LIT	Native
Potamogeton natans	LCRANS	Native
Potamogeton pectinatus	LCRANS	Native
Potamogeton pusillus	LCRANS	Native

Potamogeton richardsonii	LCRANS, LIT	Native
Potamogeton zosteriformis	LCRANS	Native
Potamogeton spp.	LCRANS	
Ranunculaceae		
Caltha asarifolia	LIT	Native
Ranunculus spp.	LI	
Rosaceae		
Argentina anserina	LIT	Native
Rubiaceae		
Galium sp.	LIT	
Galium trifidum ssp. *columbianum*	LIT	Native
Ruppiaceae		
Ruppia maritima	LCRANS, LIT	Cryptogenic
Ruppia spp.	LIT	
Salicaceae		
Salix hookeriana	LIT	Native
Scrophulariaceae		
Castilleja ambigua ssp. *ambigua*	LIT	Native
Gratiola ebracteata	LIT	Native
Gratiola neglecta	LIT	Native
Limosella aquatica	LCRANS, LIT	Native
Mimulus guttatus	LIT	Native
Sparganiaceae		
Sparganium erectum	LIT	Introduced*
Sparganium angustifolium	LCRANS	Native
Typhaceae		
Typha angustifolia	LCRANS, LIT	Introduced
Typha latifolia	LIT	Native
Typha spp.	LCRANS, LIT	
Zannichelliaceae		
Zannichellia palustris	LCRANS, LIT	Native
Zosteraceae		
Zostera japonica	LCRANS, LIT	Introduced
Zostera marina	LIT	Native
Zostera sp.	LCRANS, LIT	

= likely mis-identification   * = unsuccessful establishement

ALISMATACEAE

Alisma triviale American water plaintain
Syn: *A. brevipes, A. plantago-americanum, A. plantago-aquatica, A. subcordatum*
LIT
Origin: Native

Alisma triviale is native to the California floristic province, i.e. from the dry regions of the Great Basin and the Mojave Desert to the Pacific coast to Canada (Hickman 1993). Also found in Southe eastern US, Eurasia, eastern Africa, and perhaps Australia.

Sagittaria cuneata Sheldon duck potato, arrowhead, wapato
Syn: *Sagittaria arifolia*
LIT
Origin: Native – probably misidentified

Native to California, Pacific Northwest to Southern Canada (Hickman 1993). Only found east of Cascades in Oregon and Washington (Ecology 2003). May be confused with *S. latifolia* below. May also be confused with *Alisma* spp., *Valisneria* sp., or *Sparganium* spp. which all have ribbon-like underwater leaves but it is unlikely to be confused with other plants when the arrowhead shaped leaves are present (Ecology 2003).

Sagittaria latifolia Willd. duck potato, arrowhead, wapato
Syn: *S. chinensis, S. esculenta, S. longirostra, S. obtuse, S. ornithorhyncha, S. planipes, S. pubescens, S. viscosa*
LIT
Origin: Native

Native to California, Pacific Northwest to Southern Canada (Hickman 1993). Unlike S. cuneata, S. latifolia is common on Pacific coast, and in central, and eastern United States. In Washington it is dictrubuted primarily west of Cascades and the Columbia River Gorge. See above for notes on similar species.

APIACEAE

Angelica lucida L. seacoast angelica
Syn: *Coelopleurum actaeifolium, Coelopleurum qmelinii, Coelopleurum lucidum, Coelopleurum lucidum ssp.*
LIT
Origin: Native

Native to the Pacific coasts of North America and Siberia. Used for medicinal purposes by some Eskimo communities. Also found in coastal areas of Northeastern North America.

Heracleum maximum Bartr. cowparsnip
Syn: *H. lanatum, H. sphondylium var. lanatum, H. sphondylium ssp. montanum*
LIT
Origin: Native

Native to North America. Used as a wetland indicator species.

Hydrocotyle ranunculoides L.f. floating marsh pennywort
LCRANS, LIT
Origin: Native

Native to Washington, Oregon and British Columbia. On the rare-palnt list for Washington and B.C. *Hydrocotyle ranunculoides* is considered an aggressive invader in Australia, the U.K., and parts of Africa.

Lilaeopsis occidentalis Coult. & Rose western grasswort
LIT
Origin: Native

Distributed along the West coast of North America from California to British Columbia (Hickman 1993).

Oenanthe sarmentosa K. Presl ex DC. water parsley
LIT
Origin: Native

Western N. America - British Columbia to California.

Sium suave Walter hemlock water parsnip
Syn: *S. cicutifolium, S. floridanum, S. suave var. floridanum*
LIT
Origin: Native

Native to North America, distributed across the northern states and south to Texas. (Hickman 1993).

ARACEAE

Lysichiton americanus Hultén & St. John western skunk cabbage
Syn: *Lysichitum americanum , L.camtschatcensis*
LIT

Native to Western North America (Hickman 1993)..

ASTERACEAE

Achillea millefolium L. western yarrow, milfoil
Syn: *Achillea borealis, Achillea lanulosa*
LIT
Origin: Cryptogenic

There are both native and introduced phases of *Achillea millefolium* in North America. Introduced and native phases differ primarily in chromosome number and are difficult to distinguish morphologically. Native and introduced phases hybridize. The intricate pattern of morphologic, geographic, and ecologic variation within the species has frustrated all efforts to organize an intraspecific taxonomy on a circumboreal or even a strictly North American basis (Aleksoff, 1999).

Aster subspicatus Nees. Douglas aster
LIT
Origin: Native

Bidens cernua L. nodding beggartick
LIT
Origin: Native

Boltonia asteroides boltonia aster, white doll's daisy
LIT
Origin: Cryptogenic

Patchy distribution east of the Rockies by this native North American daisy indicated that it may have been introduced to the western U.S. According to the USDA database this is *Boltonia asteroides var. recognita* (USDA - NRCS 2004).

Canadanthus modestus Canada aster, giant mountain aster
Syn: *Aster modestus*
LIT
Origin: Native

Native to the Pacific Northwest and Canada, this species is not widespread in the U.S. (USDA - NRCS 2004).

Cotula coronopifolia L. brass buttons
LCRANS, LIT
Origin: Introduced

Endemic to South Africa, *Cotula coronopifolia* is now also found in North America. On the Pacific Coast the species has become established from British Columbia to California. Its presence on the San Francisco Peninsula was reported in 1878. The introduction of *C. coronopifolia* to California is believed to have been via ship ballast (Cohen and Carlton 1995) and may have been spread by shipping up and down the West Coast.

Helenium autumnale L. common sneezeweed
Syn: *Helenium grandiflorum*
LIT
Origin: Native

Distributed throughout the U.S. *Helenium autumnale var. grandiflorum* is most likely to be the species reported in previous literature.

Senecio triangularis Hook. arrowleaf ragwort
LIT
Origin: Native

Native to western North America (Hickman 1993).

AZOLLACEAE

Azolla mexicana Schlecht. & Cham. ex K. Presl Mexican water-fern
LCRANS
Origin: Native

Distribution: Western North America and northern South America. Other similar species of water-fern are found nearly worldwide (Ecology 2003).

BORAGINACEAE

Myosotis laxa Lehm. smallflowered forget-me-not
LIT
Origin: Native

May be confused with *Myosotis scorpiodes*, common European forget-me-not (Hickman 1993).

CABOMBACEAE

Cabomba caroliniana Gray fanwort, Carolina fanwort
LCRANS, LIT
Origin: Introduced

Native to North and South America’s eastern subtropical-temperate zones, *Cabomba caroliniana* is now found in Europe, Asia and Australia (Ecology 2001). Though the species is native to the southeastern United States it has been introduced to the northeastern US and Oregon. The attractive foliage of *C. caroliniana* has made it popular with the aquarium trade since the 1890’s. Still popular, the species has been commercially available for some time. The introduction of *C. caroliniana* has been attributed to discarded aquarium plants. Though the species can reproduce sexually, vegetative fragments are the primary mode of reproduction and dispersal. Once established, *C. caroliniana* can threaten recreational use, navigation and the habitat of native species. This species is considered invasive (Les and Mehrhoff 1999).

CALLITRICHACEAE

Callitriche stagnalis Scop. European pond water-starwart
LCRANS, LIT
Origin: Introduced

Globally widespread, *Callitriche stagnalis* is found in Europe, northern Africa, Asia, Australia and North America. Once introduced to North America, many early collections of the species occurred in coastal areas of the United States. It has been hypothesized that the species initial establishment was in or near seaports, introduced by improper disposal of shipping ballast. The first documented specimens of *Callitriche stagnalis* found in Oregon were collected from an unspecified coastal location in 1871 and Clatsop County in 1902. By the turn of the century, *Callitriche stagnalis* had become a popular plant for aquariums, facilitating the establishment of inland populations via discarded plants. *Callitriche stagnalis* is a prolific seed producer and seeds are possibly the species primary mode of dispersal. The spread of *Callitriche stagnalis* has been comparatively slow, it is not a particularly aggressive colonizer but it will displace native species once it establishes itself. (Philbrick et al. 1998).

Callitriche verna L. vernal water-starwart, spiny water-starwart
Syn: *Callitriche palustris*
LCRANS, LIT
Origin: Native

C. verna is found throughout the Northern hemisphere and is considered circumboreal.

CERATOPHYLLACEAE

Ceratophyllum demersum L. coontail, hornwort
LCRANS, LIT
Origin: Native

Ceratophyllum demersum occurs across the entire U.S. and throughout most of Canada (IFAS 2004).

CHENOPODIACEAE

Salicornia depressa Standl. low saltwort
Syn: *Salicornia europaea, Salicornia maritima, Salicornia virginica*
LIT
Origin: Native

According to the Washington Flora Project *S. virginica* may be the best name for this plant. It is distributed along the Pacific, Gulf and Atlantic coasts of the U.S.

CLUSIACEAE

Hypericum scouleri Hook Scouleri's St. Johnswort
Syn: H. *formosum* ssp. *Scouleri, H. formosum* var. *nortoniae*
LIT
Origin: Native

Native to western North America, *Hypericum scouleri* is a well-known medicinal plant.

COMMELINACEAE

Murdannia keisak (Hassk.) Hand.-Maz. Asian spiderwart
Syn: Anelimia
LCRANS, LIT
Origin: Introduced – not established

Origin: Introduced throughout the Pacific Northwest and the Southeastern U.S., *Murdannia keisak* is associated with rice culture in East Asia where it is a native plant. According to the Virginia Native Plant Society (2004) it was probably first brought to South Carolina or Louisiana in rice imported for growth in this country. In the United States, it is now found in all eastern coastal states from Delaware to Louisiana, and in Kentucky and Tennessee. The aggressive nature of this plant has now been clearly displayed by its ability to establish itself in freshwater wetlands and crowd out native vegetation by forming a solid mat of vegetation. Even in its native region, this species is a troublesome weed. Not only does it produce thousands of very small seeds, it can reproduce vegetatively. It was found in a freshwater tidal marsh on Lois Island in the Columbia River estuary. The island was resurveyed by Portland State University and Washington Department of Ecology in November, 1997 and again during LCRANS but no *M. keisak* was found.

CRASSULACEAE

Crassula aquatica (L.) Schoenl Water pygmy weed
Syn: *Tillaea aquatica* L. H&C
LIT
Origin: Native

Crassula aquatica is native to North America but is considered a rare or threatened species in many states (Rook 2002). It grows in a variety of location types including vernal pools, ponds and the edges of lakes, and may also be found in salt marshes (Hickman 1993).

CYPERACEAE

Carex lyngbyei Hornem. Lyngby's sedge
Syn: *Carex cryptocarpa, Carex cryptochlaena*
LIT
Origin: Native

A tidal wetland species, *Carex lyngbyei* is common in Pacific Northwest marsh communities. It is native to the west coast and ranges from the central coast of California to Alaska (Hickman 1993).

Carex obnupta Bailey slough sedge
Syn: *Carex magnifica*
LIT
Origin: Native

Carex obnupta is native to the west coast of North America. It can be found along the Pacific Coast from California to British Columbia. It grows in bogs, marshes, wet meadows, ditches and the edges of rivers and lakes. It is very common in areas where fresh and salt water meet but is confined to lower elevations. Hickman 1993 considers it to be a horticultural variety.

Eleocharis minima hairgrass, small spike rush
Syn: *Eleocharis bicolor, Eleocharis uncialis*
LIT
Origin: Native

May be a misidentification as this species may be confused with other *Eleocharis*. The USDA distribution map does not show this species in Oregon or Washington but considers it to be native to North America (USDA - NRCS 2004). It is used as cool-water aquarium plant.

Eleocharis palustris (L.) Roemer & J.A. Schultes common spike rush
Syn: *Eleocharis mamillata, Eleocharis perlonga, Eleocharis smallii, Eleocharis xyridiformis*
LIT
Origin: Native

A native species, *Eleocharis palustris* is found widely throughout North America (USDA - NRCS 2004).

Schoenoplectus tabernaemontani (K.C. Gmel.) Palla softstem bulrush
LIT
Origin: Native

A native sedge *Schoenoplectus tabernaemontani* is distributed throughout North America (USDA - NRCS 2004).

Schoenoplectus americanus (Pers.) Volk. ex Schinz & R. Keller chairmaker's bulrush
syn: *Scirpus americanus*
LIT
Origin: Native

This native sedge is can be found throughout much of North America with the exception of the great lakes region (USDA - NRCS 2004).

Schoenoplectus maritimus (L.) Lye cosmopolitan bulrush
Syn: *Scirpus maritimus*
LIT
Origin: Native

*Schoenoplectus maritimus,*a native bulrush, can be found throughout much of North America.

Schoenoplectus robustus (Pursh) M.T. Strong sturdy bulrush
Syn: Scirpus robutus
LIT

Although it is native to North America this record may represent a mis-identification as the USDA has no record of this speciesoccuring in OR. There are, however, many other species of sedges that may be confused with this one.

Scirpus microcarpus J.& K. Presl panicled bulrush
Syn: *Scirpus rubrotinctus* Fern.
LIT
Origin: Native

Native to North America, this sedge is distributed throughout much of the U.S. except the Southeast.

EQUISETACEAE

Equisetum fluviatile L. water horsetail

LIT
Origin: Native

An ancient plant with a circumboreal distribution, *Equisetum fluviatile* commonly grows in dense colonies along shorelines or in shallow water. Most often confused with marsh horsetail (*E. palustre*).

FABACEAE

Lathyrus palustris L. marsh pea
LIT
Origin: Native

Native to much of the U.S. *Lathyrus myrtifolius* is a state listed threatened and/or endangered species along much of the east coast (USDA - NRCS 2004).

Vicia nigricans* ssp. *gigantea (Hook.) Lassetter & Gunn. giant vetch
LIT
Origin: Native

Native to Western N. America , *Vicia nigricans* ssp. *gigantean* is found from Alaska to California (Hickman 1993).

HALORAGACEAE

Myriophyllum aquaticum (Vell.) Verdc. parrot feather watermilfoil
LCRANS, LIT
Origin: Introduced

Myriophyllum aquaticum is sold primarily for aquatic gardens, but sometimes also for aquarium use. Since 1996, sale of parrot feather has been banned in Washington because it is an aggressive invader that rapidly takes over lakes and ponds. Parrotfeather is a native of South America that grows well in Pacific Northwest waters. It is distributed throughout much of North America and Hawaii (USDA - NRCS 2004). According to the Washington Department of Ecology all of the parrot feather plants in the United States are female, so no seeds are produced. However, the plant spreads readily through fragmentation of the stems and rhizomes (Ecology 2001).

Myriophyllum sibiricum Komarov shortspike watermilfoil
Syn: *Myriophyllum exalbescens* Fern.
LCRANS
Origin: Native

Though considered native to northern North America and Eurasia, *Myriophyllum sibiricum* may possibly be a circumboreal species that has increased in range (Ecology 2001, Aiken 1981). It is distributed throughout North America except in the southeastern U.S.

Myriophyllum spicatum L. spike watermilfoil
LCRANS, LIT
Origin: Introduced

Once commonly sold as an aquarium plant, *Myriophyllum spicatum*, is native to Europe and Asia. It was introduced to North America many years ago and is now found over much of the United States (Ecology 2001). *M. spicatum* can be found in lakes, ponds, shallow reservoirs and low energy areas of rivers and streams as well as in the brackish waters of protected tidal creeks and bays. This species is considered a serious pest in waterbodies that have experienced disturbances such as nutrient loading, intense plant management, or abundant motorboat use (Nichols 1994). Milfoil is rapidly spread from lake to lake on boat trailers. Milfoil forms very dense mats of vegetation on the surface of the water interfering with recreational activities such as swimming, fishing, water skiing, and boating and clogging water intakes used in power generation and irrigation (Ecology 2001). The vast, dense mats can rob oxygen from the water by preventing the wind from mixing the oxygenated surface waters to deeper water.

HYDROCHARITACEAE

Egeria densa Planch. Brazilian waterweed
LCRANS, LIT
Origin: Introduced

Native to South America, *Egaria densa* has also become established in Europe, Japan, Australia and North America (Ecology 2001). For decades *Egaria densa* has been commercially cultivated and sold for use in water gardens and aquariums. Due to its popularity it is now found throughout the United States, apparently dispersed by improper aquarium disposal and cultivated escapees. Populations of this species occurring in North America are staminate therefore no seeds are produced. The primary mode of reproduction is asexual via vegetative fragments. Recreational boating and other activities in infested water bodies contribute to the vegetative dispersal of *Egaria densa* (Les and Mehrhoff 1999). In 1944 *Egaria densa* was found in Oregon (Cohen andCarlton 1995). Officials now consider *Egaria densa* to be one of the greatest threats to Oregon's water bodies. Silver Lake County, in Washington State spends over one million dollars a year to control *Egaria densa* (Ecology 2001). It is also illegal to sell *Egaria densa* in Washington State (Ecology 2001). Not only does *Egaria densa* displace native species, it clogs waterways and impedes navigation (Cohen and Carlton 1995). *Egaria densa* is currently considered a highly invasive species with increasing populations (Les and Mehrhoff 1999).

Elodea canadensis Michx**.** Canadian waterweed, common elodea
Syn: *Anacharis canadensis, Elodea brandegeeae, Elodea ioensis, Elodea linearis, Elodea planchonii, Philotria canadensis, Philotria linearis*
LCRANS, LIT
Origin: Native

Origin: Nativeaquatic plant distributed throughout North America. Because it is a popular aquarium plant is has been widely exported around the world, subsequently introduced and is now considered a noxious weed in parts of Europe, Australia, Africa, Asia, and New Zealand (Ecology 2001). Often confused with *Elodea nuttallii* and *Egeria densa.*

Elodea nuttallii Planch.) St. John western waterweed
Syn: *Anacharis nuttallii* Planch.*, Anacharis occidentalis* (Pursh) Victorin*, Elodea columbiana* St. John*,, Elodea minor (*Engelm. ex Caspary) Farw.*,, Elodea occidentalis* (Pursh) St. John, *Philotria angustifolia* (Muhl.) Britt. ex Rydb *, Philotria minor* (Engelm. ex Caspary) *Small, Philotria nuttallii (*Planch.) Rydb.*,, Philotria occidentalis* (Pursh) House*, , Udora verticillata var. minor*
LCRANS, LIT
Origin: Native

Occurs in the Northwest and California, but is more common in the eastern U.S. , *E. nuttallii* can be found in lakes, rivers, ponds and ditches. Unlike *E. canadensis, E. nuttallii* prefers fresh to slightly brackish water (Ecology 2001).

Vallisneria Americana Michx tapegrass, water celery
LCRANS, LIT
Origin: Introduced

Vallisneria americana is an aquatic perennial indigenous to eastern North America. The species is now also found in Asia, Australia, Central America and the Caribbean. In the Pacific Northwest *Vallisneria americana* was introduced to provide habitat for wildlife and fish. The species is not an aggressive colonizer and does not cause many of problems associated with other introduced aquatic plants. Therefore *V. americana* is not considered a pest species (Ecology 2001).

IRIDACEAE
Iris pseudacorus yellow flag iris, water flag
LCRANS, LIT
Origin: Introduced

A perennial wetland plant with attractive yellow flowers, *Iris pseudacorus* was brought to and cultivated in eastern North America during the early to mid 19th century. By the 1860's its escape from cultivation was reported. Native to Europe, it is now found throughout the United States and Canada (Cohen and Carlton 1995). Though it is invasive, *I. pseudacorus* is still offered commercially and is widely cultivated. Large, floating seeds are water dispersed. Rhizomes may also be broken off and can float downstream to establish ne populations. Due to its competiveness, *I. pseudacorus* populations are increasing. Once established, native species are displaced and the plant can become a nuisance. Little work has been done on effective removal of yellow flag; glyphosate application is somewhat effective, manual removal may more effective but may result in highly disturbed habitat.

ISOETACEAE

Isoetes tenella Léman spiny-spore quillwort
Syn: *Isoetes setacea, Isoetes muricata*, *Isoetes echinospora*, *Isoetes braunii*
LIT
Origin: Native

Origin: Nativedistribution: from Newfoundland to British Columbia, south to Pennsylvania and California (Rook 2002).

JUNCACEAE

Juncus balticus Willd. Baltic rush, wire grass
LIT
Origin: Native

Distributed throughout North America (USDA - NRCS 2004).

Juncus effusus L. common rush
LIT
Origin: Native

Distributed throughout North America, may be one or more of four var. possibilities (USDA - NRCS 2004).

Juncus filiformis L. thread rush
LIT
Origin: Native

Distributed throughout the western US and in the Great Lakes region (USDA - NRCS 2004).

Juncus nevadensis S. Wats. Sierra rush
LIT
Origin: Native

Native to the western U. S., there are four varieties found in Oregon and Washington (USDA - NRCS 2004).

Juncus oxymeris Engelm. pointed rush
LIT
Origin: Native

Origin: Nativespecies with a distribution limited to the west coast of North America (USDA - NRCS 2004).

JUNCAGINACEAE

Triglochin maritimum L. seaside arrowgrass
Syn: *Triglochin maritima* L., *Triglochin elatum* Nutt.
LIT
Origin: Native

Distributed throughout most of the U.S. except the gulf and mid Atlantic states (USDA - NRCS 2004), also found in Europe and Asia, *Triglochin maritimum* may be a circumpolar species complex.

LAMIACEAE

Mentha aquatica L. water mint
LIT
Origin: Introduced

Found primarily along the eastern coast from Nova Scotia to South Carolina, but also occurring in most of the inland eastern states and throughout the central and western United States. Water mint is native to Europe and is often sold as a water garden plant. Was probably brought to North America with European immigrants who valued it for its medicinal and herbal uses.

Mentha arvensis L. wild mint
LIT
Origin: Native

This is the only native species of *Mentha* found in the U.S., the rest are all introduced. This plant is very common and used for culinary purposes. Some states such as Nebraska consider this an invasive wetland plant. With a temperate distribution Hickman 1993 considers this to be naturalized from Europe but native tribal records indicated widespread use of this plant (http://www.wsdot.wa.gov/environment/culres/ethbot/m-p/Mentha.htm).

Mentha* x *piperita L. (pro sp.) *aquatica* × *spicata* peppermint
LIT
Origin: Introduced

Origin: Introduced hybrid of two nonnative Eurasian mint species *Mentha aquatica* x *M. spicata*, this plant is popular herb. Peppermint is found throughout much of North America. (USDA - NRCS 2004).

Prunella vulgaris L. common selfheal
LIT
Origin: Native

Prunella vulgaris is native to the continental U.S. but is considered an invasive native in the Northeast and in the Great Plains states (USDA - NRCS 2004).

LEMNACEAE

Lemna minor L. common duckweed
LCRANS, LIT
Origin: Native

Lemna minor is distributed hroughout much of the temperate and subtropical regions of the world including North America, Eurasia, Australia, and New Zealand. It may be confused with other duckweeds as well as *Azolla mexicana*. Natural duckweed mats are likely to be a mixture of species.

LILIACEAE

Veratrum californicum Dur. California false hellebore, corn lily
LIT
Origin: Native

Native to North America west of the Rockies, there are two varieties of *Veratrum californicum* found in the Pacific Northwest. Traditional uses of *V. californicum* include its use as a contraceptive, the whole plant should be considered highly toxic (The Compleat Botanica).

LYTHRACEAE

Lythrum salicaria L. purple loosestrife, salicaire, spiked loosestrife
LCRANS, LIT
Origin: Introduced

Origin: Introduced throughout much of North America, this species is considered a serious pest, is listed as a nuisance and/or noxious weed in many states, and is banned from sale in most U.S. states (USDA - NRCS 2004). Purple loosestrife disrupts wetland ecosystems by displacing native plants and animals. Economic impacts are high in agricultural communities when irrigation systems are clogged or when wetland pastures are lost to grazing.

MENYANTHACEAE

Nephrophyllidium crista-galli (Menzies ex Hook.) Gilg deercabbage
Syn: *Fauria crista-galli*
LIT
Origin: Native

Native to Oregon and Washington (in the Olympic Mountains and North Cascades) north to British Columbia and Alaska (USDA - NRCS 2004).

NYMPHAEACEAE

Nymphaea odorata* ssp *odorata American white waterlily
LCRANS, LIT
Origin: Introduced

Nymphaea odorata is native to eastern North America. It consists of two subspecies *N. odorata* ssp. *odorata* and ssp. *tuberosa* (Paine) Wiersema & Hellquist. The two subspecies are widespread in the eastern, central, and mid western United States. *N. a odorata* ssp *odorata* has been introduced into several western and northwestern states (Weirsema 1997). It is considered a class c nox weed in Washington.

ONAGRACEAE

Epilobium ciliatum Raf. ssp. ***watsonii*** (Barbey) Hoch & Raven fringed willowherb
Syn: *Epilobium adenocaulon, Epilobium americanum, Epilobium brevistylum, Epilobium californicum, Epilobium delicatum, Epilobium ecomosum, Epilobium ursinum*
LIT
Origin: Native

Native to the Pacific Northwest and California (USDA - NRCS 2004). *Epilobium ciliatum* has a nearctic distribution.

Ludwigia uruguayensis (Camb.) Hara Uruguayan primrose-willow, water primrose
LIT
Origin: Introduced

Ludwigia uruguayensis is a perennial herb with bright yellow, showy flowers and willow-like leaves that can be found creeping along the shoreline, floating on the water surface, or growing upright. It is a non-native species originally from South America and has been introduced into Europe and northern North America. Water primrose spreads by seeds and by plant fragments. It is easily dispersed by shipping, waterfowl, and human activity. It is also sold as an ornamental species. In Washington water primrose has established in the drainage canals in the Longview/Kelso area. It has been in the area for about 25 years. There is a herbarium specimen dated 1956, from the "Longview Toll Bridge" (Ecology 2001).

There has been some confusion in the past as to the origin of *L. uruguayensis*. Some authors consider this a species complex native to both South America and the Southern U.S. Jennifer Parsons of the Washington Department of Ecology and one of the taxonomic advisors to the LCRANS survey considers this whole complex to be weedy and non-native to the Pacific Northwest.

ORCHIDACEAE

Platanthera dilatata (Pursh) Lindl. ex Beck **var. *dilatata*** scentbottle
LIT
Origin: Native

Native to the northern U.S. and the western states, *Platanthera dilatata* var. *dilatata* is a rare orchid that inhabits soggy soil, bogs, marshes, meadows, fens and prefers full sun (USDA - NRCS 2004).

PLANTAGINACEAE

Plantago lanceolata L. narrowleaf plantain
LIT
Origin: Introduced

An introduced weed, *Plantago lanceolata*, is native to Europe, has been spread throughout the continental U.S., Alaska, Hawaii and Puerto Rico and thrives in many other temperate climates. *P. lanceolata* is commonly found along roadsides, railroads and other disturbed habitats. The leaves of many *Plantago* spp. have medicincal uses and it may have been intentionally transported to North America. The pollen of *P. lanceolata* is also a common allergen.

POACEAE

Beckmannia syzigachne (Steud.) Fern. American sloughgrass
Syn: *Beckmannia eruciformis auct. non; Beckmannia eruciformis ssp. baicalensis; Beckmannia eruciformis var. uniflora; Beckmannia syzigachne ssp. baicalensis; Beckmannia syzigachne var. uniflora*
LIT
Origin: Cryptogenic

Found in wet meadows, swamps, marshes and shallow water. Range Eastern Europe to central Asia and North America. Most sources consider this to be a native, new-world grass and it is considered threatened and endangered in two midwestern states (Hickman 1993, USDA - NRCS 2004) but the Global Compendium of Weeds (HEAR 2004) lists its origins as China and Asia.

Deschampsia caespitosa (L.) Beauv. tufted hairgrass
LIT
Origin: Cryptogenic

Distributed throughout the western and northern U.S. Most sources consider this to be a native, new-world grass (Hickman 1993, USDA - NRCS 2004) but the Global Compendium of Weeds (HEAR 2004) lists its origins as Eurasia, Africa, Australia (HEAR 2004).

Distichlis spicata (L.) Greene inland saltgrass
LIT
Origin: Native

Saltgrass is native to North America and is widely distributed (USDA - NRCS 2004). *Distichlis spicata* is the only saltgrass (*Distichlis*) native to the U.S.

Elymus glaucus Buckl. blue wildrye
LIT
Origin: Native

Origin: Nativegrass distributed throughout western North America (USDA - NRCS 2004). Hybridizes readily with other members of the genus *Elymus*.

Glyceria striata (Lam.) A.S. Hitchc. fowl mannagrass
LIT
Origin: Native

Origin: Nativegrass, widely distributed throughout North America (USDA - NRCS 2004). Considered invasive in the Czech Republic (Dancak 2002).

Hordeum brachyantherum Nevski meadow barley
LIT
Origin: Native

Native to the western U.S., spotty distribution in the east may indicate that it is introduced to eastern North America (USDA - NRCS 2004).

Lolium arundinaceum (Schreb.) S.J. Darbyshire tall fescue
Syn: *Festuca arundinacea* Schreb. var. *arundinacea* Schreb.
LIT
Origin: Introduced

An agronomically important forage species native to Europe, *Lolium arundinaceum* is considered a pest species in the U.S. where it is widely distributed (USDA - NRCS 2004).

Phalaris arundinacea L. reed canarygrass
LCRANS, LIT
Origin: Introduced

Phalaris arundinacea is a rhizomatous perennial grass (Ecology 2002). Reed canarygrass forms dense, highly productive stands that grow so vigorously they are able to inhibit and eliminate competing species (Apfelbaum and Sams 1987). In addition, areas that have existed as reed canarygrass monocultures for extended periods of time may also be characterized by seed banks that are lack any native species (Apfelbaum and Sams 1987, Ecology 2002).

Reed canarygrass is one of the most common species growing along the banks of the lower Columbia River system where it thrives in dense monocultures. Many recent habitat restoration projects along the system are investigating the efficacy of removing reed canarygrass stands.

Reed canarygrass is a circumboreal species (Larson 1993). While possibly native to North America, European cultivars have been widely introduced for use as hay and forage on the continent; there are no easy traits known for differentiating between the native plants and European cultivars (White et al. 1993, Ecology 2002) but it is thought that the invasive populations of reed canary grass are the result of these introduced cultivars. The species is common throughout most of southern Alaska and Canada, as well as all but the southeastern portion of the continental U.S. (Hitchcock et al. 1969).

Spartina spp. cordgrasses
LIT

Kingdom: Plantae
Division: Magnoliophyta

Origin: Introduced*

Several species of cordgrass (*Spartina alterniflora, S. anglica*, *S. densiflora,* and *S. patens*) are nonnative, invasive plants in several estuaries along the west coast of North America. As ecological engineers, spreading rapidly by both seeds and rhiozomes and forming dense monocultures, they can severely alter the natural hydrology and ecology of invaded habitats (Pfauth et al. 2003). Dense mats of *Spartina* are very effective at trapping sediments and, because of this effect, *Spartina* has, in the past, been intentionally introduced into coastal areas for erosion control. *Spartina* also impacts resident and migratoty shorebirds by converting their foraging habitat, the unvegetated, intertidal mudflats, to densely vegetated salt marsh (Pfauth et al. 2003). The growth of *Spartina* is also detrimental to eelgrass beds and the pelagic species that depend on them for food (Pfauth et al. 2003).

While *Spartina* has not been discovered growing in the lower Columbia River system, potentially viable seeds have been found associated with rafts of vegetation stranded along the interior mouth of the estuary (David Jay pers. com).

POLYGONACEAE

Polygonum hydropiperoides Michx. swamp smartweed
LIT
Origin: Native

Origin: Nativerange: Western California, from the dry regions of the Great Basin and the Mojave desert to the Pacific coast north to Canada, eastern North America and Mexico. (Hickman 1993).

PONTEDERIACEAE

Eichhornia crassipes (Mart.) Solms water hyacinth
Syn: *Eichhornia speciosa* Kunth, *Piaropus crassipes* (Mart.) Britton, *Piaropus mesomelas*, *Pontederia crassipes*, *Heteranthera formosa*
LIT
Origin: Introduced*

Origin: Introduced throughout the southern United States and California, *Eichhhornia crassipes* is native to South America (Hickman 1993). It is not established in the lower Columbia River basin and, due to colder winter temperatures, probably can't overwinter in the Pacific Northwest. Nevertheless, this popular ornamental pond species has been found in a few Washington sloughs near Longview where it is now believed to have been successfully eradicated (Jennifer Parsons pers comm.). These were either escaped plants or unwanted plants from residential ponds.

E. crassipes is an unwanted aquatic plant because its dense mats clog waterways, making boating, fishing and almost all other water activities, impossible while greatly reducing water flow and oxygen levels within the mats. Furthermore water hyacinth greatly reduces biological diversity: mats eliminate native submersed plants by blocking sunlight, alter emersed plant communities by pushing away and crushing them, and also alter animal communities by blocking access to the water and/or eliminating plants the animals depend on for shelter and nesting (IFAS 2004).

POTAMOGETONACEAE

Potamogeton crispus L. Curly-leaf pondweed, curly pondweed
LCRANS, LIT
Origin: Introduced

A native of Eurasia, *Potamogeton crispus* is now found worldwide. The earliest records of *Potamogeton crispus* in the United States that can be verified date its introduction as sometime in the 1860's. However, there are reports that date the species presence in this country to as early as 1807 (Cohen, Carlton 1995). The first documented appearance of Potamogeton *crispus* in Oregon was in the Rogue River, Curry County, 1947 (Stuckey 1979). The establishment of *Potamogeton crispus* is due to a combination of intentional introductions, careless disposal of aquaria and escapes from cultivation (Les and Mehrhoff 1999). Though, if the species were present as early as the 1807 reports state, this would point to yet another means of introduction. During the early 20th century *Potamogeton crispus* was deliberately planted in marshes for waterfowl forage and aquatic wildlife habitat. Migrating waterfowl may also have a role in dispersing *Potamogeton crispus.* Additionally, activities associated with fish hatcheries and stocking may have transported the species between water bodies. *Potamogeton crispus* also became a popular aquarium and water garden plant during the early 20th century (Les and Mehrhoff 1999). A cold-water species, it can survive the winter in most areas of the United States, which is likely one reason it became popular with water gardeners. The primary form of propagation in *Potamogeton crispus* is by turions, a form of vegetative reproduction. Turions are formed in late spring. Being a cold-water species, *Potamogeton crispus* dies back and goes dormant when water temperatures are high during the summer months. When fall arrives the turions germinate and develop into plants that remain viable throughout the winter. The plants are the most robust during the spring; this is usually when they become a nuisance (Les and Mehrhoff 1999). *Potamogeton crispus* is a highly invasive species with increasing populations.
Citations:

Potamogeton epihydrus Raf. ribbonleaf pondweed
LCRANS
Origin: Native
Potamogeton foliosus Raf. leafy pondweed
LIT

Origin: Native
Potamogeton friesii Rupr. Fries' pondweed
LIT
Origin: Native
Potamogeton natans L. floating pondweed
LCRANS
Origin: Native
Potamogeton pectinatus (L.) Boerner sago pondweed
LCRANS
Origin: Native
Potamogeton pusillus L. small pondweed
LCRANS
Origin: Native
Potamogeton richardsonii (Benn.) Rydb. Richardson's pondweed
LCRANS, LIT
Origin: Native
Potamogeton zosteriformis Fern. flatstem pondweed
LCRANS
Origin: Native

There are about 80-90 species of *Potamogeton* in the world (IFAS) and perhaps 20 of them occur in the Pacific Northwest (Ecology 2001). Most of them are native species and several of them, such as *P. pectinatus*, are considered invasive sprecies in other parts of the world. They occur in a variety of aquatic habitats. Some pondweeds are totally submersed, others have floating leaves. Although some may vary greatly in size and leaf shape, many *Potamogeton* species are notoriously difficult to tell apart. Pondweeds are very important as wildlife food and some are sold commercially as aquarium or pond plants.

RANUNCULACEAE

Caltha palustris* L. var. *palustris yellow marsh marigold
LIT
Origin: Native

This marsh marigold is circumboreal in distribution and can be found along the edges of ponds and sloughs in moist soil (Rook 2002). The roots of *Caltha palustris* were commonly used by Native Americans for medicinal purposes.

ROSACEAE

Argentina anserina (L.) Rydb. Pacific silverweed
Syn: *Argentina argentia, Potentilla anserina*
LIT

Origin: Native

Native to the coastal dunes, marsh edges and sandy bluffs of the western U.S. from Alaska to Southern California coastal areas, *Argentina anserine* also is sometimes found inland at low elevations.

RUBIACEAE

Galium trifidum ssp. columbianum (Rydb.) Hultén threepetal bedstraw
LIT
Origin: Native

Galium trifidum ssp. columbianum is distributed throughout the western U.S. and parts of the northern states and Canada (USGS- NRCS 2004).

RUPPIACEAE

Ruppia maritima L.- widgeon-grass
LCRANS, LIT
Origin: Cryptogenic

Opportunistic and tolerant to a wide range of environmental conditions, *Ruppia maritima* L. is found worldwide. Typically an inhabitant of marginal seagrass habitats, *Ruppia maritima* L can also be present as a subdominant species, becoming dominate when environmental conditions change. There are indications that *Ruppia maritima* L. becomes dominant in environmentally degraded areas and under unfavorable climatic conditions (Johnson et al. 2003).

SALICACEAE

Salix hookeriana Barratt ex Hook. dune willow, coastal willow
LIT
Origin: Native

Native to the western coast of North America the coastal willow if found from Northern California to Alaska (Hickman 1993).

SCROPHULARIACEAE

Castilleja ambigua* Hook. & Arn. ssp. *ambigua johnny-nip, Indian paintbrush, owl clover, purple owl’s clover
Syn: *Orthocarpus exsertus, Orthocarpus purpurascens*
LIT

Origin: Native

Distributed along the west coast of North America from central California to British Columbia (USDA – NRCS 2004, Hickman 1993S).

Gratiola ebracteata Benth. ex A. DC bractless hedgehyssop
LIT
Origin: Native

Gratiola ebractea can be found along the shorelines of lakes, ponds, and rivers, but never grows in deep water (Ecology 2001). Unlike *G.* neglecta, it is found only from southern British Columbia south to California and east to Montana (Ecology 2001, USDA-NRCS 2004).

Gratiola neglecta Torr. clammy hedgehyssop
LIT
Origin: Native

Gratiola neglecta can be found along the shorelines of lakes, ponds, and rivers, but never grows in deep water (Ecology 2001). It is distributed throughout most of the U.S. and Canada.

Limosella aquatica L. water mudwort, awl-leaf mudwort, northern mudwort
LCRANS, LIT
Origin: Native

May be a circumboreal species. In the U.S. it is distributed throughout the west and mid-west. Also found in Eurasia.

Mimulus guttatus DC. seep monkeyflower
LIT
Origin: Native

Distributed throughout the Western US, Canada and the great lakes region.

SPARGANIACEAE

Sparganium erectum L. simplestem bur-reed
LIT
Origin: Introduced*

Sparganium erectum, a federally listed noxious weed, was distributed to as many as 35 states, from Alaska to Georgia, after the Home Depot received it in a shipment of exotic reeds from Holland and sold them as pond plants (WAMPS 1999). This reed can choke waterways and interfere with recreation in shallow waters. The 6-foot-long, green reed has a small yellow flower that contains a bur-like fruit. The plant was not known to exist in the United States before the Dutch shipment arrived. State and federal agriculture inspectors scrambled to recover as many plants as possible but it is not known if attempts to collect all species were successful. Washington and Oregon are two states where shipments of the contaminated plants are believed to have been shipped.

Sparganium angustifolium Michx. narrowleaf bur-reed
LCRANS
Native

Narrow-leaf burr reed is native to the Western US, Alaska and can be found throughout the Great Lakes region. *Sparganium* is fodder for waterfowl, muskrats and deer. Stem base and tubers are edible (Ecology 2001).

TYPHACEAE

Typha angustifolia L.- Narrowleaf / Narrowed-leaved Cattail, Nail Rod
LIT, LCRANS
Origin: Introduced

Endemic to Eurasia, *Typha angustifolia* is now found in South America and throughout North America. The presence of *Typha angustifolia* on the eastern coast of the United States was reported in the 1820s (Cohen, Carlton 1995). The species was possibly introduced to the Atlantic coast by dry ship ballast. *Typha angustifolia* was apparently used for matting and pillow stuffing. Parts of the plant were also eaten. These uses may have facilitated the dispersal of the species (Mills et. al.1993). *Typha angustifolia* is a perennial plant that is invasive and capable of spreading rapidly.

Typha latifolia L. broadleaf cattail
LIT
Origin: Native

Origin: Nativespecies, distributed widely throughout North America and in temperate parts of Central America, Eurasia, and Africa (Hickman 1993).

ZANNICHELLIACEAE

Zannichellia palustris L. horned pondweed
LCRANS, LIT
Origin: Native

A delicate underwater branching perennial this plant has a more or less worldwide distribution and is common throughout North America. In Washington, horned pondweed is common in hard water lakes of the Columbia Basin (Ecology 2001). It may be confused with *Ruppia maritime.*

ZOSTERACEAE

Zostera japonica Aschers. and Graebn Japanese eelgrass, dwarf eelgrass
LCRANS, LIT
Origin: Introduced

Native to Japan, *Zostera japonica* is now established on the coast of the Pacific Northwest. The first recorded collection of the species on the Pacific coast was from Washington State in 1957. *Zostera japonica* has been observed to be abundant in several areas of the Pacific Northwest coast that have been or are presently used for intensive oyster cultivation. It has been suggested that *Zostera japonica* was possibly used as packing material when oyster spat was shipped from Japan to oyster farms in the PNW. Being an annual plant, *Zostera japonica* is a prolific seed producer. Seeds may now be the primary mode of dispersal for this species (Harrison and Bigley 1982).

Zostera marina common eelgrass
LIT
Origin: Native

Zostera marina is widespread throughout the Atlantic and Pacific. In the eastern Atlantic it extends from the Arctic Circle to Gibraltar, including the Mediterranean. *Z. marina* forms large colonies on muddy substrates especially in estuaries, and also occurs on sandy substrates where there is weak wave action.

Kingdom: Animalia

Phylum: Porifera

The sponges

The identification of freshwater sponges depends on characteristics of spicules and on features of intact gemmules. Species identifications depend absolutely on obtaining all types of the spicules (megascleres, gemmoscleres and, if present, microscleres) (Penny and Racek 1968; Thorp and Covich 2001). Gemnoscleres are particularly important but they may occur only during certain times of the year (Thorp and Covich 2001:115). Spicule preparations require digestion of the tissue in nitric acid in a tube immersed in boiling water for 1 hour, followed by centrifugation. The acid is then poured off and the spicules are washed in ethanol (Penny and Racek 1968, Thorp and Covich 2001).

The procedures necessary for preliminary identification were beyond the scope of this investigation although one sponge, a forest-green specimen was collected from a freshwater site at Sauvies Island, Oregon.

Phylum: Ciliophora

Class: Ciliatea

Ciliates

Protozoans are often overlooked but play a major role in nutrient cycling (Taylor and Sanders 2001).

Didiniidae		
Mesodinium rubrum	LCRANS	Native

DIDINIIDAE

Mesodinium rubrum (Lohmann, 1908)
Synonyms: *Cyclotrichium meunieri*, *Halteria rubra*, *Myrionecta rubra*
Origin: Native
LCRANS

Collected from Ilwaco Harbor and Young's Bay in October 2002 during a red tide, this is a solitary, bloom-forming, obligate autotroph (Lindholm 1985). This species contains a commensal photosynthetic alga (an endosymbiotic cryptophyte chloroplast) and is nontoxic. Identified by Dr. Rita Horner and Dr. Jin Wan Lee, it is probably a complex of closely related species. Dr. Horner relates that it is common in the northeast Pacific and considers it a native species. The unexplained global distribution of *Mesodinium rubrum* could result from it being a complex of closely similar geographically isolated species or from widespread introductions of one or more of its populations.

Phylum: Cnidaria

Class: Anthozoa

Edwardsiidae			
	Nematostella vectensis	LCRANS, LIT	Introduced

EDWARDSIIDAE

Nematostella vectensis Stephenson, 1935
Syn: *Nematostella pellucida*
LCRANS, LIT
Origin: Introduced

Fifteen *Nematostella vectensis* were collected alive from muddy sand habitats and a shallow pool of a high *Carex* salt marsh in the lower Columbia River. J. T. Carlton (in correspondence) suggests that this species may have a trans-Arctic distribution i.e. ranging south from the Arctic on northern coastlines of the northern hemisphere to northern Japan, Puget Sound, Cape Cod, and the Bay of Biscay. Hand and Uhlinger (1991) demonstrated that the low latitude populations are a single species by interbreeding females from England, Maryland, Georgia, California, Oregon and Washington with males from Nova Scotia, Maryland, Georgia and Oregon in a total of 24 crosses which all produced healthy first and second generations. The global distribution of *N. vectensis* therefore appears unlikely to be of natural processes. The lack of large-scale genetic patterns among populations in different lagoons of Great Britain is consistent with occasional passive or anthropogenic dispersal of low number of individuals between lagoons (Pearson et al. 2002). Natural occurrences of the isolated British *Nematostella* populations therefore would be difficult to explain. More likely, the British populations are introduced.

Kozloff (1983) concludes that northeast Pacific *N. vectensis* are an Atlantic species for which “the exact date of introduction into our region is unknown” while Carlton (2000) lists N. vectensis as “cryptogenic” in Coos Bay. Confusion over the origins of the northeast Pacific *Nematostella* may partly result from poor information the likely expansion of its populations since the early 1900s and its occurrence only from San Francisco Bay north, a relatively narrow range if this were a native northeast Pacific species. Hand (1957) reported “This anemone probably is the ‘will-of-the-wisp’ species that I have hunted for more than 10 years in California. In 1946, the late Prof. S. F. Light described to me a very small anemone he had seen in small pools on the Salicornia marshes of Richardson’s Bay (a part of San Francisco Bay).” Since 1957, published reports of northeast Pacific, *Nematostella* are only from Puget Sound, Washington, Coos

Bay, Oregon, Tomales Bay, California, and San Francisco Bay, California (Kozloff 1983, Hand & Uhlinger 1994). However, Jeff Cordell has found *N. vectensis* in almost every salt marsh of Oregon and Washington he has sampled in the last 20 years. In a 1994 survey of Trestle Bay in the lower Columbia River, prior to the breaching of the jetty, densities of *N. vectensis* were reported as 2,715/m^2 but two years after the breach no cnidaria were found (Hinton and Emmett 2000).

The geographical and climatic range of *Nematostella vectensis* on the eastern North American coast, from Nova Scotia to Georgia and western Florida to Louisiana (Hand & Uhlinger 1994) is much broader than the European or eastern Pacific ranges. Nova Scotia is colder and the Gulf of Mexico is warmer than temperatures of southern and eastern Britain and the eastern Pacific coast between Puget Sound and San Francisco. *N. vectensis* would therefore require pre-adapted thermal tolerances of occur western Atlantic and Gulf of Mexico range if it is native to the eastern Pacific or Europe. Therefore *N. vectensis* is more likely to be the native to the western Atlantic and Gulf of Mexico.

Hand and Uhlinger (1994) considered ballast water transport to be the most likely mechanism for dispersing *Nematostella* since it does not occur on hard substratums and is unlikely to be introduced with transplanted oysters, on ship hulls or in the fouling faunas associated with other hard substratums. The asexual reproduction of this species Hand and Uhlinger (1992) allows it to colonize new habitats with very few original propagules. Moreover, well-fed individuals can grow to 16 cm in length and individuals can survive 6 months of starvation (Hand and Uhlinger 1992). The extreme durability of this species and its close association with high intertidal sediments suggest that it could have been introduced to Britain and to the western United State in ballast sediments of early sailing ships. Many records of England indicate the regular use of ballast on board sailing vessels of the North Atlantic trade (Prowse 1895) and Dana (1840) reported sailing ship ballast dumped from the eastern United States directly into San Francisco Bay. Moreover Lindroth (1957) elegantly established the faunal connections between eastern and western North America and Great Britain via ballast sediments of sailing ships.

Class: Hydrozoa

Clavidae			
	Cordylophora lacustris	LCRANS, LIT	Introduced
Hydridae			
	Hydra spp.	LCRANS	

CLAVIDAE

Cordylophora lacustris Agassiz, 1862
Syn: *Cordylophora caspia*
LCRANS, LIT
Origin: Introduced

Cordylophora lacustris is probably native to the Caspian Sea and the Black Sea. The first report of eastern Pacific *C. lacustris* is based on specimens collected in the lower Columbia River near Astoria, Oregon from pilings and posts in low salinity or fresh water in 1965 (Haertel and Osterberg 1967). However, Carlton (1979) found specimens collected from Lake Union, Washington in 1920 and (Cohen and Carlton 1995) found specimens from San Francisco Bay, California collected around 1930. *Cordylophora lacustris* was likely spread world wide prior to the 20th century in association with ship fouling and ballast water (Carlton 1979, Cohen and Carlton 1995).

Phylum: Ectoprocta

Class: Phylactolaemata

Ectoprocts were commonly lumped together with the entoprocts and referred to generally as "Bryozoa" (Thorp & Covich 2001). The class Phylactolaemata is an exclusively freshwater colonial group of ectoprocts. Adult stages attach to submerged surfaces such as branches, rocks and logs. The phylactolaemates form statoblasts dormant seed-like buds that are resistant to dessication and can remain dormant for long periods. The statoblasts are a likely life history stage for natural or anthropgenic transport between water bodies. The distributions of ectoprocts across North America are poorly known. Few large area surveys of bryozoa have been conducted in northwestern North America (see Wood 2001). Marsh and Wood (2002) were the first to survey freshwater bryozoans of the Pacific Northwest and records from outside of northeastern North America are few (Marsh and Wood 2002).

Fredericellidae		
Fredericella browni	LIT	Cryptogenic
Fredericella indica	LCRANS, LIT	Introduced
Pectinatellidae		
Pectinatella magnifica	LCRANS, LIT	Introduced
Plumatella emarginata	LIT	Cryptogenic
Plumatella vaihiriae	LIT	Cryptogenic

FREDERICELLIDAE

Fredericella browni Rogick, 1945
LIT
Origin: Cryptogenic

Collected from the Willamette River below the Oregon City Falls (Marsh and Woods 2002) and at three other Pacific Northwest sites. This is not a common species in Northeastern and Central United States where most bryozoan surveys have taken place (Marsh and Woods 2002). Specimen have also been reported in India (Pachut 1998).

Fredericella indica (Annandale, 1909)
LCRANS, LIT
Origin: Introduced

This species is common throughout North America especially in eastern states, at scattered sites in Europe, Africa, and Asia, and probably includes several species not yet distinguished (Thorp & Covich 2001). Distribution data for both U.S. states and Canadian provinces is likely incomplete. A month-long collection trip of bryozoans and sponges in the Pacific Northwest encountered this species at only four widely dispersed localities (Marsh and Wood 2002). While the origin of this species remains uncertain (likely eastern North America were it is very common) we consider *F. indica*, which is widespread in the lower bays of the basin (in brackish as well as freshwater), to be introduced into the lower Columbia River. Further surveys may reveal less disjunct distributions, however.

PECTINATELLIDAE

Pectinatella magnifica (Leidy, 1851)
Syn: *Fredericella magnifica*
LCRANS, LIT
Origin: Introduced

The gelatinous masses of *Pectinatella magnifica* form gelatinous colonies on submerged wood of any kind including docks Smith (2003). Massive colonies may exceed 60 cm in diameter, however colony sizes of less than 10 cm may go unnoticed for long periods until residents are "shocked" by its sudden appearance when ecological conditions favor massive “alien-like” colonies (Smith 2001). *P. magnifica*, is widely distributed east of the Mississippi River and is likely to be endemic to eastern and central North America (Smith 2001). Marsh and Wood (2002) found *P. magnifica* throughout Oregon including the Columbia River. The first records of *P. magnifica* in the lower Columbia River are from the late 1990s (see EMAP 2001 and Marsh and Wood 2002). Previously, *P. magnifica* had only been recorded from as far west as eastern Texas. *Pectinatella magnifica* has been introduced to Japan, Korea, India, and Europe (Smith 2001). The first records of *P. magnifica* in the lower Columbia River are from the late 1990s (see EMAP 2001 and Marsh and Wood 2002). The anchor-spiked statoblasts of *P. magnifica* are highly adapted for hooking onto fur and feathers for dispersal on birds and mammals between isolated water bodies in regions where it occurs.

Plumatella emarginata Allman 1844
LIT
Origin: Cryptogenic

Occurring in North America, Great Britain, India, Australia and Japan; it is cosmopolitan in northern hemisphere and may be endemic to Europe (Wood 2001).

Plumatella vaihiriae (Hastings 1929)
Syn: *Hyalinella vaihiriae*
LIT
Origin: Cryptogenic – probably introduced

Previously known only from four sites in North America three of which are wastewater treatment plants, Marsh and Wood (2002) collected *Plumatella vaihiriae* from Oaks Bottom Slough (off of the Willamette River) in 1998. *Plumatella vaihiriae* is a nuisance fouling organism (Wood and Marsh 1999). The type locality of *P. vaihiriae* is a high mountain pond in Tahiti and it is known also from Hawaii and Argentina (Wood and Marsh 1999). An unconfirmed report of *P. vaihiriae* is from Australia (Wood and Marsh 1999). Unlike *Pectinatella magnifica P. vaihiriae* is characterized by rapid growth and massive colonies (Wood and Marsh 1999, Marsh and Wood 2002). Given its wide geographic range and limited literature citations this species is likely an invader but not enough information exists to confirm this.

Phylum: Entoprocta

The Entoprocts are a small group of species (~ 60 in all) that are distinct from the Ectoprocts but often lumped with them and referred to together as “Bryozoa.” *Urnatella* is the only freshwater genus in the phylum. Little is known about the distribution of entoprocts in North America as only a few large area surveys of bryozoa have been conducted (see Wood 2001) and most records from outside of northeastern North America only report relatively few species from a limited number of localities (Marsh and Wood 2002).

Urnatellidae		
Urnatella gracilis	LIT	Cryptogenic

URNATELLIDAE

Urnatella gracilis Leidy 1851
LIT
Origin: Cryptogenic

Considered by Thorp and Covich (1991) to be the most common and widely distributed of the *Urnatella*, *Urnatella gracilis* is the only species of the genus reported from North America where its distribution ranges from the east to west coast and from Texas to Michigan. *U. gracilis* has a true cosmopolitan distribution as it is found on every continent but Antarctica and Australia (Thorp and Covich 1991).

Phylum: Nemertea

Class: Enopla

Nemertean identifications were not conducted by LCRANS.

Emplectonematidae		
Paranemertes californica	LIT	Native

EMPLECTONEMATIDAE

Paranemertes californica Coe 1904
LIT
Origin: Native

Native to littoral and benthic sites in the Pacific. Reported by EMAP 1999 and EMAP 2000 collections.

Phylum: Annelida

SubClass: Oligochaeta

Very few macroinvertebrates are more poorly studied in the lower Columbia River than the oligochaetes. Few prior studies on the lower Columbia conducted oligochate identifications, only noting the presence of oligochaetes when encountered. There are several reasons for this. Oligochaete taxonomy is widely regarded as a difficult field and expert identifications may be beyond the scope of many projects. In addition, traditional sorting and preserving techniques used for benthic samples often damage worms beyond identification. Very little is known about native origins and transport of many species, the majority of species are simply labeled as having cosmopolitan or near cosmopolitan distributions

In the lower Columbia River special interest was paid to proper oligochaetes collection and preservation. In 2003 oligochaete samples were identified by Dr. Steve Fend. *Teneridrilus columbiensis* (a species named after its collection location – the Columbia River) was not found in the course of our sampling. Furthermore, some species limited to specific habitats (like banks or sandy weed beds) may not have been found at multiple stations because few such habitats were sampled overall. Of the seven native species collected, only three were found at nine or more stations (out of 45 possible stations) further indictating that collection efficiency was low and more comprehensive collection efforts should be undertaken.

Introduction mechanisms for oligochaetes are varied. Ballast water is a likely vector for many species, others may arrive in new habitats associated with sediments of nonnative ornamental aquatic plants or semi-aquatic plants.

While oligochaetes are considered freshwater organisms but species such as *Tubifex tubifex* and *Limnodrilis hoffmeisteri* can withstand exposures of up to 10 ppt (Brinkhurst and Gelder 2001). Most others can onlt survice exposures of 5 ppt or less. However, recent studies have shown that low salinity water may improve the ability of oligochaetes to withstand stress (Brinkhurst and Gelder 2001).

Enchytraeidae		
Enchytraeus spp.	LIT	
Lumbriculidae		
Eclipidrilus n. sp.	LCRANS, LIT	Native
Kincaidiana hexatheca	LCRANS	Native
Rhynchelmis sp.	LCRANS	
Stylodrilus heringianus	LCRANS	Introduced
Naididae		
Amphichaeta sannio	LCRANS	Cryptogenic
Arcteonais lomondi	LCRANS	Cryptogenic
Chaetogaster diaphanous	LCRANS	Introduced
Chaetogaster nr. diastrophus	LCRANS	Cryptogenic
Dero digitata	LCRANS	Cryptogenic
Nais cf. elinguis	LCRANS	Cryptogenic
Nais cf. simplex	LCRANS	Cryptogenic
Nais communis	LCRANS	Cryptogenic
Nais pardalis	LCRANS	Cryptogenic
Nais variabilis	LCRANS	Cryptogenic
Ophidonais serpentina	LCRANS	Cryptogenic
Paranais frici	LCRANS	Introduced
Paranais litoralis	LCRANS	Cryptogenic
Pristina aequiseta	LCRANS	Cryptogenic
Pristina osborni	LCRANS, LIT	Cryptogenic
Slavina appendiculata	LCRANS	Cryptogenic
Stylaria lacustris	LCRANS	Cryptogenic
Ocnerodrilidae		
Eukerria saltensis	LCRANS	Introduced
Tubificidae		
Aulodrilus pluriseta	LCRANS	Cryptogenic
Bothrioneurum vejdovskyanum	LCRANS, LIT	Cryptogenic
Branchiura sowerbyi	LCRANS, LIT	Introduced
Ilyodrilus frantzi	LCRANS, LIT	Native
Ilyodrilus templetoni	LCRANS, LIT	Cryptogenic
Limnodrilus hoffmeisteri	LCRANS, LIT	Cryptogenic
Limnodrilus silvani	LIT	Cryptogenic
?Limnodrilus udekemianus	LCRANS, LIT	Cryptogenic
Rhyacodrilus coccineus	LCRANS, LIT	Cryptogenic
Rhyacodrilus spp.	LIT	

Spirosperma nikolskyi	LCRANS, LIT	Cryptogenic
Spirosperma spp.	LIT	
Tasserkidrilus harmani	LCRANS, LIT	Cryptogenic
Telmatodrilus vejdovsky	LIT	Cryptogenic
Teneridrilus columbiensis	LIT	Native
Teneridrilus mastix	LCRANS, LIT	Native
Teneridrilus cf. calvus	LCRANS, LIT	Native
Tubifex tubifex	LCRANS, LIT	Cryptogenic
Tubificidae sp 1	LIT	
Tubificidae sp 2	LIT	
Varichaetadrilus pacificus	LCRANS, LIT	Native

LUMBRICULIDAE

Eclipidrilus n. sp.
LCRANS, LIT
Origin: Native

First collected from the lower Columbia River during Miller Sands examination (Date) not enough specimens were collected to make ID. LCRANS collected this species from Miller Sands as well as other sites in Cathlamet Bay. Further collections need to be conducted to gather more type specimens.

Kincaidiana hexatheca Altman, 1936
LCRANS
Origin: Native

Identified and labeled as native to northwestern North America by Steve Fend.

Stylodrilus heringianus Claparede, 1862
LCRANS
Origin: Introduced

This is a holarctic freshwater species whose status as an invasive species has been debated for many years (See Brinkhurst 1968, 1976). Likely native to Europe, this species has also been collected from places as diverse as Japan, Malaysia, and Egypt indicating that transport and introduction of *Stylodrilus heringianus* is certainly possible.

NAIDIDAE

Amphichaeta sannio Kallstenius 1892
LCRANS
Origin: Cryptogenic – probably introduced

Considered a European estuarine species by some (not reported from North America prior to the publication of Kathman and Brinkhurst 1998). Possibly synonymous with *A. raptisae.* Steve Fend considers this of unknown origin with a holarctic distribution.

Arcteonais lomondi (Martin 1907)
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998), unknown origin, holarctic distribution.

Chaetogaster diaphanus (Gruithuisen, 1828)
Syn: *Nais diaphana, Chaetogaster diaphanus cyclops*
LCRANS
Origin: Introduced

A freshwater species with a holartic distribution (S. Fend personal communication), *Chaetogaster diaphanous* is considered by the California Department of Fish and Game to be an introduced species (CDFG 2002). During their survey of the California coastal and estuarine waters this species was found only in the Sacramento San Joaquin Delta region of the San Francisco Bay (CDFG 2002). In the lower Columbia River a single specimen of *C. diaphanous* was found at a station located at the mouth of the Columbia Slough in Portland. Although its native range is unknown, the scattered and rare distribution of this species along the West Coast likely indicates that it is indeed nonnative to this region.

Chaetogaster nr. diastrophus (Gruithuisen 1828)
syn: *Pseudochaetogaster longmeri, C. langi*
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998), near cosmopolitan, possibly holartic in origin.

Dero digitata (Muller 1773)
Syn: *Nais digitata*
LCRANS
Origin: Cryptogenic – probably introduced

Widespread (Kathman and Brinkhurst 1998), near cosmopolitan, probably tropical in origin.

Nais cf. elinguis Muller 1773
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998), near cosmopolitan, possibly holartic in origin.

Nais cf. simplex Piguet 1906
LCRANS
Origin: Cryptogenic

Widespread east of the Mississippi, also known from British Columbia (Kathman and Brinkhurst 1998), near cosmopolitan, possibly holartic in origin.

Nais communis Piguet 1906
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998). *Nais communis* and *N. variabilis* features often overlap, complex needs revision overall.

Nais pardalis Piguet 1906
LCRANS
Origin: Cryptogenic

Widespread, previously known as a variant of *N. bretscheri*, often confused with *N. variabilis (*Kathman and Brinkhurst 1998). Near cosmopolitan distribution, possibly holartic in origin.

Nais variabilis Piguet 1906
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998). *Nais communis* and *N. variabilis* features often overlap, complex needs revision overall.

Ophidonais serpentina (Muller 1773)
Syn: *Nais serpentina*
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998), unknown origin, near cosmopolitan distribution.

Paranais frici Hrabe, 1941
Syn: *Wapsa mobilis?*
LCRANS
Origin: Introduced

Near cosmopolitan distribution. It is most often found in coastal waters, but usually in freshwater. This is a brackish water genus (likely originated in the Tethys) (Timm 1980). Considered introduced in San Francisco Bay and parts of Southern California by Brinkhurst and Cook (1980) and Cohen and Carlton (1995). Two specimen were collected in the lower Columbia River in a grab sample taken at the Sportsmen's Club boat launch in Kalama, WA. Species is present in Kozloff (1987) and probably established in the Pacific Northwest, but requires further confirmation. Considered introduced in the Baltic and in the Great Lakes. Timm (1980) considers it recently introduced to North America.

Paranais litoralis (Muller 1784)
Syn: *Nais litoralis*
LCRANS
Origin: Cryptogenic

Widespread, mostly coastal in tidal fresh or brackish water (Kathman and Brinkhurst 1998) but of unknown origin.

Pristina aequiseta Bourne 1891
Syn: *P. foreli* and *P evelinae*
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998).

Pristina osborni (Walton 1906)
Syn: *Naidium minutum, Naidium osborni Pristina minutum*
LCRANS, LIT
Origin: Cryptogenic

Member of a "group of taxonomically problematic species" (Collado and Schmelz 2002). Kathman and Brinkhurst (1998) report it from Illinois, the east coast of North America and Argentina.

Slavina appendiculata (d'Udekem 1855)
Syn: *Nais appendiculata, Nais gracilis*
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998), near cosmopolitan, unkown origin.

Stylaria lacustris (Linnaeus 1767)
Syn: *Nereis lacustris, Nereis proboscidea*
LCRANS
Origin: Cryptogenic

Widespread (Kathman and Brinkhurst 1998), holarctic and African distribution, possibly holartic in origin.

OCNERODRILIDAE

Eukerria saltensis (Beddard, 1895)
LCRANS
Origin: Introduced

Native to South America, this worm is considered an invasive pest species in Australia where severe infestations can damage rice crops (see http://www.ricecrc.org/reader/Oligochaeta_aquatic_earthworms.htm). It is not an obligate aquatic species, and can survive in irrigated pastures. It is considered a tropical species with a near cosmopolitan distribution.

TUBIFICIDAE

Aulodrilus pluriseta (Piguet 1906)
Syn: *Naidium pluriseta*
LCRANS
Origin: Cryptogenic

The genus Aulodrilus is currently being rewritten to clear up misidentifications especially *A. pluriseta* and *A. japonica* (Kathman and Brinkhurst 1998). A widespread species, most North American *A. pluriseta* may actually be *A. japonica*.

Bothrioneurum vejdovskyanum Stolc 1886
LCRANS, LIT
Origin: Cryptogenic

Widespread in North America, especially in sandy situations, may be synonymous with *B. americanum.*

Branchiura sowerbyi Beddard, 1892
LCRANS, LIT
Origin: Introduced

Native to tropical and sub-tropical Asia, *Branchiura sowerbyi*, is a widely introduced oligochaete. This tubificid worm may have originally been spread around the world in the water and sediments associated with ornamental aquatic plants such as water-lilies (Cohen and Carlton 1995). Often only conspicuous in artificially warm water (where it grows to a large size) *B. sowerbyi* can be found at locations scattered throughout North America (Brinkhurst 1986). The first record of this species in North America came from the Ohio River in 1930 (Spencer 1932). *B. sowerbyi* was discovered in San Francisco

Bay in 1950 and the Bay had the only recorded west coast population until now (Cohen and Carlton 1995, NAS 2003). However, as only three specimen were found as a single sampling station on the lower Columbia River (in Crane Lake on Sauvie Island – note a shallow warm lake), we are uncertain as to how widespread or established this population is. In addition, fragments of *B. sowerbyi* may be erroneously identified as *Aulodrilus pluriseta* (Brinkhurst 1986)

Ilyodrilus frantzi Brinkhurst 1965
LCRANS, LIT
Origin: Native

Distributed throughout western North America.

Ilyodrilus templetoni (Southern 1904)
Syn: *Tubifex templetoni*
LCRANS, LIT
Origin: Cryptogenic

Widespread and common. Similar to *Tubifex tubifex* (Kathman and Brinkhurst 1998).

Limnodrilus hoffmeisteri Claparede 1862
LCRANS, LIT
Origin: Cryptogenic

Native to North America *Limnodrilus hoffmeisteri* is considered a pollution indicator species. *L. hoffmeisteri* can also inhabit brackish waters to 10 ppt (Brinkhurst and Gelder 2001).

Limnodrilus silvani Eisen, 1879
LIT
Origin: Cryptogenic

Limnodrilus udekemianus Claparede 1862
LCRANS, LIT
Origin: Cryptogenic – possibly native

May be native to North America but has a cosmopolitan distribution

Rhyacodrilus coccineus (Vejdovsky 1875)
Syn: *Tubifex coccineus*
LCRANS, LIT
Origin: Cryptogenic

Widespread North American distribution (Kathman and Brinkhurst 1998), the origin of this species is unclear and complicated by its cosmopolitan distribution.

Spirosperma nikolskyi (Lastochkin and Sokolskaya 1935)
syn: *S. variegatus, S. oregonensis, Pelsoscolex oregonensi,*
LCRANS, LIT
Origin: Cryptogenic

Widespread, this genus may need more taxonomic work (Kathman and Brinkhurst 1998). Of unknown origin this species is distributed throughout Asia and North America.

Tasserkidrilus harmani (Loden 1979)
Syn: *Tubifex harmani*
LCRANS, LIT
Origin: Cryptogenic

This species is reported as widely distributed species throughout the North America but this is based on prior observations that were not made using all the accepted characteristics (Kathman and Brinkhurst 1998). It is a nearctic species with widely scattered records. It is probably native to North America.

Telmatodrilus vejdovsky Eisen 1879
LIT
Origin: Cryptogenic

Teneridrilus columbiensis (Brinkhurst and Diaz 1985)
Syn: *Isochaetides columbiensis*
LIT
Origin: Native

Type specimen collected in the lower Columbia River at Miller Sands. Not known from any other locations (Brinkhurst and Diaz 1985, Erseus et al. 1990).

Teneridrilus mastix (Brinkhurst 1978)
Syn: *Ilyodrilus mastix*
LCRANS, LIT
Origin: Native

Collected from the Fraser River, British Columbia; Columbia River, Oregon; San Francisco Bay, California; and Pearl River, China (Brinkhurst 1986, Erseus et al 1990). Carlton and Geller (1993) list *T. mastix* as a nonnative species introduced via ballast water from China. The California Department of Fish and Game (2002) lists the same species as cryptogenic but identify its origin as Asia. Although some controversy exists as to the origin of this species we do not believe that enough information exists to contradict the original description of the species as native to western North America.

Teneridrilus cf. calvus Erseus and Brinkhurst 1990
LCRANS, LIT
Origin: Native

Type specimen from Sacramento-San Joaquin Delta, California collected in freshwater muddy sediments (Erseus et al. 1990).

Tubifex tubifex (Muller 1774)
Syn: *Lumbricus tubifex*
LCRANS, LIT
Origin: Cryptogenic

Widespread but not as common as general texts suggest, this species occurs in marginal habitats (oligotrophic or hyereutrophic) and cold climates perhaps because it can avoid competetion at such extremes (Kathman and Brinkhurst 1998). This is likely a complex with multiple variants. Susceptible to parasite infections such as whirling disease (*Myxobolus cerebralis*). *Tubifex tubifex*, like *Limnodrilus hoffmeisteri*, can withstand prolonged exposure to salinities up to 10ppt (Brinkhurst and Gelder 2001).

Varichaetadrilus pacificus (Brinkhurst 1981)
LCRANS, LIT
Origin: Native

Unlike many oligochaetes of the family Tubificidae, *Varichaetadrilus pacificus* is contaminant intolerant (Canfield et al., 1994). This species is native to North America.

Phylum: Annelida

Subclass: Polychaeta

Older polychaete keys specific to the Pacific Northwest are considered to be full of errors and thus the taxonomic certainty of polychaetes found during the literature review is uncertain. Polychaete taxonomy on a world-wide basis is in a state of flux and disagreements between experts on identifications, origins and distribution complicate the process of identifying introduced polychates in the lower Columbia River.

Errant Polychaetes

Glyceridae		
Glycera americana	LIT	Cryptogenic
Glycera macrobranchia	LIT	Native
Glycera nana	LIT	Cryptogenic
Glycera tenuis	LIT	Native
Hemipodus borealis	LIT	Native
Goniadidae		
Glycinde armigera	LIT	Native
Glycinde picta	LIT	Native
Glycinde polygnatha	LIT	Cryptogenic
Hesionidae		

Hesionella mccullochae	LIT	Native
Podarkeopsis brevipalpa	LIT	Cryptogenic
Nephtyidae		
Nephtys caecoides	LIT	Native
Nephtys californiensis	LIT	Native
Nephtys cornuta	LIT	Native
Nephtys ferruginea	LIT	Native
Nephtys parva	LIT	Native
Nereididae		
Hediste limnicola	LCRANS, LIT	Native
Phyllodocidae		
Eteone columbiensis	LIT	Cryptogenic
Eteone dilatae	LIT	Native
Eteone lighti	LIT	Cryptogenic
Eteone longa	LIT	Cryptogenic
Eteone spilotus	LCRANS, LIT	Native
Eteone sp.	LCRANS	
Podarkeopsis brevipalpa	LIT	Cryptogenic
Podarkeopsis glabrus	LIT	Cryptogenic#
Syllidae		
Syllis spp.	LIT	

GLYCERIDAE

The family family Glyceridae has been reevaluated by Markus Böggemann (2002). He concluded that of the 172 published species only 42 taxa remain valid. However the polychaete experts and members of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT 2002) disagreed with many of Böggemann’s conclusions regarding Pacific taxa. In light of this lack of agreement on Glyceridae taxonomony the introduction status of many of these species remains unclear.

Glycera americana Leidy 1855 tufted gilled bloodworm
LIT
Origin: Cryptogenic

Glycera macrobranchia Moore 1911
Synonyms *Glycera convoluta*
LIT
Origin: Native

Glycera nana Johnson, 1901
LIT
Origin: Cryptogenic

Glycera tenuis Hartmann 1944
LIT
Origin: Native

Many Glycera spp are reported from areas around the world. The actual origin of most of these species and their pattern of introduction is unknown. The genus Glycera, commonly known as blood worms, contains species typically found on the bottom of shallow marine waters, living on the sandy or silty bottoms of the intertidal or subtidal regions.
Species such as *Glycera dibranchiata*, are extensively harvested for use as bait in fishing. While planktonic larval forms exist they may be demersal.

Hemipodus borealis Johnson, 1901
Syn: *Hemipodus roseus*
LIT
Origin: Native

Found in mudflats and gravelly or sandy beaches, *Hemipodus borealis,* is common along the shore from British Columbia to Southern California.

GONIADIDAE

Glycinde armigera Moore 1911
LIT
Origin: Native

Common along the Southern California coastal shelf, also recorded in the Fraser River this is a species with a marine to brackish salinity tolerance.

Glycinde picta (Berkeley, 1927)
LIT
Origin: Native

There is some debate over the validity of both *G. picta* and *G. polygnatha* as they are very similar morphologically. Genetic or developmental studies might be needed to resolve this question. *G. picta* was described from British Columbia.

Glycinde polygnatha Hartman, 1950
LIT
Origin: Cryptogenic

See *G. picta*

HESIONIDAE

Hesionella mccullochae Hartman, 1939
LIT

Origin: Native

Specimens need to be examined to check the identification. The genera Hesionella and Microphthalmus are very close morphologically. Species belonging to Microphthalmus have been reported from many more localities in the Northeast Pacific than *Hesionella mccullochae.*

Podarkeopsis brevipalpa (Hartmann-Schroeder, 1959)
Synonyms: *Gyptis brevipalpa*
LIT
Origin: Cryptogenic

Probably also includes species mis-identified in the literature as *Podarkeopsis glabrus*.

Podarkeopsis glabrus Hartman 1961
LIT

See *Podarkeopsis brevipalpa.*

NEPHTYIDAE

Nephtys caecoides Hartman 1938
LIT
Origin: Native

Nephtys californiensis Hartman 1938
LIT
Origin: Native

Nephtys cornuta Berkeley and Berkeley, 1945
LIT
Origin: Native

Nephtys ferruginea Hartman 1940
LIT
Origin: Native

Nephtys parva Clark and Jones, 1955
LIT

Nephtys parva is a junior synonym of *N. cornuta*, however the specimens keyed out to this using local references probably belong to an undescribed species.

NEREIDIDAE

Hediste limnicola (Johnson 1903)
Synonyms: *Neanthes limnicola*
LCRANS, LIT
Origin: Native

PHYLLODOCIDAE

Eteone columbiensis Kravitz & Jones, 1979
LIT
Origin: Cryptogenic

Recently described from the Columbia River mouth, this species could be either native or introduced.

Eteone dilatae Hartman 1936
LIT
Origin: Native

Specimens mentioned in the literature should be examined to check the identification as there are several undescribed species in the Northeast Pacific.

Eteone lighti Hartman 1936
LIT
Origin: Cryptogenic

Described from San Francisco Bay and possibly introduced.

Eteone longa (Fabricius, 1780)
LIT
Origin: Cryptogenic

Specimens mentioned in the literature should be examined to check the identifications as it is unlikely that these are true *E. longa*. There are several undescribed species in the Northeast Pacific.

Eteone spilotus Kravitz & Jones, 1979
LCRANS, LIT
Origin: Native

Probably native, having been found in shelf sediments from California to Washington.

Sedentary Polychaetes

Ampharetidae		
Hobsonia floridana	LCRANS, LIT	Introduced

Kingdom: Animalia
Phylum: Annelida

Capitellidae		
Barantolla nr americana	LIT	Native
Capitella capitata	LIT	Cryptogenic
Heteromastus filiformis	LIT	Cryptogenic
Heteromastus filobranchus	LIT	Native
Mediomastus acutus	LIT	Native
Mediomastus californiensis	LIT	Cryptogenic
Mediomastus sp.	LCRANS	
Cirratulidae		
Chaetozone spinosa	LIT	Cryptogenic#
Cirratulus cirratus	LIT	Cryptogenic#
Magelonidae		
Magelona hobsonae	LIT	Native
Magelona pitelkai	LIT	Native
Magelona sacculata	LIT	Native
Opheliidae		
Armandia brevis	LIT	Native
Euzonus mucronata	LCRANS	Native
Euzonus williamsi	LIT	Native
Ophelia limacina	LIT	Cryptogenic
Ophelina acuminata	LIT	Cryptogenic
Ophelina breviata	LIT	Cryptogenic#
Orbiniidae		
Leitoscoloplos pugettensis	LIT	Native
Oweniidae		
Owenia fusiformis	LIT	Native
Paraonidae		
Paraonella platybranchia	LIT	Native
Phyllodocidae		
Phyllodoce spp.	LIT	
Polygordiidae		
Polygordius spp.	LIT	
Spionidae		
Malacoceros fuliginosus	LIT	Cryptogenic
Polydora brachycephala	LIT	Cryptogenic
Polydora cornuta	LCRANS, LIT	Introduced
Polydora sp.	LCRANS	
Prionospio lighti	LIT	Native
Pseudopolydora kempi	LIT	Introduced
Pseudopolydora sp.	LCRANS	
Pygospio californica	LIT	Native
Pygospio elegans	LCRANS, LIT	Cryptogenic
Scolelepis foliosa	LIT	Cryptogenic
Scolelepis squamata	LIT	Cryptogenic
Scolelepsis n. sp. ?	LCRANS	Native
Scoloplos armiger	LIT	Cryptogenic

Spio butleri	LIT	Native
Spio filicornis	LIT	Cryptogenic
Spiophanes berkeleyorum	LIT	Native
Spiophanes bombyx	LIT	Cryptogenic
Streblospio benedicti	LCRANS, LIT	Introduced
Sabellidae		
Manayunkia aestuarina	LCRANS, LIT	Introduced
Manayunkia speciosa	LCRANS, LIT	Introduced
Manayunkia sp.	LCRANS	

AMPHARETIDAE

Hobsonia floridana (Hartman 1951)
Syn: *Hobsonia florida, Amphicteis floridus*
LCRANS, LIT
Origin: Introduced

CAPITELLIDAE

Barantolla* nr *americana Hartman, 1963
LIT
Origin: Native

Specimens need to be examined to check the identification. *Barantolla americana* is found in shelf & slope depths off California. A related form, known as *B.* nr. *americana*, has been found in shallower water in Puget Sound and Alaska.

Capitella capitata (Fabricius, 1780)
Syn: *Lumbricus capitatus*
LIT
Origin: Cryptogenic

Should be referred to as "*Capitella capitata* complex". Formerly considered a cosmopolitan species but now recognized as a complex of sibling species that vary morphologically, genetically, and developmentally. Extensive laboratory work would be required.

Heteromastus filiformis (Claparde, 1864)
LIT
Origin: Cryptogenic

Considered to be cosmopolitan but records from around the world are likely to contain several species (pers. com. Leslie Harris). Believed to be native to the

Atlantic Ocean from the Gulf of Mexico to the Arctic, it can also be found in South Africa, New Zealand and Australia. The first West Coast record of this worm is from San Francisco Bay in 1936, and it is now well established in California, Oregon, Washington and British Columbia. It is likely transported in sediment and ballast water.

Heteromastus filobranchus Berkeley and Berkeley, 1932
LIT
Origin: Native

Mediomastus acutus Hartman, 1969
LIT
Origin: Native

Mediomastus californiensis Hartman, 1944
LIT
Origin: Cryptogenic

Reported from several areas of the world but validity of all records is unknown, as is the origin and pattern of introduction.

CIRRATULIDAE

Chaetozone spinosa Moore, 1903
LIT
Origin: Cryptogenic – likely mis-identified

Local records are unlikely to be correctly identified. This is a deep-water species and there are no verified shallow water records for the Northeast Pacific.

Cirratulus cirratus (Müller, 1776)
Syn: *Lumbricus cirratus*
LIT
Origin: Cryptogenic – likely mis-identified

Unlikely to be correctly identified. Many previous Northeast Pacific records of this species have been assigned to local species.

MAGELONIDAE

Magelona hobsonae Jones 1978
LIT
Origin: Native

Magelona pitelkai Hartman, 1944
LIT

Origin: Native

Magelona sacculata Hartman, 1961
LIT
Origin: Native

OPHELIIDAE

Armandia brevis (Moore, 1906)
Syn:
LIT
Origin: Native

Euzonus mucronata (Treadwell, 1914) bloodworms
Syn:
LCRANS
Origin: Native

Euzonus mucronata is common in the upper intertidal of sandy/silty beaches along the West Coast. *Euzonus* have high hemoglobin content turning them a distinctive red color. These worms were found by LCRANS in the high salinity tidal pools along Clatsop spit.

Euzonus williamsi (Hartman, 1938)
Syn:
LIT
Origin: Native

See above.

Ophelia limacina (Rathke, 1843)
Syn:
LIT
Origin: Cryptogenic

A boreal species. Local specimens need comparison to type or topotype material in order to confirm the id.

Ophelina acuminata Oersted, 1843
LIT
Origin: Cryptogenic

Considered cryptogenic here due to the paucity of characters used to distinguish species. Genetic and development studies may be required for speciation.

Ophelina breviata (Ehlers, 1913)

Syn: *Ammotrypane breviata*
LIT
Origin: Cryptogenic#

Known from Arctic and Subantarctic waters. Local specimens are likely to belong to another species.

ORBINIIDAE

Leitoscoloplos pugettensis (Pettibone, 1957)
Syn: *Leitoscoloplos elongatus*
LIT
Origin: Native

A marine species, probably only recorded from sampling at the mouth of the Columbia.

OWENIIDAE

Owenia fusiformis delle Chiaje, 1841 single-tube worm
LIT
Origin: Native

A widely distributed marine species probably only recorded from sampling at the mouth or outside of the Columbia.

PARAONIDAE

Paraonella platybranchia (Hartman, 1961)
Syn:
LIT
Origin: Native

A marine species, probably only recorded from sampling at the mouth or outside of the Columbia.

SPIONIDAE

Malacoceros fuliginosus (Claparede, 1868)
LIT
Origin: Cryptogenic

Specimens need to be compared to type or topotype material to confirm the identification. Found in the Eastern Atlantic in high salinity bays and lagoons.

Dipolydora caulleryi Hartman, 1936

Syn: *Polydora brachycephala*
LIT
Origin: Cryptogenic

Reported from the Columbia River as *Polydora brachycephala* this species has been synonymized with *Dipolydora caulleryi*. *D. caulleryi* is reported from both sides of the US, Europe, and Surinam. Its origin & pattern of introduction is unknown. It is considered an introduced marine polychaete by the California Department of Fish and Game.

Polydora cornuta Bosc, 1802
Syb: *Polydora ligni*
LCRANS, LIT
Origin: Introduced

Verified records are found worldwide. The origin of the species and its pattern of distribution is unknown. Considered by Cohen and Carlton (1995) to be native to the North Atlantic and introduced to San Fransico Bay by the 1930s via ballast water or in association with oyster planting.

Prionospio lighti Maciolek, 1985
LIT
Origin: Native

Pseudopolydora kempi (Southern, 1921)
Syn: *Pseudopolydora kempi japonica, P. kempi kempi*
LIT
Origin: Introduced

Native to Japan, there remains some doubt as to whether the local specimens actually belong to this species. Specimens collected by LCRANS were only identified as *Pseudopolydora* sp. The subspecies *Pseudopolydora kempi japonica* has been considered both valid species and a junior synonym of *P. kemp.* We consider it a junior synonym as prior species identifications could nto be verified. Also reported as introduced on the West Coast but not from the Columbia River is the closely related species *Pseudopolydora paucibranchiata*. Both species have planktonic larvae and could be readily transpoted via ballast water.

Pygospio californica Hartman 1936
LIT
Origin: Native

Found in marine intertidal sandflats (Blake 1975)

Pygospio elegans (Claparede, 1863)
Syn: *Spio rathbuni*

LCRANS, LIT
Origin: Cryptogenic

Unknown if this is a species complex or a single widely distributed species; also its origin and pattern of introduction is unknown.

Scolelepis foliosa (Audouin and Milne Edwards, 1833)
Syn: *Nerine foliosa, Scolelepis foliosa occidentalis*
LIT
Origin: Cryptogenic

Local specimens need to be compared to type or topotype material to confirm the identification.

Scolelepis squamata (Mueller, 1806)
Syn: *Lumbricus squamatus*
LIT
Origin: Cryptogenic

Local specimens need to be compared to type or topotype material to confirm the identification.

Scoloplos armiger (Müller, 1776)
Syn: *Scoloplos elongata*
LIT
Origin: Cryptogenic

Local specimens may not be the same as the true *S. armiger* from Norway.

Spio butleri Berkeley & Berkeley, 1954
LIT
Origin: Native

Spio filicornis (Müller, 1776)
Syn: *Nereis filicornis*
LIT
Origin: Cryptogenic

Spiophanes berkeleyorum Pettibone, 1962
LIT
Origin: Native

Spiophanes bombyx (Claparede, 1870)
LIT
Origin: Cryptogenic

Another cosmopolitan species that may consist of sibling species.

Streblospio benedicti Webster, 1879
LCRANS, LIT
Origin: Introduced

Origin and pattern of introduction of *Streblospio benedicti* are unknown. This variable species may prove to be another species complex.

SABELLIDAE

Manayunkia aestuarina (Bourne, 1883)
LCRANS, LIT
Origin: Introduced

Local references only used one character to speciate Manayunkia. Local records in the literature review must be compared to type or topotype material of *M. speciosa* for confirmation of identification. *Manayunkia aestuarina* is native to eastern North America and may have been introduced via ballast water or in association with stocked fish from eastern North America. EMAP specimens were confirmed as *M. aestuarina*.

Manayunkia speciosa Leidy, 1859
LCRANS, LIT
Origin: Introduced

Local references only used one character to speciate Manayunkia. This is inadequate and Local records in the literature review must be compared to type or topotype material of *M. speciosa* for confirmation of identification. *Manayunkia speciosa* is native to eastern North America and may have been introduced via ballast water or in association with stocked fish from eastern North America.

Phylum: Mollusca

SOME FRESHWATER MOLLUSKS OF THE LOWER COLUMBIA RIVER, OREGON AND WASHINGTON

Terrence J. Frest and Edward Johannes

Relatively little is known currently of the freshwater mollusk fauna of the mainstem Columbia River, particularly of its lower reaches, despite frequent visits by malacologists dating to before 1838. Historic data is considerable but mostly unpublished museum records. Much of the more recent information is in the rather voluminous gray literature and needs to be reviewed and reidentified. A short survey of 12 sites in late June, 2002 from Portland, Oregon to the estuary provides some useful data as to historic vs. modern freshwater mollusk faunas. One emphasis was to search for so-called exotic (non-indigenous, non-native species). At least one such, the bivalve *Corbicula fluminea*, has been known to be present since perhaps 1937 (Burch, 1944; Counts, 1985).

Though the site coverage is limited, our results indicate that more detailed study would be rewarding. Exotics are more widespread than expected from the literature and native taxa have declined considerably. Still, more than one undescribed taxon was encountered. All of these considerations suggest that detailed survey should be undertaken.

We briefly review below necessary background information on the Columbia River freshwater malacofauna. We then systematically review species found. Finally, we discuss their significance within a historic context and within the wider context of other molluscan introductions.

MOLLUSK FAUNA OF THE COLUMBIA SYSTEM

There has been relatively little published on the malacofauna of the mainstem Columbia River, despite the fact that some of the earliest western U. S. mollusk records are from this stream. There are no particular titles devoted solely to it, in fact. However, numerous references are scattered through the literature and there are large numbers of largely untapped museum records. We have collected the system extensively since 1988. A fair number of recent records are contained in Neitzel & Frest (1989, 1993). Quite a few collections were made from the lower Columbia by NMFS teams during the last 20 years. Unfortunately, the quality of identifications in these latter publications is quite low (note numerous allusions to amnicolids, for example, which are not present). Also, recent revisions have made many of the older literature identifications clearly mistaken. For example, Hershler & Frest (1996) revised the described species of the lithoglyphid *Fluminicola*, one of the two most common Oregon-Washington freshwater snail genera. On their evidence, probably 90-95% of literature records and most museum records are wrong. Recent work by Frest & Johannes (unpublished) indicates a similar error ratio in identifications of the other very common genus, Juga. Another very widespread western U. S. genus, *Pyrgulopsis*, has been expanded from about 20 species to about 170 in the last fifteen years (Frest, 1995; Hershler & Sada, 2002). The majority of these new taxa are Western. Taylor (1975) opined that at least half of museum lots of Western freshwater mollusks were wrongly identified; Frest et al. (2002) reiterate this figure for Idaho lots and note that gray literature reports are proportionately even less likely to be correct. Hence, caution should be used in making mollusk identifications from Washington and Oregon freshwater sites, as elsewhere in the West, and dependence on older records is unwise.

Western freshwater habitats differ considerably in taxonomic composition from those elsewhere in the U. S. Large freshwater mussels (unionoids) are relatively non-diverse (about 10 vs. about 300 taxa) and hydrobiids are much more diverse. Only sphaeriids (fingernail clams) are about equal in diversity in both areas. Per site (a) diversity seems lower in the West; but overall (g) diversity is more or less comparable, with hydrobiids and lithoglyphids making up for the low unionoid diversity. This faunal makeup may be universal for Western stream mollusks (Frest & Johannes, 2002). Western and Eastern malacofaunas differ considerably at the generic level, with the usual pattern being different genera or at least subgenera in those families held in common. Hence, *Fluminicola* (West) vs. *Somatogyrus* (East); *Juga* (West) vs. *Elimia* and 6 other pleurocerid genera (East), etc. It now appears likely that the western hydrobiid swarm differs at the generic level from the eastern also (Hershler, 1994; pers. comm., 2003), instead of *Pyrgulopsis* being common to both.

Leaving aside taxonomic composition, there are significant differences in Western and Eastern-Central U. S. preferred freshwater mollusk habitats as well. Spring and cold, clear, low nutrient, flowing habitats with few macrophytes are more typically Western stream habitats (Frest, 2002a,b), often relatively warm, turbid, with abundant macrophytes and comparatively high dissolved nutrient and lower dissolved oxygen levels, are more significant in the East. Large permanent streams are relatively uncommon in the West. Western drainages are relatively young for the most part but have been considerably modified by geologic factors. Endemism and short-rage species are the norm; and perhaps only 40-50% of total diversity has been formally described to date (Frest & Roth, 1995). It is thus not surprising that several new taxa were noted in this brief survey (Table 2). Over the last 15 years, some 100+ newly described species have been added to the Western freshwater mollusk fauna (Frest, 1995). Moreover, Western mollusk biogeographic provinces are small (Frest & Johannes, 2001). There is nothing at all comparable in size in the western U. S. to the Mississippi freshwater Province. In effect, al western freshwater mussels occur in one Province, the Pacific, equal to the Eastern Division; while several very areally limited terrestrial provinces are needed for land forms. Based upon snail genera, terrestrial and freshwater provinces are surprisingly congruent (Frest & Johannnes, 2001; in press). Hence, even large streams like the Columbia, Klamath, or Sacramento may range across provinces and not have a uniform fauna in the mainstem, let alone the tributaries. This situation is not limited to mollusks but characterizes the fish fauna as well (McPhail & Lindsey, 1986; Minkley et al., 1986).

In dealing with Western freshwater mollusks, in is important to keep in mind such biogeographic considerations. Despite their relative youthfulness, most Western streams are composite systems geologically, recently assembled and with segmented and composite biotas. This much complicates distributional scenarios both for fish and for mollusks (Minkley et al, 1986; Smith et al., 2000, 2002; Taylor, 1985, 1988a,b; Taylor & Bright, 1987; Hershler & Sada, 2002).

The lower Columbia, not surprisingly after the foregoing, thus had several taxa endemic to it historically and before damming was a cold-water, rocky bottom stream with little in the way of stable soft substrate habitats and macrophyte beds. Dams and dredging have much modified most of the original exposed bedrock (e.g., The Dalles) and hard substrate habitat (Magnuson, 1996). Lower Columbia endemics are believed to have included such taxa as *Fluminicola nuttalliana* and perhaps one other extinct species (see Hershler & Frest, 1996 for discussion); *Vorticifex neritoides*; *Physella columbiana sensu* Taylor (1985) and probably several other taxa. Most of these are either much reduced or perhaps even extinct currently (see Table 2 for most historic species and their habitats). Similarly, reduction in salmon (the glochidial host) runs and in suitable habitat seems to have nearly extirpated the formerly very widespread freshwater mussel *Margaritinopsis falcata* from the lower Columbia and habitat changes alone much reduced others, such as *Gonidea angulata*. Native pleurocerids, hydrobiids, and lithoglyphids have likely also declined considerably. The native lancid *Fisherola nuttalli*, a member of a subfamily or family restricted to the West, is also now quite rare (not found in this survey but living at a few of our lower Columbia sites). We believe that the aberrant planorbid genus *Vorticifex*, another Western endemic, was historically one of the more common lower Columbia snails; it is now one of the more rare.

Perhaps because of habitat changes, introduced taxa such as *Corbicula* are among the most commonly encountered forms. However, as yet relatively few taxa have been introduced. Recent finds of the New Zealand mudsnail are very disturbing, however, and the non-native *Radix auricularia* is a snail community dominant higher in the system (Frest & Johannes, pers. obs.). We expect that, in its current condition, the lower Columbia would provide excellent habitat for the zebra mussel and predict that it could readily become a major pest species, a well as further degrading the native mollusk fauna. The New Zealand mudsnail, *Potamopyrgus antipodarum*, is a serious pest snail in parts of the middle Snake River in Idaho and is rapidly spreading both up and down stream. We have considerably expanded its known range in the lower Columbia River from Astoria and areas ca. 20 miles upstream (Tongue Point) some 60 miles closer to Portland.

Taxonomy herein is based upon the names utilized in Burch (1972-1989), modified where necessary by Taylor (1981) and Turgeon et al. (1998). The latter is the source for common names. We have also used the periodical literature extensively to update all sources and to reflect more recent nomenclatorial changes.

Phylum: Mollusca

Class: Gastropoda

** - considered probably extinct in the lower Columbia River

Ancylidae		
Ferrissia californica	LCRANS, LIT	Native
Ferrissia parallelus	LIT	Native
Ferrissia rivularis	LCRANS, LIT	Native
Ferrissia rowelli	LIT	Native
Hydrobiidae		
Fluminicola n. sp. 1	LCRANS	Native
Fluminicola n. sp. 2	LCRANS	Native
Fluminicola n. sp. 3	LCRANS	Native
Fluminicola fuscus	LIT	Native**
Fluminicola nuttallianus	LIT	Native**
Fluminicola virens	LCRANS, LIT	Native
Potamopyrgus antipodarum	LCRANS, LIT	Introduced
Lymnaeidae		
Fisherola nuttalli	LIT	Native
Fossaria (B.) bulimoides cockerelli	LCRANS	Native
Radix auricularia	LIT	Introduced

	Stagnicola (Stagnicola) apicina	LCRANS, LIT	Native
	Stagnicola caperata	LCRANS	Native
	Stagnicola (Stagnicola) elodes	LCRANS, LIT	Native
	Stagnicola sp. (juv)	LCRANS	
Margaritiferidae			
	Margaritinopsis falcate	LIT	Native
Olividae			
	Olivella biplicata	LIT	Native
Physidae			
	Physella (Physella) gyrina	LCRANS, LIT	Native
	Physella (Physella) columbiana	LIT	Native
	Physella (Physella) hordacea	LIT	Native
	Physella (Physella) lordi	LIT	Native
	Physella (Physella) propinqua	LCRANS, LIT	Native
	Physella (Physella) traski	LIT	Native
	Physella (Physella) virginea	LIT	Native
	Physella sp.	LCRANS	
Planorbidae			
	Gyraulus parvus	LCRANS, LIT	Native
	Menetus (menetus) callioglyptus	LCRANS	Native
	Menetus dilatatus	LCRANS	Native
	Menetus opercularis	LIT	Native
	Planorbella subcrenatum	LIT	Native
	Planorbella columbiense	LIT	Native
	Promenetus umbilicatellus	LIT	Native
	Pyrgulopsis n. sp. 1 *cf. robusta*	LCRANS	Native
	Pyrgulopsis n. sp. 6	LIT	Native
	Vorticifex effusus effusus	LCRANS	Native
	Vorticifex effusus costata	LCRANS, LIT	Native
	Vorticifex neritoides	LIT	Native
Pleuroceridae			
	Juga (J.) n. sp.	LCRANS	Native
	Juga hemphilli	LIT	Native
	Juga (J.) plicifera bulimoides	LCRANS	Native
	Juga (J.) plicifera plicifera	LCRANS, LIT	Native
	Juga silicula	LIT	Native
Polygyridae			
	Vespericola sp.	LCRANS	
Viviparidae			
	Cipangopaludina chinesis malleatus	LCRANS	Introduced

ANCYLIDAE

Ferrissia californica (Rowell, 1863) fragile ancylid
LCRANS, LIT

Origin: Native

Taylor (1981) believes that this name precedes *Ferrissia fragilis* for the common North American river limpet. This taxon is uncommon in the West and seems to prefer low-elevation, rather warm and eutrophic habitats, often with low flow (lotic) or is found in similar lentic habitats, such as ponds and lakes.

Ferrissia parallelus
LIT
Origin: Native

Ferrissia rivularis
LCRANS, LIT
Origin: Native

Ferrissia rowelli
LIT
Origin: Native

HYDROBIIDAE

Fluminicola n. sp. 1
LCRANS
Origin: Native

There appear to be at lest three *Fluminicola* in the lower Columbia and two in the lower Willamette. Aside from *virens*, or virens-like forms, at least one undescribed taxon occurs in both rivers. Formerly, both likely had the probably extinct *Fluminicola nuttalliana*; and there are historic records for *F. fuscus* (under the name *columbiana*) for the lower Columbia, and possibly the lower Willamette, as well (Neitzel & Frest, 1989, 1993). Hershler & Frest (1996) report another likely extinct taxon from the lower Willamette and possibly form the Columbia below Portland. There are only two remaining lower Columbia taxa found in some numbers; *virens* and this form. Both are probable cold-water stenotopes and often co-occur with *Juga (J.)plicifera plicifera*. Like most larger pebblesnails, this taxon seems to prefer cold and relatively pristine hard-substrate habitats, with little disturbance. Note that this taxon and the foregoing occurred historically in the Columbia upstream only as far as the Hanford Reach, while *fuscus* ranged into the Snake River (Frest, unpub.) and several other interior Washington tributaries (Neitzel & Frest, 1989, 1993; Hershler & Frest, 1996). This taxon has been cited as *Fluminicola* n. sp. 1 in Frest & Johannes (1993, 1995, 1996)

Fluminicola n. sp. 2
LCRANS

Origin: Native

This *virens*-group taxon seems to be restricted to relatively small and more or less pristine oligotrophic stream habitats. So far, it appears that this undescribed taxon may be restricted to small tributaries in Oregon and Washington below Portland.

Fluminicola fuscus (Haldeman, 1841) Columbia pebblesnail
LIT
Origin: Native

Possibly locally extinct. This species until very recently was confused with several other taxa, and most commonly is cited as *Fluminicola columbiana* Hemphill. Original distribution: Lower Columbia River and a few of its major tributaries in WA, OR, ID, and BC (and probably MT as well). Possibly extinct in the lower Columbia River, WA-OR, and definitely extinct in most of the middle and upper Columbia River, WA, MT, and British Columbia.

Fluminicola nuttallianus
Flumincola nuttalliana
LIT
Origin: Native

Probably extinct (See Frest on *Flumincola* n. sp. 1)

Fluminicola virens (Lea, 1838) Olympia pebblesnail
LCRANS, LIT
Origin: Native

This pebblesnail taxon seems characteristic of the lower Columbia and middle to lower Willamette, although similar undescribed taxa occur widely in western Washington and Oregon. There is some possibility that the Columbia form is a distinct species: we are currently exploring that possibility using molecular genetic methods. The group including virens, recently redescribed by Hershler & Frest (1996), likely represents a monophyletic clade at a higher taxonomic level than species, as yet unnamed. Note that the common name is completely inappropriate. Pebblesnails are for the most part cold-water stenotopes and historically had very wide distribution in Oregon and Washington clear oligotrophic streams and springs. The common name is mysterious in origin, as the type locality is in Oregon and there is no reason to think Olympia, Washington *Fluminicola* are conspecific.

Potamopyrgus antipodarum (Grey 1853) New Zealand mudsnail
LCRANS, LIT
Origin: Introduced

The New Zealand mudsnail was first noticed in the Columbia River in 1995, at Youngs Bay near Astoria, Oregon (Wonham and Carlton in press). Since then, it has been reported as far east as Cathlamet Bay, Oregon. We herein extend the species considerably eastward, to St. Helens, Oregon. Specimens at our two non-estuary sites are as yet quite rare; but massive increases are likely, to judge by the species' history in the middle Snake River. We expect that the Columbia will provide sufficient degraded habitat as to allow this taxon to become a true nuisance species. While Mackie (1999b) does not seem to regard this taxon as a nuisance, except possibly to native mollusks, experiences in the middle Snake River (Bowler & Frest, 1992; Frest & Johannes, 1992) suggest that it not only negatively impacts native mollusks but also can be both an aesthetic irritant and impediment to hydroelectric, trout rearing, and irrigation facilities. Aside from impacts on native species (USFWS, 1995; Richards et al., 2001: see also earlier references in Frest et al., 2002), the species is a biofouler. At one Idaho Power hydroelectric facility, for example, it has proved necessary to operations to remove some 30 tons of organic detritus per day. Half of that by weight is P. antipodarum. Impact is further discussed below.

This taxon may have been introduced independently several times into the U. S. Gangloff (1998) regards the Lake Ontario (1991-1994), Idaho (1987), Lower Columbia (1997 sic) and Yellowstone National Park (1995) occurrences as separate. We regard at least the Montana (Yellowstone)) as derived from Idaho sources. There is also another introduction, possibly independent, in the Colorado River system in Arizona (pre-1998). Since 1998, other introductions have turned up in Owens Valley, CA, Polecat Creek, Wyoming likely derived from Yellowstone populations, and in two other areas in coastal and interior Oregon (Frest & Johannes, unpub.). Ballast water is suggested as the venue in Lake Ontario (Zaranko et al., 1997) and generalized in Mackie (1999b) but this hypothesis is untenable for most introductions, the lower Columbia being a possible exception. Several reported introductions have proven incorrect and due to confusion with native hydrobiids. This is a problem in the lower Columbia as well, as native *Pyrgulopsis* occurs here also (see below). Supposed *P. antipodarum* finds should always be confirmed by a specialist.

LYMNAEIDAE

Fisherola nuttalli (Haldeman, 1841) shortfaced lanx
LIT
Origin: Native

The native lancid *Fisherola nuttalli*, a member of a subfamily or family restricted to the West, is also now quite rare (not found in this survey but living at a few sites along the lower Columbia). Type locality: "Lower Columbia River" near the old mouth of the Willamette River near Portland, Multnomah Co., OR (could have been from the Willamette River itself). Formerly widespread in the lower Columbia River, Snake River, and a few major tributaries, WA-OR-ID-MT-BC. The lower Columbia River populations are largely extinct due to habitat modification caused by Bonneville Power Administration dams and impoundments (Frest and Johannes 1995).

Fossaria (B.) bulimoides cockerelli
LCRANS
Origin: Native

Radix auricularia (Linnaeus, 1758) Big-ear Radix
Syn: *Lymnaea auricularia*
LIT
Origin: Introduced

The non-native *Radix auricularia* is a snail community dominant higher in the Columbia River system (Frest & Johannes, pers. obs.), also introduced in the Great Lakes (http://nas.er.usgs.gov) prefers still or standing water, Euarasian aquarium species, first collected from Great Lakes in 1901 (Mills et al. 1993)

Stagnicola (Stagnicola) apicina
LCRANS, LIT
Origin: Native

Stagnicola caperata
LCRANS
Origin: Native

Stagnicola (Stagnicola) elodes (Say, 1821) marsh pondsnail
LCRANS, LIT
Origin: Native

We are more familiar with this taxon as a swamp and wetland taxon in the Midwest. It is relatively rare in the Western U.S. Large stream sites are more common in the West, while the typical eastern site is more likely to be a warm pond or ditch or very small stream. In much of the lower Columbia, including more or less undisturbed habitats, this taxon seems to be replaced by *Stagnicola apicina*, not noted at our sites during this survey.

MARGARITIFERIDAE

Margaritinopsis falcata (Gould 1850) western pearlshell
Syn: *Margaritifera falcata*
LIT
possibly locally extinct

Reduction in salmon (the glochidial host) runs and in suitable habitat seems to have nearly extirpated the formerly very widespread freshwater mussel

Margaritinopsis falcata from the lower Columbia. Original distribution: Southern Alaska to central California, eastward to western Montana, western Wyoming, and northern Utah (Frest and Johannes 1995). Threats such as extensive diversion of rivers for irrigation, hydroelectric, and water supply projects has much reduced the WA, OR, ID, and CA range of this species. In the lower Columbia River region threats include impoundments: continued siltation and other impacts on the few remaining sites with habiiat characteristics approximating pre-impoundment conditions on the lower Columbia. Harbor and channel "improvements" in the vicinity of The Dalles and John Day Dam; nutrient enrichment of the lower Columbia due to agricultural run-off.
This taxon is declining, in terms of area occupied and number of sites and individuals.

OLIVIDAE

Olivella biplicata
LIT
Origin: Native

PHYSIDAE

Physella (Physella) gyrina (Say, 1821) tadpole physa
LCRANS, LIT
Origin: Native

Physids are among the common river snails in the Western U. S., as they are in the East as well. Taxonomy is badly in need of revision; and we follow Taylor (1981) and Burch (1982) here, recognizing a small number of taxa in the West. Forms of *gyrina* are widespread in a variety of habitats in Western North America. Many literature reports are more likely ascribable to *Physella (Physella) propinqua*. This taxon seems to prefer small stream, pond, and lake habitats locally.

Physella (Physella) columbiana
LIT
Origin: Native

Physella (Physella) hordacea
LIT
Origin: Native

Physella (Physella) lordi
LIT
Origin: Native

Physella (Physella) propinqua (Tryon, 1865)Rocky Mountain physa

LCRANS, LIT
Origin: Native

In contrast to *Physella (Physella) gyrina*, some forms of this taxon appear to prefer large river habitats, while others are more restricted (Frest & Johannes, 2001). Precise relationships of lower Columbia specimens remain to be determined. In relatively natural Columbia habitats, this taxon is rather rare. It seems to have benefited from siltation and eutrophication.

Physella (Physella) traski
LIT
Origin: Native

Physella (Physella) virginea
LIT
Origin: Native

PLANORBIDAE

Gyraulus parvus
LIT
Origin: Native

Menetus (menetus) callioglyptus (Vanatta, 1895) button sprite
LCRANS
Origin: Native

Note that most sources regard this taxon as *Menetus opercularis* (Gould, 1847); but Taylor (1981) argues that that name applies to snails from Mountain Lake, California and now extinct. This is a widespread taxon in western Washington, northern Oregon, and northwestern California in a variety of habitats. It is usually uncommon in larger streams.

Menetus dilatatus
LCRANS
Origin: Native

Menetus opercularis
LIT

INVALID NAME – See above section on *Menetes callioglyptus*

Planorbella subcrenatum
LIT

Origin: Native

Planorbella columbiense
LIT
Origin: Native

Promenetus umbilicatellus
LIT
Origin: Native

Pyrgulopsis* n. sp. 1 *cf. robusta
LCRANS
Origin: Native

This taxon was first noticed in the lower Columbia in the John Day and Bonneville pools by FWS personnel in 1988. Immature specimens possibly belonging to this taxon were noted far downstream during this survey. The taxonomic status of this taxon is currently under investigation using molecular genetic methods. We will need adults to obtain a full suite of morphological characters. The lower Columbia juveniles as live photographed differ in coloration from equivalent life stages of Pyrgulopsis n. sp. 6 collected upstream. Relationships seem to be with other native U. S. Pyrgulopsis, notably P. idahoensis, P. hendersoni, and P. robusta (R. Hershler, pes comm., 2003; pers. obs.).

***Pyrgulopsis* n. sp. 6**
LIT
Origin: Native

Vorticifex effusus effuses
LCRANS
Origin: Native

Vorticifex effusus costata (Hemphill, 1890)artemisian ranshorn
LCRANS, LIT
Origin: Native

This appears to be the sole surviving species in the genus in the Columbia. We have not seen live *V. neritoides*, limited to the River historically below Portland, in the last few years. For distribution maps of these taxa, see Taylor (1985). *V. effusa costata* seems not to have occurred historically in the River above Grand Coulee. It is also absent from most tributaries, especially on the east side of the Washington and Oregon Cascade Mountains.

Vorticifex neritoides
LIT
Origin: Native
Possibly extinct (see above description)

PLEUROCERIDAE

***Juga (J.)* n. sp.**
LCRANS
Origin: Native

This undescribed Juga taxon may be characteristic of immediate lower Columbia tributaries. It has been noted at several other sites in the first 100 river miles of the Columbia system (Frest & Johanes, unpub.). Sites are typically cold and oligotrophic, with clear water, moderate to high velocity currents, and rocky substrate.

Juga hemphilli
LIT
Origin: Native

Juga (J.) plicifera plicifera (Lea, 1838) pleated juga
LCRANS, LIT
Origin: Native

This is basically a big-river *Juga* species, characteristic of the Lower Columbia and middle-lower Willamette. While formerly much more widespread, it still appears frequently in lower Columbia habitats. Most reports from other streams appear to refer to other subspecies or other *Juga* taxa. Note that historically *Juga* may have reached no farther upstream than just below the Hanford Reach or the mouth of the Yakima River (Frest, unpub.).

Juga silicula
LIT
Origin: Native

POLYGYRIDAE
Vespericola sp.
LCRANS

The common Columbia River taxon is *Vespericola columbianus*; another taxon found in the lower Columbia region is *V. columbianus latilabris*. Other taxa are found by the mouth of the Columbia Gorge. These specimens appear to differ in morphology from any yet described.

VIVIPARIDAE
Cipangopaludina chinesis malleatus (Reeve, 1863) Chinese mystery snail
LCRANS
Origin: Introduced

This non-indigenous taxon has been reported widely in North America (Burch, 1989) but this is the first finding in the Columbia River system. It does not appear likely to become a pest species or to have major negative impact (Mackie, 1999c). However, its occurrence is symptomatic of many others likely to have been so far unnoticed. Hanna (1966) and Mackie (1999c) emphasizes food usage as the rationale for introductions. However, the aquarium trade route is much more likely for most (this species is not mentioned in Mackie, 1999a, nor are apple snails Pomacea). The species is raised specifically for this purpose in the middle Snake River region (Bowler & Frest, 1992) and has commonly seen in pet stores throughout the U. S., as are apple snails, for at least 30 years. Note that all of the non-native taxa mentioned in Bowler & Frest (1992) could quite easily be introduced into the Columbia: many may have already been.

Phylum: Mollusca

Class: Bivalvia

Cardiidae			
	Clinocardium nuttallii	LIT	Native
Corbiculidae			
	Corbicula fluminea	LCRANS, LIT	Introduced
Mactridae			
	Tresus capax	LIT	Native
Margaritiferidae			
	Margaritifera (Margaritifera) falcate	LIT	Native
Myidae			
	Cryptomya californica	LCRANS, LIT	Native
	Mya arenaria	LCRANS, LIT	Introduced
Mytilidae			
	Mytilus edulis	LIT	Cryptogenic
	Mytilus ?trossulus?	LCRANS	Native
Pharidae			
	Siliqua patula	LIT	Native
Pisidiidae			
	Musculium raymondi	LCRANS	Native
	Musculium securis	LIT	Native
	Pisidium casertanum	LCRANS, LIT	Native
	Pisidium compressum	LCRANS, LIT	Native
	Pisidium pauperculum	LCRANS	Native
	Pisidium variabile	LCRANS, LIT	Native
	Sphaerium patella	LIT	Native
	Sphaerium simile? (juv.)	LCRANS	Native
	Sphaerium striatinum	LCRANS	Native
Psammobiidae			
	Nuttallia obscurata	LCRANS	Introduced
Tellinidae			
	Macoma baltica	LCRANS, LIT	Native
Thyasiridae			
	Axinopsida serricata	LIT	Native

Unionidae		
Anodonta californiensis	LCRANS, LIT	Native
Anodonta kennerlyi	LIT	Native
Anodonta nuttalliana	LIT	Native
Anodonta oregonensis	LCRANS, LIT	Native
Anodonta wahlametensis	LCRANS, LIT	Native
Gonidea angulata	LCRANS, LIT	Native

CARDIIDAE

Clinocardium nuttallii (Conrad, 1837) Nuttall cockle
Synonyms: *Clinocardium corbis*
LIT
Origin: Native

CORBICULIDAE

Corbicula fluminea (Müller, 1774) Asian clam
LCRANS, LIT
Origin: Introduced

Corbiculids were native residents of North America for a considerable time before becoming extinct on the continent relatively recently (Taylor, 1988a,b). The recent introductions from the Western Pacific seem to have begun in the Columbia in the last 75 years; and this corbiculid is now widely distributed across the continent. Taxonomic status of *Corbicula* in North America is still somewhat cloudy, with claims for at least two taxa. More recently, morphological differences within the introduced populations have been ascribed to origin as separate clones of uncertain number, distribution, and status. If more than one taxon is present, the morphological range seen in the Columbia is great enough to suggest that two taxa may be present, although most populations may be mixes of two clones belonging to one only. Despite the early introduction, *Corbicula* is only moderately successful as an invader in Washington and Oregon, especially as compared with, say, the Tennessee Valley. It is a pest species with considerable economic impact in the central and eastern states.

McMahon (1999, fig. 22.2; 2001, fig. 11) seems to restrict *Corbicula* to the lower Columbia in Washington; but the species also occurs commonly to the Idaho border and in the Snake River in Idaho, as well as in Utah (Counts, 1985, 1986). The Idaho records date to at least 1966 (Hanna, 1966; Frest & Bowler, 1993; Frest & Johannes, 2001). McMahon (1999, p. 317) states that *Corbicula* in North America likely derives from a single introduction in northeastern Washington. Presumably, he means southwestern Washington, i.e., the lower Columbia River, as Counts (1986) says.

MACTRIDAE

Tresus capax (Gould, 1850) fat gaper

LIT
Origin: Native

MARGARITIFERIDAE

Margaritifera (Margaritifera) falcata (Gould, 1850) western pearlshell
LIT
Origin: Native

Populations in the Columbia River greatly reduced due to human mediated erosion, reservoir construction etc. Once an important food item for tribal peoples.

MYIDAE

Cryptomya californica (Conrad, 1837) false mya, California softshell clam
LCRANS, LIT
Origin: Native

Mya arenaria Linnaeus 1758 softshell clam
LCRANS, LIT
Origin: Introduced

Established from Monterey Bay, CA to Prince William Sound, AK *Mya arenaria* is most abundantly in intertidal and shallow subtidal areas. Probably introduced unintentionally to the West Coast of North America with oyster shipments from the Atlantic coast, *Mya* was later intentionally planted to establish a commercially harvestable population in many West Caost bays.

MYTILIDAE

Mytilus edulis Linnaeus, 1758 blue mussel
LIT
Origin: Cryptogenic

Mytilus edulis is native to the Atlantic Coast. Introduced *M. edulis* have been reported in Puget Sound. Readily confused with *M. trossulus*, it can also hybridize with other *Mytilus* species.

Mytilus trossulus Gould, 1850 bay mussel, foolish mussel
LCRANS
Origin: Native

The native mussel, *Mytilus trossulus*, is often difficult to distinguish from *M. edulis* and *M. galloprovincalis*, two introduced mussels with which it can readily hybridize. No records of the Mediterranean *M. galloprovincalis* exist for the Columbia River Estuary but it can be found in other bays along the West Coast and was probably introduced via ballast water.

PHARIDAE

Siliqua patula
LIT
Origin: Native

PISIDIIDAE

Musculium raymondi (Cooper, 1890) lake fingernail clam
LCRANS
Origin: Native

As the common name would suggest, this taxon is most often found in lentic habitats, or at least in low flow situations. It has been found elsewhere in the lower Columbia proper; but not yet here. The most frequent name seen in the literature for this taxon or others resembling it is *Musculium lacustre*; but Taylor (1981) feels that western U.S. populations are best ascribed to a separate taxon. *Lacustre* is a frequently seen taxon in eastern and central North America in warm-water, soft-sediment situations but is rather uncommon in the West (Frest & Johannes, 2001).

Musculium securis (Prime, 1852) pond fingernailclam
LCRANS
Origin: Cryptogenic

Despite the common name, this taxon in the Northwest is most frequently (not often, but increasingly!) seen in larger, warmer rivers with slow flow and definite nutrient enhancement. It is quite uncommon here in pristine habitats but very frequently encountered in eastern North America.

Pisidium casertanum (Poli, 1791) ubiquitous peaclam
LCRANS, LIT
Origin: Native

As the common name implies, this is a very frequently encountered sphaeriid species, perhaps the most widespread native mollusk in the northern hemisphere. It is rapidly spreading currently south of the Equator a well. Very frequent in a wide variety of habitats in the West. For examples, see Frest & Johannes (2001).

Pisidium compressum Prime, 1852 ridgebeak peaclam
LCRANS, LIT
Origin: Native

This small taxon is found widely in both the western and eastern portions of the U. S. It is perhaps less common in the West, particularly in the formerly ubiquitous cold oligotrophic habitats once prevalent but now much reduced in areal extent.

Pisidium pauperculum Sterki, 1896 fat peaclam
Syn: *P. nitidum*
LCRANS
Origin: Native

Specimens from the lower Columbia are among the largest seen of this small taxon. It is most often a lentic taxon but can occur in soft substrate lotic habitats as well. In the West, these are most often impounded rivers that have slow flow and are somewhat eutrophic. Rather uncommon in the Northwest in a variety of low-elevation habitats. We follow Taylor (1981) in recognizing this species, sometimes (e.g., Clarke, 1981) synonymized with *P. nitidum*.

Pisidium variabile
LCRANS, LIT
Origin: Native

Sphaerium patella
LIT
Origin: Native

Sphaerium simile
LCRANS
Origin: Native

Sphaerium striatinum
LCRANS
Origin: Native

PSAMMOBIIDAE

Nuttallia obscurata (Reeve, 1857) purple mahogany-clam, purple varnish clam, dark mahogany-clam
LCRANS
Origin: Introduced

Nuttallia obscurata is a brackish bivalve native to Asia, primarily Japan and Korea. It is believed that *N. obscurata* was introduced to the west coast of North America via ballast water to Strait of Georgia region in the late 1980s (Mills 1999). Now established from Coos Bay to Vancouver Island, N. obscurata may have arrived at the mouth of the Columbia River through natural spread, as a discarded live seafood species or via coastal ballast water.

TELLINIDAE

Macoma baltica (Linnaeus, 1758) altic macoma
Syn: *M. inconspicua*
LIT, LCRANS
Origin: Native

Common in mid to low intertidal and distributed from San Francisco Bay to the Bering Straight (Ricketts et al. 1985). May have been introduced by man southern most limit in San Francisco Bay (Cohen and Carlton 1995).

THYASIRIDAE

Axinopsida serricata
LIT
Origin: Native

UNIONIDAE

Anodonta californiensis Lea, 1852 California floater
LCRANS, LIT

This mussel is widely but sporadically distributed in eastern Washington but is much less common west of the Cascades in Washington. The species may well be composite (Taylor, 1981; pers. obs.). It is currently rare in the southwestern states and southern California, which area includes the type locality, and is understudy for possible listing there. The species appears to be declining seriously in Washington, including in the Columbia proper.

Anodonta kennerlyi
LIT
Origin: Native

Anodonta nuttalliana Nuttal’s floater
LIT
Origin: Native

This native floater has been found, along with A. oregonesnis and A. wahlametenis in the Columbia River Slough by Al Smith (pers com 2004).

Anodonta oregonensis Lea, 1838 Oregon floater
LCRANS, LIT
Origin: Native

The Oregon floater was first described from the lower Columbia River but appears currently uncommon to rare in it. It is found over much of Washington and Oregon, although seldom in large numbers. Along the Cascade axis, it seems to be replaced by *Anodonta kennerlyi*, and is more often found in streams than that largely lentic taxon.

Anodonta wahlametensis Lea, 1838 Willamette floater
LCRANS, LIT
Origin: Native

Also first described from the lower Columbia and Multnomah Channel, this species has a disjunct range, with only a small portion in the lower Columbia River. Most of the range is in extreme southern Oregon and northern and central interior California. Much of the original range is no longer inhabited by the taxon (Taylor, 1981; 1985; pers obs.)

Gonidea angulata (I. Lea, 1838) Western ridged mussel
LCRANS, LIT
Origin: Native

Should be a common species in the Columbia River but habitat changes may have significantly reduced its numbers.

Phylum: Arthropoda

Subphylum: Crustacea

Infraclass: Cirripedia

Acorn barnacles, Cirripedia, are conspicuous sessile crustaceans that form volcano like shells of their plates in massive numbers on solid substratums such as rocks, pilings boats and floats. Barnacles are very special crustaceans because they undergo two metamorphic changes (rather than one or none) during development. The acorn barnacles use their feet (cirripedia) to feed on plankton and are economically significant due to the problems the cause when attached to marine structures.

Balanidae		
Balanus crenatus	LIT	Native
Balanus improvisus	LCRANS, LIT	Introduced
Balanus glandula	LCRANS, LIT	Native
Balanus sp. unk	LCRANS	

BALANIDAE

Balanus crenatus Bruguiére, 1789
LIT
Origin: Native

Bering Sea to Santa Barbara, California. Pleistocene: Alaska, British Columbia, Washington, Oregon, California (Pitumbo & Ross 2002:100). Not expected in the low salinity areas of the Lower Columbia River where reports of it are probably misidentifications of *Balanus improvisus* or *B. glandula*.

Balanus improvisus Darwin, 1854
LCRANS, LIT
Origin: Introduced

Balanus improvisus is tolerant of long exposures to freshwater and full seawater and can reproduce in salinities as low as 10 PSU. *Balanus improvisus* is native to the north Atlantic and has been introduced all over the world on the hulls of sailing ships and with transplanted oysters. The east Pacific distribution of *B. improvisus* is from Vancouver Island, Canada to Monterey, California, and Equador (Pitombo & Ross 2002:101, Carlton 1979:592-597, Zullo 1979, Cohen & Carlton 1995:79-80). The first record of *B. improvisus* in the lowerbia River specimens occurring on the shells of the native crayfish, *Pacifasticus trowbidgii* collected in brackish waters of Young's Bay in 1957 (Miller 1965, Carlton 1979, Zullo 1979). *Balanus improvisus* is readily distinguished from all other northeast Pacific barnacles by the combination of its calcareous base, extended spur of the tergum, large adductor ridge of the scutum, wall plates with internal tubes and its occurrence in very low salinities.

Balanus glandula Darwin, 1854
LCRANS, LIT
Origin: Native

The most common balanoid of the northeastern Pacific, *B. glandula* occurs in bays and polyhaline waters and on the open rocky coast in the intertidal from the Unilaska Island, Aleutian Islands, Alaska to Bahia de San Quintin, Baja California, Mexico (Henry 1942) and in Pleistocene deposits (Ross 1976). This species was probably introduced to Puerto del Mar del Plata, Argentina (Newman & Abbott, 1980) from the Northeast Pacific. This is the most common barnacle in the lower Columbia River.

***Balanus* sp. unk** (Chapman)
LCRANS
Indeterminate

With carina, rostrum, lateral plates and deep spur of tergum similar to *B. improvisus.* The spur is up to 1/3 width of tergum and is far wider than expected for *B. improvisus.* The sharply quadrate articular ridge of the scutum is aligned with the angular aductor ridge but separated by a deep incision that is partially formed by a hatchet like extension of the articular ridge. The depressor muscle crests of the tergum are wide relative to illustrations of *B. improvisus.* (Specimens from 6.1332x, Port of Ilwaco, Washington, Baker Bay, Columbia River, April 17, 2002.)

Kingdom: Animalia
Phylum: Chordata
Class: Amphibia

Phylum: Arthropoda

Subphylum: Crustacea

Class: Ostracoda

Ostracods were neither targeted nor sent to experts for taxonomic identification by this survey. Further work is needed to determine both ethe native and introduced species present in the lower Columbia River.

Cyprididae		
Cypria spp.	LIT	
Eucypris spp.	LIT	
Candonidae		
Candona spp.	LIT	
Darwinulidae		
Darwinula stevensoni	LIT	Cryptogenic
Limnocytheridae		
Limnocythere spp.	LIT	

DARWINULIDAE

Darwinula stevensoni (Brady and Robertson, 1870)
Syn: *Polycheles improvisa, Polycheles stevensoni*

May be a cosmopolitan ostracod, asexual reproduction, common in European waters.

Phylum: Arthropoda

Subphylum: Crustacea

Subclass: Copepoda

Species descriptions by Jeff Cordell

The following copepods collected in the lower Columbia River consist of those taxa for which a strong case can be made for their status as introduced species. Several of these taxa (*Leimia vaga*, *Tachidius triangularis*) are regarded as cryptogenic because they are small and easily overlooked in typical sampling programs, and their distributions are poorly known. However, they are included in the list because they occur in widely disjunct populations, and/or previous authors have regarded them as introduced to the northeastern Pacific. A number of other harpacticoid copepods were collected in this survey that were described from elsewhere and may have been introduced to the northeastern Pacific. These were not included in this list because they are very widely distributed, (e.g., on both coasts of the United States and in Europe) and/or their taxonomy is poorly known, and therefore their status as introduced or cryptogenic is less clear. These species include *Coullana canadensis, Huntemmania jadensis, Limnocletodes behningi, Microarthridion littorale, Nannopus palustris, Onychocamptus mohammed, Paronychocamptus cf huntsmanni*, and *Tachidius (Tachidius) discipes*. Also, several specimens of an unidentified species of Thermocyclops were found in this survey. Thermocyclops has not been previously recorded from western North America, but is widespread, occurring in southeastern North America, Central and South America, Europe, Asia, the Indian subcontinent, and Africa (Ueda and Reid 2003). The disposition of this species as introduced is unknown, and will become clearer if enough specimens can be examined to make a specific identification.

CALANOID COPEPODS		
Calanoid	LIT	
Acartiidae		
Acartia tonsa	LIT	
Acartia sp.	LIT	
Acartia clausi	LIT	
Acartia longiremis	LIT	
Acartiella sinensis	LIT	Introduced
Calanidae		
Calanus sp.	LIT	
Calanus finmarchicus	LIT	
Centropagidae		
Centropages sp.	LIT	
Centropages abdominalis	LIT	
Centropages mcmurrichi	LIT	
Osphranticum labronectum	LCRANS	Cryptogenic
Sinocalanus doerri	LCRANS, LIT	Introduced
Diaptomidae		
Diaptomidae	LCRANS	
Diaptomus ashlandi	LIT	
Diaptomus novamexicanus	LIT	
Diaptomus franciscanus	LIT	
Diaptomus sp.	LIT	
Hesperodiaptomus kenai	LCRANS	Native
Leptodiaptomus novamexicanus	LCRANS, LIT	Cryptogenic
Leptodiaptomus sp.	LCRANS	
Skistodiaptomus pallidus	LCRANS	Cryptogenic
Skistodiaptomus sp., undescribed	LCRANS	
Eucalanidae		
Eucalanus sp.	LIT	
Eucalanus bungii	LIT	
Metridiidae		
Metridia lucens	LIT	
Paracalanidae		
Paracalanus parvus	LIT	
Paracalanus sp.	LIT	

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea

Pontellidae		
Epilabidocera longipedata	LIT	
Epilabidocera amphitrites	LIT	
Pseudocalanidae		
Clausocalanusarcuicornis	LIT	
Clausocalanusparapergens	LIT	
Ctenocalanus vanus	LIT	
Microcalanus sp.	LIT	
Pseudocalanus sp.	LIT	
Pseudocalanus minutus	LIT	
Pseudodiaptomidae		
Pseudodiaptomus forbesi	LCRANS, LIT	Introduced
Pseudodiaptomus inopinus	LCRANS, LIT	Introduced
Scolecithricidae		
Scolecithricella sp.	LIT	
Temoridae		
Epischura nevadensis	LIT	
Eurytemora affinis	LCRANS, LIT	Native
Eurytemora americana	LIT	
Eurytemora hirundoides	LIT	
Eurytemora sp.	LIT	
Tortanidae		
Tortanus discaudatus	LIT	
CYCLOPOID		
Cyclopoida	LCRANS, LIT	
Corycaeidae		
Corycaeus affinis	LIT	
Corycaeus anglicus	LIT	
Corycaeus sp.	LIT	
Cyclopidae		
Acanthocyclops robustus s.l.	LCRANS	Native
Acanthocyclops vernali	LIT	
Cyclops bicuspidatus thomasi	LIT	
Cyclops vernalis	LIT	
Cyclops sp.	LIT	
Diacyclops thomasi	LCRANS, LIT	Native
Eucyclops cf. elegans	LCRANS	Cryptogenic
Eucyclops conrowae	LCRANS	Cryptogenic
Eucyclops elegans	LCRANS	Cryptogenic
Halicyclops spp.	LCRANS	
Macrocyclops albidus	LCRANS, LIT	Cryptogenic
Mesocyclops edax	LCRANS, LIT	Cryptogenic
Orthocyclops modestus	LCRANS	Cryptogenic
Paracyclops chiltoni	LCRANS	Cryptogenic
Paracyclops fimbriatus	LIT	
Paracyclops poppei	LCRANS	Cryptogenic

Thermocyclops sp.	LCRANS	Cryptogenic
Limnoithona sinensis	LIT	Introduced
Limnoithona tetraspina	LCRANS	Introduced
Oithonidae		
Oithona similis	LIT	
Oithona spinirostris	LIT	
Oithona sp.	LIT	
HARPACTICOID		
Harpacticoida	LCRANS, LIT	
Ameiridae		
Nitocra sp.	LIT	
Canthocamptidae		
Attheyella illinoisensis	LCRANS	Cryptogenic
Attheyella sp.	LIT	
Bryocamptus hiemalis	LIT	
Bryocamptus sp.	LIT	
Canthocamptus robertcokeri	LCRANS	Cryptogenic
Elaphoidella bidens	LCRANS	Cryptogenic
Mesochra alaskana	LCRANS, LIT	Cryptogenic
Mesochra lillijeborgi	LIT	
Mesochra pygmaea	LIT	
Mesochra rapiens	LCRANS	Cryptogenic
Mesochra sp.	LIT	
Canuellidae		
Coullana canadensis	LCRANS, LIT	Cryptogenic
Cletodidae		
Huntemannia jadensis	LCRANS, LIT	Cryptogenic
Leimia vaga	LCRANS, LIT	Cryptogenic
Limnocletodes behningi	LCRANS, LIT	Cryptogenic
Nannopus palustris	LCRANS	Cryptogenic
Cylindropsyllidae		
Paraleptastacus sp.	LIT	
Diosaccidae		
Schizopera knabeni	LIT	
Schizopera sp.	LCRANS, LIT	
Ectinosomidae		
Ectinosoma sp.	LIT	
Microsetella sp.	LIT	
Pseudobradya sp.	LCRANS, LIT	
Harpacticidae		
Harpacticus sp.	LIT	
Laophontidae		
Onychocamptus mohammed	LCRANS, LIT	Cryptogenic
Paronychocamptus cf. huntsmanni	LCRANS, LIT	Cryptogenic
Tachidiidae		
Microarthridion littorale	LCRANS, LIT	Cryptogenic

Microarthridion sp.	LIT	
Tachidius discipes	LCRANS, LIT	Cryptogenic
Tachidius triangularis	LCRANS, LIT	Introduced
Tachidius sp.	LIT	
Thalestridae		
Diarthrodes sp.	LIT	
OTHER COPEPODS		
Nicothoidae		
Hansenulus trebax	LIT	Native

Pseudodiaptomus inopinus (Burkardt, 1913)

Pseudodiaptomu inopinus is native to the Indo-Pacific, and occurs in a variety of fresh and brackish water habitats from Siberia to the South China Sea, and on both coasts of Japan. The first record of this species on the west coast of the North America was in 1990, from the Columbia River estuary (Cordell et al. 1992). It was subsequently found to be established in many smaller estuaries in the Pacific Northwest, probably via introduction by ballast water (Cordell and Morrison 1996). *P. inopinus* appeared to be a stable and dominant component of the zooplankton in the tidal tributaries of the Columbia River estuary until 2002, when it was found to have been replaced by two other Asian calanoid copepods, *Pseudodiaptomus forbesi* and *Sinocalanus doerri*. Studies on the Chehalis River, which is north of the Columbia River, have found that when *P. inopinus* dominates the plankton in tidal brackish areas it can be important prey of the native shrimps *Neomysis mercedis* and *Crangon franciscorum* (J. Cordell, unpublished data). However, in this survey its abundance peak in the late summer-early fall did not correspond to times when juvenile salmon and other planktivorous fish are present, and it did not occur in their diets. In addition, *P. inopinus* may have ecological effects on other zooplankton. For example, another estuarine copepod, *Eurytemora affinis*, appears to be restricted temporally and spatially with regard to its expected distribution when *P. inopinus* is present (J. Cordell, unpublished data).

Pseudodiaptomus forbesi (Poppe & Richard, 1890)

In its native range, *P. forbesi* has been reported from the Yangtze River in China and from Japan (http://www.obs-banyuls.fr/Razouls/Webcd/Pseudodiaptomidae.htm). It was first collected in the northeastern Pacific from the upper San Francisco Bay estuary in 1987 (Orsi and Walter 1991), where it now appears to be a permanent part of the brackish-oligohaline plankton assemblage. This species was first found in the Columbia River estuary in benthic samples taken by the WEMAP survey. Along with *Sinocalanus doerri*, it appears to have replaced *P. inopinus* in this estuary. In 2003 samples from this survey, *P. forbesi* was one of the most abundant mesozooplankton species in tidal tributaries of the main estuary, comprising up to 52% of the plankton numbers in the Grays River. It occurred in the furthest upstream samples taken in this survey, and in summer 2003 comprised 31% of the plankton numbers in Crane Lake, which is located near the city of Portland, Oregon.

Sinocalanus doerri (Brehm, 1909)

This species was introduced to San Francisco Bay from its native range in mainland China (Orsi et al. 1983). In the early 1980s it was the most abundant copepod in the oligohaline-tidal fresh region of the Sacramento-San Joaquin delta, but by the mid 1990s it had declined greatly (Orsi 1999). It first was first reported from the Columbia River estuary in 2002, by this survey. It occurred upstream to Crane Lake near Portland, Oregon, and was very abundant in tidal tributaries of the estuary, where it comprised up to 47% of the plankton numbers in summer 2003 samples.

Limnoithona sinensis (Burkhardt, 1912)

This cyclopoid copepod was first collected in San Francisco Bay estuary in 1979, from the San Joaquin River. It is a fresh water species native to the Yangtze River. It was also collected from the Columbia River from 1979 to 1980 during the CREDDP surveys. This species was not found in the present survey. It has been reported to have disappeared from the San Francisco Bay estuary, having been replaced by its congener *L. tetraspina*, another introduced species (Orsi and Ohtsuka 1999). However, recent analyses of ballast water taken from upper San Francisco Bay in 1999 show that *L. sinensis* was still present at that time (J. Cordell and G. Ruiz, unpublished data). Therefore, this species may still exist in a restricted range in upper San Francisco Bay.

Limnoithona tetraspina (Zhang & Li, 1976)

Limnoithona tetraspina, which is native to the Yangtze River, first occurred on the North American west coast in 1993, in the upper part of San Francisco Bay. Since its introduction there, it has been the most abundant copepod in the bay, with mean abundances of >10,000 m^{-3}. Three specimens of this species were found in 2003 samples from this survey, from both lower (Grays River) and upper (Trojan Power Plant) sites.

Leimia vaga (Willey, 1923)

This harpacticoid copepod can be regarded as a cryptogenic species. Described from Nova Scotia, it is also abundant in many estuaries in Oregon and Washington, where it is restricted to brackish water (J. Cordell, unpublished data), and has also been reported from Prince William Sound, Alaska (Hines and Ruiz, 2000). It was not reported from brackish water habitats in the Nanaimo River estuary, British Columbia in Kask's (1982) checklist of harpacticoids from there. The fact that *L. vaga* has restricted habitat requirements and apparently disjunct populations on the Pacific coast may indicate that it has been introduced.

Tachidius (Neotachidius) triangularis Shen and Tai, 1963

This species is one of the most abundant harpacticoids in marine-influenced tidal channels of coastal Pacific Northwest estuaries; and also occurs in eelgrass beds. Described from the Pearl River delta, South China, Kask et al. (1982) regarded it as a probable introduction to the Nanaimo River estuary, British Columbia. In this survey *T. (N.) triangularis* occurred in Baker Bay and in the early 1990s it was recorded in Trestle Bay in an unpublished USFWS study.

Phylum: Arthropoda

Subphylum: Crustacea

Suborder: Cladocera

Cladocera	LCRANS, LIT	
Bosminidae		
Bosmina sp.	LIT	
Bosmina longirostris	LCRANS	Cryptogenic
Chydoridae		
Alona rustica	LIT	
Alona costata	LIT	
Alona sp.	LIT	
Alona quadrangularis	LIT	
Alona affinis	LIT	
Alona guttata	LIT	
Alonella sp.	LIT	
Camptocercus reticrostris	LIT	
Chydorus sphaericus	LIT	
Chydorus spp.	LCRANS, LIT	
Eurycercus lamellatus	LIT	
Eurycercus sp.	LCRANS, LIT	
Leydigia quadrangularis	LIT	
Leydigia acanthocercoides	LIT	
Leydigia sp.	LCRANS, LIT	
Other Chydoridae	LCRANS	
Monospilus dispar	LIT	
Pleuroxus striatus	LIT	
Pleuroxus denticulatus	LIT	
Pseudochydorus globosus	LIT	
Daphnidae		
Ceriodaphnia pulchella	LIT	
Ceriodaphnia quadrangula	LIT	
Ceriodaphnia reticulata	LIT	
Ceriodaphnia spp.	LCRANS, LIT	
Daphnia parvula	LIT	

Daphnia retrocurva	LIT	
Daphnia galeata	LIT	
Daphnia rosea	LIT	
Daphnia pulex	LIT	
Daphnia longispina	LIT	
Daphnia spp.	LCRANS, LIT	
Scapholeberis mucronata	LIT	
Scapholeberis sp.	LCRANS	
Holopediidae		
Holopedium gibberum	LCRANS	Cryptogenic
Leptodoridae		
Leptodora kindtii	LCRANS, LIT	Cryptogenic
Macrothricidae		
Illyocryptus sordidus	LIT	
Ilyocryptus sp.	LIT	
Macrothrix spp.	LCRANS, LIT	
Moinidae		
Moina spp.	LIT	
Polyphemidae		
Evadne nordmanni	LIT	
Pleopsis polyphaemoides	LIT	
Podon leuckartii	LIT	
Podon polyphemoides	LIT	
Podon sp.	LIT	
Sididae		
Diaphanosoma brachyurum	LIT	
Diaphanosoma sp.	LCRANS	
Sida crystallina	LIT	
Sida sp.	LCRANS	

Phylum: Arthropoda

Subphylum: Crustacea

Class: Malacostraca

Peracarida – Cumacea

Section write ups by John Chapman

Cumaceans small motile animals that brood their young in a pouch. Few species produce more than one or two brood in their life but they can reach great abundances in some areas nevertheless. Only *Cumella vulgaris* and *Nippoleucon hinumensis* were collected in the lower Columbia Riversurvey. Both species are tolerant of reduced salinities and are likely to be the only species that permanently reside in the estuary. All other

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea

Cumacean species reported in the lower Columbia River are either obligate marine species that are perhaps were incidental or are likely misidentifications.

Diastylidae			
	Colurostylis occidentalis	LIT	Native^
	Colurostylis spp.	LIT	
	Diastylopsis dawsoni	LIT	Native^
	Diastylopsis spp.	LIT	
Lampropidae			
	Lamprops sp. A	LIT	
Leuconidae			
	Eudorellopsis sp.	LIT	
	Hemileucon comes	LIT	Introduced#
	Hemileucon spp.	LIT	
	Leucon sp.	LIT	
	Nippoleucon hinumensis	LCRANS, LIT	Introduced
Nannastacidae			
	Cumella vulgaris	LCRANS, LIT	Native

= probable misidentification, ^ = marine species

DIASTYLIDAE

Anchicolurus occidentalis (Calman, 1912)
LIT
Origin: Native

(Calman, 1912); *Colurostylis (?) occidentalis* - Calman, 1912:605,670, figs.100-112; *Colurostylis occidentalis* - Zimmer, 1936:439; Zimmer, 1940:61; Zimmer, 1941:35, fig.44; Lie, 1969:23; *Anchicolurus occidentalis* - Stebbing, 1912:176; Stebbing, 1913:130-131, figs.85-86; Gladfelter, 1975:242, tab.2; Gladfelter, 1975b:275; Bacescu, M., 1992:267,
An offshore marine species not encountered in the present survey and of doubtful occurrence in the non-marine LCR.

Diastylopsis dawsoni (Smith, 1880)
LIT
Origin: Native

Diastylopsis Dawsoni - Smith, 1880:(app B), 215B; Sars 1900:3(5-6):64; *Diastylopsis dawsoni* - Zimmer 1908:8(3):190; Calman 1912:41, 605, 662-666, fig. 81-90; Stebbing 1913:39:110, 111, fig. 66-67; Zimmer 1930:16(4)653; Zimmer 1941:5(1)(4):22, ffigs. 21-22; Zimmer 1943:12(1):169; Gamo 1963:79, pl 12 fig. 1; Lie 1969:23; Gladfelter, 1975b:275.

A probable native species not encountered in the present survey and of doubtful occurrence in the non-marine LCR. A complication with *Diastylopsis dawsoni*, however, is that it has been reported from the North Atlantic, and the western Pacific in addition to the eastern Pacific. Possibly eastern Pacific records of *D. dawsoni* are in fact the extremely similar native *Diastylopsis tenuis* and the western populations are a separate species. On the other hand fully marine species have been introduced to the eastern Pacific (Gosliner, T. 1995. The introduction and spread of *Philine auriformis* (Gastropoda: Opisthobranchia) from New Zealand to San Francisco Bay and Bodega Harbor. *Marine Biology*, 122: 249-255).

LEUCONIDAE
Hemileucon comes Calman,1907
LIT
Origin: Introduced – probable misidentification

Calman 1907:38-39, pl. 9, figs. 26-32; Bacescu 1988:149.
Hemileucon comes is native to New Zealand and its occurrence in the northeastern Pacific is unconfirmed. However it resembles and thus is a probable misidentified record of *Nippoleucon hinumensis* in the LCR.

Nippoleucon hinumensis Gamo, 1967
LCRANS, LIT
Origin: Introduced

Hemileucon hinumensis - Gamo 1967:151-156, fig 5-7; Cohen & Carlton, 1995:146; *Nippoleucon hinumensis* - Watling 1991:576; Hancock et al., 1997:524,574; Fields, W. & C. Messer, 1999:40; Ruiz, et al. 2000:503; Carlton, J.T., 2001:20.

The type locality of *N. hinumensis* is the brackish water Lake Hinuma, Honshu Japan. In the northeast Pacific, *Nippoleucon hinumensis* has been variously misidentified in collections from the northeast Pacific as *Leucon* or *Hemileucon*. Carlton (1979) did not find it in his comprehensive survey of San Francisco Bay NAS but then it became abundant and widespread in San Francisco Bay since at least 1986 (Cohen & Carlton 1995). *Nippoleucon hinumensis* could be a ballast water intoduction (Cohen and Carlton 1995) but it occurs even in estuaries of the NEP that do not receive ballast water traffic, and its spread along the northeastern Pacific coast prior to 1986 is unknown. Other mechanisms of introduction, including transplanted oysters from Japan have not been examined closely. *Nippoleucon hinumensis* is one of the many likely introductions of the NE Pacific that have not yet been published in the peer-reviewed sources. *N. hinumensis* ranges between Elliot Bay, Puget Sound Washington to San Francisco Bay in the NE Pacific (Cohen *et al.* 2001). Surprisingly Wasson et al. (2001) do not report *N. hinumensis* from Elkhorn Slough, California, which is only 150 km south of San Francisco Bay. *Nippoleucon hinumensis* can readily be confused with *Leucon* or *Hemileucon*.

NANNASTACIDAE
Cumella vulgaris Hart, 1930
LCRANS, LIT
Origin: Native

Hart, J.F.L. 1930:37-38, fig.5A-D; Zimmer 1943:154-158, figs.38-47; Lomakina 1958:255-257, fig.171; Lomakina 1968:69, fig.9(7-9); Shih, Figueira & Grainger, 1971:161; Gladfelter 1975:242,244, tab.2; Gladfelter 1975b:275; Valentin 1978:3; Bacescu, M., 1992:227-228.

Cumella vulgaris is tiny and common to abundant on shallow subtidal muddy/sand bottoms, of marine intertidal and rocky intertidal pools. It ranges from Alaska to central California (Gladfelter 1975, Basecu 1992:227) and tolerates extremely broad temperature and salinity ranges. Few species have such broad geographical and physiological ranges. *Cumella vulgaris* may consists of more than one species.

Phylum: Arthropoda

Subphylum: Crustacea

Class: Malacostraca

Peracarida – Tanaidacea

Section write ups by John Chapman

Tanaidacea are distant relatives of Isopoda with long bodies and chelate first walking legs. Tanaidaceans undergo complex sequential sex and morphology changes in response to local population and environmental conditions. The enormous morphological changes greatly complicate taxonomic analyses. The taxonomy of northeastern Pacific tananaidaceans is poorly resolved. As in all peracaridans, juvenile development is direct, requires significant parental care and occurs without a pelagic larval dispersal stage.

Leptocheliidae		
Leptochelia dubia	LCRANS	Cryptogenic
Tanaidae		
Sinelobus stanfordi	LCRANS	Introduced

LEPTOCHELIIDAE

Leptochelia savignyi (Kroyer, 1842)
LCRANS
Origin: Cryptogenic

(Kroyer, 1842); Ishimaru 1985(with citations); Dojiri & Sieg, 1997:213-214,217, figs.3.9, 3.10; Carlton, J.T., 2001:20.

Leptochelia savignyi has also been referred to as *Leptochelia dubia* in the northeast Pacific. However *L. dubia* is one of many synonyms of *L savignyi*. The *Leptochelia savignyi* complex occurs on all temperate and boreal marine coasts of the northern hemisphere but not in the Arctic Ocean (Ishimaru 1985). The biogeography and taxonomy of the species are too poorly resolved to decipher the native or introduced origins of this species. *Leptochelia savignyi* is a dominant benthic organism in many high salinity areas and its tube building can effect significant alterations of sediment stability in northeast Pacific estuaries. Few *L. dubia* were encountered in the Columbia River.

TANAIDAE

Sinelobus stanfordi (Richardson, 1901)
Syn: *Leptochelia philetaerus, Tanais estuaries, Tanais herminiae, Tanais philetaerus, Tanais stanfordi, Tanais sylviae*
LCRANS
Origin: Introduced

Richardson 1901b; Nunomura 1979; Sieg 1976; Lang 1956; Gardiner 1975; Gutu & Ramos 1995; Menzies & Miller 1970 & Miller 1968 (as "*Tanais sp*."); Sieg, J. & R.N. Winn, 1981:315-343; Sieg, J., 1983:31-39; Heard 2002:376.

Sinelobus stanfordi is a cosmopolitan, tropical and temperate latitude freshwater and marine, shallow water species with a complex taxonomy and massive list of synonymies (Sieg 1980:60-68, Sieg & Winn 1981:329, fig. 6). Very likely transported around the world since 1500 in association with solid ballast, in fouling communities associated the hulls of sailing ships and then again with ballast water and aquaculture transplants. Its origins in the LOWER COLUMBIA RIVERcould be due to many mechanisms. The specific name is by consensus among local taxonomists and the species epthet is very unlikely to remain after its taxonomy is more clearly resolved.

Phylum: Arthropoda

Subphylum: Crustacea
Class: Malacostraca
Peracarida – Isopoda

Section write ups by John Chapman

Isopoda occur in fresh and marine waters and in most terrestrial environments. Most isopods are dorsoventally flattened and have 7 pairs of walking legs of similar form. *Argaia*, and *Liriopsis* are parasites of marine fish, encountered only incidentally within the Columbia River. The all native Idoteidae species are marine and also are encountered only incidentally within the lower Columbai River.

A notable missing species in the lower Columbaia River is the Asian idoteid *Synidotea laevidorsalis* Miers, 1881 introduced to San Francisco Bay over 100 years ago. *Synidotea laevidorsalis* can reproduce in salinities as low as 10 PSU and occurs in Willapa Bay, Washington, immediately north of the lower Columbia River but has not been reported from the lower Columbai River. Possibly, the record of *Synidotea angulata* (below) was actually *S. laevidorsalis*.

Epicaridea	LIT

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea

Asellidae		
Caecidotea occidentalis	LCRANS, LIT	Native
Caecidotea racovitzai racovitzai	LCRANS, LIT	Introduced
Caecidotea sp cf *racovitzai* (fem)	LCRANS	Introduced
Caecidotea tomalensis	LIT	Native
Caecidotea sp.	LCRANS	
Bopyridae		
Argeia pugettensis	LIT	Native
Chaetiliidae		
Mesidotea entomon	LCRANS, LIT	Cryptogenic
Cirolanidae		
Excirolana chiltoni	LCRANS	Native
Cryptoniscidae		
Liriopsis pygmaea	LIT	Native#
Idoteidae		
Idotea fewkesi	LIT	Native
Synidotea angulata	LIT	Native#
Synidotea spp.	LIT	
Ligiidae		
Ligia pallasii	LCRANS	Native
Limnoriidae		
Limnoria lignorum	LIT	Native
Oniscidae		
Porcellio scaber	LIT	
Sphaeromatidae		
Bathycopea daltonae	LIT	Native
Gnorimosphaeroma insulare	LCRANS	Native
Gnorimosphaeroma oregonense	LCRANS, LIT	Native
Gnorimosphaeroma spp.	LIT	
Tecticeps convexus	LIT	Native#

= probably misidentification

ASELLIDAE

The epigean *Asellus* of the northeast Pacific consist of the native *A. alaskensis* Bowman & Holmquist, 1975, *A. occidentalis* Williams, 1972 and *A. tomalensis* Bowman 1974 and the introduced nonindigenous *A. hilgendorfii* Bovallis, 1886 and *A. racovitzai racovitzai* Williams, 1970. The incomplete taxonomy and geographical information on these species greatly complicates efforts to resolve their origins.

Caecidotea occidentalis (Williams 1970)
LCRANS, LIT
Origin: Native

See discussions of *A. tomalensis* and *A. racovitzai racovitzai* below.

Caecidotea racovitzai racovitzai (Williams, 1970)
LCRANS, LIT
Origin: Introduced

Asellus racovitzai racovitzai - Williams 1970:16, 17, 43-47, figs. 29, 31, 32; *Asellus communis* – Racovitza 1920:79-115; *Asellus tomalensis* – Winger et al. 1972:; *Caecidotea racovitztai* – Toft et al. 1999:; Toft et al. 2002:190, 193, fig. 2.

The palm of the propodus of the first pereopod bears a triangular process near the midpoint and the first pleopod of the male is subequal to the second pleopod. The mesial process of the endopod of the second male pleopod is present and the cannula is relatively long and narrow with the caudal process acutely pointed. *Asellus communis* was the first specie of North American *Asellus* to be described. Say's (1818) brief description provided no details or figures of the male sexual pleopods. It is uncertain whether any of the several subsequent redescriptions of this species (none of which referred to the type material) in fact apply to *A. communis* Say, 1818. Williams (1970) reports *Asellus racovitzai racovitzai* and A. communis from broad regions of the eastern Great Lakes and the northeastern U.S. William's (1970) western North American records of both species are from Echo Lake, Kings County, Washington.

The male triangular extension of the mid propodus of pereopod 1 and three tipped endopodite of the second pleopod clearly distinguish *Asellus racovitzai* from *A. communis*, *A. occidentalis* and *A. tomalensis*. Hatch (1947) reports *A. communis* from Ontario, Quebec and Nova Scotia, from the Arboretum, and the Plantation Pond, Lake Washington, Univ. Washington Campus. This species has been referred under *Caecidotea sp*. (Smith 2001, Thorp & Covich 2001). However, Birstein (1951:48-59) argues for the synonymy of Caecidotea under *Asellus,* which appears to have been accepted by Williams (1970) and Bowman (1974) and Miller (1975). Hatch's (1947) records and others assumed by Bowman (1975) to be *A. occidentalis* are not confirmed and could be in fact be *A. racovitzai* or *A. communis* "occurring in the side channels and on vegetated shores in areas of dense aquatic vegetation of the Columbia River".

Toft et al. (2002) review the criteria for nonindigenous species that apply to the possible introduction of C. racovitzai to the San Francisco Bay delta
Origins: Very likely, an introduction from the eastern U.S. but requiring more detailed taxonomic analyses.

Caecidotea* sp cf *racovitzai (Chapman)
LCRANS

These female specimens are possibly *Caecidotea racovitzai racovitzai* but cannot be identified with confidence. They should be counted as a record for the genus but not as additions to species lists.

Caecidotea tomalensis Harford, 1877
LIT
Origin: Native– possibly misidentified

Asellus tomalensis Harford 1877:53-54; Richardson 1904a:224-226. figs. 110-112; Richardson 1904b:668-669, figs. 15-17; Richardson 1905:431-433, figs. 487-489; Johansen 1922:156; Fee 1926:20-21; Van Name 1936:459-461, fig. 288 (part); Van Name 1940:133; Carl 1937:451; Hatch 1947:170-171, figs. 31-32; Ellis 1971:passim; Bowman 1974:431-441, figs. 9-11, 18-20,26-28, 29-39,35-37; Miller 1975:298, 308.

The dactyl and propodus palm of pereopod 1, postmandibular lobes of head and the distal endopod of male pereopod 2 closely match *A. occidentalis* of Williams (1970) and Bowman (1974). However, the male pleotelson is more similar to Williams (1970, fig. 53G) than to Bowman (1974, fig. 18). The pleotelson shape is constant among males ranging from 3-8 mm in length in sample 8.501x.

Asellus occidentalis is distinguished from *A. communis* and *A. racovitzae* (the only other species known from Washington and Oregon) by the absence of a anterior tooth and mid triangular process on the palm of the propodus of male pereopod 1 and by the absence of a process on the lateral edge of the base of the endopod of the male second pleopod. Characters that distinguish these *Asellus occidentalis* from the *A. tomalensis* are the long, triangular apex of the endopod of male pleopod 2, which is rounded in *A. tomalensis*, and the acute postmandibular lobes of the head, which are evenly rounded in *A. tomalensis*. The steeply inclined posterior edges of the telson of these specimens more closely match *A. tomalensis* of Bowman (1974). Ellis (1971) found *A. occidentalis* (as *A. tomalensis*) an intermittent pond adjacent to the south fork of the Klaskanin River in Clatsop County, Oregon, but not in apparently suitable habitats of the south fork above and below the pond. Williams (1970) in his revision of 14 epigean species of North American *Asellus*, lists only *A. occidentalis* as restricted to the Pacific coast (Oregon, Washington, British Columbia). The only other Pacific coast epigean species that Williams listed, (*A. communis* and *A. racovitzai*) were known then only from Echo Lake, Washington. Both, *A communis* and *A. racovitzai* where collected by E. L Bousfield 20 August 1955. Both of these species appear to be introduced to the Pacific coast from the eastern United States (Bowman 1974, Toft et al. 2002).

Williams (1970:13) considered Bousfield's material from Echo Lake and personal notes to be "of considerable interest" and included them in his publication: Bousfield personal commuication to Williams, (1 Sept. 1967) "Echo Lake is the type locality of *Crangonyx richmondensis occidentalis* H. & H., one of a species complex that is usually found together with *A. communis* in the east. . . . *Crangonyx psuedogracilis* Bousf., formerly thought to be endemic to eastern North America, has also turned up in material from Oregon and Washington cf. Bousfield, 1961, and indicates that freshwater peracaridans may have much wider distributions than formerly believed." Indeed, since Bousfield's 1967 note, the introductions of *C. pseudogracilis* (Costello 1993, Chapman 2000) and *A. communis* (Williams 1972, Chapman 2000) were discovered in Europe, and *A. racovitzai* has since appeared in San Francisco Bay (Toft et al. 1999, 2002).

Williams (1972) described his Pacific coast *Asellus* material as a new species (*Asellus occidentalis*) rather than *Asellus tomalensis* Harford, 1877 (as others had done e.g., Fee

1926, Carl 1937, Hatch 1947, Ellis 1971). William's justification of this designation was that the published descriptions of *A. tomalensis* were inadequate (Bowman 1974). The single type specimen of *A. tomalensis*, collected by Lockington in "Tomales Bay, and vicinity", California, was in the California Academy of Sciences, collections that were destroyed in the 1906 San Francisco earthquake. Attempts by William's colleagues to collect more specimens from Tomales Bay were unsuccessful. Willaims was therefore uncertain whether *A. occidentalis* was in fact, a distinct species from A. tomalensis. Bowman, concluding that *C. tomalensis* is a freshwater species, and accordingly searched adjacent creeks and ponds of Tomales Bay for it but without success. However, E. Iverson and J. T. Carlton later found specimens in a shallow pond adjacent to Bolinas Lagoon, less than 24 km south of Tomales Bay. Bowman's (1974) compared these topotypes with *A. occidentalis* and concluded that the two species are valid. However, the synonymies proposed by Bowman (1974) are for dates prior to Williams 1970 since the specimens were not examined.

The discovery of *A. racovitzai* in the Columbia River (see below) and its recent appearance in San Francisco Bay, since its discovery in Echo Lake in 1955, indicate that it is spreading on the Pacific coast. The inability of William's colleagues and of Bowman to find and *A. tomalensis* around Tomales Bay suggests that this species has a restricted or limited distribution in the region. Toft et al. (2002) could not confirm previous records of *A. tomalensis* in San Francisco Bay its absence the bay delta prior to European settlement while occurring in surrounding drainages is unlikely. The exclusive occurrence of *A. racovitzai* and *A. hilgendorfii* and complete absence of *A. tomalensis* in thousands of samples from the San Francisco Bay delta may indicate the local extinction of *A. tomalensis* and perhaps its replacement by *A. racovitai* and *A. hilgendorfii*.
Native to eastern Pacific but perhaps confused in the Columbia River with native or nonindigenous species.

BOPYRIDAE

Argeia pugettensis Dana, 1853
Syn: *Argeia pauperata* Stimpson, 1857; *Argeia calmani* Bonnier, 1900; *Argeia pingi* Yu 1935.
LIT
Origin: Native

Ranging from the Bearing Sea to southern California, Japan and Korea, *Argeia pugettensis* is a branchial parasite of Crangonid shrimps.

CHAETILIIDAE

Mesidotea entomon (Linnaeus, 1767).
Mesidotea Richardson, 1905. = *Saduria* Adams in White, 1852; Kussakin 1982:73-77, figs. 49-50; *Saduria entomon* - Schultz 1969:59, fig. 63.
LCRANS, LIT

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea
Origin: Native

Mesidotea entomon was formerly placed under *Oniscus* and several other genera. However, the identity of this large isopod has remained clear in the literature. In the northeast Pacific this species has been commonly known as *Saduria entomon*. The species is rare in muddy sands and gravels of coastal rivers, bays and beaches of Washington and Oregon but attracts attention due to its large size, reaching 30 mm in length.
Distribution - Circumpolar, western coast of North America to Pacific Grove, CA; Stockholm, Germany, Labrador, Kara Sea.

CIROLANIDAE
Excirolana chiltoni (Richardson, 1905)
LCRANS
Origin: Cryptogenic

(Formerly placed in *Cirolana*). British Columbia to CA; Japan, Taiwan, Hong Kong. Intertidal. = *E. kincaidi* (Hatch, 1947); = *E. vancouverensis* (Fee, 1926); = *E. japonica* Richardson, 1912 (See Brusca *et al.* 2004)

An open coastal and marine bay species of clean sand. Northeast Pacific species of these environments are commonly considered to be native due to the vast majority of of other species in those habitats that are native. However, the spread of the introduced Asian clam *Nuttallia obscurata* in these same environments from along the coast (see below) and the probable introduction of the surf zone diatom *Chaetocerus armatum* (Lewin, J. and Norris, R.E. 1970, Lewin, J. and Rao, V.N.R. 1975, Lewin, J. and Schaefer, C.T. 1983) indicate that the origins of many of these species should be examined more carefully.

CRYPTONISCIDAE

Liriopsis pygmaea (Rathke, 1843)
LIT
Origin: Native– probably misidentified

An obscure nearly cosmopolitan hyperparasite of rhizocephalin barnacles that infect lithodid crabs and hermit crabs (Lovrich et al 2004). The occurrence of this species in the LOWER COLUMBIA RIVERshould be held in doubt since none of the hosts are reported from the LCR.

IDOTEIDAE

Idotea fewkesi Richardson, 1905
LIT
Origin: Native

Richardson 1905:359-360, fig. 387-388; Fee 1926:17-18; Hatch 1947:218; Mezies 1950:161-164, pl. I, fig. A-I; Schultz 1969:76, fig. 93; Kussakin 1982:147-148, ffig. 108.

A common inhabitant of shallow water and rocky intertidal macrophytes from Alaska to southern California . *Idotea fewkesi* is a probable incidental species of the LOWER COLUMBIA RIVERand unlikely permanent resident.

Synidotea angulata Benedict, 1897
LIT
Origin: Native- possibly misidentified

Benedict 1897:395-396, fig. 6; Richardson 1899a:847-848, Richardson 1899b:268; Richardson 1905:376, figs. 418-419; Hatch 1947:220, fig. 97; Schultz 1969:68, fig. 77; Kussakin 1982: 245-247, figs. 181-182; Rafi & Laubitz 1990:2674, figs. 19-20;

The range of *Synidotea angulata* is British Columbia to Northern California and it occurs in full marine deep waters (57-69 m) that would not be expected in the LCR. However, *S. angulata* resembles and could be confused with the introduced *Synidotea laevidorsalis* Meirs, 1881. *Synidotea laevidorsalis* is a full estuarine low salinity species introduced over 100 years ago, (Chapman and Carlton 1991, 1994) but is known in the eastern Pacific only from San Francisco Bay, California and Willapa Bay, Washington.
Origin: Nativeif correctly identified. *Synidotea laevidorsalis* was reported for the first time in the northeast Pacific along with the original description of *S. angulata* (Benedict, 1897).

LIGIIDAE

Ligia pallasii Brandt, 1833
LCRANS
Origin: Native

Van Name 1936:46-44, fig. 7 (with synonymy); Hatch 1947:187-188.

Ligia pallasii is a cockroach-like isopod that scavenges decaying plant and animal material. It occurs in deep crevices of high intertidal rocky areas predominantly on open coasts and often near freshwater seeps. Females reach 2.5 cm in length.
Distribution - Alaska to Santa Cruz, California.

LIMNORIIDAE

Limnoria lignorum (Rathke, 1799)
LIT
Origin: Native

Hatch 1947:211-212, fig. 81; Kussakin 1979:315-316, figs. 181-182 (with synonymy).
Limnoira lignorum is conspicuous where it occurs because it bores into wood.

Distribution – Kodiak, Island, Alaska to Pt. Arena, California, 0-20 m, tolerant of low salinities.

ONISCIDAE

Porcellio scaber Latreille, 1804
LIT
Origin: Introduced

Van Name 1936:226-227 (with sysnonymies)

The most common introduced terrestrial isopod of western North America. A cosmopolitan species of European origin. = *Porcellio scaber americanus* Arcangeli, 1932 (Brusca et al. 2004)

SPHAEROMATIDAE
Bathycopea daltonae (Menzies and Barnard, 1959)
LIT
Origin: Native

Ancinus daltonae - Menzies and Barnard, 1959:31, fig. 25; *Ancinus granulosus* - Holmes & Gay; Schultz 1969:115; *Bathycopea daltonae* – Lyola & Silva 1971:217-222, fig. 5-7. Subtidal marine species of medium course greay sands. Monterey Bay to San Miguel Islands, CA. 19-20 m. Occurrence of this species in the Columbia River would be a range extension and thus is more likely to be a misidentification.
Distribution – Monterey to Santa Cruz Island, California, unless this record stands.

Gnorimosphaeroma insulare (Van Name, 1940)
LCRANS
Origin: Native

Syn: *Gnorimosphaeroma lutea* (Van Name, 1940). The species was formerly placed also in *Exosphaeroma* (Brusca et al. 2004, Kussakin 1979:409-410, figs. 263-264).

Distinguished from *G. oregonense* by pointed rather than square hinge notches between telson and 3rd pleonite, by the projection of the 3rd pleonite short of the lateral edge of the pleon. Morphological differences between *Gnorimosphaeroma insulare* and *G. oregonense* are subtle (especially comparing 4.897x and 5.898x of 10 July 2002, Young's Bay Rip rap). The shape of hinge notches vary with angle of perspective and the only illustrations are at different angles. The extension of the third pleonite and the body length are also variable. There seems to be no salinity gradation associated with their distributions in the Columbia River and they seem doubtfully distinct species.
Distribution - Popof Island, Alaska to San Nicolas Island, California. Fresh and brackish water estuaries and lagoons along the northeast Pacific coast. = *G. oregonensis lutea* Menzies, 1954; = *G . lutea* Menzies, 1954.

Hoestlandt, H. 1977. Description complementaire de l'isopode flabellifere *Gnorimosphaeroma insulare* Van Name et synonimie de *G. luteum* Menzies avec cette espece. *Crustaceana* **32**:45-54.

Gnorimosphaeroma oregonense (Dana, 1852)
LCRANS, LIT
Origin: Native

Syn: *Sphaeroma oregonensis, Sphareoma olivacea, Exosphaeroma oregonensis, Neospharoma oregonense, Gnorimosphaeroma oregonensis oregonensis* (Dana, 1852); *Sphaeroma oregonense* Dana, 1852:778; Atlas, 1855:pl.52; Stimpson, 1857:509; Richardson, 1899:836; Richardsonk, 1900a:223; Richardson, 1904b:214; Richardson, 1904c:659; Richardson, 1905:216; *Sphaeroma olivacea* Lockington, 1877:45; *Exosphaeroma oregonensis* Richardson, 1905b:296-298, figs.315,316; Richardson, 1909:92; Van Name, 1936:450-451, fig.282; Hatch, 1947:213, figs.82-83; *Neosphaeroma oregonense* Monod, 1932:67-82, fiug.74; Monod, 1936:123-124(partim:fig.70); *Gnorimosphaeroma oregonensis oregonensis* Menzies, 1954:8-11, fig.5,7A-E, 12; Riegel, 1959:272-284; *Gnorimosphaeroma oregonense* Hoestlandt, 1964:872-877; Miller, 1968:12-13; Schultz, 1969:129, fig.187a; Hoestlandt, 1973b:355-369, figs.1-9; Kussakin, O., 1979:406-407,409, figs.260-262.

Distinguished from *G. insulare* by square rather than pointed hinge notch between telson and 3rd pleonite, by the projection of the 3rd pleonite to the lateral edge of the pleon. This is one of the most ubiquitous northeast Pacific coastal isopods.
Distribution - Central California to Alaska, intertidal to 22 m.

Tecticeps convexus Richardson, 1899
LIT
Origin: Native

Tecticeps convexus - Richardson, 1899:837; Richardson 1905b:278, figs. 290-291; Kussakin 1979:347-350, figs. 210-211.

The previously known range of *T. convexus* is Oregon border to Point Conception, California (Brusca et al. 2004). Thus, specimens from the Columbia River would be a range extension or, the specimens could also be misidentified. *Tecticeps convexus* is a full marine species that occurs at depths of 0- 9 m

Phylum: Arthropoda

Subphylum: Crustacea
Class: Malacostraca
Peracarida – Amphipoda

Section write up by John Chapman

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea

The large order Amphipoda is represented locally by the suborders, Gammaridea, Caprellidea and Hyperiidea but only the Gammaridea permanently occupy the lower Columbia River. The Gammaridea however, are by far the most abundant and familiar suborder of benthic Crustacea in the fresh, brackish and marine waters of the loer Columbia River and occupy even the supralittoral fringe and in a few almost terrestrial habitats. Gammaridean amphipods, brood their eggs in a pericaridial pouch from which the fully formed young emerge. The juveniles do not have a specialized larval dispersal stage. The native *Corophium salmonis* and *Corophium spinicorne* are critical food sources of juvenile salmon in the lower Columbia River.

Ampeliscidae		
Byblis spp.	LIT	
Ansiogammaridae		
Anisiogammarus sp.	LIT	
Eogammarus confervicolus	LCRANS, LIT	Native
Eogammarus sp. A	LCRANS, LIT	Native
Eogammarus sp.	LIT	
Rammellogammarus oregonensis	LIT	Native#
Rammellogammarus sp. A	LCRANS, LIT	
Aoridae		
Grandidierella japonica	LCRANS, LIT	Introduced
Atylidae		
Atylus tridens	LIT	Native
Corophiidae		
Americorophium brevis	LCRANS, LIT	Native
Americorophium salmonis	LCRANS, LIT	Native
Americorophium spinicorne	LCRANS, LIT	Native
Corophium acherusicum	LIT	
Crangonyctidae		
Crangonyx floridanus subgroup	LIT	Cryptogenic#
Crangonyx pseudogracilis	LCRANS	Introduced
Crangonyx spp.	LIT	
Haustoriidae		
Eohaustorius brevicuspis	LCRANS	Native
Eohaustorius estuaries	LCRANS, LIT	Native
Eohaustorius sp.	LIT	
Monoporeia affinis	LIT	Cryptogenic#
Monoporeia sp.	LIT	
Hyalellidae		
Hyalella azteca	LCRANS, LIT	Cryptogenic
Hyalidae		
Allorchestes angusta	LIT	Native
Hyperiidae		
Hyperoche spp.	LIT	

Isaeidae		
Photis macinerneyi	LIT	Native
Photis spp.	LIT	
Lysianassidae		
Hippomedon columbianus	LIT	Native
Melitidae		
Melita cf. nitida	LCRANS	Introduced
Oedicerotidae		
Americhelidium shoemakeri	LIT	Native
Americhelidium spp.	LIT	
Pacifoculodes spinipes	LIT	Native
Pacifoculodes spp.	LIT	
Phoxocephalidae		
Foxiphalus obtusidens	LIT	Native
Grandifoxus grandis	LCRANS, LIT	Native
Mandibulophoxus gilesi	LIT	Native
Paraphoxus sp.	LIT	
Rhepoxynius abronius	LIT	Native
Rhepoxynius daboius	LIT	Native
Rhepoxynius heterocuspidata	LIT	Native
Rhepoxynius tridentatus	LIT	Native
Rhepoxynius spp.	LIT	
Talitridae		
Megalorchestia pugettensis	LCRANS	Native
Traskorchestia traskiana	LCRANS	Native

ANSIOGAMMARIDAE

Only two native species of Anisogammaridae appear to exist in the present lower Columbia River, *Eogammarus confervicolus* and *Ramellogammarus sp. A. Ramellogammarus sp. A* appears to be a new species, distinct from *Ramellogammarus oregonensis* and *R. vancouverensis*.

Eogammarus confervicolus (Stimpson, 1856)

LCRANS, LIT
Origin: Native

Mara confervicola - Stimpson, 1856:90; *Gammarus confervicolus* - Stimpson, 1857:520-521; Holmes 1904:239; Bate, 1862:218, pl.38, fig.9; *Melita confervicola* - Stebbing, 1906:428; *Anisogammarus (Eogammarus) confervicolus* - Barnard 1954a:9-12, pls.9-10; Bousfield, 1958:86, fig.10; Tzvetkova 1972; Tzvetkova 1975; *Anisogammarus confervicolus* - Saunders 1933:248; Carl 1937; Barnard, J.L. 1954; Filice, F.P., 1958:183; Shoemaker, 1964:423-427, figs.14-15; Bousfield, E.L. & J.D. Hubbard, 1968:3; Barnard 1975:351,358; *Eogammarus confervicolus* - Bousfield 1979:317-319, fig.4; Klink, R.W. 1980:242; Barnard & Barnard 1983:585; Austin, 1985:607; Carlton, J.T. & J. Hodder 1995:725; Staude, 1997:373, 383, fig. 18.75; Bousfield 2001:108.

Among the most prevalent species of estuary samples sites in the LCR. Sample 14.1135x has a particularly large specimen.
Distribution - Southeastern Alaska to southern California, 0-30m .

Eogammarus oclairi Bousfield, 1979
LIT
Origin: Native

Eogammarus oclairi - Bousfield 1979:319-321; Barnard & Barnard 1983:585; Austin, 1985:608; Staude, 1997:373, 383; Bousfield 2001:108.

The pesence of two spines rather than one on the distal ends of the telson lobes are the primary feature distinguishing *Eogammarus oclairi* from *E. confervicolus.* Whether differences between *E. confervicolus* and *E. oclairi* are due to speciation or intraspecific allometric variation is unclear. The largest specimens in the collections (samples, 28.725x, 17.1229x, 12.1249x, 40.1252x) are mixed in with *E. confervicolous* morphotypes. This largest specimen has two stout distal spines on one telson lobe and one on the other. *Eogammarus oclairi* is thus a doubtful species.

Ramellogammarus sp. A
LCRANS, LIT

Specimen 1.1164x (female, Ft. Canby interior, 25 June 2003) has tiny pleonal spines that might be considered spines. This species occurs only in completely fresh water and appeared to be replaced by *E. confervicolus* occurred where salinities exceeded about 5 PSU. The possibility that this "new" *Ramellogammarus* is the long lost *Rammellogammarus ramellus* seems remote. (Weckel, 1907) reports *Ramellogammarus (Gammarus) ramellus* from Portland, Oregon. But also that: “These specimens were larger and stouter than those from California.” Possibly Weckel misidentified his material and had *Rammellogammarus sp. A.* of this study. Either we did not find *Ramellogammarus ramellus* or Weckel's illustrations are misleading.

Rammellogammarus sp. A also does not appear to be *Ramellogammarus oregonensis* (Shoemaker, 1944) or *Ramellogammarus vancouverensis* Bousfield, 1979. Dorsal pleon spines of *E. sp. A* are 6-12 and variable in number and positioned on the extreme posterior edge of the pleonites. The pleonal spines of *R. oregonensis* and *R. vancouverensis* are clearly more anterior to the posterior pleonal edge than the spines of *R. sp. A.* Moreover, *R. ramellus* is without pleonal spines and *R. vancouverensis* have only 1-2 spines. Previous reports of *Ramellogammaurs ramellus, R. oregonensis* and *R. vancouverensis* from the Columbia River are probably in fact, *Ramellogammarus sp. A.* Only a single species seems to be involved whether it is a new species cannot be addressed here.

The eyes lack pigment and spines occur on the absolute posterior edges of pleonites 3, 2 and sometimes 1 which do not occur on *E. confervicolus*. Specimens 4.1085x (Gray's

River Log scrape, 6/26/2003); specimens 3.1329x (Sportsmens Club boat launch, Kalama, 6/27/2002, sample 9.3). A large male with typical *Eogammarus* peg-spines was found among among specimens 7.1013x (Creek below Lewis & Clark Falls, Gravel bucket swirl, 26 June 2003). An ovigerous female, the largest specimen is in sample 6.1153x (Gray's River, bryozoans etc. scraped from a log, 26 June 2003). The posterodorsal pleonites of this specimen are lined only with setae but the remaining 25 specimens have stouter spines.

Distribution – Known only known freshwater reaches of the Columbia River.
Origins – Presumed native, if it is indeed a good species, due to its extreme similarity to the native *Ramellogammarus* species and *Eogammarus confervicolous*.

Rammellogammarus oregonensis (Shoemaker, 1944)
LIT
Origin: Native

Anisogammarus (Eogammarus) oregonensis - Shoemaker, 1944:89-93, figs.1-2; Barnard 1954a:13; Bousfield 1961:5; *Ramellogammarus oregonensis* - Bousfield, 1979:340-341; Austin, 1985:608; Bousfield 2001:108.

Bousfield (1979) reports *R. oregonensis* from Creeks and lakes of Lincoln and Lane Counties in Oregon and Lake Oswego (Bousfield 1979). However, this species was also not observed in the survey.

Distribution - A freshwater species that ranges from Eureka, California north to Cape Flattery, Washington.

AORIDAE
Grandidierella japonica Stephensen, 1938
LCRANS, LIT
Origin: Introduced

Grandidierella japonica - Stephensen, 1938:179-184, figs. 1-2; Ueno 1938:156; Nagata 1960:179. Pl. 17, fig. 103; Barnard, J.L. 1975:333(key), 360; Chapman & Dorman 1975:105-108, figs.1-4; Page & Stenzel 1975; Stenzel et al. 1976; Nichols 1977; Carlton, J.T. 1979a:127,144,146-147,152,179,192,662-663,866-868,880; Carlton, J.T. 1979b:433; Hirayama 1984a:15, figs. 53, 55, 56; Austin, 1985:614; Barnard & Karaman 1991:196; Ishimaru 1994:33-34; Greenstein, D.J. & L.L. Tiefenthaler, 1997:101-105; Muir, D.G. 1997:51; Staude, 1997:386; Smith et al. 1999:8-9, figs. 1, 3; Carlton, J.T., 1999:9; Chapman 2000:tab. 2; Bousfield 2001:112; Lowry & Stoddart 2003:71.

Distribution - Japan: Eastern coast of Japan, from Nakaminata, Honshu to southern Point of Kyushu, and southern coast of Korea between Pusan and Wando, including islands of Korea Strait. North America: Frasier River estuary, British Columbia, south to Bahia de San Quintin, Baja California, Mexico. Australia: Sydney, from Port Macquarie south to Cape Howe at New South Wales on the Victoria border. Europe: southern

England. The Fraser River and English populations are at the highest latitudes any other populations of *Grandidierella* and far exceed the maximum latitude of the native *Grandidierella* populations of Japan. *Grandidierella japonica* is an estuarine species transferred around the world most likely with transplanted oysters and ballast water.

ATYLIDAE
Atylus tridens (Alderman, 1936)
LIT
Origin: Native

Nototropis tridens - Alderman, 1936:58-59, figs 20-25; *Atylus tridens* - Mills, 1961:25, fig.3; Barnard, J.L. 1966a:61; Barnard, J.L., 1975:340(key),346,359, fig.216; Klink, R.W. 1980:240; Austin, 1985:604; Staude, 1987:382, figs. 18.54, 18.63; Barnard & Karaman, 1991:265; Bousfield & Kendall, 1994a:10,20,22, fig. 9; Staude, 1997:361, 382, fig. 18.63; Bousfield 2001:97.
Distribution - Queen Charlotte Islands south along the outer coasts of British Columbia to Oregon and central California (Bousfield & Kendella 1994:22), 0-135m. *Atylus tridens* is an entirely marine species that is only likely to occur in the lower Columbia River incidentally

COROPHIIDAE
Americorophium brevis (Shoemaker, 1949)
LCRANS, LIT
Origins: Native

Corophium brevis - Shoemaker, 1949:70-72, fig.4; Barnard, J.L., 1954a:36; Barnard, J.L., 1975:340(key),359, figs.67,116,148,149; Otte, G., 1975:9, figs.4i-k,5g-I; Coyle & Mueller, 1981:9; Austin, 1985:615; Staude, 1987:349(key),386; Barnard & Karman, 1991:185; Staude, 1997:349, 386; Americorophium brevis - Bousfield & Hoover, 1997:90,92,95,97-98, fig. 17; Bousfield 2001:115.

Americorophium brevis is a predominatly shallow water marine and high salinity estuary species that usually occurs in fouling communities and open coasts and marine bays. Distribution - Prince William Sound, Alaska to San Francsico Bay, California, subtidal to 35 m (Bousfield & Hoover 1997:98).

Americorophium salmonis (Stimpson, 1857)
LCRANS, LIT
Origin: Native

Corophium salmonis - Stimpson, 1857:514-515; Stimpson 1857:74-75; Stebbing, 1906:692; Bradley 1908:235-241, pl.11, figs.20-27, pl.12, figs.28-35, pl.13, figs.38-39; MacGinitie 1935:700; Crawford 1937:603; Shoemaker, C.R. 1949:66-68, fig.1; Barnard, J.L., 1954a:36; J. Exp. Mar. Biol. Ecol. 1964:50; Otte, 1975:9(key), figs.4d-h,5d-f; Eckman 1979:437-457; Albright & Armstrong 1981:63 pp.; Wilson, S.L., D.L. Higley, & R.L. Holton 1981:273; Taghon 1982:295-304; Eckman 1983:241-257; Austin, 1985:615;

Staude, 1987:349(key),386, fig.18.26; Barnard & Karaman, 1991:186; Staude, 1997:349, 386, fig. 18.26; *Americorophium salmonis* - Bousfield & Hoover, 1997:90,92,94, figs.14-15; Bousfield 2001:116.

Distribution - Its northeast Pacific range extends from south Alaska to Humboldt Bay, California. *Americorophium salmonis* is an endemic estuary species that has been introduced above the tidal range of the Columbia River dams and into Putah Creek, California. *Americorophium salmonis* does not attach its tubes to solid substratums and occurs exclusively on muddy to sandy bottoms in of estuaries, and slow moving rivers. Native to coastal regions and introduced inland.

Americorophium spinicorne (Stimpson, 1856c)
LCRANS, LIT
Origin: Native

(Stimpson, 1856c); *Corophium spinicorne* - Stimpson, 1856c:89; Stimpson, 1857:514; Bradley, 1908:227, pls.9-10; Essig 1925:189-190; MacGinitie 1935:700; Carl 1937:450; Crawford 1937:604; Shoemaker, 1949:74-76, fig.6; Barnard, J.L. 1952b:33; Barnard, J.L., 1954a:36-37; Bousfield 1958b:111; Filice 1958:184; Aldrich, 1961:21, fig.2; Bousfield 1961:2; Reish & Barnard 1967:16; Bousfield & J.D. Hubbard 1968:6; Eriksen 1968:1-12; Barnard, 1975:340(key),359, fig.141; Otte, G., 1975:9, figs.4a-c,5a-c; Siegfried, Kopache & Knight 1980:296; Austin, 1985:615; Staude, 1987:349(key); Barnard & Karaman, 1991:186; Staude, 1997:349, 386; *Americorophium spinicorne* - Bousfield & Hoover, 1997:90-93, fig.13; Bousfield 2001:115; Thorp & Covich 2001:780,785.

An endemic polyhaline species endemic to tidal bays, estuaries and freshwater river mouths of the northeast Pacific that ranges between Amchitka Island, Alaska to Morro Bay, California. *Americorophium spinicorne* has been introduced above the tidal range of the Columbia River (e.g., Thorp & Covich 2000) and up other rivers by human activities. *Americorophium spinicorne* occurs on fouling surfaces and mud bottoms in association with the NZMS. Native to coastal areas.

Monocorophium acherusicum (Costa, 1851)
LIT
Origin: Introduced

Podocerus cylindricus - Say 1818:387-388; Lucas 1842:232; Stebbing 1914:372-373; *Corophium cylindricum* - Smith 1873:566; Holmes 1905:521-522; Paulmier 1905:167, fig.37(in part); Holmes 1905:521-522, fig.; Johansen 1930:93; Cowles 1930:351; Shoemaker 1930a:128-129; Kunkel 1981:171-173, fig.52; (*Corophium cylindricus* ?Stebbing 1914:372-373;); *Audouinia acherusica* - Costa 1851:24; *Corophium contractum* - Thomson 1881:220-221, fig.9; *Corophium crassicorne* - Walker 1895:318; *Corophium bonellii* - Barnard, K.H., 1932:244; *Corophium acherusicum* - Costa 1853:178; Costa 1857:232; Bate 1862:282; Heller 1867:51-52, pl.4, fig.14; Della Valle 1893:367, pl.1, fig.2, pl.8, figs.17-18,20-41; Sowinsky 1897:9; Sowinsky 1898:455;

Chevreux 1900a:109; Graeffe 1902:20; Stebbing, 1906:692-740; Chevreux 1911:271; Barnard, K.H., 1916:272-274; Stebbing 1917a:448; Ussing & Stephensen 1924:78-79; Chevreux 1925c:271; Chevreux & Fage 1925:368, fig.376; Chevreux 1926:392; Cecchini 1928b:309-312, fig.1; Cecchini 1928e:8, pl.1, fig.6a; Schellenberg 1928:672; Miloslavskaya 1931:61(footnote); Schijfsma 1931a:22-25; Monod 1931a:499; Fage 1933:224; Candeias 1934:3; Shoemaker 1934c:24-25; Cecchini-Parenzan 1935:227-229, fig.52; Shoemaker 1935c:250; Crawford 1936:104; Schellenberg 1936c:21; Schijsfma 1936:122-123; Crawford 1937:617-620, fig.2; Crawford 1937a:650; Monod 1937:13; Miloslavskaya 1939:148-149; Barnard, K.H. 1940:482; Bassindale 1941:174; Stephensen 1944a:134; Shoemaker 1947:53, figs.2,3; Mohr & LeVeque 1948a; Shoemaker 1949a:76; Soika 1949:210-211; Gurjanova 1951:977-978, fig.680; Reid 1951:269; Stock & Bloklader 1952:4-5; Barnard, J.L. 1954a:36; Hurley 1954e:442-445, figs.35-39; Reish & Winter 1954; Barnard, J.L. 1955a:37; Irie 1957:5-6, fig.6; Barnard, J.L. 1958; Barnard, J.L. 1959b:58; Barnard, J.L. 1959c:38 (with references); Nayar 1959:43-44, pl.15, figs.14-20; Reish 1959b:39; Nagata 1960:177; Reish 1960:100-101; Barnard, J.L. 1961:173,175,182; Barnard, J.L. 1961:169,176; Reish 1961a; Reish 1961c; Jones, M.L. 1961:288; Reish 1963a; Reish 1963b; Barnard, J.L. 1964a:111, chart 5; Reish 1964b; Reish 1964c; Johnson & Juskevice 1965; Nagata 1965c:317; Painter 1966; Reish & Barnard 1967:12-13,16; Ledoyer 1968:214; Fearn-Wannan 1968b:134-135; Reish 1968b:49; Keith 1969; Mordhukai-Boltovskoi 1969:485, pl.25, fig.2; Sivaprakasam 1969d:156, fig.14; Bellan-Santini 1971:260-261; Barnard, J.L., 1971a:59; Reish 1971a; Stout 1971:68; Barnard, J.L., 1972b:48; Reish 1972:78; Bousfield, 1973:201, pl.62.2; Griffiths 1974a:181-182; Griffiths 1974b:228; Griffiths 1974c:281; Barnard, J.L. 1975:338-340(key),359, figs.143,144, 147; Chapman & Dorman 1975; Griffiths 1975:109; Otte, G., 1975:10, figs.6i-k,7d-f; Page & Stenzel 1975; Reish et al. 1975; Standing et al. 1975; Armstrong et al. 1976; Otte, 1976:8(key), figs. 6,7; Chapman 1978; Carlton, J.T. 1979:144-145,152,156,172,192,202,629,653-656,658,859-860,863-875,879; Carlton, 1979:655 (distribution list, Alaska to California); Klink, R.W. 1980:240; Hong, 1983:143-147, figs. 6-8; Hirayama, 1984:13, fig.50; Austin, 1985: 615; Staude, 1987:386, fig.18,27; Barnard & Karaman, 1991:185; Kim, 1991:114, fig.26; Ishimaru, 1994:35; Staude 1997:351, 386, fig. 18.16, 18.27; Carlton, J.T., 1999:9; Monocorphium acherusicum - Bousfield & Hoover 1997:111,112, 117,118,119, fig,30; Bousfield 2001:116; Lowry & Stoddart 2003:90. . . . . and on and on . . . .(note - John Chapman)
Distribution – One of the most widely distributed and reported medium to high salinity estuary organisms, *Monocorophium acherusicum* occurs in all large estuaries at all latitudes less than 50^{o} (north or south).

In the northeast Pacific, its presence in central Alaska is not confirmed. However, it occurs in nearly every estuary from the Strait of Georgia to the Panama Canal and has likely been in the northeast Pacific for 200+ years. Not to finding it in the lower Columbia River survey was a surprise.

CRANGONYCTIDAE

Reports of *Crangonyx floridanus* subgroup and *Crangonyx spp.* in the lower Columbia River are likely to comprise a single species, *Crangonyx pseudogracilis*.

Crangonyx floridanus

LIT
Origin: Introduced – probably misidentified

Bousfield, E.L., 1963:2-6, figs.1-2; Barnard & Barnard 1983:434; Toft, J., T. Cordell, & C. Simenstad, 1999:35-36, tab.1, fig.1A; Bousfield 2001:101.

This Gulf coast species differs from *C. pseudogracilis* only by subtle, mostly microscopic characters that are seldom examined in routine synoptic surveys. The Columbia River records of this species are doubtful. More likely it is *Crangonyx pseudogracilis*. Distribution - Gulf coast, sloughs, swamps, caves, and ponds, San Francisco Bay, California. Introduced into San Francisco Bay but doubtful in the lower Columbia.

Crangonyx pseudogracilis Bousfield 1958

LCRANS
Origin: Introduced

Melita parvimana- Holmes 1905; ?*Crangonyx gracilis* - Forbes 1876:6; Hynes 1955; ?*Melita parvimana* Holmes 1904:506, fig.; *Eucrangonyx gracilis* - Kunkel 1918:94, fig.20; Johansen 1920:128; Hubricht & Mackin 1940:199, fig.7; *Eucrangonyx gracilis* - Tattersall 1937:593; *Crangonyx gracilis* - Hubricht 1943:691; *Crangonyx pseudogracilis* Bousfield 1958:102-105, fig.17; Mills 1964a:4-5; Bousfield 1973:68-69, pl 8.1; Holmes 1975; Gledhill et al. 1976; Thomas, J.D. 1976:90; Barnard & Barnard 1983:435; Austin, 1985:597; Pinkster et al. 1992; Costello 1993:292; Bousfield 2001:101.

Bousfield (1963) described *C. pseudogracilis* from the Napanee River, Ontario and from other material from Quebec, Vermont and Missouri. In the same paper, Bousfield reports the introduction of *C. pseudogracilis* to the British Isles based on specimens from Gloucestershire, England. Bousfield (1958:105) further reports that Holme's (1905:94, fig.) "*Melita parvimana*" from Connecticut is "unquestionably a Crangonyx and very probably a pseudocrangonyx". Bousfield (1958) distinguishes *C. pseudogracilis* from the superficially similar C. gracilis Smith 1871, "hence the specific name."

Crangonyx pseudogracilis "breeds in spring and throughout the summer" Bousfield (1958) and is frequently taken "along with *Gammarus fasciatus* and *Hyalella azteca*, though less often with *C. gracilis* and *G. pseudolimnaeus* (in northern areas)". The distribution and ecology of the species is "rivers, river mouths, lakes, sloughs, quarry ponds, dams, and other larger freshwaters that tend to be somewhat turbid and warm in summer".

The combination of bifid spines lining the palm, and singly inserted simple setae on lateral anterior edge of the propodus of female gnathopod 1 place specimens 31.503x, outside of Holsinger (1972) couplet 1. However, Bousfield (1958, fig. 17) clearly indicates the presence of these characters. Bousfield's (1973, pl. VIII) illustration of *P. pseudocrangonyx*. Figure 2A of *Crangonyx floridanus* from San Francisco Bay

Toft et al. (2002) is an unpublished illustration of *Crangonyx forbesi* (Hubricht and Mackin 1940) from the Subterranean Amphipod Database (http://web.odu.edu/sci/biology/amphipod/cc_pictu.htm).

The combination of comb setae lining the dorsal lateral edge of the outer ramus of male uropod 2, and special ventral spines on the inner margin of the outer ramus of male uropod 2 (unique among species of *Crangonyx*) distinguish this species from all others (Zhang 1998). However, Zhang's illustrations of *C. floridanus* and *C. pseudogracilis* indicate that morphological differences are subtle if they are real.
Distribution - Introduced to Great Britain and Ireland (Costello 1993), NW and NE North America, Oregon. Inhabits aquatic vegetation in still an slow flowing waters, including organically polluted and saline waters (Holmes 1975, Gledhill et al. 1976, Pinkster *et al*. 1992, Costello 1993). It clings to plants when removed from water and is thus further distributed in Ireland (O'Connor et al. 1991).

HAUSTORIIDAE

Eohaustorius brevicuspis Bosworth, 1973

LCRANS
Origin: Native
Eohaustorius brevicuspis - Bosworth, 1973:255, 257, 259, fig. 1k-o, fig. 2b, f, n; Austin, 1985:605; Staude, 1987:383,372(key); Barnard & Karaman, 1991:363; Bousfield & Hoover 1995:50, fig.10; Staude, 1997:372, 383, fig. 18.11; Bousfield 2001:107.

Samples 11.1389x, (Baker Bay, Fort Columbia Tide flats, 11 June 2002), specimens do not have a cusp on the dorsal posterior of basis of pereopod 7 and pereopod 6 have only a single seta on the lateral faces of articles 5 and 6. These differences are consistent and suggest that these populations are a new species. However, a single individual of specimens 7.993x (Sand Island, Outer Beach, High Intertidal 25 June 2003) has the dorsal cusp and all specimens have two or more setae on the lateral faces of articles 5 and 6 of pereopod 6. Size, instar, age, seasonal differences in morphology should be examined in these species.

Distribution - Central California north to the Strait of Juan de Fuca (Bousfield & Hoover 1995:50) in high beach pools, river mouths, and estuaries in clean sand, 0-1 m.

Eohaustorius estuarius Bosworth 1973

LCRANS, LIT
Origin: Native

Eohaustorius estuarius - Bosworth, 1973:257-258, 259, figs. 2c, g, i-m; Austin, 1985:607; Staude, 1987:372(key),383, fig. 18.11; Barnard & Karaman, 1991:363; Bousfield & Hoover 1995:40,41,42, fig.4; Staude, 1997:372, 383; Bousfield 2001:107.
Distribution - Occurring in clean sand areas of estuaries and freshwater seeps and is very abundant in sandy areas of the lower Columbia River. Does not occur in completely

fresh water. Sample 120.991 (inside Coast Guard Jetty 25 June 2002). *Eohaustorius estuarius* was the most abundant *Eohaustorius* and the only species other than *E. brevicuspis* encountered in the LCR. Since *Eohaustorius* are difficult to distinguish, the other species identified previously from the LCR, *Eohaustorius sawyeri* and *Eohaustorius washingtonianus* are more likely to be *E. estuaries.* Distribution - Oregon, Eureka, California north to Cape Flattery, Washington, 0-7m.

Monoporeia sp.
Syn: Previously misidentified as *Pontoporeia affinis.*
LIT
Origin: Cryptogenic

The Columbia River population is the only population of the genus reported south of Alaska. This disjunct distribution has all appearances of a cold-water introduction, which would be unique among NE Pacific amphipods. However, the rapidly evolving state of the taxonomy of pontoporeiids prevents a definitive identification of this species presently. This species is reported only from lower Columbia River, however, Jeff Cordell has seen it in other adjacent estuaries.

HYALELLIDAE
Hyalella azteca (Saussure, 1858)
LCRANS, LIT
Origin: Cryptogenic

Amphithoe aztecus - Saussure 1858:474; *Allorchestes knickerbockeri* - Bate 1862:250; *Hyalella dentata* - Smith 1874:609, fig.1; *Lockingtonia fluvialis* - Harford 1877:54; *Hyalella knickerbockeri* - Weckel 1907:54, fig.15; *Hyallela Hyalella azteca* - Bousfield 1996:183; Bousfield 2001:104; *Hyallela azteca* - Stebbing 1906:575; Stout, V.R. 1913:635; Saunders 1933:245, fig.1; Shoemaker 1942b:80,82; Bulycheva 1957:181, figs.66a-b; Bousfield 1958b:109, fig.20; Bousfield 1961:5; Bousfield 1973:154, pl 43.2; Thomas, J.D. 1976:91-92; Barnard & Barnard 1983:708; Austin, 1985:595; Bousfield 1996:206, 207-209, figs. 3, 12, 17E; Hendrycks & Bousfield 2001:28, figs.4-5,6a,14; Bousfield 2001:104; Gonzalez & Watling 2002:173-183, figs. 1-5.

Specimen from 7.767x Carroll's Channel Log raft, 26 June 2002 has particularly prominent dorsal carina on pleonites. This distinctive species, or species complex, has eluded taxonomist for 150 years and I am unable to resolve it here. Its very broad geographic distribution and many associations with introduced species, including introduced aquatic plants, suggest the almost certain possibility that populations have been moved about. However, the existance of many species within this complex is also likely. Resolution of the evolutionary origins of these populations and the role of humans in their distributions is not yet possible. Figure 2A of *Hyalella* from San Francisco Bay Toft *et al.* (2002) is an illustration from (Cole & Watkins 1977) of a specimen from Montezuma Well, Yavapai Co., Arizona.

Distributions - Fresh waters of north and central America and Caribbean islands north to the tree line of North America and in larger rivers seaward into tidal fresh waters, and fresh-water barrier beach lagoons (Bousfield 1973:154) and freshwater and slightly brackish waters of lakes, rivers, upper estuaries of Mexico and California north to Alaska (Hendrycks & Bousfield 2001:28).

Hyalidae
Allorchestes angusta Dana, 1856
LIT
Origin: Native

Allorchestes angustus - Dana 1856:177; Barnard 1952:20-23, pl. 5, figs. 2-6; *Allorchestes angusta* - Barnard 1974:42; Barnard, J.L. 1975:343(key),358; Barnard 1979:91, figs. 50-52 (part); Bousfield 1981:81, figs. 12, 13; Bousfield 1996:178, fig. 1; Barnard; Bousfield 1996:181; Hendrycks & Bousfield 2001:10, 24-25, 1-6h, 12; non *Allorchestes angustus* - Barnard 1954c:21-23, Pl. 21 (=*A. bellabella*); *Allorchestes oculatus* - Stout 1913:651?
Distribution - Japan northward through Kuriles, across Aleutian Chain to Alaska then southward to California, generally intertidal, phycophilous, rarely subtidal (Barnard, 1979), high rocky intertidal and among algae wrack in protected bays and high salinity estuaries, 0-4m

ISAEIDAE
Photis macinerneyi Conlan, 1983
LIT
Origin: Native

Conlan, 1983:54, fig.27; Austin, 1985:612; Barnard & Karaman, 1991:226; Staude, 1997:351, 385, fig. 18.33; Bousfield 2001:114; Cadien 2001:98.
Distribution - Lady Ellen Point, Broughton Strait, Vancouver Island south to Neah Bay, Clallam County, Washington (Conlan 1983) and southern California (Cadien, 2001), 0-45m. A probable incidental species in the LCR.

LYSIANASSIDAE
Hippomedon columbianus Jarrett and Bousfield, 1982
LIT
Origin: Native

Hippomedon denticulatus - Barnard 1954:4, pls. 2,3 (in part) not Bate 1857; Hurley 1963:137-140, fig.45; Barnard 1971:31-34, fig.21(form with gaped gnathopod 2); *Hippomedon columbianus* - Jarrett & Bousfield 1982:109-111, fig.3; Barnard & Karaman, 1991:490; Bousfield 2001:76; Cadien 2001:94.
Distribution - Oregon, 100-150m (Barnard 1971:34), British Columbia (Jarrett & Bousfield 1982), Southern California (Cadien 2001), 4-320m, probably incidental marine species of the LCR.

MELITIDAE
Melita cf. nitida (Smith, 1874)
LCRANS
Origin: Introduced

Melita nitida - Smith, 1874; Shoemaker, C.R., 1935b:70-71, fig.2; Light 1941:180-190; ?Barnard 1954f:161; Mills 1964a:5-7, fig. 1; Bousfield, 1973:65, pl.9.2; Barnard, J.L. 1975:361; Chapman & Dorman 1975; Levings & McDaniel, 1976:5?; Thomas, J.D. 1976:90-91; Chapman, C.J., 1977:101; Carlton, J.T. 1979a:120,146-147,192,672-673,859,868-869,877; Carlton 1979b:433; Sheridan 1980:61-62, Figs. 1-2; Barnard, J.L. & C.M. Barnard, 1983:665; Oritz 1983:26; Austin, 1985:610(part); Chapman, J.W. 1988:372-374, fig.5F; Jarrett & Bousfield 1996:51,57,59, figs.35,36; Carlton, J.T., 1999:9; Bousfield 2001:110; Faasse & Moorsel 2003:16-18, figs. 1&2, tabs. 1&2; *Melita sp.* - Light 1941:180; *Melita sp.A* - Barnard 1975:361; ?*Melita setiflagella* - Yamato, 1988:80-86, figs. 2-6; ? Kim et al. 1992b:116, 119, fig. 3; Jarrett & Bousfield 1996:51,61, fig.38c; non Melita nitida - Shoemaker, 1935:70, fig.2.

This is the first likely record of *M. nitida* from the Columbia River. The two damaged specimens, one male and one female are similar to *M. nitida* in the nearly bare posterior urosome, quadrate epimeron and general shape of male gnathopod 1, but the female coxa 5 does not have the extended posterior that appears to be a stridulating organ on *M. nitida* s.s.

Distribution - Southern British Columbia and nothern Washington, also in Columbia estuary, parts of San Francisco Bay and south of Point Conception, in summer-warm brackish localities (Jarrett & Bousfield 1996). North-western Atlantic distribution is from New England to at least the southern Gulf of Mexico, 0-20m. It may also occur in Japan if *Melita setiflagella*Yamato, 1988 proves to be a junior synonym.

OEDICEROTIDAE
Americhelidium shoemakeri (Mills, 1962)
LIT
Origin: Native

Synchelidium shoemakeri - Staude, 1997:362, 368; Synchelidium shoemakeri - Mills 1962:15-17, figs.4, 6A; Barnard, J.L. 1966a:79; Barnard, J.L. 1966b:27; Barnard, 1969a:195; Barnard, J.L. 1971b:51; Barnard, 1975:345(key), 363, fig.136; Klink, R.W. 1980:246; Austin, 1985:591; Staude, 1987:378; Barnard & Karaman, 1991:566; Thomas & McCann 1997:57, fig.2,36; *Americhelidium shoemakeri* - Bousfield & Chevrier 1996:132-134, fig.37; Bousfield 2001:91.
Americhelidium shoemakeri occurs in full marine sandy sediments from British Columbia to southern California and in the intertidal to 183m (Thomas & McCann 1997). Its occurrence within the LOWER COLUMBIA RIVERis likely to be incidental.

Pacifoculodes spinipes (Mills, 1962)
LIT
Origin: Native

Monoculodes spinipes - Mills, 1962:12-14, fig.3,6C; Barnard, J.L., 1962e:368-369, fig.10; Barnard, J.L., 1966b:26; Barnard, J.L., 1971b:51; Klink, R.W., 1980:246; Austin, 1985:591; Staude, 1987:378; Barnard & Karaman, 1991:560; Staude, 1997:362, 378; Thomas & McCann, 1997:55-56, fig.2.34; *Pacifoculodes spinipes* - Bousfield & Chevrier, 1996:103-104, fig.16; Bousfield 2001:92; non *Monoculodes spinipes* - Mills, cf. Barnard, J.L., 1962:368, fig.10.
Distribution - British Columbia to southern California, intertidal to 98m (Thomas & McCann 1997); North-eastern Pacific boreal, 0-50m. Occurrences of thus fully marine species in the LOWER COLUMBIA RIVERare probably incidental.

PHOXOCEPHALIDAE
Grandifoxus grandis (Stimpson, 1856)
LCRANS, LIT
Origin: Native

Phoxus grandis - Stimpson, 1856:90; Stimpson, 1857: 81-82; Stimpson, 1857:521-522; Pontharpinia grandis - Stebbing, 1906: 147; *Pontharpinia milleri* - Thorsteinson, 1941:82, pl. 5, figs.52-62; *Paraphoxus milleri* - Barnard, J.L., 1958:147; Barnard, J.L., 1960:266, pl 40; Barnard, J.L., 1975:362; *Pontharpinia longirostris* - Gurjanova 1938:263-267,385, fig.7; Gurjanova 1951:385-387, fig.235; *Pontharpinia robusta* - Gurjanova 1938:262-263, fig.6a; Gurjanova 1951:384-385, figs.233-234; Gr&ifoxus gr&is - Barnard, J.L., 1979:375; Barnard, J.L., 1980b:495-500, fig.1 upper right; Coyle, 1982:449, fig. 10 g, h; Austin, 1985:597; Barnard & Karaman, 1991:611; Jarrett & Bousfield, 1994a:63,64,67,68, fig. 1; Staude, 1997:363, 380, 503; Bousfield 2001:86.
Distribution – The range of *Grandifoxus grandis* is Dixon Entrance, Alaska to Pacific Grove, California, often occurring in reduced or brackish salinities (Jarrett & Bousfield 1994a:67) at depths of 0-1m. *Grandifoxus grandis* may permanently reside in the LCR.

Mandibulophoxus gilesi Barnard, J.L., 1957
LIT
Origin: Native

Mandibulophoxus uncirostratus - Barnard 1960a:359; Barnard 1969a:196; *Mandibulophoxus gilesi* - Barnard 1957a:433-435, figs. 1-2; Gray & McCain, 1969:189, fig.1; Barnard 1975:348(key),361; Barnard, J.L. & Drummond, 1978:91(key); Barnard & Karaman, 1991:620; Jarrett & Bousfield 1994b:78,80, figs.3,4; Klink, R.W. 1980:247; Staude, 1997:363, 380, 503; Bousfield 2001:87.
Distribution - Central British Columbia to southern California, intertidal to shallow subtidal depths and subtidally in substrata exposed to tidal currents (Jarrett & Bousfield 1994b:80) boreal, 0-14m

Foxiphalus obtusidens (Alderman, 1936)

LIT
Origin: Native

Pontharpinia obtusidens - Alderman 1936:54-56, figs.1-13,19; Hewatt 1946:199; Barnard, J.L. 1954a:4; *Parapinia sic pontarpioides* - Gurjaonva 1953:229; *Paraphoxus obtusidens* - Barnard, J.L., 1958a:147; Barnard, J.L., 1960:249-259, pl.33-37; Barnard, J.L. 1964a:105, chart 6; Barnard, J.L. 1964c:244; Barnard, J.L., 1966a:89; Barnard, J.L., 1966b:29; Barnard, J.L. 1969a:197; Barnard, J.L., 1970b:3; Barnard, J.L. 1971b:70; Barnard, J.L., 1975:362, pl. 72(22); *Foxiphalus obtusidens* - Barnard, J.L., 1979a:373; Klink, R.W., 1980:247; Barnard, J.L. & C.M. Barnard, 1982b:4-12, fig.1(part); Austin, 1985:597; Barnard & Karaman, 1991:610; Jarrett & Bousfield, 1994a:63,93,94; Staude, 1997:364, 380, 503; Thomas & McCann, 1997:78-79, figs.2.53, 2.59; Bousfield 2001:86; not - *Paraphoxus obtusidens major* - Barnard, J. L 1960:259-261, pl.32.
Distribution - Kuril Islands, Okhotsk Sea, Alaska, common from California to British Columbia in sandy tidepools, 0-210 m (Thomas & McCann 1997:79), 0-210, ?459m.

Rhepoxynius abronius (Barnard, J.L. 1960)
LIT
Origin: Native

Paraphoxus abronius - Barnard, 1960:203, pl.5; Barnard, J.L. 1966a:88; *Rhepoxynius abronius* - Barnard & Barnard, 1982a:26; Slattery, P.N., 1985:635--647; Robinson, A.M., et at. 1988:953-958, tables 1-4; Bousfield, 1990:13; Barnard & Karaman, 1991:629; Bousfield, 1991:84; Jarrett & Bousfield 1994a:63,108,109-110, fig. 21; Staude, 1997:363, 380, 506; Bousfield 2001:86.
Distribution - Queen Charlotte Islands southward to California, commonly and abundantly inshore and sub-tidally, mostly at surf-protected localities, in sand of protected bays and shorelines to below 50 m (Jarrett & Bousfield 1994a); San Diego: Point Conception, southern California south to Ensenada, Baja California, Bathyal, 9-274 m.

Rhepoxynius daboius (Barnard 1960)
LIT
Origin: Native

Paraphoxus daboius - Barnard 1960a:210-212, pls.10-11; Barnard 1966a:88; Barnard 1971b:70; *Rhepoxynius daboius* - Barnard 1979:372; Klink, R.W., 1980:248; Barnard, J.L. & C.M. Barnard, 1982a:30-32; Austin, 1985:599; Barnard & Karaman, 1991:629; Jarrett & Bousfield, 1994a:63,108,122, fig.26; Staude, 1997:363, 380; Thomas & McCann, 1997:95-96; Bousfield 2001:86.
Distribution - Alaska to southern California, 77-813m. An entirely marine species possibly incidental or misidentified in the LCR.

Rhepoxynius heterocuspidatus (Barnard, J.L., 1960)
LIT
Origin: Native

Paraphoxus heterocuspidatus - Barnard 1960:224-226, pls.19-20; Barnard 1964a:103,105; Barnard 1966a:89; Barnard 1969a:196-197; *Rhepoxynius heterocuspidatus* - Barnard 1979:372; Barnard, J.L. & C.M. Barnard, 1982a:38-42, fig.4 (part); Austin, 1985:599; Barnard & Karaman, 1991:629; Jarrrett & Bousfield 1994a:63; Staude, 1997:364, 380; Thomas & McCann, 1997:96, fig.2.75; Bousfield 2001:87.
Distribution - Point Conception, California to Bahia de Los Angeles, Baja California, 0-146m (Thomas & McCann 1997). Occurrences of *R. heterocuspidatus* in the LOWER COLUMBIA RIVERare doubtful.

Rhepoxynius tridentatus (Barnard 1954)
LIT
Origin: Native

Pontharpinia tridentata - Barnard, J.L. 1954a:4-6, pls.4-5; *Paraphoxus tridentatus* - Barnard, J.L. 1960a:261-265, pls.38-39; Barnard, J.L. 1966a:90; Barnard, J.L. 1969b:224; Barnard 1975:362; *Rhepoxynius tridentatus* - Barnard 1979:372; Klink, R.W. 1980:248; Barnard & C.M. Barnard, 1982a:42-44, fig. 6 bP7; Austin, 1985:599; Barnard & Karaman, 1991:629; Jarrett & Bousfield, 1994a:63,108,110; Staude, 1997:363, 380; Bousfield 2001:87; not: *Paraphoxus tridentatus pallidus* - Barnard 1960:261, pls. 38-39; not: *Paraphoxus heterocuspidatus* - Barnard 1960:224, pls.19-20.
Distribution - Puget Sound, Washington to vicinity of Point Conception, California, 0-89m (Barnard & Barnard 1982a). Occurrences of *R. tridentatus* in the LOWER COLUMBIA RIVERare probably incidental.

TALITRIDAE
Megalorchestia pugettensis (Dana, 1853)
LCRANS
Origin: Native

Orchestia (Talitrus) pugettensis - Dana, 1853&1855:859, t.57, fig.3a-d; Stimpson 1857:516; *Orchestoidea pugettensis* - Thorsteinson, 1941:pl.1, figs.1-9; Bousfield 1958:890, fig.2a,10i; Bousfield, 1961:7, fig.3; Bowers, 1963:317, figs.3e,4; Bousfield, 1975:355,364, fig.232; Bowers, 1975:357, fig.228; Staude et al., 1977:12, fig.20a; Klink, R.W., 1980:249; Bousfield, 1981:fig.18; *Orchestoidea corniculata* - Thorsteinson, 1941:55; *Talorchestia tridentata* - Stebbing, 1899:398, t.30b(male); *Megalorchestia pugettensis* - Bousfield, 1982b:37-38, fig.16; Austin, 1985:596; Staude, 1997:353, 355, 380; Bousfield 2001:106; Not - *O. Pugettensis* - Stebbing 1906a:528.
Distribution -Southern Alaska to central California, high intertidal coastal beaches and estuaries in high salinities and brackish water areas.

Traskorchestia traskiana (Stimpson, 1854)
LCRANS
Origin: Native

Orchestia traskiana - Stimpson 1854:98; Stimpson 1856:90; Stimpson 1957:517-518; Bate, S. 1862:19, pl.3, fig.4; Stebbing 1906a:534; Stout 1912:134, figs.74-75; Stout, V.R. 1913:635; Thorsteinson, E.D. 1941:54-55, pl.1, figs.1-9; Shoemaker 1942:13; Barnard, J.L. 1952b:23; Barnard, J.L., 1954a:23; Bousfield 1958a:885-887, figs.2d,10d; Bousfield 1961:3, fig.1-2; Barnard 1964a:116; Bousfield 1975:363, fig.236; Klink, R.W. 1980:249; Bousfield 1981:83, fig.17; *Orchestia sp*. - O'Clair 1977:446; *Traskorchestia traskiana* - Bousfield 1982b:10-13, fig.5; Staude, 1997:355, 380; Bousfield 2001:105; not *Orchestia taskiana* - Bulycheva 1957:166, fig.60.
Distribution - Amchitka Island, Alaska to Bahia de San Quintin, Baja California.

Phylum: Arthropoda

Subphylum: Crustacea
Class: Malacostraca
Peracarida – Mysida

Section write up by John Chapman

Mysids are integral components of nearshore, estuary and freshwater food-webs of western North America both as predators of and food for many commercially and recreationally important fishes. Mysids, being peracaridan crustaceans, brood their eggs in a brood pouch (thus the vernacular name "opossum shrimp"). The brood pouch is formed by inner lamellae extending from the walking legs and the hatched young emerge from the pouch after they are fully formed. And the young emerge fully formed. Although half of all mysid species in San Francisco Bay are introduced, no introduced mysids were found in this survey of the lower Columbia River.

Mysidae		
Acanthomysis macropsis	LIT	Native
Archaeomysis grebnitzkii	LIT	Native
Exacanthomysis spp.	LIT	
Neomysis integer	LIT	Native
Neomysis kadiakensis	LIT	Native
Neomysis mercedis	LCRANS, LIT	Native
Neomysis rayii	LIT	Native
Neomysis spp.	LIT	

Acanthomysis macropsis (Tattersall, 1932)
LIT
Alenacanthomysis macropsis Tattersall 1932; Neomysis macropsis Tattersall 1932; Li 1936; Alienacanthomysis macropsis Tattersall 1932; Holmquist 1981; Daly & Holmquist 1986:1208.
Distribution – California to Alaska in shallow water among eelgrass and algae, "not uncommon".
Origin: Native.

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea

Archaeomysis grebnitzkii Czerniasky, 1882
LIT
Callomysiss maculata - Holmes 1894; non *Archaeomysis maculata* - (Holmes 1894); Tattersall 1932 (see Holmquist 1975).
Distribution – California to western Alaska and Japan. Intertidal, common to abundant in open coastal, unprotected inland waters above sandy bottoms, uncommon in brackish waters.
Origins: native.

Neomysis integer (Leach, 1815)
LIT
Neomysis integer, Praunus integer, Neomysis vulgaris, Mysis scoticus - See Gordan 1957:367-368 for synonymy.

Neomysis integer is a dominant mysid shrimp in the upper reaches of estuaries in Europe where it occurs in non-tidal lagoons, isolated bodies of nearly freshwater, and in high shore hypersaline pools, but is rare in fully marine habitats. There are no other reports of this species in the lower Columbia. This record is either an unrecognized introduction into the lower Columbia River or a misidentification.
Origins: Introduced (not seen)

Neomysis awatchensis see *N. mercedis*
LIT

Neomysis kadiakensis Ortmann, 1908
LIT
Tattersall 1951:192-194; Gordan 1957:368; Daly & Holmquist 1986:1209; Kathman et al. 1986:202-203, fig.
Distribution – southern Alaska to southern California, neritic, to 200 m.
Origin: Native (not seen):

Neomysis mercedis Holmes, 1897
LCRANS, LIT
Neomysis awatchensis – Brandt 1851;Tattersall 1951:190-192; Banner 1954; Gordan 1957:366-367; *Neomysis mercedis* – Holmes 1897:199; Holmes 1900:222; Tattersall 1932b:318;Tattersall 1933:11; Scheffer & Robinson 1939:135; Banner 1948b:75; Tattersall 1951:187; Pennak 1953:323, 422; Smith et al. 1954:136; Gordan 1957:368; Daly & Holmquist 1986:1209; Kathman et al. 1986:204-205, fig.
Distribution - Southern Alaska to southern California, euryhaline, fresh to marine, littoral and shallow neritic marine waters.

A few 15 mm specimens (the greatest length observed), had a pointed antennal scale, quadrangular or rounded rostrum, widely separated spines of the telson of both sexes, and by the 4th male pleopod which has a short terminal article of the exopod (less than 1/3length first article) and the thick, short lateral extension of the endopod.
Origin: Native

Neomysis rayii
LIT
Tattersall 1951:181-186, figs. 68-71; Gordan 1957:368-369; Daly & Holmquist 1986:1209; Kathman et al. 1986:206-207, fig.

A probable misidentification or incidental species in the LCR.
Distribution – Kamchatka Peninsula, Russia and central California to northern Alaska, neritic to 300 m.
Origins: native.

Phylum: Arthropoda

Subphylum: Crustacea

Class: Malacostraca

Decapoda

Section write up by John Chapman

Decapoda have ten feet and a carapace that covers the united head and thorax. Decapoda are the most important crustacean food source for humans. *Cancer magister* is the most important commercially fished crustacean in the northeast Pacific. Decapod juveniles hatch out of the booded eggs at the nauplius stage (exept in peneid shrimps) and undergo extended larval dispersal before metamorphsis and settling back to the benthos.

* - unsuccessful introduction

Astacidae			
	Pacifastacus leniusculus klamathensis	LIT	Native
	Pacifastacus leniusculus trowbridgii	LIT	Native
	Pacifastacus leniusculus leniusculus	LCRANS, LIT	Native
Callianassidae			
	Neotrypaea californiensis	LCRANS, LIT	Native
Cancridae			
	Cancer magister	LIT	Native
	Cancer oregonensis	LIT	Native
	Cancer spp.	LIT	
Crangonidae			
	Crangon franciscorum franciscorum	LCRANS, LIT	Native
	Crangon nigromaculata	LIT	Native
	Crangon spp.	LIT	
	Lissocrangon stylirostris	LIT	Native
	Neocrangon alaskensis	LIT	Native
Grapsidae			
	Eriocheir japonica	LIT	Introduced*
	Hemigrapsus oregonensis	LCRANS, LIT	Native
Hippolytidae			

Heptacarpus brevirostris	LIT	Native
Nephropidae		
Homerus americanus	LIT	Introduced*
Palaemonidae		
Exopalaemon modestus	LCRANS, LIT	Introduced
Porcellanidae	LIT	
Upogebiidae		
Upogebia pugettensis	LIT	Native

ASTACIDAE

Pacifastacus leniusculus klamathensis (Stimpson 1857a)
LIT
Hobbs 1989:7, fig. 6 (with synonymy)
Distribution – British Columbia and Idaho south to central California, in cold, swift streams.
Origins: Native.

Pacifastacus leniusculus trowbridgii (Dana, 1852)
LIT
Hobbs 1989:7-8, fig. 5 (with synonymy)
Distribution – In North America: British Columbia, California, Idaho, Nevada, Oregon, Utah, and Washington, in streams and lakes. Introduced to Sweden (Svardson 1965:92) and Japan (Kamita 1970:140).
Origins: Native.

Pacifastacus leniusculus leniusculus (Dana, 1852)
LCRANS, LIT
Hobbs 1989:7, fig. 6 (with synonymy)
Distribution – British Columbia and Idaho south to central California, in cold, swift streams.
Origins: Native.

NEPHROPIDAE

Homerus americanus Milne-Edwards, 1837
LIT
Many unsuccessful introductions have been attempted in the region since 1874 without success Carlton 1979:691-695.
Not established*

THALASSINIDEA
CALLIANASSIDAE

Callianassidae see *Neotrypaea*
Neotrypaea californiensis (Dana, 1854)

LCRANS, LIT
Callianassa californiensis – Dana 1854; Hart 1982:58, 60, fig. 15; *Neotrypaea californiensis* - Manning & Felder 1991:771, fig. 10 (with synymy); Jensen 1995:43, 78, fig. 158.
Distribution – Mutiny Bay, Alaska to Punta Banda, Baja California, 0 – 50 m.
Origins: Native.
Manning, R. B. and D. L. Felder 1991. Revision of the American Callianassidae (Crustacea: Decapoda: Thalassinidea), Proceedings of the Biological Society of Washington 104-764-792.

UPOGEBIIDAE
Upogebia pugettensis (Dana, 1852)
LIT
Upogebia pugettensis - Schmitt 1921:115-116, fig. 77 (with synonymy); Williams 1986 (with synonymy); Hart 1982:52-53, fig. 12; Jensen 1995:43, 78, fig. 160.
Distribution – Valdez Narrows, Alaska to Morrow Bay, California.
Origins: native.
Williams, A. B. 1986. Mud shrimps, *Upogebia*, from the eastern Pacific (Thalassinidea: Upogebiidae), San Diego Natural History, Memoir 14:1-60.

BRACHYURA
CANCRIDAE
Cancer magister Dana, 1852
LIT
Hart 1982:23, 33, 34, 212, fig. 87; Jensen 1995:14, 27, 28, fig. 31.
Distribution – Pribilof Islands, Alaska to Santa Barbara, California, 0 – 179 m.
Origin: Native

Cancer oregonensis (Dana, 1852)
LIT
Cancer oregonensis - Schmitt 1921:234-235, Pl. 36, figs. 3-4 (with synonymy); Hart 1982:23, 33, 34, 210, fig. 87; Jensen 1995:36, fig. 29.
Distribution – Bering Sea to Santa Barbara, California, 0- 436 m.
Origin: native

CARIDEA
CRANGONIDAE

Crangon franciscorum franciscorum Stimpson, 1856
LCRANS, LIT
Holthuis 1980:150 (with citations); Butler 1980:101-102, 107; Jensen 1995:40-41, fig. 57.
Specimen #1120x, Ft. Canby, Jetty exterior, 25 June 2003, has C. nigricauda antenna scale and palm of leg 1 but short tooth on abdominal segment 5 rather than prominent long tooth.

Distribution – Resurection Bay, Alaska to San Diego, California, intertidal to 91 m. *Crangon franciscorum franciscorum* is the estuarine form that occasionally occurs in nearly fresh water and was once the basis of a commercial fishery in San Francisco Bay. This was the only form found in the survey.
Origin: Native

Crangon nigromaculata Stimpson, 1856
LIT
Holthuis 1980:150-151 (with synonymy); Butler 1980:95, 102; Jensen 1995:41, fig. 60. *Crangon nigromaculata* was once fished commercially along with *Crangon franciscorum franciscorum* in San Francisco Bay (Holthuis 1980).
Distribution – Northern California to Baja California, sand bottoms 5 – 174 m. Probably not correctly identified in the LCR.
Origins: Native.

Lissocrangon stylirostris (Holmes 1900)
LIT
Crangon stylorostris – Butler 1980:98-99, fig.; Jensen 1995:41, fig. 61; *Lissocrangon stylirostris* – Kuris & Carlton 1977:551-552.
Distribution – Chirikov Island, Alaska to San Louis Obisbo Bay, California.
Origins: native.

Neocrangon alaskensis (Lockington, 1877)
LIT
Crangon alaskensis - Holthuis 1980:150-151 (with original citations); Butler 1980:108-109, fig.; Kuris & Carlton 1977:547; Jensen 1995:40, fig. 59; *Neograngon alaskensis* - **Zarenkov 1965**.

Crangon alaskensis and *C. nigricauda* may be hybids (Jensen 1995).
Distribution - Bering Sea to San Diego, 0 – 555 m.
Origins: Native.
Zarenkov, N.A. 1965. Revision of the genus *Crangon* Fabricius and *Sclerocrangon* G.O. Sars (Decapoda,Crustacea) Zool. Zhur., 44(12): 1761-1775 (InRussian).

HIPPOLYTIDAE
Heptacarpus brevirostris (Dana, 1852)
LIT
Holthuis 1980:126 (with synonymy); Butler 1980:231-232, fig.; Jensen 1995:46, fig. 75. Abundant in rocky intertidal full marine areas in salinities 9-31 PSU.
Distribution – Attu, Aleutian Islands, Alaska to Bahia Magdalina, Baja California, intertidal to 128 m.
Origins: Native

PALAEMONIDAE
Exopalaemon modestus Heller, 1862
LCRANS, LIT

Leander modestus - Heller, 1862; *Leander czerniavskyi* - Brashnikov, 1907; *Leander czerniavskyi lacustris* - Brashnikov, 1907; *Palaemon leander* - modestus Gee 1925; *Leander modestus sibirica* - Brashnikov, 1907; *Exopalaemon modestus* – Holthius 1980:83.
Exopalaemon modestus is distinguished from *E. carinicauda* (introduced into San Francisco Bay Wicksten 1997) by its smaller chelae of the second pereopod and by two distal spines which extend beyond the tip of the median telson process, in contrast to the small distal spines of *E. carinicuada* which are short of the median telson process.
Distribution – In Asia, siberian prawn ranges from northern Korea to southern China in freshwater lakes and rivers. *Exopalaemon modestus* is presently known in the eastern Pacific only from the Columbia River and the Willamette River (Emmett *et al.* 2002:447-450).

[Ed. Note: CDFG reports *E. modestus* from the Sacramentor River see http://www.dfg.ca.gov/cabw/camlnetste.pdf but the author of this sectior is doubtful of correct identification]

Origins: Most probably introduced into the Columbia River with ballast water traffic from Asia sometime before 1995.

GRAPSIDAE
Eriocheir japonica de Haan, 1835
Japanese mitten crab
LIT
Abundant in San Francisco Bay, California and in northern Europe. One male specimen was caught on a line by a sturgeon fisherman in the Columbia River near Astoria in the summer of 1998. No other crabs of the genus *Eriocheir* have been captured since.
Origins: Introduced but not established in LCR.*

Hemigrapsus oregonensis (Dana, 1851)
LCRANS, LIT
Schmitt 1921:274-276, fig. 162 (with synonymy); Hart 1982:220-221, fig. 91; Jensen 1995:17, fig. 18.
Distribution – Resurection Bay, Alaska to Baja California, Mexico, almost exclusively intertidal, tolerates reduced salinities and fresh water for brief periods.
Origin: Native.

Phylum: Chordata

Subphylum: Vertebrata
Superclass: Osteichthyes

* - resulted in an unsuccessful introduction

Acipenseridae

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes

Acipenser medirostris	LIT	Native
Acipenser transmontanus	LIT	Native
Acipenser or *Scaphirhynchus*	LIT	Introduced*
Agonidae		
Occella verrucosa	LIT	Native
Pallasina barbata	LIT	Native
Stellerina xyosterna	LIT	Native
Ammodytidae		
Ammodytes hexapterus	LIT	Native
Anguillidae		
Anguilla sp.	LIT	Introduced*
Catostomidae		
Catostomus macrocheilus	LIT	Native
Catostomus platyrhynchus	LIT	Native
Centrarchidae		
Ambloplites rupestris	LIT	Introduced
Lepomis cyanellus	LIT	Introduced
Lepomis gibbosus	LIT	Introduced
Lepomis gulosus	LIT	Introduced
Lepomis macrochirus	LIT	Introduced
Lepomis microlophus	LIT	Introduced
Micropterus dolomieu	LIT	Introduced
Micropterus salmoides	LIT	Introduced
Pomoxis annularis	LCRANS, LIT	Introduced
Pomoxis nigromaculatus	LIT	Introduced
Characidae		
Piaractus brachypomus	LIT	Introduced*
Pygocentrus nattereri	LIT	Introduced*
Clupeidae		
Alosa sapidissima	LIT	Introduced
Cobitidae		
Misgurnus anguillicaudatus	LIT	Introduced
Cottidae		
Artedius fenestralis	LIT	Native
Cottus aleuticus	LIT	Native
Cottus asper	LIT	Native
Enophrys bison	LIT	Native
Hemilepidotus hemilepidotus	LIT	Native
Hemilepidotus spinosus	LIT	Native
Leptocottus armatus	LIT	Native
Scorpaenichthys marmoratus	LIT	Native
Cyprinidae		
Acrocheilus alutaceus	LIT	Native
Carassius auratus	LIT	Introduced
Ctenopharyngodon idella	LIT	Introduced
Cyprinus carpio	LIT	Introduced

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes

Mylocheilus caurinus	LIT	Native
Oregonichthys crameri	LIT	Native
Ptychocheilus oregonensis	LIT	Native
Rhinichthys cataractae	LIT	Native
Rhinichthys falcatus	LIT	Native
Richardsonius balteatus	LIT	Native
Tinca tinca	LIT	Introduced
Embiotocidae		
Amphistichus rhodoterus	LIT	Native
Cymatogaster aggregata	LIT	Native
Embiotoca lateralis	LIT	Native
Hyperprosopon anale	LIT	Native
Hyperprosopon argenteum	LIT	Native
Hyperprosopon ellipticum	LIT	Native
Phanerodon furcatus	LIT	Native
Rhacochilus vacca	LIT	Native
Engraulidae		
Engraulis mordax	LIT	Native
Esocidae		
Esox lucius x masquinongy	LIT	Introduced
Fundulidae		
Fundulus diaphanus	LIT	Introduced
Gadidae		
Lota lota	LIT	Native
Microgadus proximus	LIT	Native
Gasterosteidae		
Gasterosteus aculeatus	LIT	Cryptogenic
Gobiidae		
Lepidogobius lepidus	LIT	Native
Hexagrammidae		
Hexagrammos decagrammus	LIT	Native
Ophiodon elongatus	LIT	Native
Ictaluridae		
Ameiurus catus	LIT	Introduced
Ameiurus melas	LIT	Introduced
Ameiurus natalis	LIT	Introduced
Ameiurus nebulosus	LIT	Introduced
Ictalurus furcatus	LIT	Introduced
Ictalurus punctatus	LIT	Introduced
Merlucciidae		
Merluccius productus	LIT	Native
Moronidae		
Morone chrysops	LIT	Introduced
Morone chrysops x saxatilis	LIT	Introduced
Morone saxatilis	LIT	Introduced
Osmeridae		

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes

Allosmerus elongatus	LIT	Native
Hypomesus pretiosus	LIT	Native
Spirinchus starksi	LIT	Native
Spirinchus thaleichthys	LIT	Native
Thaleichthys pacificus	LIT	Native
Paralichthyidae		
Citharichthys sordidus	LIT	Native
Citharichthys stigmaeus	LIT	Native
Percidae		
Perca flavescens	LCRANS, LIT	Introduced
Stizostedion vitreum	LIT	Introduced
Percopsidae		
Percopsis transmontana	LIT	Native
Petromyzontidae		
Lampetra ayresii	LIT	Native
Lampetra richardsoni	LIT	Native
Lampetra tridentata	LIT	Native
Pholidae		
Pholis ornata	LCRANS, LIT	Native
Pleuronectidae		
Platichthys stellatus	LIT	Native
Pleuronichthys coenosus	LIT	Native
Psettichthys melanostictus	LIT	Native
Pleuronectidae		
Isopsetta isolepis	LIT	Native
Parophrys vetulus	LIT	Native
Poeciliidae		
Gambusia affinis	LIT	Introduced
Rajidae		
Raja binoculata	LIT	Native
Salmonidae		
Oncorhynchus clarki	LIT	Native
Oncorhynchus clarki x mykiss	LIT	Introduced
Oncorhynchus keta	LIT	Native
Oncorhynchus kisutch	LIT	Native
Oncorhynchus mykiss	LIT	Native
Oncorhynchus mykiss gairdneri	LIT	Native
Oncorhynchus nerka	LIT	Native
Oncorhynchus tshawytscha	LIT	Native
Prosopium williamsoni	LIT	Native
Salmo trutta	LIT	Introduced
Salvelinus confluentus	LIT	Native
Salvelinus malma	LIT	Native
Scorpaenidae		
Sebastes melanops	LIT	Native
Sebastes miniatus	LIT	Native

Serrasalmidae		
Piaractus brachypomus	LIT	Introduced
Squalidae		
Squalus acanthias	LIT	Native
Stichaeidae		
Lumpenus sagitta	LIT	Native
Syngnathidae		
Syngnathus leptorhynchus	LIT	Native
Trichodontidae		
Trichodon trichodon	LIT	Native

ACIPENSERIDAE

Acipenser medirostris Ayres, 1854 green sturgeon
LIT
Origin: Native

Origin: Nativedistribution: Pacific Coast of North America from Alaska to Baja California. In estuaries, the lower reaches of large rivers, and in salt or brackish water off of river mouths (Froese and Pauly 2003).

Acipenser transmontanus Richardson, 1836 white sturgeon
LIT
Origin: Native

Native distribution: Pacific Coast of North America from Alaska to Monterey, California. Considered landlocked in parts of the Columbia River drainage. Spends most of its time in the sea, usually close to shore then enters estuaries of large rivers and moves inland to spawn (Froese and Pauly 2003).

***Acipenser* or *Scaphirhynchus* sp. - unk.** Eastern sturgeon
LIT

At the conclusion of the 1905 Lewis and Clark Exhibition held in Portland, Oregon two specimen of Eastern sturgeon from the Atlantic coast of North America (exact species unknown) were released into Guilds Lake on the Willamette River (Lampman 1946). However, no sightings or catches of Eastern sturgeon have been reported in the lower Columbia River since then. It is likely that these fish perished naturally or were caught prior to the opening of Guild’s Lake to the Willamette River in 1909.

AGONIDAE

Occella verrucosa (Lockington, 1880) warty poacher
Synonyms: *Brachyopsis verrucosus*
LIT
Origin: Native

Marine species, distributed throughout the Eastern Pacific from Bristol Bay, Alaska to California (Froese and Pauly 2003). Probably an infrequent visitor to the lower Columbia River estuary.

Pallasina barbata (Steindachner, 1876) tubenose poacher
Synonyms: *Siphagonus barbatus*
LIT
Origin: Native

Intertidal species often found in ellegrass or seagrass beds. Native distribution: North Pacific from the Sea of Japan to the Bering Sea and to Central California (although this may represent two subspecies) (Froese and Pauly 2003).

Stellerina xyosterna (Jordan & Gilbert, 1880) pricklebreast poacher
Synonyms: *Brachyopsis xyosternus*
LIT
Origin: Native

Demersal, marine species. Native distribution: Eastern Pacific from British Columbia to Baja California (Froese and Pauly 2003).

AMMODYTIDAE

Ammodytes hexapterus Pallas, 1814 Pacific sand lance
LIT
Origin: Native

Origin: Nativedistribution: Arctic and Pacific south to Southern California, and the Western Atlantic (although this may be a separate species) (Froese and Pauly 2003). Found in brackish and marine waters in schools or buried in the sand.

ANGUILLIDAE

***Anguilla* sp.** eel
LIT
Origin: Introduced

Unsuccessful introduction. Reports of *Anguilla* on the west coast of North America were reviewed by Williamson and Tabeta (1991) following the capture of several eels presumed to have escaped or released after importation as live seafood. J.L. Galbreath captured three unidentified eels of the genus Anguilla in the Willamette River at Portland in 1981, 1982 and 1983. Williamson and Tabeta (1991) concluded that all of the eels captured on the West Coast were the result of intentional or unintentional introductions and do not represent natural spread via oceanic currents. In addition, *Anguilla* eels are catadromous, spawning in areas of the open ocean where temperatures and salinities are consistently high. Such areas are not available to eels on the west coast of North America and introduced *Anguilla* would be unable to successfully reproduce upon reaching maturity. With no further reports of eels we assume that this limited introduction has been naturally extirpated from the lower Columbia River basin.

CATOSTOMIDAE

Catostomus macrocheilus Girard, 1856 largescale sucker
LIT
Origin: Native

Native to Western North America (Froese and Pauly 2003).

Catostomus platyrhynchus (Cope, 1874) mountain sucker
Synonyms: *Minomus platyrhynchus*, *Pantosteus jordani*, *Pantosteus columbianus*
LIT
Origin: Native

Native to Western North America (Froese and Pauly 2003).

CENTRARCHIDAE

Note: Identification of specific dates and mechanisms of introductions of Centrarchidae and other spiny-rayed fishes into the lower Columbia River Basin is complicated by several poorly documented intentional fish releases. In 1893 the United States Fish Commission (USFC, predecessor of the U.S. Fish and Wildlife Service) released 50 largemouth bass, *Micropterus salmoides,* along with “various sunfish” into the Willamette River just north of Salem from a shipment of fishes captured in the Illinois River (Lampman 1946). Anecdotal information compiled by Lampman (1946) suggests that the “various sunfish” included *Pomoxis annularis, Pomoxis nigromaculatus, Lepomis gibbosus, Ambloplites rupestris*, and other juvenile sunfish as well as several types of catfish and channel cats. Twelve years later, at the 1905 Lewis and Clark Centennial Exhibition in Portland, the USFC displayed a tank of spiny-rayed fishes. At the conclusion of the Exhibition these fishes were reportedly released into the waters of Guild’s Lake on the Willamette River (Lampman 1946). An accurate inventory of the exhibit is unavailable but one exhibitor recalled that the collection of freshwater fishes included large- and smallmouth bass (*Micropterus salmoides, M. dolomieu*.), crappies (*Pomoxis annularis, P. nigromaculatus*), bluegill (*Lepomis macrochirus)* and two eastern sturgeon (*Acipenser* or *Scaphirhynchus* sp.) (Lampman 1946). The waters of the lake were dammed for the exhibition but the dam leading to the Willamette River was removed in 1909 after which the lake was filled in and turned into an industrial site. Between 1905 and 1909 the lake was a popular fishing hole, especially for local youth

(Lampman 1946). Many of these repeatedly introduced species became established and *Pomoxis annularis, P. nigromaculatus, Micropterus dolomieu, M. salmoides, Lepomis macrochirus, L. gibbosus*, and *L. gulosus* continue to be captured in fish surveys of the Willamette and parts of the lower Columbia (Hutchinson and Aney 1964, Farr and Ward 1993, North et al. 2002).

Ambloplites rupestris (Rafinesque, 1817) rock bass
Synonyms: *Bodianus rupestris*
LIT
Origin: Introduced

Unsuccessful introduction. Native to the Great Lakes region of North America, *Ambloplites rupestris* was first introduced unsuccessfully into the Willamette River near Salem, Oregon along with large mouth bass imported from Ohio around 1888 by Gideon Steiner, a local fish and poultry businessman (Lampman 1946). In 1893 the USFC may have also unsuccessfully introduced the rock bass into the Willamette River (see overview of the Centrarchidae above). Since that time sporadic records of *A. rupestris* in the Willamette have been attributed to misidentifications of the successfully introduced warmouth *Lepomis gulosis* (Lampman 1946). *A. rupestris* has been introduced in several lakes and rivers in Washington (Wydoski and Whitney 1979) but it is unknown if any of these introductions have been spread into the lower Columbia River basin. However, intentional stocking of *A. rupestris* for sportfishing was widespread in the late 1800s through the 1940s with successfully established populations common in the Mid-West and the Mid-Atlantic states (NAS 2003).

Lepomis cyanellus Rafinesque, 1819 green sunfish
LIT
Origin: Introduced

Native to many river basins in central and eastern North America, *Lepomis cyanellus* may have been intentionally introduced in 1893 when the USFC released “various sunfish” captured in Illinois into the Willamette River just north of Salem (Lampman 1946). *L. cyanellus* may also have been introduced into Blue Lake (Hutchinson and Aney 1964), a small lake along the bank of the Columbia River near Troutdale, Oregon that continues to be popular with sport fishermen, but the date of that introduction is not known. *L. cyanellus* has been widely introduced throughout the west and, in California, has been held partially responsible for the decline of many native amphibians and fishes (NAS 2003, Moyle 1976). In the 1960s, an attempt by the Washington Department of Fish and Wildlife to extirpate *L. cyanellus* from Satcheen Lake, Washington failed (Wydoski and Whitney 1979). The status of *L. cyanellus* as an invasive species in the lower Columbia River Basin is elusive. Lampman (1946) reported that *L. cyanellus* might occur in the river basin and noted that while previous surveys of the Willamette River failed to capture this species a suspicious hybrid *Lepomis* (green sunfish hybridizes readily with other *Lepomis* (Moyle 1976)) had been caught. In addition, *L. cyanellus* has long been documented in Washington and Oregon at locations outside of the lower Columbia River drainage basin (Chapman 1942, Wydoski and Whitney 1979, Bond 1994) and Altman et al. (1997) report green sunfish present in two major rivers, the Pudding and the Tualatin, both which converge with the Willamette River

Lepomis gibbosus (Linnaeus, 1758) pumpkinseed
Synonyms*: Perca gibbosa*, *Eupomotis gibbosus, Pomotis vulgaris*
LIT
Origin: Introduced

Lepomis gibbosus, a sport fish native to many river basins in central and eastern North America, may also have been introduced in 1893 when the USFC released "various sunfish" captured in Illinois into the Willamette River (Lampman 1946). Although no records of this introduction exist with the USFC an editorial in *The Oregonian* makes special mention of this event reporting that *L. gibbosus* had been captured during a salvage operation on the overflowing waters of the Illinois River and released later in Oregon waters (Lampman 1946). A popular sport fish *L. gibbosus* has been widely and successfully introduced in the waters of Oregon and Washington and has been found in the Willamette and the lower Columbia River (Chapman 1942, Lampman 1946, Hutchinson and Aney 1964, Wydoski and Whitney 1979, Farr and Ward 1993, Bond 1994, Altman et al. 1997, and North et al. 2002).

Lepomis gulosus (Cuvier, 1829) warmouth
Synonyms: *Pomotis gulosus, Chaenobryttus gulosus*
LIT
Origin: Introduced

Easily misidentified as various other species of sunfish *Lepomis gulosus*, native to many river basins in central and eastern North America, may have been released into the Willamette in 1893 by the USFC but records of this species in the lower Columbia River basin were sporadic until the later half of the 20th Century. Chapman and DeLancy (1933) published the first report of warmouth from Washington State having capturing several fish during a survey in 1930 in a slough of the Kalama River near Kalama, Washington. It is worth noting the conspicuous absence of any mention of this species in Lampman (1946) as *The Coming of the Pond Fishes* is one of the most thorough reports of intentional and unintentional fish introductions into the Willamette and lower Columbia rivers prior to the 1950s. Current populations of warmouth may be derived from numerous plantings. Discussions of *L. gulosus* in Bond (1994) and Altman et al. (1997) indicate that the popular sport fish is widely established in the freshwaters of the lower Columbia Basin. Most recently Farr and Ward (1993) and North et al. (2002) confirmed the presence of *L. gulosus*, capturing it in fish surveys along the lower Willamette.

Lepomis macrochirus Rafinesque, 1819 bluegill, bluegill sunfish
LIT
Introduced

Similar in history to *Lepomis gulosus, L. macrochirus,* native to many river basins in central and eastern North America (Page and Burr 1991), is widely distributed throughout the Willamette and parts of the lower Columbia River Basin. *L. macrochirus* was likely to have first been intentionally introduced into the system during the 1893 USFC release of fish near Salem. Chapman and DeLancy (1933) captured two specimens of bluegill, along with *L. gulosis,* in 1930 near Kalama, Washington. Pond stocking and plantings by individuals may also have contributed to the successful establishment of the bluegill. *L. macrochirus* are regularly reported in fish surveys of the lower Willamette (North et al. 2002, Altman et al. 1997, and Farr and Ward 1993). According to Froese and Pauly (2003) several countries (South Africa, Kenya, Venezuela, Panama, Japan and Mexico) have reported adverse ecological effects after establishment of this widely introduced species sportfish.

Lepomis microlophus (Günther, 1859) redear sunfish
Synonyms: *Pomotis microlophus*
LIT
Origin: Introduced

Unlike many of the above sunfish, *L. microlophus* is native to the south-eastern United States (Page and Burr 1991). According to Mills et al. (1993), redear sunfish were first introduced into the Great Lakes Basin in 1928 and then spread into inland areas of the basin, making it less likely that the redear was introduced into the Willamette in the assortment of Illinois sunfish released by the USFC in 1893. Bond (1994) lists *L. microlophus* as found in parts of western Oregon including ponds in the Willamette Valley but includes no additional location information. Altman et al (1997) reports that *L. microlophus* has been recorded in the lower Willamette however none were captured in surveys by Farr and Ward (1993) or North et al. (2002). It is possible that reports of this species may be misidentifications of other introduced *Lepomis* or hybrids, and that introduced redear have not escaped the ponds mentioned in Bond (1994). If redear sunfish are present in the Columbia River Basin they might be considered a threat to endemic mollusks of concern as *L. microlophus* is a more voracious molluscivore than other sunfishes (NAS 2002). Ecological effects are unknown from introductions in other countries (Froese and Pauly 2003).

Micropterus dolomieu Lacepède, 1802 smallmouth bass, smallie, black bass, brown bass, white trout, green trout
Synonyms: *Centrarchus fasciatus*
smallmouth bass, smallie, black bass, brown bass, white trout, green trout

Established in the lower Columbia River basin. Native to the Midwestern United States (Scott and Crossman 1973), *Micropterus dolomieu* has been intentionally introduced throughout the world to enhance sport fishing (Froese and Pauly 2003). In 1874, Livingston Stone, inventor of the “aquarium car” used by the USFC to transport fish stock by rail across the U.S., transported 99 *M. dolomieu* from the east coast to California releasing the surviving 85 fish into tributaries of San Francisco Bay (Smith 1896). The first reported introductions of *M. dolomieu* to the lower Columbia River Basin took place nearly 50 years later in the 1920s. In 1923, fish from Wisconsin were introduced by a local game warden without the approval of the USFC into Lake Oswego, Oregon (Lampman 1946). The survival of these fish is uncertain however in 1924 the same game warden imported bass from a lake in the Puget Sound region and released them into the Willamette River (Lampman 1946). In 1925 *M. dolomieu* were planted in the middle stretch of the Columbia River Basin as well. *M. dolomieu* continue to be caught by recreational fishermen and in regional fish surveys (Farr and Ward 1993). In other states introduced *M. dolomieu* have been implicated in the decline or elimination of native fishes (Minckley 1973, Jenkins and Burkhead 1994). Smallmouth bass, which have been shown to prey on smolts of Pacific salmonids under laboratory conditions, may pose a threat to declining populations of wild salmon in the lower Columbia River Basin (Dentler 1993).

Micropterus salmoides (Lacepède, 1802) largemouth bass, black bass, green trout
Synonyms: *Labrus salmoides, Huro salmoides, Aplites salmoides, Perca nigricans, Huro nigricans, Grystes megastoma*
LIT
Origin: Introduced

With a native range stretching from the Great Lakes to the Gulf Coast of North America (Page and Burr 1991), *M. salmoides* is a popular sport fish and has been introduced widely throughout the world (Froese and Pauly 2003). The first largemouth bass were introduced to the Willamette River in 1888 in two separate plantings. Gideon Steiner (a fish and poultry businessman), feeling that the area lacked the “splendid eastern game fish of his childhood”, imported and released a shipment of *M. salmoides* and *Ambloplites rupestris* from Toledo, Ohio into Willamette River near Salem, Oregon (Lampman 1946). The same year a prominent Portland lawyer, Edward Bingham, released 25 bass into the Willamette River, presumably near his home in Lake Oswego, Oregon (Lampman 1946). Four years later, the USFC released 500 *M. salmoides* in the Willamette River with subsequent smaller releases throughout the lower Willamette Rive basin in 1895 (Smith 1896). Between 1890 and 1895 the USFC also planted 5442 largemouth bass throughout the state of Washington and 1597 largemouth bass in the Boise River (a population that was subsequently boosted by a private release of 2240 bass the same year in the middle stretch of the Columbia River basin) (Smith 1896, Lampman 1946). In early August 1898, The Oregonian reported the capture of the first largemouth bass in the Columbia River just downstream of where Bonneville Dam now stands. It is not known which of the aforementioned releases led to the establishment of largemouth bass throughout the lower Columbia River basin.

Along with other introduced predatory centrarchids *M. dolomieu* may also be responsible for declines in native amphibian populations (NAS 2003). Adult fish feed on other fishes, crayfish and frogs while immature *M. dolomieu* feed on crustaceans, insects and small fishes (Page and Burr 1991). Adverse ecological effects have also been reported from France, Italy, Japan, South Africa, Cuba, Guatemala, and Mexico (Froese and Pauly 2003).

Pomoxis annularis Rafinesque, 1818	white crappie, calico bass
Pomoxis nigromaculatus (Lesueur, 1829)	black crappie, calico bass

Synonyms: *Cantharus nigromaculatus, Pomoxis sparoides*
LIT
Origin: Introduced

It is largely impossible to discuss these two established species separately as they are often lumped together and referred to solely as "crappie," as *Pomoxis* spp., and/or misidentified as a single species (Dill and Cordone 1997). *Pomoxis* spp. are native to North America spanning the Great Lakes, Hudson Bay and Mississippi River basins, Ontario, Canada west to Minnesota and South Dakota, and south to the Gulf of Mexico (Page and Burr 1991). Two prominent releases of crappie into the lower Columbia River system were made by the USFC in 1893 and in 1905. In 1893 the USFC released 50 largemouth bass, *Micropterus salmoides,* along with "various sunfish," including crappie, into the Willamette River (Lampman 1946). At the 1905 Lewis and Clark Centennial Exhibition in Portland, the USFC displayed a tank of spiny-rayed fishes that were later released into the waters of Guild's Lake on the Willamette River (Lampman 1946). According to a member of the Oregon Game Commission the crappie were so abundant in Guild's Lake during their four year impoundment that small boys were catching large quantities of them using fish books baited with paraffin chewing gum (Lampman 1946). These fish are considered "harmless" by the IUCN and no ecological impacts have been reported from introduced locations around the world (Froese and Pauly 2003)

CHARACIDAE

Piaractus brachypomus (Cuvier, 1818) pirapatinga, pacu, red bellied pacu
Synonyms: *Myletes brachypomus, Colossoma brachypomum*
LIT
Origin: Introduced

One of several reoccurring but unsuccessful exotic aquarium species in the lower Columbia River Basin, *Piaractus brachypomus* is a tropical South American fish popular in the aquarium trade (Froese and Pauly 2003). The pacu is a member of the Serrasalminae family, a family that includes piranha, and these fish are often imported and sold under the misnomer "vegetarian piranhas." Pacu have a rapid growth rate and voracious appetite, and may readily outgrow the hobby tank they were originally housed in. These characteristics may lead frustrated fish owners to dispose of the fish in nearby waters. Pacu have developed a reputation as the species most often found in non-native waters that creates a piranha scare in the local media especially as juveniles are readily mis-identified as the traumatogenic red-bellied piranha (NAS 2003). The first *P. brachypomus* found in Oregon waters was a specimen caught in July 1988 by a fisherman in the Willamette River near the Port of Portland's Terminal Four (Logan et al. 1996). Since that time two additional *P. brachypomus* have been collected from the Willamette River in 1992 and 1995 respectively and two additional unverified sightings were reported from Hood River and Salem, Oregon in 1990 and 1991 (Logan et al. 1996). It is highly unlikely that all of these fish were the result of one single release but rather represent five separate releases. Logan et al. (1996) tested the thermal tolerance of *Piaractus* and determined that it is not low enough to tolerate to survive normal water temperatures found in the lower Columbia River basin from November through April making it impossible for these fish to overwinter in these waters. As these fish have a primarily herbivorous and insectivorous diet no adverse effects on local fish populations have been reported (Froese and Pauly 2003).

Pygocentrus nattereri Kner, 1858 red piranha, red-belly piranha
Serrasalmus nattereri, Pygocentrus altus, P. ternetzi.
LIT
Origin: Introduced

Unsuccessful introduction. *Pygocentrus nattereri*, a common aquarium species, is notorious for its reputation as a traumatogenic species (Froese and Pauly 2003). Concern about the establishment of this species in Florida or Texas in Gulf of Mexico drainages (where water temperatures are high enough for them to overwinter) is high. While the waters of Oregon and Washington are too cold in winter for *P. nattereri* to become established, this species could pose a threat to salmon smolts and other small fishes (Quinn 2003). In August 2003, a single *P. nattereri* was caught by a teenager in Johnson Creek, Oregon (a stream that drains to the lower Willamette) (Quinn 2003).

CLUPEIDAE

Alosa sapidissima (Wilson 1811) American shad, common shad, white shad
Synonyms: *Clupea sapidissima*
LIT
Origin: Introduced

Native to the Atlantic coast of North America from Labrador to Florida (Scott and Crossman 1973), shad were planted in the Sacramento River, California in 1871 having been transported across country from the Atlantic coast (Smith 1896). Although the Columbia River was intentionally stocked several times in the late 1880s (Smith 1896, Linder 1963, Wydoski and Whitney 1979) anecdotal evidence suggests that shad began showing up in the Columbia River as early as 1876 (Smith 1896) with the first published capture of a shad made by the ichthyologist David Starr Jordan in 1880 (Jordan 1916). Due to repeated introductions into the Sacramento and Columbia Rivers, *Alosa sapidissima* is now established on the west coast from Alaska to Baja California (Froese and Pauly 2003). Large runs of shad are common in the Columbia River and the impoundment of the Columbia may have improved conditions for spawning and rearing (Sherwood and Creager 1990, Weitkamp 1994, Petersen unpublished). Returns of introduced *A. sapidissima* to the Columbia River increased significantly between 1960 and 1990, and as a result, shad have become so abundant in the fish ladders that they may interfere with the passage of other fishes (NAS 2003). Although there is a commercial fishery for shad it is considered under-harvested (~ 9% of the population that passes through Bonneville Dam is caught annually by limited commercial and recreational fishing) because the timing coincides with an endangered summer Chinook salmon (Petersen et al. unpublished).

The ecological effects of *A. sapidissima* in the lower Columbia River are poorly understood. It has been speculated that juveniles could alter the zooplankton community, enhance the diet of resident predators, and/or compete with native salmon for habitat or food resources however data to support or dismiss these theories are limited (Petersen et al unpublished).

COBITIDAE

Misgurnus anguillicaudatus (Cantor, 1842) Oriental weatherfish, pond loach
Synonyms: *Cobitis anguillicaudata*
LIT
Origin: Introduced

Native to Eastern Asia, *Misgurnus anguillicaudatus* has been introduced into Hawaii, the U.S. mainland, the Philippines, Australia, Palau, Turkmenistan, and Mexico (Froese and Pauly 2003). The earliest records of *M. anguillicaudatus* in the continental United States date back to the 1930s when escapes from aquarium fish culture facilities were reported (Courtenay and Hensley 1980). While it is a popular aquarium fish and many introductions may be attributable to aquarium dumping this species has been introduced for the purposes of aquaculture in several countries where it is reared as a food fish, for bait, and for the aquarium industry (Froese and Pauly 2003, NAS 2003). *M. anguillicaudatus* has several life-history traits that may contribute to successful establishment – wide tolerance of physiological parameters, low vulnerability to predation, a flexible diet, and a high reproductive potential (Logan et al. 1996). In Oregon, an established population of *M. anguillicaudatus* has been reported from a diked secondary channel of the Clackamas River where it was discovered in the mid 1980s (Logan et al 1996). Several fish were also collected in 1997 from Multnomah Channel near the Columbia River (NAS 2003). Reports of *M. anguillicaudatus* are likely to under-represent their populations as these fish are typically found in shallow, muddy waters with dense vegetation, i.e. even when abundant they are difficult to capture with standard fish survey gear (NAS 2003). The dispersal ability of the Clackamas population of *M. anguillicaudatus* (and its relation to the population in Multnomah Channel) is unknown (Logan et al. 1996). It may be likely that these two occurrences are the result of separate aquarium releases. Adverse ecological impacts have been reported in Hawaii and Australia (Froese and Pauly 2003, NAS 2003) where these species are suspected of being carriers of fish pathogens and predators on native aquatic species.

COTTIDAE

Artedius fenestralis Jordan & Gilbert, 1883 padded sculpin
LIT

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes
Origin: Native

Intertidal marine species native to the eastern Pacific: from Alaska to Southern California *(*Froese and Pauly 2003).

Cottus aleuticus Gilbert, 1896 coastrange sculpin
LIT
Origin: Native

Cottus aleuticus is a catadromous sculpin, native to the Pacific Coast of North America from Alaska to Northern California *(*Froese and Pauly 2003). It inhabits gravel and rubble riffles of medium to large rivers and rocky shores of lakes and occasionally enters estuaries *(*Froese and Pauly 2003).

Cottus asper Richardson, 1836 prickly sculpin
LIT
Origin: Native

Native to Pacific coast drainages of North America. The coastal form of this species is catadromous. Sometimes used as a bait species. May have been introduced east of the Rockies in Canada (Froese and Pauly 2003).

Enophrys bison (Girard, 1854) buffalo sculpin
Synonyms: *Aspicottus bison*
LIT
Origin: Native

Native to the eastern Pacific from Alaska to central California, *Enophrys bison* is a marine species commonly found in inshore rocky and sandy areas (Froese and Pauly 2003).

Hemilepidotus hemilepidotus (Tilesius, 1811) Red Irish lord
Synonyms: *Cottus hemilepidotus*
LIT
Origin: Native

A commercially and recreationally harvested marine sculpin, *Hemilepidotus hemilepidotus* is native to the North Pacific from Kamchatka, Russia to central California (Froese and Pauly 2003).

Hemilepidotus spinosus Ayres, 1854 Brown Irish lord
LIT
Origin: Native

A marine species, *Hemilepidotus spinosus* is native to the eastern Pacific from southeastern Alaska to southern California (Froese and Pauly 2003).

Leptocottus armatus Girard, 1854 Pacific staghorn sculpin
LIT
Origin: Native

A brackish to marine species, *Leptocottus armatus* is native to the west coast of North America from Alaska to Baja California (Froese and Pauly 2003).

Scorpaenichthys marmoratus Girard, 1854 cabezon
LIT
Origin: Native

A marine species, *Scorpaenichthys marmoratus* is native to the west coast of North America from Alaska to Baja California (Froese and Pauly 2003).

CYPRINIDAE

Acrocheilus alutaceus Agassiz & Pickering, 1855 chiselmouth
LIT
Origin: Native

Native to the Pacific Northwest, *Acrocheilus alutaceus* is a freshwater fish that inhabits flowing pools, creeks and small to medium rivers (Froese and Pauly 2003).

Carassius auratus (Linnaeus, 1758) goldfish
Synonyms: *Cyprinus auratus, Cyprinus langsdorfi, Cyprinus thoracatus, Carassius chinensis, Cyprinus maillardi*
LIT
Origin: Introduced

Origin: Introduced throughout the world, goldfish are native to central Asia. *Carassius auratus* is cultured widely by the aquarium and ornamental pond trades. It is occasionally reared for use as bait and less frequently as a food item (Froese and Pauly 2003). Goldfish have been widely and repeatedly stocked in the United States from many points of origin, including both Asia and Europe. Having been bred for a range of body forms and colors there are many varieties of goldfish in U.S. waters. It is common for goldfish to hybridize with common carp *Cyprinus carpio* (another introduced species)(NAS 2003). During the late 1800s the USFC breed goldfish and distributed them to states as fish suitable for aquaria, fountains, and ornamental ponds (McDonald 1887, 1893 in NAS 2003). Introductions in the Pacific Northwest may represent escapes from private ponds (Smith 1896) as well as from aquarium releases by individuals (Courtenay and Hensley 1979). The earliest report of goldfish in the lower Columbia River basin comes from Lampman (1946) who notes seeing goldfish feeding in the Willamette River in 1933. Chapman (1942) reports capturing goldfish in surveys at the mouth of the Columbia River and near Kalama, Washington. In the 1960s, Hutchinson and Aney (1964) report goldfish scattered throughout the lower Willamette Basin. Wydoski and Whitney (1979) note that the distribution of goldfish in the northwest is "subject to constant change because people thoughtlessly discard goldfish into various waters," and also observed that a small number of goldfish were being raised locally for bait.

Ctenopharygodon idella (Valenciennes, 1844) grass carp, white amur
Synonyms: *Leuciscus idella*
LCRANS, LIT
Origin: Introduced

Grass carp (*Ctenopharyngodon idella*), also known as the white amur, is an herbivorous fish native to parts of eastern Asia from the Amur River of eastern Russia to southern China (NAS 2003). Grass carp have been widely introduced throughout the world although not all populations have become established (Froese and Pauly 2003). Rationalization for intentional stocking includes commercial aquaculture and exploration of aquaculture potential, research, establishment of a food resource, and biological control (Froese and Pauly 2003). First introduced from Malaysia into the U.S. by the USFWS Fish Farming Experimental Station in 1962, established populations of *C. idella* exist in parts of the Mississippi and Missouri Rivers, as well as in Alabama and Florida (Courtenay et al. 1984). Grass carp are reported to occur in 45 states (although establishment of populations is uncertain because of their primarily triploid status) where they can cause significant changes in macrophyte, phytoplankton and invertebrate communities, etc. The loss of aquatic vegetation caused by grass carp has been implicated in the decline of waterfowl habitat (NAS 2003). Stocking of triploid (functionally sterile) grass carp, both authorized and unauthorized, is a widely implemeted biological control method used to reduce unwanted aquatic vegetation. According to NAS (2003) "the species has spread rapidly as a result of widely scattered research projects, stockings by federal, state, and local government agencies, legal and illegal interstate transport and release by individuals and private groups, escapes from farm ponds and aquaculture facilities; and natural dispersal from introduction sites (e.g., Pflieger 1975; Lee et al. 1980 et seq.; Dill and Cordone 1997)." However, the effectiveness of grass carp as biological control has been criticized on several levels; grass carp often consume non-target native plants as well as or in preference to unwanted weeds (Taylor et al. 1984), the reproductive potential of triploids has been questioned (as has the success of suppliers in creating truly triploid fish), and the potential for negative interactions between grass carp and both invertebrates and fishes has been raised as a unwanted cost (Courtenay et al. 1984).

Grass carp will seek out and follow flowing water, so that all inlets and outlets of the pond or lake where they have been introduced for biological control must be screened. During flood events grass carp may escape even screened ponds. Loch and Bonar (1999) observed 49 adult grass carp migrating up the Columbia River in 1996 and 1997, emphasizing the need for the carp to be truly sterile. Although they may not be established (i.e. reproducing) in the lower Columbia River a repeated pattern of escape into the river, combined with the potential for non-triploid introductions, and the longevity of the species (10-40 years) have created an “artifically established” population in the lower river. Large grass carp are regularly caught in Youngs Bay and other parts of the lower Columbia River, and have been recorded passing through the fish ladders at Bonneville Dam (Jim Athern personal communication).

Cyprinus carpio Linnaeus, 1758 common carp
LIT
Origin: Introduced

Native to Eurasia (Page and Burr 1991) *Cyprinus carpio*, better known as the common carp, has been introduced into every state in the United States except Alaska (and it is believed to be established in all but Maine) (NAS 2003). Records disagree as to when and where the first carp were introduced. DeKay (1842 in NAS 2003) reported that the species was first brought into New York from France by a private citizen and released into the Hudson River a few years later but debate over the species identification exists for this and other early reports (NAS 2003). Smith (1896) reported that common carp first appeared in the United States in 1872 when several fish imported from Germany, planted in private ponds in Sonoma, California, propagated for commercial rearing, and distributed to individuals on the west coast for rearing as food fish (Lampman 1946). In 1880, one Captain Harlow of Portland, Oregon imported 35 mature German carp from San Francisco to breed and sell carp for stocking private ponds. In spring 1881, the Sandy River flooded and washed an estimated 3000 immature carp from Captian Harlow’s breeding pond into the Columbia River (Lampman 1946). This may not have been an isolated event as reports show that in 1877 the USFC imported carp from Germany and began shipping domestically breed carp to private applicants in Oregon and Washington as early as 1882 (Smith 1896, Lampman 1946). Within ten years of Captain Harlow’s carp escape *C. carpio* had established itself throughout the lower Columbia River basin and was no longer popular with the local fishermen. The Oregonian newspaper reported that locals were offering carp for sale for use as fertilizer at a price of $5/ton (Lampman 1946). In the Columbia River *C. carpio* continue to be abundant in the sloughs and inlets of the lower river (often hybridizing with *Carassius auratus*) and populations supported a small commercial fishery in Lake Vancouver, Washington through the late 1930s (Chapman 1942). Today, *C. carpio* is regarded as a potential pest species because of its widespread introduction and establishment, and because its feeding behavior (rooting in soft sediment) often leads to the loss of vegetation and increased sediment suspension (Laird and Page 1996). Of primary concern is the destruction of submerged and emergent aquatic vegetation that provide habitat for native fish and food for waterfowl (Dentler 1993). There is also evidence that *C. carpio* will prey on fish eggs (Moyle 1976). In the Pacific Northwest, Miller and Beckman (1996) documented white sturgeon *Acipenser transmontanus* eggs in the stomachs of common carp in the Columbia River.

Mylocheilus caurinus (Richardson, 1836) peamouth
Synonyms: *Clarkina caurina, Cyprinus caurinus*
LIT
Origin: Native

Native to the Pacific Slope of North America (Froese and Pauly 2003).

Oregonichthys crameri (Snyder, 1908) Oregon chub
Synonyms: *Hybopsis crameri*
LIT
Origin: Native, endangered

Endemic to the Willamette and Umpqua River drainages in Oregon. It is rare in Willamette because of habitat alteration (Froese and Pauly 2003). Loss of habitat combined with the introduction of non-native fish species to the Willamette Valley such as largemouth bass, smallmouth bass, crappie, bluegill, and mosquitofish has resulted in a sharp decline in Oregon chub abundance. The chub was given "endangered" status under the federal Endangered Species Act in 1993.

Ptychocheilus oregonensis (Richardson, 1836) Northern pikeminnow
Synonyms: *Cyprinus oregonensis*
LIT
Origin: Native

Although native to Pacific drainages of North America (Froese and Pauly 2003), *Ptychocheilus oregonensis*, is considered a pest species because large concentrations of squawfish near hydroelectric projects are responsible for substantial salmonid predation and may further increase salmonid mortality by reducing the fish guidance efficiency of submersible traveling screens (NOAA 1994). *P. oregonensis*, a lake-adapted fish, has responded favorably the creation of reservoirs and other slow moving water habitat creation along the Columbia River. In free-flowing areas the bottom- and bank-hugging pikeminnow is not as problematic a predator for salmonid smolts.

Rhinichthys cataractae (Valenciennes, 1842) longnosed dace
Synonyms: *Gobio cataractae, Rhinichthys marmoratus*
Lit
Origin: Native, sensistive

The longnose dace is present on both sides of the Continental Divide and is one of the most widely distributed of the western fishes (Froese and Pauly 2003). *Rhinichthys cataractae* ssp. is listed by the ODFW as a sensistive species or “Species of Concern” in Oregon waters.

Rhinichthys falcatus (Eigenmann & Eigenmann, 1893) leopard dace
Synonyms: *Agosia falcata*
Lit
Origin: Native

The leopard dace is native to the Fraser and Columbia River drainages (Froese and Pauly 2003). It is primarily found in slow streams and gravel runs in the upper Columbia R. drainage.

Richardsonius balteatus (Richardson, 1836) redside shiner
LIT
Origin: Native

Native to Pacific Slope drainage British Columbia to southern Oregon, including the Columbia Basin (Froese and Pauly 2003), the redside shiner has been introduced (probably as bait) to drainages in Arizona, Colorado, Montana and Utah (NAS 2003).

Tinca tinca (Linnaeus 1758) tench, green tench, golden tench
Synonyms: *Cyprinus tinca*
LIT
Origin: Introduced

Native to Eurasia as well as the British Isles (Berg 1949), *Tinca tinca* was introduced to numerous locations in Africa, Australia, Japan, and North America with no known adverse ecological impacts (Froese and Pauly 2003). Prized by recreational fishermen for their tasty flesh, tench are omnivorous, feeding on benthic invertebrates, aquatic insect larvae, and algae some other invertebrates. In Great Britain tench are popular ornamental pond species but a search of ornamental pond websites in the United States did not reveal a similar opinion. Wydoski and Whitney (1979) write, in reference to the Washington tench population, “to our knowledge it has not created any particular problems.” In the late 1800s, spurred by the success in Australia with tench breeding and introduction programs, the USFC imported tench from Europe (Baughman 1947). Raised in fish ponds in Washington State, 450 *T. tinca* were introduced into several lakes and ponds in the lower Columbia River basin between 1895-1896 (Smith 1896, Baughman 1947). The current status of *T. tinca* in the lower Columbia River basin remains uncertain. Tench appear to have spread (or were transplanted) from their original introduction sites and into the lower Columbia within 40 years of the USFC planting. Chapman (1942), in a paper on introduced fishes in the Pacific Northwest, noted that tench, while found in the Columbia River, were nowhere near as abundant as were *Cyprinus carpio* (habitat requirements of tench are similar to that of *C. carpio*, and the two species are superficially similar, with tench being the smaller of the two). Hutchinson and Aney (1964) list *T. tinca* on their list of known fish species in the Willamette basin, and note their distribution as “Columbia mainstem, probably lower Willamette. Wydoski and Whitney (1979) report *T. tinca* as present in the Columbia River system, Spokane River, and Lake Washington. Bond (1961) noted tench as introduced to the Columbia River and the Willamette River but in later revisions (Bond 1973, 1994) stated that the species was in the Columbia River and was once present in lower Willamette River. No further captures of tench have been reported in the lower

Columbia but tench are occasionally captured in the middle Columbia River (USFWS http://hanfordreach.fws.gov/fish.html)

EMBIOTOCIDAE

Amphistichus rhodoterus (Agassiz, 1854) redtail surfperch
Synonyms: *Holconotus rhodoterus, Cymatogaster pulchellus, Cymatogaster larkinsis, Amphistichus heermanni*
LIT
Origin: Native

Brackish, marine species native to the Eastern Pacific (Froese and Pauly 2003), popular with commercial and recreational anglers.

Cymatogaster aggregata Gibbons, 1854 shiner perch
LIT
Origin: Native

Brackish, marine species native to the Northeastern Pacific (Froese and Pauly 2003).

Embiotoca lateralis Agassiz, 1854 striped seaperch, blue seaperch
LIT
Origin: Native

Marine species found in coastal areas, native to the Eastern Pacific (Froese and Pauly 2003). Minor commercial importance, often targeted by aquarium enthusiasts.

Hyperprosopon anale Agassiz, 1861 spotfin surfperch
LIT
Origin: Native

Marine species native to the Eastern Pacific (Froese and Pauly 2003) often found in surf on sandy beaches.

Hyperprosopon argenteum Gibbons, 1854 walleye surfperch
LIT
Origin: Native

Marine gamefish native to the Eastern Pacific (Froese and Pauly 2003).

Hyperprosopon ellipticum (Gibbons, 1854) silver surfperch
Synonyms: *Cymatogaster ellipticus*
LIT
Origin: Native

Small marine fish native to the Eastern Pacific (Froese and Pauly 2003).

Phanerodon furcatus
LIT
Origin: Native

Marine fish native to the Eastern Pacific, usually found offshore (Froese and Pauly 2003).

Rhacochilus vacca (Girard, 1855) pile perch
Synonyms: *Damalichthys vacca, Ditrema vacca, Damalichthys argyrosomus*
LIT
Origin: Native

Marine fish native to the Eastern Pacific, usually found along the rocky shore (Froese and Pauly 2003).

ENGRAULIDAE

Engraulis mordax Girard, 1854 Northern anchovy, California anchovy
LIT
Origin: Native

Pelagic, marine species native to the Northeast Pacific (Froese and Pauly 2003). Commercially harvested along the West Coast.

ESOCIDAE

Esox lucius x masquinongy tiger muskellunge, tiger musky
LIT
Origin: Introduced

Hybrid freshwater species *Esox lucius* x *Esox masquinongy*. Tiger muskellunge have been bred artificially and stocked by state fish and game agencies for sport fishing throughout North America. Populations are often maintained by stocking as male tiger muskellunge are always sterile, but females are often fertile (Becker 1983). This hybrid predator is probably deleterious to smaller fish. Tiger musky in the lower Columbia River basin were reported by the Warmwater Fisheries Resource Manager, Washington Department of Wildlife, Olympia, WA in 1992 (NAS 2003).

FUNDULIDAE

Fundulus diaphanous (Lesueur, 1817) banded killifish
Synonyms: *Hydrargira diaphana, Fundulus multifaciatus*
LIT

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes

Origin: Introduced

Note: Froese and Pauly (2003) treats F. diaphanous and F. diaphanous diaphanous as valid synonyms while NAS (2003) lists F. d. diaphanous and F. d. menona as eastern and western subspecies

Fundulus diaphanous is native to Atlantic slope drainages in North America (Froese and Pauly 2003) and has been introduced to parts of Ohio, Pennsylvania, South Dakota, Oregon and Washington (NAS 2003). Banded killifish are grown commercially for aquariums and for use as bait (Froese and Pauly 2003). The ecological implications of introduced populations are not known. Banded killifish were first recorded from the upper Columbia River estuary at Jones Beach in 1971 (Misitano and Sims 1974) but were not consistently captured in fish surveys until the late 1980s (Hinton et al 1990). The source of the Columbia River introduction is unknown but thought to be the result of a bait dump (NAS 2003). Other introductions across the United States have been attributed to accidental introduction along with stocked largemouth bass (South Dakota) or as the result of an aquarium release (Ohio) (NAS 2003). The continued presence of *F. diaphanous* in the Willamette River as well as the lower Columbia River is well documented (see Misitano and Sims 1974, Hjort et al 1984, Hinton et al 1990, Hinton et al. 1992b, Farr and Ward 1993,Weitkamp 1994, Hinton and Emmett 2000, and North et al. 2002).

GADIDAE

Lota lota (Linnaeus, 1758) burbot
Synonyms: *Gadus lota, Gadus lacustris, Gadus maculosus*
LIT
Origin: Native

Lota lota is the only freshwater member of the Gadidae family. Congregate in deep pools of large rivers and lakes. Circumarctic distribution (Froese and Pauly 2003).

Microgadus proximus (Girard, 1854) Pacific tomcod
Synonyms: *Gadus proximus, Morrhua californica, Gadus californicus*
LIT
Origin: Native

Brackish and marine species native to the Eastern Pacific (Froese and Pauly 2003). Minor commercial and recreational species.

GASTEROSTEIDAE

Gasterosteus aculeatus stickleback
LIT
Origin: Cryptogenic

Wide distribution may indicate that this species should be considered cryptogenic although previous studies consider this to be a native species. Large salinity tolerence can range from freshwater to marine salinities. Distributed along the West Coast of North America from Baja California to the Bering Sea (Fishbase 2004), as well as throughout the coastal regions in the North Pacific and North Atlantic.

GOBIIDAE

Lepidogobius lepidus bay goby
LIT
Origin: Native

Intertidal marine demersal species, likely only found near the mouth of the Columbia.

HEXAGRAMMIDAE

Hexagrammos decagrammus kelp greenling
LIT
Origin: Native

Marine species, likely not a resident of the lower Columbia River estuary.

Ophiodon elongatus lingcod
LIT
Origin: Native

Marine species, likely not a resident of the lower Columbia River estuary.

ICTALURIDAE

Catfish, popular as both food and sport fish, were among the first fishes introduced to the West Coast (Smith 1896). In 1874, Livingston Stone and his USFC aquarium car are responsible for the first western movement of catfish and bullhead across the Rocky Mountains, their natural westernmost boundary (Smith 1896). Present on this train were three species, *Ameiurus catus*, *Ameiurus nebulosus* and *Ictalurus punctatus*) (Smith 1896). It is unknown if the first catfish stocked in the Pacific Northwest were descended from this original population or the result of later importations. By the 1880s catfish (of many unreported species) had become successfully established in Silver Lake, Washington (stocked by an unknown person). Fearing that the catfish would be “another enemy to our salmon” a former Fish Commissioner of Oregon asked the Washington Commissioners of Fish for permission to rid Silver Lake (which connects to the Columbia via Cowlitz River) of its catfish population (Smith 1896). It has been theorized that fishermen’s fears were heightened by speculation that the introduced catfish population included specimen of *Ictalurus furcatus*, blue catfish, native to the

Mississippi, growing to over 100 lbs (the maximum recorded weight of a blue catfish is 186 lbs), and theoretically capable of consuming 20 lb salmon (Lampman 1946). However, due to importation and release of a variety of catfish species by private parties into the lower Willamette and Columbia Rivers in the 1880s, extirpation of the Silver Lake population would not have kept catfish out of the Columbia River (Lampman 1946). By 1890, The Oregonian newspaper carried an article on the newly arrived catfish stating, “The ponds and lakes of Sauvie Island are literally alive with catfish which have been carried in by the late flood waters. By every appearance our waters will soon be swarming with these fish, as they increase at an appalling rate” (Lampman 1946). By 1894 catfish were thoroughly established throughout the lower Columbia and Willamette Rivers and by the 1890s a commercial harvest of catfish had begun (Lampman 1946) however, by 1938 only 2.5 percent of the recorded catch of game fish in Washington was catfish (Chapman 1942). Due to the voracious and predatory nature of catfish most are considered ecological pests. Several species of introduced North American freshwater catfish have been implicated in the decline of native fish (Marsh and Douglas 1997, Froese and Pauly 2003) and amphibians (Rosen et al. 1995) both in the United States and elsewhere. Declared a game species by the State of Oregon in 1913, catfish are no longer commercially harvested in the Pacific Northwest. The three most common catfish species in the lower Columbia River are *A. nebulosus, A. natalis and I. punctatus*.

Ameiurus catus (Linnaeus, 1758) ESTABLISHED
Ictalurus catus, *Silurus catus*
white catfish, white bullhead

Native to the Atlantic and Gulf slope drainages of the United States, *Ameiurus catus* were first released in California in the San Joaquin River in 1874 (Smith 1896). It is likely that they were part of the population planted in Silver Lake, Washington in the early 1880s and became distributed throughout the lower Columbia River basin by 1894 (Lampman 1946). In spite of this planting and at least one additional intentional introduction in 1930 by an Oregon hatchery superintendent (Lampman 1946) *A. catus* has never been a plentiful species in the lower Columbia River basin (Wydoski and Whitney 1979). In Bond’s (1994) revision of his key to Oregon fishes he is uncertain of their establishment, however a report by the Oregon Department of Fish and Wildlife lists a 15lb white cat was caught in Tualatin River in 1989 by Wayne Welch and setting a new state record (http://www.dfw.state.or.us/ODFWhtml/InfoCntrFish/FishRecords.html) indicating that their may indeed still be an established population of *A. catus* in the lower Columbia River basin.

Ameiurus melas (Rafinesque, 1820) ESTABLISHED
Ictalurus melas, Ictalurus melas, melas, Aneiurus melas melas, Silurus melas
black bullhead, black catfish

Native to North America east of the Rockies excluding the Atlantic slope, *Ameiurus melas* has been intentionally stocked throughout the west coast and other parts Europe for sport and as a food fish (Froese and Pauly 2003, NAS 2003). Countries such as Germany, Spain and Hungary report adverse ecological impact after introduction (Froese and Pauly 2003). Voracious predators, black bullhead, along with other catfish, have been implicated in the decline of native fish (Marsh and Douglas 1997) and amphibians (Rosen et al. 1995) in the United States. In addition, the black bullhead is considered a nuisance fish by anglers targeting other gamefish (Froese and Pauly 2003). The first *A. melas* in the Columbia River basin was caught in the Willamette in 1894 (Smith 1896, Lampman 1946) but it is not known when or where this species was first introduced. A 1945 Oregon State College surveyed the fishes of the Willamette River system and reported the presence of three species of bullhead catfish: *A. nebulosis, A. natalis* and *A. melas* (Lampman 1946). Although it is not one of the commonly captured catfish, Bond (1994) continues to list it as present in the Columbia River drainage.

Ameiurus natalis (Lesueur, 1819) ESTABLISHED
Pimelodus natalis, *Ictalurus natalis*
yellow bullhead

Native to the North America from the Mississippi basin east (Page and Burr 1991), *Ameiurus natalis* has been widely and successfully stocked throughout the western United States (NAS 2003). It has been introduced into Italy and Mexico where adverse ecological impacts have been reported from the later country where it has replaced several endemic species (Froese and Pauly 2003). Although *A. natalis* is a popular sport and food fish, predation by it and other catfish may have an impact on its introduced habitat. Lampman (1946) asserts that the first introduction of yellow bullheads in the region was probably in 1905, when tanks of warm water display fish were released following the Lewis and Clark Centennial exposition in Portland see centrarchidae discussion above for more information. *A. natalis* have been common in the Willamette Valley since then. They were captured by the 1945 Oregon State College survey of the Willamette River (Lampman 1946), as well during the Farr and Ward 1993 survey of the lower Willamette.

Ameiurus nebulosus (Lesueur, 1819) ESTABLISHED
Ictalurus nebulosus, *Pimelodus nebulosus*
brown bullhead, brown catfish

Native to Atlantic and Gulf slope drainages and parts of the Mississippi River drainage basin (NAS 2003), *Ameiurus nebulosus* is the most common catfish in the lower Columbia River basin and is especially abundant in the sloughs and slack waters of the basin (Chapman 1942, Wydoski and Whitney 1979). During the 1890s and up until catfish were declared game species by the state of Oregon (thus not open to commercial harvest) in 1913, there was a thriving commercial fishery for *A. nebulosus*, mostly in the shallow lakes of Sauvie Island. At its peak, this fishery annually produced over 100,000 pounds of catfish (Lampman 1946). Collections of *A. nebulosus* span most of the lower Columbia River basin (see Smith 1896, Chapman 1942, Lampman 1946, Bond 1973, 1994, Wydoski and Whitney 1979, Hjort 1984, Farr and Ward 1993, and USFWS 1993)

Ictalurus furcatus (Valenciennes, 1840) UNKNOWN
Pimelodus furcatus, *Ictalurus meridionalis*

blue catfish

Native to the Mississippi River basin, the status of *Ictalurus furcatus*,is unknown however it seems unlikely that this species of catfish is established in the lower Columbia River. Unlike many of the above catfish, *I. furcatus* prefers deeper, clear, flowing water habitats, and it not considered a pest species by Froese and Pauly (2003). Bond (1994) describes *I. furcatus* as “introduced, Columbia River, not common” but it is unclear which portion of the Columbia River he is referring to. *I. furcatus* are present in both the Snake and the middle reach of the Columbia River but are rarely reported below the Bonneville Dam. It seems that the dreaded salmon-eating blue catfish of Silver Lake never materialized in the lower Columbia River see above discussion of Ictaluridae. It is interesting to note however that blue catfish have been intentionally stocked in parts of California for biological control of *Corbicula fluminea*, the non-native Asian clam under the hope that, even if clam populations were not controlled, the biomass of the clams would at least be significant enough to create trophy-sized catfish (Dill and Cordone 1997).

Ictalurus punctatus (Rafinesque, 1818) ESTABLISHED
Silurus punctatus
channel catfish, graceful catfish

Ictalurus punctataus, native to the central drainages of North America from Southern Canada to Northern Mexico, is a commercially important species, is heavily aquacultured species and an Albino form is commonly encountered in the aquarium trade (Froese and Pauly 2003). In 1893, 100 channel cats were released into the Boise River in Idaho (Smith 1896). Reports of *I. punctatus* caught in the lower Columbia river were sporadic up until the 1940s, but it is suspected that channel cats were stocked in the Willamette River in the 1920s by an Oregon hatchery superintendent (Lampman 1946). Additional releases were made in ponds, lake, and rivers throughout Washington and Oregon as many species of catfish became established. Now they exist primarily in mid-Columbia and Snake River although they are established in the Willamette River as well (Hjort et al 1984, Farr and Ward 1993). Sterile populations of channel cats have been stocked in Washington lakes by the Washington Department of Fish and Wildlife, introduced to increase predation on over-abundant forage fish populations, and to add diversity to gamefish populations (WDFW 2003).

MORONIDAE

Morone chrysops (Rafinesque, 1820) ESTABLISHED
Perca chrysops, *Roccus chrysops*
white bass

Native to the Mississippi River drainage basin, *Morone chrysops*, have been stocked legally and illegally throughout much of the United States (NAS 2003). First transported west in 1895 by the USFC with a shipment of black bass from Illinois, *M. chrysops* were introduced into California waters for breeding purposes (Smith 1896). Lee et al. (1980) reports a population of *M. chrysops* with a limited range in the lower Lewis River drainage basin in Washington.

Morone chrysops x saxatilis UNSUCCESFUL
wiper, sunshine bass, whiterock, palmetto, Cherokee

An artificial hybrid, *Morone chrysops x saxatilis* has no native range. This cultivated sport fish has been introduced to numerous watersheds in central and eastern United States. Where one or both parent species exists with *M. chrysops x saxatilis* backcrosses are often present and are considered detrimental to the native parent population (NAS). specimen turned into ODF during Farr and Ward sampling? (Morone hybrid?). Populations of *M. chrysops x saxatilis* are artificially maintained in all locations where they have been intentionally stocked for sport. An experimental stocking program using *M. chrysops x saxatilis* exists in southwestern Oregon in Ten Mile Lakes (Farr and Ward 1993, Bond 1994). The three *M. chrysops x saxatilis* hybrids caught by anglers in the Willamette River and turned over to the fish surveys of Farr and Ward (1993) may have been migrants from this program or were illegally introduced specimen.

Morone saxatilis (Walbaum, 1792) ESTABLISHED
Perca saxatilis, *Roccus saxatilis*
striped bass, striper, rock, rockfish

Morone saxatilis is a highly prized sportfish native to Atlantic slope drainages and the northeastern Gulf slope of the United States (Page and Burr 1991). Striped bass have been widely stocked for sportfishing in coastal waters from New York to California (landlocked stocked populations exist also) (NAS 2003). In addition, between 1886 and 1992, *M. saxatilis* has been introduced to and become established in Mexico, South Africa, Iran, Russia, Ecuador, and British Columbia (Froese and Pauly 2003). According to Chapman (1942) there are no records of stripped bass introduced into the coastal waters of the Pacific Northwest however in 1879, 135 fingerlings from New Jersey were introduced into San Francisco Bay by Livingston Stone (Smith 1896). Supplemented in 1882 with 300 additional fish from New Jersey (Smith 1896), *M. saxatilis* spread up and down the West Coast and now range from British Columbia to Baja California (NAS 2003, Froese and Pauly 2003). As this is a highly valued sportfish it is interesting to note that detrimental ecological and nuisance effects of ANS on *M. saxatilis,* itself an ANS, have been described and along the West Coast (e.g. *Potamocorbula amurensis* reducing striped bass food availability, and bait theft by *Eriocheir sinensis* of anglers targeting this species). The distribution of *M. saxatilis* in the Columbia River is well documented (see Moyle 1976; Wydoski and Whitney 1979; Grabowski et al. 1984; Bond 1994) and stripped bass is closed to commercial fishing throughout the state. Impacts of striped bass are unknown – however Morgan and Gerlach (1950) reported finding numerous trout and salmon fry as well as fingerlings in gut content surveys in Coos Bay, Oregon.

PERCIDAE

Perca flavescens (Mitchill, 1814) ESTABLISHED
Morone flavescens
yellow perch, American perch, lake perch

Native to much of the Atlantic, Great Lakes, and Mississippi River basins (Wydoski and Whitney (1979), *Perca flavescens* is introduced or native in all but five U.S. states. The introduction of yellow perch to West Coast habitats by Livingstone Stone and his Aquarium Car was justified by Stone who wrote, "*Perca flavescens* is at all events far preferable to most of the fish at present existing in the freshwaters of California, and even if it destroyed four-fifths of the other fish there it would replace them by a better kind" (Smith 1896). Established in the Willamette and lower Columbia River (Farr and Ward 1993, NAS 2003), yellow perch are often considered a nuisance in lakes and rivers where they compete with adult trout for food resources and prey upon younger trout (Coots 1966). The Columbia River population may have been the result of several intentional introductions. In 1894, the USFC planted *Perca flavescens* in Silver Lake (on the Cowlitz River) and over the next ten years almost 1000 perch were planted in Washington lakes (Wydoski and Whitney 1976). In 1905, yellow perch were believed to be present in the aquarium exhibit released into Guild Lake (Lampman 1946). In the 1930s, *Perca flavescens* was an important species in regional lake fisheries in the 1930s but it sustainable population levels were rapidly exceeded and most fish were reported to appear "stunted" (Lampman 1946).

Sander vitreus (Mitchill, 1818)
Stizostedion vitreum, *Perca vitrea*
walleye, walleye pike
LIT
Introduced

Although *Sander vitreus* were first transplanted to the West Coast in 1874 by Livingston Stone (Smith 1896), walleye were not captured in the lower Columbia River basin until 1980 (Li et al 1979, Farr and Ward 1993, NAS 2003). It is believed that, since their introduction into the upper Columbia near Lake Roosevelt in the 1940s or 1950s, walleye have gradually spread downriver and may have established a limited population in the lower Columbia (Dentler 1993, Farr and Ward 1993, NAS 2003). Native to the Great Lakes through the Mississippi basin (Froese and Pauly 2003), *S. vitreus* is a popular gamefish that lives in aquatic habitats from ponds to large rivers. A recent literature review by McMahon and Bennett (1996) found that the effects of walleye introductions in the Pacific Northwest were complex but posed a threat to salmonids through smolt predation. Because of this *S. vitreus* is banned from introduction into Oregon waters (McMahon and Bennett 1996).

POECLIIDAE

Gambusia affinis (Baird & Girard, 1853)

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes

Syn: *Heterandria affinis, Gambusia affinis affinis*
Mosquitofish
Introduced
LIT

Previously reported as the sub-species *Gambusia affinis affinis* but now recognized asa full species (Moyle and Davis 2000), the western mosquitofish is native to the Atlantic and Gulf Slope drainages from New Jersey to Mexico and the Mississippi River basin (Froese and Pauly 2003, NAS 2003). *Gambusia affinis* is one of the most successful introduced fish species in the world having gained a near global distribution (Welcomme 1988). Adverse ecological impacts have been reported from Europe, Asia, India, Australia, Africa and South America as well as from numerous island counties where *G. affinis* has been extensively introduced for mosquito control (see Froese and Pauly 2003). While *G. affinis* was introduced to much of the United States and to countries around the world for mosquito control starting in the 1960s, recent critical reviews of this practice suggest that this fish may not be any more successful than native minnows at consuming mosquito larvae and reducing mosquito-borne disease (Courtenay and Meffe 1989). However, adverse ecological effects have resulted from mosquitofish predation on the eggs, larvae, and juveniles of various native fishes. Although still distributed to private parties for mosquito control, in the Western United States *G. affinis* has been implicated in the extirpation and/or decline of populations of federally endangered and threatened species of minnow and chub (Courtenay and Meffe 1989). In Oregon, the sharp decline in the population of *Oregonichthys crameri*, the Oregon chub - an endangered species, has been attributed to habitat loss and predation by introduced fishes including *G. affinis* (Scheerer 1999)

SALMONIDAE

Oncorhynchus clarki x mykiss Artificially? ESTABLISHED
cuttbow trout

The status of cutbow trout as a nonindigenous species is non-straightforward. *Oncorhynchus clarki x mykiss,* the result of a cross between *O. clarki* x *O. mykiss,* is considered an artificial hybrid occurring in the wild where parent species come in contact with one another through stocking, and not present (or rare) where both parents occur naturally together in their native range (Sigler and Miller 1963). While both parent species are native to the lower Columbia River basin both species have been widely stocked throughout the Columbia River, the result of fish enhancement and hatchery programs (Froese and Pauly 2003). Further complicating matters, the hybrid cutbow has also been intentionally stocked in the western U.S. as sport fish (NAS 2003). The ease of hybridization between the two parent species may be contributing to a reduction in genetic integrity of these species and the replacement of threatened cutthroat trout populations by hybridization and competition (NAS 2003).

Kingdom: Animalia
Phylum: Chordata
Superclass: Osteichthyes

Salmo trutta Linnaeus, 1758 UNKNOWN
brown trout, German brown trout

Salmo trutta is native to Europe and western Asia (Page and Burr 1991). First introduced to the inland waters of North American in 1883 by the USFC, *S. trutta* is now present throughout the U.S. (Courtenay et al. 1984, NAS 2003). Natural reproduction rates in North America are poor thus many states actively stock this popular gamefish to maintain desirable population sizes (NAS 2003). Chapman (1942) reports that while *S. trutta* was widely planted in Oregon and Washington it was successful in only a few locations.

Phylum: Chordata

Subphylum: Vertebrata

Class: Amphibia

Ranidae			
	Rana catesbeiana	LCRANS, LIT	Introduced

RANIDAE

Rana catesbeiana Shaw, 1802 bullfrog, American bullfrog
LCRANS, LIT
Introduced

Native to eastern and central North America, *Rana catesbeiana*, the bullfrog, is widely introduced in the western states including Hawaii. Speculation as to the intent of early introductions includes plantings intended for food (to provide frog legs for the West Coast frog leg market which declined in the 1930s) (ODFW 2001) as well as for aesthetic purposes (i.e. for their distinctive croaking sound) (Lampman 1946). In 1914, the Oregon Fish and Game Commission granted permission to a private individual to introduce this frog into the mid-Columbia River basin below John Day (Lampman 1946). In 1924 or 1925, reports Lampman (1946), bullfrogs resulting from the above planting were shipped to Portland for further distribution in the lower Columbia River basin. Mature bullfrogs are responsible for significant levels of predation on native aquatic species, including the spotted frog (*Rana pretiosa*), the Western pond turtle (*Clemmys marmorata*) and the Oregon chub (*Oregonichthys crameri)* (ODFW 2001, Crayon 2002).

Phylum: Chordata

Subphylum: Vertebrata
Class: Reptilia
Order: Testudines

Reptiles were not collected or identified over the course of this study. Nonnative turtles have been introduced numerous times over the years, likely both intentionally to enhance wildlife and through aquarium/terrarium disposal. The introduced species pose a threat to native species whose popularions are in decline.

Chelydridae		
Chelydra serpentina serpentina	LIT	Introduced
Emydidae		
Chrysemys picta bellii (Wpaint t)	LIT	Native
Clemmys marmorata (WPT)	LIT	Native
Trachemys scripta elegans	LIT	Introduced

CHELYDRIDAE
Chelydra serpentina serpentina Gray, 1831 Eastern snapping turtle
LIT
Introduced

Native to eastern North America several established populations of this snapping turtle have been reported from the Willamette Valley including Portland, OR (see http://nas.er.usgs.gov/queries/SpFactSheet.asp?speciesID=1226 for more information).

EMYDIDAE
Chrysemys picta bellii (Gray, 1831) Western painted turtle
LIT
Native

This turtle is found primarily in northern Willamette Valley and ranges east through the Columbia River Gorge and Columbia Basin.

Clemmys marmorata (Baird and Girard, 1852) Western pond turtle
LIT
Native

Clemmys marmorata is considered to be rare throughout its range. It is almost extirpated in Washington State, and the current western pond turtle population in Oregon is thought to be less than 10% of its historical population.
https://www.nwp.usace.army.mil/op/V/western.htm

Trachemys scripta elegans (Weid-Neuwied, 1838) red-eared slider
LIT

Kingdom: Animalia
Phylum: Chordata
Class: Reptilia

Introduced

Native to the Southeastern United States and popular as an aquarium species since the 1930s, *T. scripta elegans* has been introduced throughout the western United States primarily through aquarium releases and escapes. NAS attributes part of the the turtle's recent popularity and subsequent releases/escapes tto the Teenage Mutant Ninja Turtle television cartoon craze of the late 1980s - see http://nas.er.usgs.gov/queries/SpFactSheet.asp?speciesID=1261

Phylum: Chordata

Subphylum: Vertebrata

Class: Mammalia

Order: Rodentia

Echimyidae		
Myocastor coypus	LCRANS, LIT	Introduced

ECHIMYIDAE

Myocastor coypus Kerr, 1792 Nutria, coypu, coypu rat, swamp beaver, nutria rat
LCRANS, LIT
Introduced

Native to South America, *Myocaster coypus* - an aquatic rodent, is a textbook example of how far astray well-intentioned importation and release of nonnative species can go. Introduced numerous times into the United States, beginning as early as 1899 in California (USGS 2000), most releases (and escapes) of nutria were intended to enhance the fur trade. For example, in 1938, twenty nutria were imported from Argentina to Louisiana by Tabasco sauce tycoon E.A. McIlhenny, these nutria reportedly escaped captivity during a hurricane in the early 1940s and subsequently spread along the Gulf Coast (NAS 2003). Other introductions of nutria in North America were made for biological control of unwanted aquatic weeds such as water hyacinth (*Eichhornia crassipes*) and alligator weed (*Alternanthera philoxeroides*) (USGS 2000) a program that failed to significantly reduce the target plants. Nutria are considered an economic liability in many areas as their burrowing activity can damage earthen dams and dikes and because they often feed on the young shoots of crop plants (ODFW 2001). The burrowing activity of nutria may also contribute to streambed erosion in the lower Columbia River basin. Severe ecological impacts have been reported in the southern Atlantic states where nutria has caused extensive loss of marshland (NAS 2003). Nutria may also compete with native muskrats populations for food and habitat. ODFW (2001) reports that anecdotal evidence suggests that in locations where nutria are abundant, muskrat populations decline. Nutria were introduced into the wilds of the Pacific Northwest in 1937 when an unknown number escaped from a fur farm in

Tillamook Co. aided by a large flood. Today, nutria can be found throughout the lower Columbia River basin and much of western Oregon and Washington (ODFW 2001).