Oithona davisae (Copepoda: Cyclopoida), A Potential Invader to the Pacific North West, A Guide to its Identification, Invasion Pathways, and Life History

Nissa C. Ferm
anteriorly, naked; flap of dorsal seta well developed, extending beyond posterodorsal margin of caudal ramus.

Head rounded or produced into pointed rostrum. Posteroventral margin of caudal ramus straight, serrate; flap of dorsal seta reduced or excising beyond posteroventral margin of caudal ramus. Flap of dorsal seta well developed, extending beyond posteroventral margin of caudal ramus.

3. Third exopod of swimming leg four with one to two outer marginal spines (C). First and second basal segments of antennae two with one to two outer marginal setae. (D) 4. Second basal segment of the mandible with one thick spine and one slender seta on distal margin. First and second basal segments of antennae two with three thick spines or two thick spines and two thin hooks (E). First and second basal segments of antennae two with one thick spine and one slender seta.
7. Rosulum sharply pointed in ventral view.
8. Rosulum rounded in ventral view.
9. genital segment and urosome segment three with dorsal transverse rows of setules; genital segment with lateral hairs. Distal margin of first inner lobe on maxillae one setae are thick, very short, and do not extend to the middle of next seta.

Oithona brevicornis

10. Exopod of maxillae one with three setae.

Oithona davisae

9. Exopod of maxillae one with four setae.

Oithona wellerhausi

10. Endopod of maxillae one with three setae.

Oithona davisae

1. Endopod of maxillae one with one seta.

Oithona brevicornis
Second basal segment of mandible with one pointed and one blunt terminal spine

9. Distal margin of first inner lobe of maxillae one with long seta, extending far beyond tip of the third inner lobe terminal seta

10. Endopod of maxillae one with one seta

Oithona davisae

12. Exopod of maxillae one with four setae

Oithona aruensis

Origin and Distribution

In 1979, California Fish and Game identified the first specimens of *O. davisae* in San Francisco, California. Re-examined San Francisco estuary archival samples from various sources showed that *O. davisae* inhabited the estuary since 1963. Ferrari and Orsi put forward that *O. davisae* was not native to the San Francisco estuary because of its taxonomic similarity to other Indo-Pacific *Oithona* species. They suspected ballast water was the vector of introduction [2]. The introduction was most likely from Japan, as *O. davisae* was first reported in Japanese scientific literature in 1985. A study published in 1985, but started in 1971, determined that *O. davisae* was the most abundant copepod in mudflats of Kyushu, Japan [4]. Subsequent studies showed that various sources showed that *O. davisae* inhabited the estuary since 1963. Ferrari and Orsi, and San Francisco, California, re-examined San Francisco estuary archival samples from 1979, California Fish and Game identified the first specimens of *O. davisae* in San Francisco.
The Pacific Northwest has the fifth busiest port in North America and with shipping comes the possibility of ballast water mediated introductions. A majority of the shipping traffic comes from Asian ports, specifically Japan. Besides Japan, the Pacific Northwest receives domestic traffic from the San Francisco Bay Area. These two shipping traffic sources from Asian ports, specifically Japan, besides Japan, the Pacific Northwest has the fifth busiest port in North America and with shipping.

Probability of Invasion for the Pacific Northwest

where only one-third of females are reproductively capable. An abundance peak in December and July with high densities reproductive success is hampered by high female to male sex ratios. Even higher in inner Tokyo Bay, densities of adults and copepodites can reach 779,000 per square meter. O. davisae can be the most abundant mesozooplankton species in its native habitat, copepodite and adult. The naupliar and copepodite phases are separated into six naupliar stages each. O. davisae is a pelagic cyclopoid copepod. Copepods have four major life stages: egg, nauplii, copepodite and adult. Unpublished data showed that O. davisae was not found in a 2001-2004 invasive species survey of Puget Sound waters did not find O. davisae (unpublished data). Even so, 2005 invasive species survey of Puget Sound waters did not find O. davisae.

Life-history and basic ecology

O. davisae is a pelagic copepod, Cyclopoids have four major life phases: egg, nauplii, copepodite and adult. The naupliar and copepodite phases are separated into six naupliar stages each. O. davisae can be the most abundant mesozooplankton species in its native habitat. In inner Tokyo Bay, densities of adults and copepodites can reach 779,000 per square meter. An abundance peak in December and July with high densities reproductive success is hampered by high female to male sex ratios.
Biological samples and determine if a vessel is compliant with regulations.

Wildlife monitor ships entering Puget Sound and the Columbia River by tagging

Monitoring projects:

- (2001- ongoing) University of Washington and Washington Department of Fish and

Current Research

...on an annual basis, so invasions can be detected as early as possible.

presence of invasive species. Field monitoring for invasive zooplankton needs to be done

implemented a ballast water-monitoring program, which looks at vessel compliance and

of a vessel becoming established in the Pacific Northwest. Washington State has already

Compliance with ballast water regulations is necessary to reduce the risk of

tolerate salinity and temperature fluctuations in coastal environments.

organisms are unable to survive in oceanic conditions and oceanic organisms cannot

through empty refill or flow-through methods. The theory behind exchange is that coastal

ballast water exchange: Coastal waters in ballast tanks are swiped with oceanic waters,

Today the only method to reduce the risk of ballast water mediated invasions is

suggested.

Economic zone of the United States. In 2004, NISA was federally enacted and is

supplemental to ballast water regulations for vessels coming from outside the Exclusive

Economic Zone (EEZ) of the United States. NISA was expanded to include ballast water and

required vessels to exchange ballasts in 2002 (ORS Chapter 783.620). The state laws

require vessels in exchange ballasts required exchange of ballast water in 2002 and

Oregon have enacted regulations to control or real ballast water entering the waters of the state.

Federal, and International levels. In the Pacific Northwest, only Washington and Oregon

Federal Ballast Water regulations are implemented by the United States Coast Guard.

International agreements supplement the ballast water policies of the United States

International Maritime Organization implements the

International Convention for the Control and Management of Ships Ballast Water (BWM).

The policy created in 2004 calls for port state control of ballast water and treatment

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Ballast Water regulations for vessels coming from outside the Exclusive Economic

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operations of the International Convention for the Control and Management of Ships Ballast

Washington State has already implemented a ballast water-monitoring program, which looks at vessel compliance and treatment technologies by 2010 (RCW 77.120.030 and WAC 220.77.090 and 095).

Oregon Department of Fish and Wildlife monitor ships entering Puget Sound and the Columbia River by tagging biological samples and determine if a vessel is compliant with regulations.

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(2005-ongoing) EPA bar-coding project. Taxonomic identification of zooplankton and gene sequencing, for future use with micro-array. In the future ballast samples will be genetically analyzed.

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