Invasive Species of the Pacific Northwest:

Nuttallia obscurata: Purple Varnish Clam, Varnish Clam, Savory Clam, or Dark Mahogany Clam

Katie Jackson
FISH 423
Autumn 2014

Figure 1: Left image shows a view exterior of the shells of the Varnish Clam. It is oval in shape and is deep mahogany color with a large hinge ligament. The interior of the shell has a purple tint that is especially dark on the adductor scars (right). Left source: bcbiodiversity.lifedesks.org. Right source: www.flickr.com.

Diagnostic Information

Scientific name
Order: Veneroida
Superfamily: Tellinoidea
Family: Psammobiidae
Genus: *Nuttallia*
Species: *obscurata*
*(*Reeve, 1857)

Common names
Purple Varnish Clam, Varnish Clam, Dark Mahogany Clam, Savory Clam

Basic identification key

The varnish clam is a small to medium sized marine clam. The valves (shells) of *N. obscurata* are medium to dark brown or mahogany. The outermost layer of the shell, the periostracum, is thick causing the shell to appear shiny. There are thin growth rings present across the shells, but annuli are difficult to distinguish. The shells are oval in shape and are slightly wider in the posterior side. There is a large, distinctly large hinge ligament that is present near the umbo, also known as the hinge, (see Figure 1).

The inside of their shells are a solid purple color, which can range from off-white to indigo as seen in Figure 1. Like all other clams, they have two adductor scars where their muscles were attached that may appear darker in color than the rest of the shell. The purple color may also appear on the external side of the shell of small animals due to the thickness of their shells.

As a clam this very good at burrowing, it has relatively flat shells and large, long siphons. The siphons are not fused together like the geoduck (*Panopea generosa*). The foot is also large in order to facilitate digging into the substrate.

The largest varnish clam recorded had a shell length of 68 mm and reaches approximately 38mm at four years of age (WDFW). This growth rate is similar to the manila clam (*Venerupis philippinarum*), which is also non-native in the Pacific Northwest.

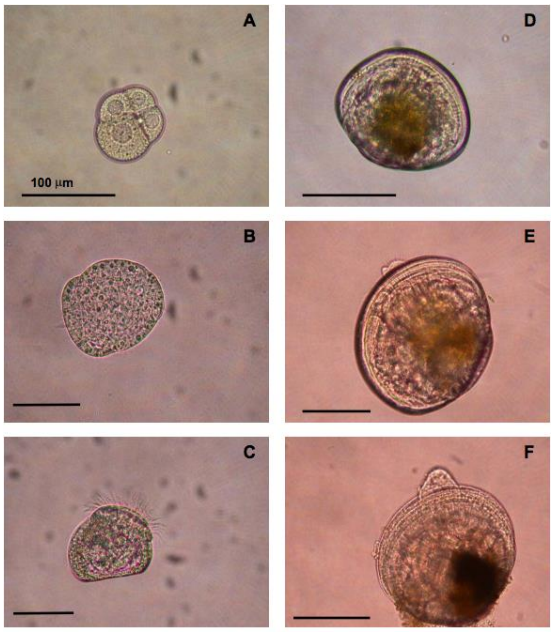

Figure 2: Varnish clam larvae from fertilization to the juvenile stage (about 33 days) Source: Dudas and Dower (2005)

Life History and Basic Ecology

Life cycle

The life cycle of *N. obscurata* is the same as other clams in form, but not in timing. These animals are broadcast spawners. Fertilization and early development both occur during in the water column. They have a relatively long planktonic period when compared to other species. The first cellular divisions occur three hours after fertilization. The first larval stage, which occurs sixteen hours post fertilization, is called the trocophore stage. At this stage, the larvae are free swimming. After 43 hours, the larvae are obtaining their own food from the food column, the velum is present, and there is a "D-shaped shell", but the larvae do not reach the veliger stage until day 15 in ambient conditions. By day 27, the foot is formed and the larvae have reached the pediveliger stage, which is the stage in which they settle into the substrate. The clams have settled and are considered

juveniles after around thirty-three days (See Figures 2 and 3). Higher temperatures and salinity may speed up the development of these animals. (Dudas and Dower, 2006). Because of this, there may be quicker development in Puget Sound and the coast of Oregon.

Varnish clams, like the majority of bivalves are sequential hermaphrodites. In general, they will produce male gamete before ever producing eggs. This is due to the energy costs associated with oogenesis. The smallest male recorded in a study by Dudas and Dower (2005) was 16mm while the smallest female was 23mm.

Figure 2: Varnish clam larvae from fertilization to the juvenile stage (about 33 days) Source: Dudas and Dower (2005)

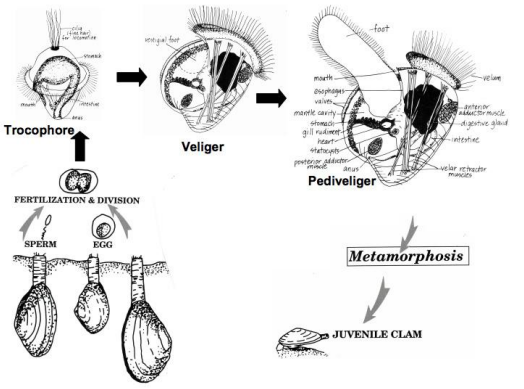

Figure 3: Life cycle of a clam. This image depicts broadcast spawning and the subsequent metamorphosis of the clam larvae. This process takes about 33 days in *N. obscurata.* Source: www.maineclammers.org

Feeding habits

N. obscurata are both suspension and deposit feeders. While suspension feeding, varnish clams eat, mostly, algae. They can use either method depending on the habitat they are in. Suspension feeding is common among all bivalves. When water is pulled into the incurrent siphon by cilia in the mantle cavity. The water flows over the ctenidia, organs for food sorting and gas exchange, and food particles are pulled out and sorted. From there, the particles are moved to the mouth then the stomach where they are further ground by an organ called the crystalline style and digested with enzymes. The food moves into the intestine where nutrients are absorbed before being excreted out of the excurrent siphon along with the outgoing water and pseudofeces, particles that get brought in with the water that is not usable by the animal.

Varnish clams are able to deposit feed using their foot. The foot can collect the food from the substrate and carry it to the mouth as it is brought back into the mantle cavity. This method could be useful when the siphons are retracted and the clam is buried in the substrate.

Reproductive strategies

As mentioned in the "Life cycle" section, *N. obscurata* are sequential hermaphrodites. This means that they change sexes, typically, every year. While varnish clams are typically male their first spawning season because of size, there are many factors that determine sex in later years. Varnish clams start reproducing at younger ages than almost every other Pacific Northwest bivalve species at only one year of age. Other species range from two years in *Mya aranaria (soft shelled clam),* manila clams, and *Protothaca staminea* to four years in *Tresus capax and Saxidomus giganteus.* Gametic tissue is typically present in May with intermittent spawning occurring between June and August, while the water temperature is the highest. Varnish clams have a longer spawning range than the majority of the other bivalve species in the Pacific Northwest; many of which are only summer or spring and summer while *N. obscurata* can spawn through early fall in some cases. (Dudas and Dower, 2006)

Environmental optima and tolerances

Very little work has been done to assess the environmental and habitat tolerances of *N. obscurata*.

Varnish clams are most commonly found in in the upper intertidal zone and less so in the

middle intertidal. When *N. obscurata* is the only clam present, densities can remain high through the lower intertidal. (WDFW)
N. obscurata is found burrowed at different depths in the substrate depending on substrate type. Most commonly, these clams are observed at shallow depths on muddy and rocky beaches and at deep depths in sandy substrates (Shishido et al, 2010). The typical depth at which to find them is six to ten inches deep into the substrate.
Varnish clams are able to metamorphose successfully in temperatures above 9 degrees Celsius, with the highest temperature tested being 20 degrees. As far as salinity goes, they require higher than 15psu, but they highest tested was 20psu. (Dudas and Dower 2005).

Biotic association (pathogens, parasites, and commensals)

While there has been fairly limited work on *N. obscurata* in general, there has been at least two papers interested in parasites that can be found to be associated with the species. More than sixty percent of the clams observed were infected by *Mytilicola*-like copepods called red worms (Marshal et al 2003). Red worms were found in the lumen of the digestive tract (Figure 3). Similar species can cause decreased shell growth, impaired spawning ability, and scarring of the intestinal tract of other bivalves in instances of a serious infestation (NOBANIS).
In Marshall et al (2003), up to one quarter of the varnish clams observed had either male or immature *Pinnotheridae feba*, a species of pea crab, inside of their mantle cavity. Pea crabs are small, brachyuran crabs that can live inside of bivalves during certain life stages. *N. obscurata* are present. While some describe these creatures as commensal (Becker and Turkay, 2010), sustain themselves on food collected by their host, which causes them to be parasitic (Marshall et al, 2003). Shishido et al (2010) found a difference between the infection rate of *N. obscurata* with pea crabs at different sites with different sediment types.

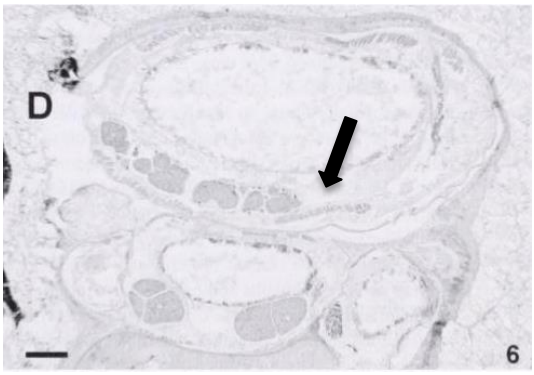

Figure 4: Red worms (*Mytilicola feba*) present in the intestine of *N. obscurata*. They are present where the arrows points. Source: Marshall et al (2003)

Current Geographic Distribution

Distribution in the United States and the Pacific Northwest

Varnish clams are currently present in all saltwater systems from the northern side edge of Vancouver Island to Southern Oregon including northern Puget Sound and Georgia Strait (Figure 5). The densities are the highest in the Georgia Strait and range between about 135 and 440 per meter squared in different location in Canada as of 2003 (Dudas and Dower, 2006). There have been no recorded sightings farther south or on the Atlantic coast.

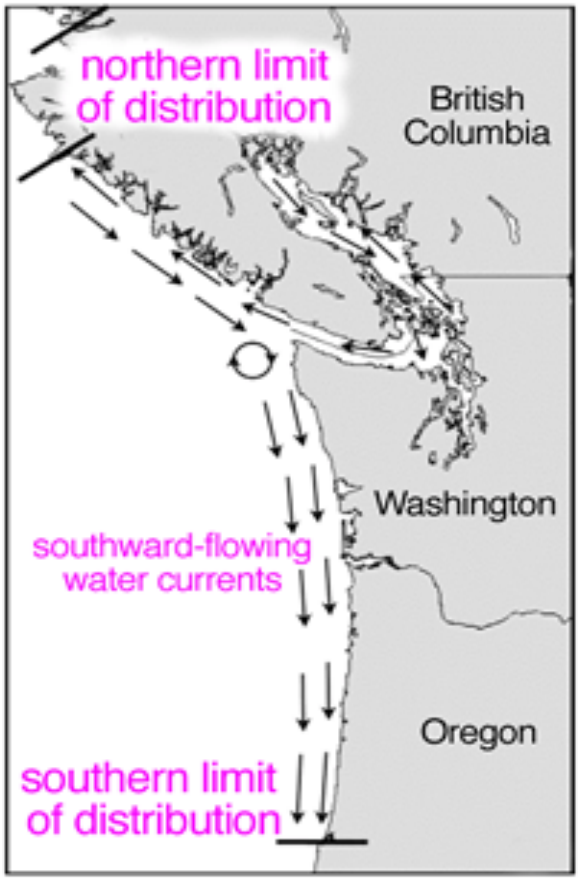

Figure 5: Map of Distributions – Range is from the northern limit of Vancouver Island to southern Oregon. The general ocean currents are also depicted. Source: www.asnailsodessey.com

History of Invasiveness

The Varnish clam is native to Japan. It has previously invaded the coasts of both China and Korea before being introduced to the waters of British Columbia and Oregon in two separate introductions. Clearly, *N. obscurata* is a strong invader since it has succeeded in multiple new habitats.

Invasion Process

Pathways, vectors and routes of introduction

The current hypothesis of how *N. obscurata* was introduced in North America is by either ballast water or hull fouling in the early 1990s. The pathway that was likely responsible for this is international trade, which brings many large ships across the ocean. These ships release their ballast into the local waters releasing anything else that happened to survive the journey. Clam larvae are excellent candidates for transport via this vector. Varnish clams have an extensively long (around thirty-three day) planktonic period. While they do require nutrients from the environment for the majority of that time, they are very small, up to 180 micrometers in length and require only small amounts of algae to survive.

Hull fouling is a slightly less likely explanation for this invasion. Clams do not have byssus like mussels or do they attach themselves to a substrate like oysters. There is a chance that they could get stuck in other things that foul the ship, algae, for instance. This is only possible for larvae, as they have no other way to become suspended in the water column.

Factors influencing establishment and spread

Varnish clams do require certain environmental factors to successfully establish. They are unable to develop fully in water that is 9 degrees Celsius or colder. This limits the location and season in which they can establish. This temperature limit may also be a major factor in the latitude range the species is found in. *N. obscurata* have better development in moderate salinities (20psu) (Dudas and Dower, 2005). This is lower than the oceans average salinity of about 34psu (NOAA, 2009) and coincides with Claudia Mill's observations that varnish clams are most commonly found near points of freshwater runoff. Mills also discusses the clams' sensitivity to highly polluted or dirty water.

Luckily for the varnish clam, spread is very easy. Gametes travel after being released into the water column. The planktonic larvae move with the water current (see Figure 5). Since their planktonic stage is so long, they can move fairly long distances. As long as there are other individuals near the place they settle, the animals will be able to reproduce there and continue the spread of their species. The ability for offspring to

settle far from their parents and siblings also decreases the opportunity for inbreeding and decreased genetic diversity; although, there will be a founder effect especially if the new location has a small population.

Potential ecological and/or economic impacts

While there are no current plans for a fishery in Washington State, it is currently classified as a shellfish under WAC 220.12.020. People are allowed to harvest them as part of their daily limit.

In British Columbia, there has been extensive research to determine the suitability of a fishery for *N. obscurata*. Claudia Mills knew of at least one place they were being sold in BC in 2002. In Canada, they are being marketed as the "Savory Clam".

Chan and Bendell (2013) looked into the potential effects varnish clams at different densities can have on the natural substrates. They found that the organic makeup of the sediments did not change in any of the densities tested, but the ammonium concentration was effected at both the medium and lowest depths. While varnish clams were present in the regions they studied, they did not make up the majority of the clam population, which was still held by the native littlenecks and manila clams. Although varnish clams have the possibility of outcompeting both species, mainly due to their flexibility in feeding methods, it does not seem that they are currently posing a large threat to either species.

Management Strategies and Control Methods

There are no efforts or plans currently in place to manage or eradicate *N. obscurata* from Washington, Oregon, or British Columbia. In Washington, shellfish growers have said that there is little risk of the varnish clam becoming a nuisance species.

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University of Washington – Claudia Mills
http://faculty.washington.edu/cemills/Nuttallia.html

A Snail's Odyssey
www.asnailsodyssey.org

Washington Department of Fish and Wildlife
http://wdfw.wa.gov/ais/nuttalia_obscurata/

World Register of Marine Species
http://www.marinespecies.org/aphia.php?p=taxdetails&id=397157

Regional Contacts
Sarah Dudas
Sarah.Dudas.viu.ca
Centre for Shellfish Research
Vancouver Island University
900 Fifth Street
Nanaimo, BC V9R 5S5 Canada

Claudia Mills
cemills@u.washington.edu
Friday Harbor Laboratories
University of Washington