

FEBRUARY 2007

WASHINGTON STATE'S RESPONSE TO AN INVASION OF NON-NATIVE TUNICATES

Accomplishments, Challenges and Next Steps

Report to the Legislature



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Office of the Governor, State of Washington



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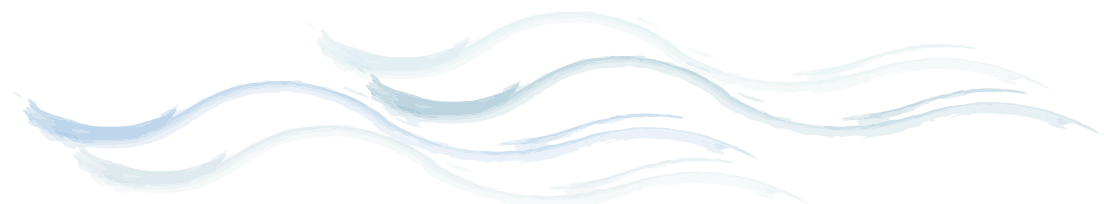
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PHOTOS TOP TO BOTTOM:
Styela clava; *Ciona savignyi*;
Styela clava. Janna Nichols,
Pacific Northwest Scuba.
Dock wrapped in plastic. Jesse
Schultz, WDFW.

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LESSONS LEARNED

1. Early detection and rapid response to contain and kill invaders is imperative if the state wishes to effectively manage non-native invasions. It is far cheaper to prevent introductions than it is to contain and eradicate them.
2. The state does not yet have an adequate early detection program, taxonomic support or agreements among agencies for responding to newly found invaders. Nor do agencies have the proper tools for successfully responding to invasions, especially if chemical controls are required.
3. Chemical control methods in aquatic environments are regulated under the state-administered National Pollutant Discharge Elimination System (NPDES) program. Washington State Department of Ecology (Ecology) is the delegated administrator of the federal NPDES program. Ecology is in the process of developing a general NPDES permit for this purpose.
4. The Tunicate Response Advisory Committee (TRAC) adamantly asked the state to refrain from designating infested waters and imposing management measures in the inlets and bays in which club tunicates were found. TRAC did not want the state to quarantine these areas. Committee members felt that voluntary compliance would work better than a strong regulatory approach. Whether a voluntary approach is effective remains to be seen. Washington Department of Fish and Wildlife (WDFW) has decided to move forward to list the three invasive tunicate species as prohibited under state law. The department intends to use these listings to better manage invasive tunicates in Puget Sound.
5. The state was hampered in its response to this invasion because there are no established and proven methods to control, remove and eradicate invasive tunicates. The state experimented with various survey techniques and methods for killing invasive tunicates.



Styela clava. Janna Nichols, Pacific Northwest Scuba

6. The Action Team has received very few calls on the agency's toll-free phone line and no electronic reports to the invasive tunicate Web page. This indicates that the communications strategy for this project needs to be improved.
7. Due to safety and liability concerns, WDFW could not effectively engage divers from non-governmental groups, such as Reef Environmental Education Foundation (REEF), to conduct surveys and eradication efforts. The state needs to re-think how to effectively engage such groups.
8. Hiring commercial dive companies to eradicate *Styela clava* is expensive and may be cost prohibitive. Using agency divers is a more cost effective approach to control and manage invasive tunicates.

INTRODUCTION

Governor Chris Gregoire directed the Puget Sound Action Team (Action Team), in collaboration with the Department of Fish and Wildlife to report to her and the Legislature by January 15, 2007 on the expenditure of emergency and supplemental funds made available to respond to the problem of invasive tunicates in Puget Sound waters, and to recommend further actions if necessary.

This is a report on the progress to stop invasive tunicates from spreading in Puget Sound and to eradicate them.

THE PROBLEM

In December 2006, the Governor and the Legislature provided a total of \$250,000 in emergency and supplement funds to respond to and prevent invasive tunicates from spreading in Puget Sound.

Non-native tunicates are innocuous-looking organisms that are particularly prolific spawners. In some cases, they can reproduce once every 24 hours when the water temperatures warm to the right conditions. They out compete native organisms for food and space. They attach to boat hulls, docks and marina structures, and also to shell stock, shellfish-growing equipment and in other water equipment that can be moved from location to location.

Researchers identified three species of non-native tunicates in Puget Sound:

- **Club tunicate** (*Styela clava*). Attaches to hard surfaces including boat hulls and docks (Figure 1).
- **Transparent tunicate** (*Ciona savignyi*). Found in extremely large concentrations in southern Hood Canal, over and around geoduck tracts (Figure 2).
- **Colonial tunicate** (*Didemnum sp.*). Grows as a colony and form living mats that smother native organisms and habitats (Figure 3).

Club tunicates aggressively reproduce and have the potential to spread rapidly throughout the Sound. In 1998, WDFW surveyed geoduck beds in lower Hood Canal and did not find *Ciona savignyi*. But in late 2005, WDFW found a huge population. The size of the population is enough to cause concern about the effects on geoducks and other native species in the canal.



Figure 1: Invasive club tunicate, *Styela clava*.
Pam Meacham, WDFW



Figure 2: Invasive transparent tunicate, *Ciona savignyi*.
Janna Nichols, Pacific Northwest Scuba



Figure 3: Invasive colonial tunicate *Didemnum sp.* on mussels in Puget Sound and mussel cage in British Columbia. U.S. Geologic Survey Science Center, Woods Hole, MA

Map 1 (page 11) identifies the location of the known or suspected locations of invasive tunicates reported by divers, boaters and researchers.

In the winter of 2006, researchers also discovered club tunicates were fouling recreational boats in three Puget Sound marinas: Pleasant Harbor on Hood Canal, Blaine and Semiahmoo marinas in Whatcom County, and reportedly in Neah Bay Marina in Clallam County.

Researchers were concerned that recreational boats infested with non-native tunicates would move from infested areas during the spring 2006 boating season to uninfested areas where the animals could spawn and spread.

At the time, agencies did not have sufficient funds to respond immediately to this threat.

Timely funding has since allowed the Action Team, WDFW and Washington Department of Natural Resources to respond quickly to stop invasive tunicates from spreading in Puget Sound and to begin evaluating the extent of the invasion.

HOW DID THESE ANIMALS GET HERE?

Puget Sound is home to many native tunicate species.

The club tunicate, *Styela clava*, is native to Asia. Researchers suspect that they traveled as hitchhikers on fouled hulls of recreational boats arriving from Canada.

The invasive transparent tunicate, *Ciona savignyi*, is native to Japan. It was probably brought into Puget Sound by trans-oceanic shipping in ballast water or as adult animals attached to ships' hulls.

The invasive colonial tunicate, *Didemnum sp.*, is native to Europe and probably came to this region in ballast water discharged from ships, as hitchhikers on recreational boats or on shellfish and/or shellfish equipment brought to the region for other locations. This species is also found in waters of British Columbia and San Francisco Bay.



Styela clava. Simon Geerlofs, University of Washington

FUNDING

In January 2006, the director of the Action Team discussed his concerns about the invasion with the Governor’s Natural Resources Sub-cabinet, and asked for funding to support an immediate state response to the problem.

On February 15, 2006, the Governor appropriated \$75,000 from her Emergency Fund to WDFW. She specifically directed the department to use the funds to:

1. Designate inlets and bays in which invasive club tunicates are found and impose management measures to control their spread.
2. Eliminate invasive tunicates from boat hulls at infested marinas.
3. Remove tunicates from floats, moorings, in-water structures and areas surrounding the marinas.

In April 2006, the legislature passed its supplemental budget that included \$175,000 to eradicate club tunicates, to survey other areas for the presence of invasive non-native tunicates and to evaluate their environmental effects.

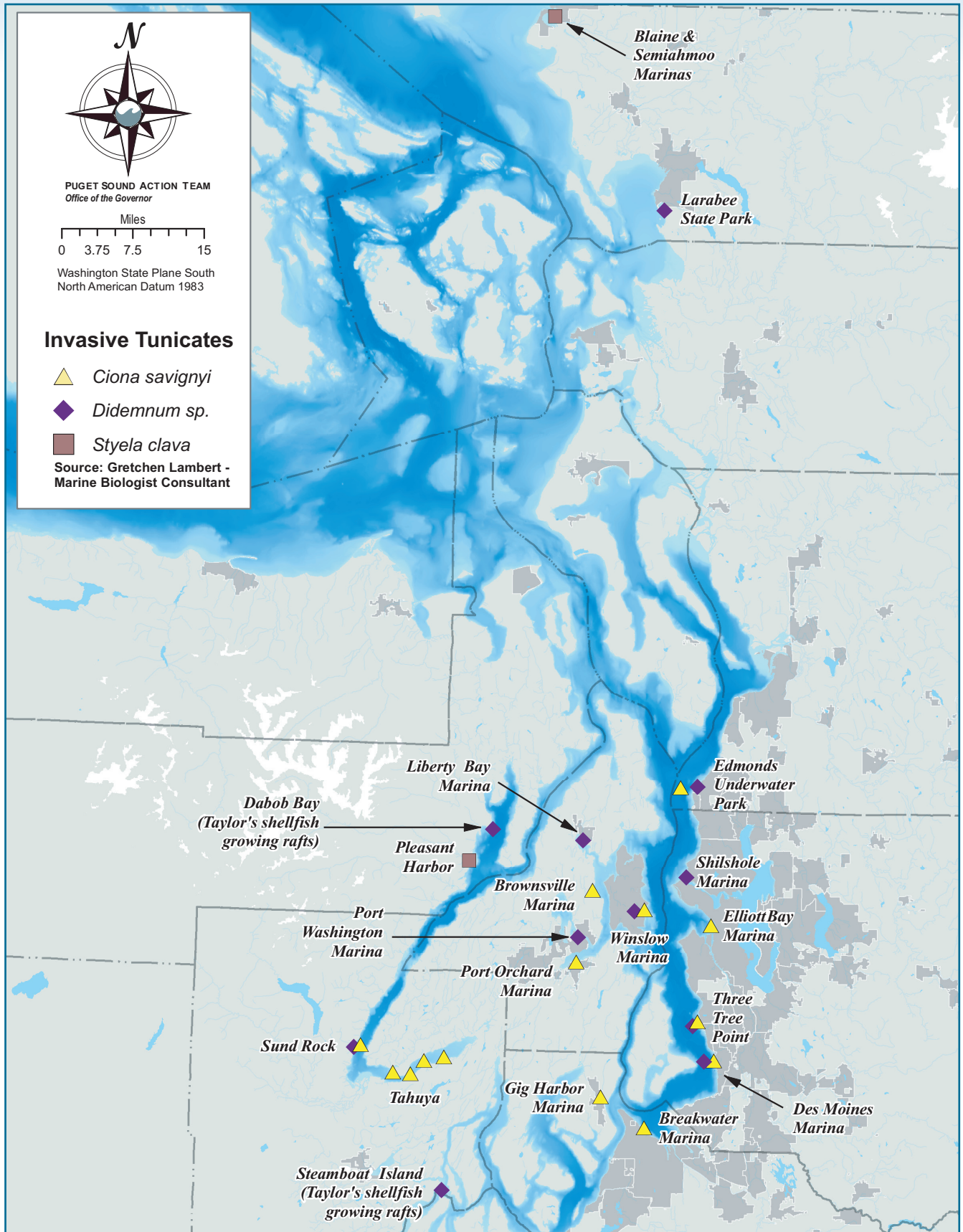
The cost to contain, control and eventually kill club tunicates at marinas in known locations is small compared to the potential costs to boaters and shellfish farmers, and the cost of lost habitat and displaced native species—especially if tunicates spread to wider areas of the Sound.

Part of the emergency funds will be used to study the distribution and ecosystem effects of the non-native transparent tunicate (*Ciona savignyi*) found in extremely large concentrations over geoduck tracts in southern Hood Canal. WDFW surveyed geoduck tracts in 1996 and did not find *Ciona savignyi*, but 10 years later they found a huge population in the same area. The size of the population is enough to cause concern about the effects of these large populations on geoducks and other native species in Hood Canal.

Based on a rapid response plan developed by an interagency team, funds provided by the Governor and supplemental state funds were distributed to agencies to carry out specific tasks (Table 1).

TABLE 1: Spending Plan

AGENCY AND TASK	SPEND BY		TOTAL
	June 30, 2006	June 30, 2007	
Action Team to develop public education and outreach materials on invasive tunicates	\$20,000	\$5,000	\$25,000
DNR to survey the extent and distribution of an invasive tunicate in lower Hood canal	\$15,000	\$15,000	\$30,000
Private contractor to survey public and private docks for the presence/absence of invasive tunicates	\$14,500		\$14,500
WDFW to remove and stop invasive tunicates at infested marinas from spreading to other areas in Puget Sound	\$113,500	\$67,000	\$180,500
TOTAL	\$163,000	\$87,000	\$250,000



Source: Gretchen Lambert, Marine Biologist Consultant

AGENCY ROLES

The following are agency roles in this response.

- **Washington Department of Fish and Wildlife** responds to, controls and eradicates non-native animals, including invasive marine animals. WDFW had insufficient resources to respond to this threat, so the department relied largely upon volunteer divers to control invasive tunicates.
- **Washington State Department of Natural Resources** is the aquatic lands steward, ensuring that trust lands are managed and protected for the public. DNR must determine that lease opportunities are not adversely affected by pollution or other threats such as invasive species. DNR responds to invasive species found on state-managed submerged lands.
- **Washington State Department of Ecology** (Ecology) authorizes the use of chemicals and biocides in water to kill invasive plants and animals. Last year, the department issued emergency waivers to control the non-native colonial tunicate, *Didemnum sp.*
- The **Puget Sound Action Team** coordinates and supports interagency efforts to contain, stop the spread of and eradicate these non-native invasive animals in Puget Sound.

These control and eradication efforts are consistent with the priorities of the Puget Sound Action Team member agencies to protect critical areas that provide important ecological functions and to restore degraded habitat.



Styela clava. Janna Nichols, Pacific Northwest Scuba



Styela clava. Janna Nichols, Pacific Northwest Scuba



Boat propeller covered in *Styela clava*. Janna Nichols, Pacific Northwest Scuba

RESULTS FOR THE PERIOD APRIL 1 THROUGH JUNE 30, 2006:

1. The Puget Sound Action Team convened and hosted an interagency caucus group and tunicate response advisory group to develop an effective response to invasive species. The Action Team drafted a *Tunicate Response Plan* that guides the actions of the state and others in responding to invasive tunicates. A copy of the plan and the status of various work elements is in Appendix 1.
2. The Action Team set up a toll-free line (800-54-SOUND) and an invasive tunicate Web site (www.wainvasivespecies.org) to provide information on the invasion and to allow people to report invasive tunicates online.
3. The Action Team designed, printed and distributed 25,500 invasive tunicate identification cards, 370 posters and 46,000 billing inserts to advise recreational boaters moored at Puget Sound marinas about the problem and to provide them with a list of things to do to minimize spreading these animals.
4. Commercial divers under contract to the WDFW removed all invasive club tunicates found on recreational boats in four marinas and surveyed other areas to determine if the invaders had spread. They removed more than 90 pounds from 150 recreational boats at Blaine, Semiahmoo, Pleasant Harbor and Home Port marinas. All boats, except one, were cleaned in these marinas. By removing the tunicates from boats before the start of the spring boating season, the department may have successfully stopped these animals from spreading to other locations around the Sound (Appendix 2).
5. The contract divers also surveyed about 30,000 square meters of docks in the four infested marinas, cleaned about 33 percent of the area and removed about 2,000 pounds of invasive club tunicates. All the docks and pilings in the Semiahmoo marina in Drayton Harbor were cleaned except for an artificial jetty at the marina. More work is needed to remove the remaining tunicates from these infested marinas. (Appendix 2).
6. WDFW also hired an expert in tunicate identification to survey 55 marinas for the presence or absence of the three invasive tunicates. Based on the survey, club tunicates do not appear to have spread beyond four infested marinas. The non-native transparent tunicate, *Ciona savignyi*, and non-native colonial tunicate, *Didemnum sp.*, initially reported at one location in 1998, were found at eight other marinas. (Appendix 4).
7. DNR contracted with the Skokomish Tribe to survey the extent and distribution of invasive transparent tunicates, *Ciona savignyi*, in lower Hood Canal. They found that the species is distributed from the Great Bend (Bald Point) toward Belfair. They found these invaders in 19 of the 22 transects, with the highest densities located between 40 to 65 feet. In most cases, transparent tunicates are the predominant species in the areas that were surveyed. This animal was not present in this location when DNR surveyed geoducks in 1996. (Appendix 3).

Styela clava covered in *botryllus*. Simon Geerlofs, University of Washington



EFFECTIVENESS OF TREATMENTS

WDFW tested three methods for removing invasive tunicates from docks: hand pulling or picking, pressure washing and wrapping docks in plastic. Each method has its limitations and can be used only in specific instances and on specific types of dock structures.

Hand Pulling. This method works well on docks that use Styrofoam flotation. It is a labor-intensive and time-consuming process and is not effective in removing all tunicates. Yet, it is one of the few methods available for removing tunicates.

Erin Grey, a doctoral candidate at the University of Chicago, surveyed the Pleasant Harbor marina before and after divers had removed the invasive club tunicates using this method. She counted the number of individual tunicates 24-by-24 cm quadrants for a total of 72 randomly selected replicates. She surveyed docks A through H in May 2006 and only docks A through E in September 2006.

The results from her survey show that divers using the hand-pulling method effectively reduced the density of club tunicates on the infested docks at Pleasant Harbor. They reduced the density of about 3.5 individuals per 24 cm² quadrant before control efforts in May 2006 to less than 2 individuals per 24 cm² quadrant after the control effort in September 2006. (See figure 4)

Pressure washing. This method is highly effective and will remove almost all living organisms from a dock; however, it can only be used on docks that use concrete or metal flotation. As with any underwater work, pressure washing is time consuming and labor intensive. Biological debris is not collected following pressure washing.

WDFW tested the pressure washing techniques at the Blaine Marina. Figure 5 shows before-and-after results of pressure washing.

Wrapping in plastic. This method used plastic sheets to completely wrap infested docks and pilings. The objective is to deprive organisms under the plastic of oxygen and food, thereby killing them.

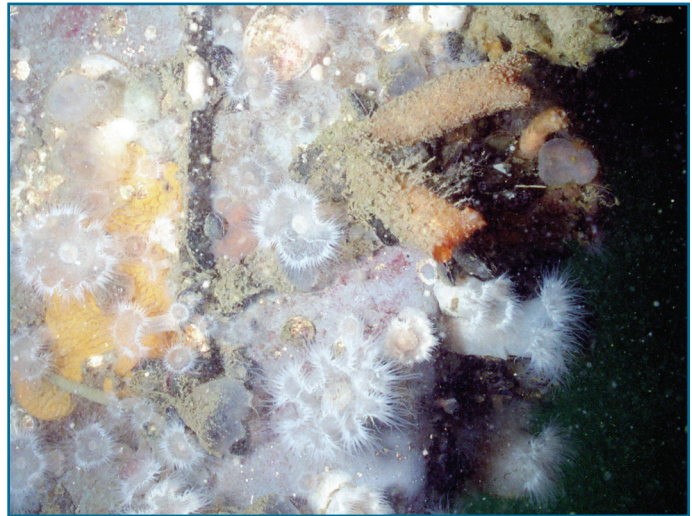


Figure 5: Concrete dock before and after pressure washing.
Jesse Schultz, WDFW

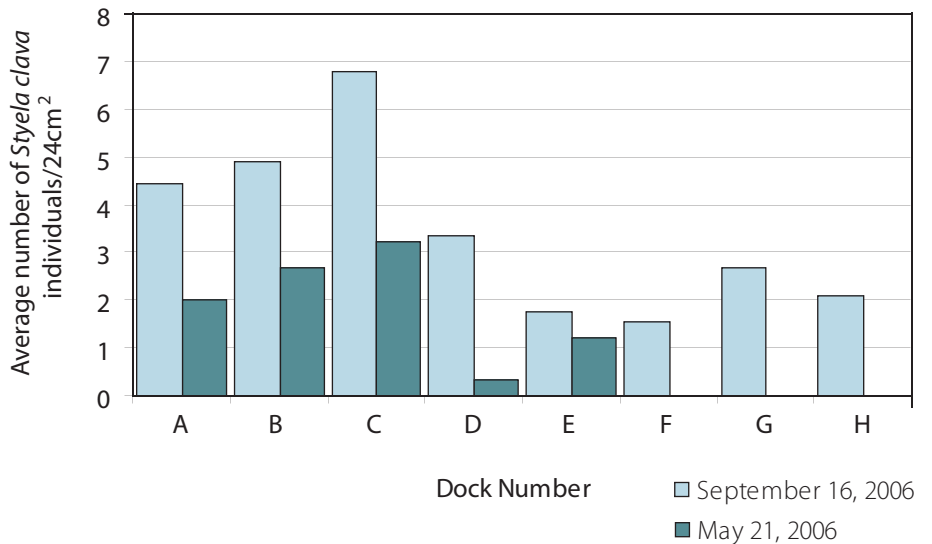
The state of Hawaii successfully used this method to eradicate invasive corals in several Hawaiian marinas.

WDFW tested this method in Pleasant Harbor and found that the technique does not appear to work very well for various reasons, but primarily because it is difficult to completely seal off the dock from the outside environment. Figure 6 shows the plastic-wrapping method.



Figure 6: Dock wrapped in plastic.
Jesse Schultz, WDFW

FIGURE 4. Effectiveness of Hand Pulling Method at Pleasant Harbor Marina: Density of *Styela clava* before and after eradication



Source: Erin Grey, University of Chicago

IMMEDIATE NEXT STEPS: JULY 2006 TO JUNE 2007

Between July 2006 and June 2007, the responding State agencies will focus on the following goals identified in the ***Interagency Invasive Tunicate Response Plan***:

1. Eradicate known populations of the invasive club tunicate, *Styela clava*.
2. Identify current locations of other non-native tunicate species including *Ciona savignyi* and *Didemnum sp.*; assess the risks that these populations pose to the environment and economy; and, if necessary, develop a long-term strategy to contain and eradicate tunicates from identified locations.
3. Develop a long-term strategy for ongoing monitoring of non-native tunicates, and implement measures to minimize their spread.

Work plans for July 1, 2006 through June 30, 2007

Washington Department of Fish and Wildlife ~ Total \$67,000

Phase 2 of the department's club tunicate eradication project is scheduled for October 1, 2006 through June 30, 2007.

The department will:

1. Monitor and control new populations of *Styela clava*, as well as two other species of invasive tunicates (*Ciona savignyi* and *Didemnum sp.*).
2. Develop newer, more cost-effective methods to eradicate these invasive tunicates.
3. Focus on removing *Styela clava* from the Pleasant Harbor Marina. Its location and size, along with a decreased population due to Phase 1 removal efforts, make it more feasible to completely eradicate tunicates in Pleasant Harbor rather than at the two marinas in Blaine.

WDFW will outsource the fieldwork in an open bid competition and will also use agency divers to carry out part of Phase 2.

Using WDFW divers is a cost-efficient approach and supplements the work of contract divers. Table 2 shows the cost saving per week by using agency divers over contract divers.

Washington Department of Natural Resources ~ Total \$15,000

The invasive tunicate, *Ciona savignyi*, was found on the Tahuya tract and in Union marina in Hood Canal. This is a particularly aggressive non-native species, that spreads rapidly. Little is known about how *Ciona savignyi* gets established and spreads in Puget Sound, nor about its environmental and economic effects.

Phase 2 builds upon Phase I, in which the distribution and density of *Ciona savignyi* was mapped and measured in lower Hood Canal. Through dive surveys, DNR mapped dense populations of *Ciona savignyi* at depths between 25 and 65 feet from Bald Point to Belfair in lower Hood Canal.

DNR will conduct the second phase of this project between July 1, 2006 and June 30, 2007, and will involve researching the effects of the *Ciona savignyi* in the marine nearshore environment. Wild stocks of geoducks (*Panopea abrupta*) grow at the same depth and in the same habitat type as *Ciona savignyi* and they provide a significant industry to the region. Therefore, DNR proposes conducting mesocosm or laboratory-scale studies to assess how *Ciona savignyi* may affect geoduck populations. DNR will measure the effects of *Ciona savignyi* populations on geoduck growth and establishment. DNR will also investigate if and how the



Ciona savignyi. Janna Nichols, Pacific Northwest Scuba

species compete for available nutrients and whether or not *Ciona savignyi* directly filters out geoduck larvae from the water column prior to their settling.

In addition to better understanding *Ciona's* environmental effects, DNR's work will collect information to decide if a control plan is needed and, if so, to support the development of such a plan. The information collected may suggest that *Ciona savignyi* is not a significant environmental problem or, conversely, that decisive action be taken immediately to protect valuable geoduck resources.

TABLE 2

	Private Contractor	WDFW	Cost Savings
One time cost gear	-----	\$3,100	-----
Weekly personnel cost	\$13,350	\$1,450	\$11,900

LONGER TERM NEXT STEPS: JULY 2007 THROUGH JUNE 2009

The draft *2007-2009 Puget Sound Conservation and Recovery Plan* includes the following budget request to contain, control and kill invasive tunicates:

Personal Service Contract for *Styela clava* Control and Response

FY 2007	FY 2009	Total
\$150,000	\$150,000	\$300,000

Invasive *Styela clava* tunicates attach to the bottom of recreational boats, marina docks, pilings and other in-water structures such as mussel racks. This funding request would continue work started in 2006 to survey and remove this invasive tunicate from recreational boats and docks at three marinas.

Continuing Control on *Ciona savignyi* and *Didemnum*

FY 2007	FY 2009	Total
\$30,000	\$30,000	\$60,000

Invasive *Ciona savignyi* and *Didemnum* spread on the surface of aquatic lands down to a depth of 60 feet or more. These varieties differ from the *Styela clava* in that they do not attach themselves to the bottoms of boats or structures. DNR is concerned about the impact of *Ciona savignyi* and *Didemnum* on aquatic resources, such as geoducks. This portion of the funding request would be used for contracts with divers to identify and carry out methods of control and eradication of this species. Control and eradication methods for this variety differ from methods used to remove *Styela clava*; therefore, this is a separate line item.

Survey and Research on *Ciona savignyi* and *Didemnum*

FY 2007	FY 2009	Total
\$30,000	\$15,000	\$45,000

The scope and extent of *Ciona savignyi* and *Didemnum* infestation is not entirely known. However, recent video surveys of the fish kill in Hood Canal revealed extensive coverage of the sea floor with these tunicates in areas that only a year earlier had no tunicates. This funding would be used to survey areas for tunicate coverage and study its effects on native species.



Styela clava. Janna Nichols, Pacific Northwest Scuba

Educate Boaters

FY 2007	FY 2009	Total
\$40,000	\$25,000	\$65,000

The funding provided to remove the tunicate *Styela clava* is not enough to remove them from all recreational boats. To aid in identification and removal, the State Caucus on Tunicate Removal recommends a boater education program that engages recreational boaters in a “Keep Your Boat Hull Clean” campaign. This would save state resources by asking boat owners to take responsibility for removing tunicates from their boats. WDFW experience with FY 2006 resources for boater education revealed that the cost of printing and distributing materials is very expensive. But targeted efforts, such as direct mail to boat owners through marina billings, have yielded positive results.

Administration

FY 2007	FY 2009	Total
\$12,500	\$12,500	\$25,000

These funds will be used to develop a tunicate response management plan and to support increased work with the Invasive Species Council.

APPENDICES

Appendix 1. Interagency Invasive Tunicate Rapid Response Plan

Appendix 2. Department of Fish and Wildlife: Results of Eradicating Club Tunicates

Appendix 3. Skokomish Tribe: Ciona Assessment in Lower Hood Canal

Appendix 4. Gretchen Lambert: Survey Results for the Presence or Absence of Invasive Tunicates in Puget Sound

APPENDIX 1: INTERAGENCY INVASIVE TUNICATE RAPID RESPONSE PLAN

Short-Term Goals (April 2006 – June 2006):

- a. Prevent known populations of the invasive club tunicate, *Styela clava*, from spreading to other areas in Puget Sound before June 30, 2006.

Long-Term Goals (July 2006 – June 2007):

- a. Eradicate known populations of the invasive tunicate *Styela clava*.
- b. Identify current locations of other non-native tunicate species including *Ciona* and *Didemnum*, and develop a long-term strategy to contain and eradicate tunicates from identified locations.
- c. Develop a long-term strategy for ongoing monitoring of non-native tunicates, and implement measures to minimize their spread.

Action Plan

A. Leadership, Coordination and Regulatory Authority

Short-term coordination needs: A coordinated effort to stop the invasive tunicate *Styela clava* from spreading and establishing new populations in Puget Sound.

Objective 1: Create a state agency caucus and a stakeholder Tunicate Response Advisory Committee (TRAC) to promote effective coordination across jurisdictions and interests.

Actions:

- a. By March 2006, the Puget Sound Action Team (Action Team) will establish a TRAC with representatives from all interested and affected parties including tribal governments, boating and marina associations, recreational divers, local and regional education networks, federal agencies, etc. to help shape the state's response to invasive tunicates.
Status: TRAC established and held three meetings in 2006.
- b. By March 2006, the Action Team will create a state agency caucus to coordinate interagency issues including jurisdictional conflicts, communications, track progress of state response, resolve and

overcome barriers to progress, and identify current and future needs.

Status: State agency caucus established and held several meetings.

Long-term coordination needs: A coordinated effort to identify, control and eradicate all species of the non-native invasive tunicate in Puget Sound.

Objective 1: Continue the state agency caucus and Tunicate Response Advisory Committee (TRAC) to promote effective coordination across jurisdictions and interests.

Actions:

- a. By September 2006, the Action Team will use the state agency caucus to coordinate interagency issues including jurisdictional conflicts, communications, response strategies, resolve and overcome barriers to progress, identify current and future needs, and to develop necessary research, monitoring and implementation plans.
Status: Ongoing – developed agency budget briefing packages to fund ongoing tunicate response work. Included actions for ongoing control and management of tunicates in draft 2007-2009 Puget Sound Conservation and Recovery Plan.

- b. By September 2006, the Action Team and WDFW will work with the state agency caucus and TRAC to develop long-term strategies to manage invasive tunicates. Strategies will include a comprehensive analysis of pathways of introduction and spread as well as an assessment of relative risk.

Status: Ongoing

- c. By September 2006, the Action Team and WDFW will identify agency resource needs to accomplish the objectives of the long-term goals.

Status: Ongoing – see a. above

Objective 2: Continue to work with the state agency caucus and Tunicate Response Advisory Committee to develop and secure long-term funding for ongoing invasive tunicate research and monitoring, control and education.

Actions:

- a. By September 2006, the Action Team will use the state agency caucus to coordinate interagency biennial budget development for this objective and seek support through the Action Team work plan process.

Status: WDFW, DNR and the Action Team budget briefing papers developed and submitted to executive management for consideration.

B. Prevent the spread of the club tunicate, *Styela clava*

Short-term prevention needs: Enhance the state’s ability to detect new infestations of club tunicates and minimize the spread of pioneer populations.

Objective 1: Educate the public and natural resource managers about the club tunicate, how it spreads and ask them to report new sightings. Target boat owners, marina operators, boat supply stores, commercial boat cleaners, boat launch operators and others.

Actions:

- a. Beginning in March 2006, the Action Team will design and implement outreach activities to educate target audiences to prevent spreading invasive tunicates.

Status: Education materials developed, printed and distributed to all marinas in the Puget Sound basin. See b. below for additional information.

- b. Beginning in March 2006, the Action Team will develop a point of contact for citizens to find out more about invasive tunicates, things that they can do to minimize their spread, and a way to report

sightings of non-native tunicates. The Action Team will widely publicize a single point of contact for reporting new tunicate sightings through both a toll free number and a dedicated web page.

Status: 1-800-54-SOUND accepts reports of new tunicate sightings. Created a stand-alone Web page www.wainvasivespecies.org for information and for reporting invasive tunicates online.

WDFW staff continues to meet with marinas owners and survey boaters providing opportunities to discuss invasive tunicates and the need to control and eradicate them.

The Puget Soundkeeper Alliance continues to meet with marina operators on clean marina issues including invasive tunicates.

- c. Beginning in March 2006, the Action Team will consult with the state agency caucus and TRAC to develop and print laminated tunicate identification cards, tunicate posters, and a tri-fold brochure about clean boating, the risks that invasive species pose and things that people can do to prevent them from spreading.

Status: Designed, printed and distributed 20,000 identification cards and posters.

- d. Starting in April 2006, PSAT will work with the state agency caucus and TRAC to develop and post signage at high-risk waterways, marinas, boat launches, state parks and other saltwater access points.

Status: Completed

- e. Beginning in April 2006, the Action Team will develop an outreach kit for use by others i.e., Puget Soundkeeper Alliance Clean Marina Program, Hood Canal Education Network (HCWEN), etc.

Status: Ongoing

- f. Beginning in April 2006, the Action Team, WDFW, Parks, NWIFC and DNR will distribute tunicate identification cards to all registered boat owners, tribal fishers, public and private marinas, and boat supply stores.

Status: Completed

Objective 2: Expand capacity and coordination of monitoring programs to identify and track invasive species including tunicates.

Actions:

- a. Beginning in September 2006, WDFW will work with the managers of existing monitoring program to incorporate tunicate monitoring into these existing programs and new marine surveys, general plans, etc.

Status: Not started

Long-term prevention needs: Keep stakeholders informed of ongoing work to kill and minimize the spread of invasive tunicates in Puget Sound.

Objective 1: Develop ongoing education program.

Actions:

- a. Starting in September 2006, the Action Team will work with state caucus and TRAC to develop ongoing education program.

Status: Not started

Objective 2: Report on the successes and failures, and identify next steps and recommend ways to improve control and eradication of invasive tunicates.

Actions:

- a. By December 2007, the Action Team and WDFW will work with the state agency caucus group and TRAC to prepare a report on effectiveness of containment and control efforts and recommended improvements. Report to legislature and Governor.

Status: Various draft progress reports completed.

C. Manage, control and eradicate invasive tunicates

Short-term management needs: Contain and kill club tunicates at three marinas with known infestations before boating season.

Objective 1: Classify club tunicates as prohibited species, designate infested waters and impose management measures.

Actions:

- a. Beginning in March 2006, WDFW will work with invasion biology experts, the Fish and Wildlife Commission and stakeholders to classify invasive tunicates as prohibited species, designate infested waters and develop appropriate management measures.

Status: Under consideration. WDFW met with the Fish and Wildlife Commission in June 2006 to discuss progress.

- b. Beginning in April 2006, WDFW will refine and publicize best management practices for handling tunicates on boats and docks through the invasive species Web page.

Status: Ongoing

Objective 2: Identify locations of and eradicate club tunicates from boat hulls and marina structures in infested marinas before June 30, 2006.

Actions:

- a. By March 2006, WDFW will submit an NPDES application to Ecology to cover a variety of possible treatment options to kill club tunicates.
- b. By April 2006, Ecology will issue an NPDES permit or short-term water quality certification to allow WDFW to treat infestation.

Status: Complete

Status: In development

- c. Starting in March 2006, WDFW will survey vessels and structures in infested marinas to identify location and density of tunicate infestations. WDFW will use commercial divers and video equipment to conduct surveys within marinas.

Status: Preliminary test of techniques completed. Decided to use visual survey techniques instead

- d. Starting in March 2006, WDFW will remove club tunicates from boats and structures using commercial divers, haulouts and new methods depending on the degree of fouling.

Status: Contract divers surveyed infested marinas and removed invasive tunicates from infested boat hulls. Report on file. Funds ran out before work on marina pilings and floats could be cleaned of tunicates. WDFW is exploring less expensive options to eradicate tunicates on marinas infrastructures

- e. Starting in March 2006, WDFW will develop and test strategies to eradicate tunicates on boats and marina structures where other methods are not effective.

Status: See d. above. WDFW is currently testing an eradication method used in Hawaii. The method involves by wrapping docks in plastic sheeting. WDFW will evaluate costs and success of this method

- f. Starting in March 2006, WDFW will hire a contractor to survey areas within and adjacent to infested waters to discover, contain and control club tunicates.

Status: See c. above. WDFW staff continues to survey marinas and private docks outside of infested marinas for presence/absence of invasive tunicates

- g. Starting in June 2006, WDFW will develop a handbook of various strategies to effectively eradicate invasive tunicates.

Status: Ongoing

- h. The Action Team will provide a forum (e.g. TRAC) for stakeholder to participate in education, control and eradication efforts.

Status: Ongoing

Objective 3: Monitor and report on the effectiveness of eradication efforts and identify improvements.

Actions:

- a. Starting in March 2006, WDFW will develop and implement methods to assess the effectiveness of control methods and success of operations.
- b. Starting in March 2006, WDFW will document and evaluate the costs of mobilization, containment and control.

Status: Not started

Status: Ongoing – preliminary cost evaluation completed

Objective 4: Identify high-risk areas likely invaded by club tunicates.

Actions:

- a. Starting in March 2006, WDFW will hire a contractor to survey other areas where club tunicates are likely to be found.

Status: Completed. Contracted with Gretchen Lambert to carry out visual surveys of 41 additional marinas for presence/absence of invasive tunicates.

- b. Starting in April 2006, WDFW will work with recreational dive organizations to survey for invasive tunicates in popular dive destinations and at targeted location in which tunicates are likely to be found.

Status: Work with REEF to develop a strategy for carrying out recreational divers' surveys and for reporting new invasive species discovered through this process.

- c. Starting in March 2006, WDFW will identify new populations and take action to contain and minimize the spread of these animals.

Status: Ongoing – see Objective 2 f. above

Long-term management needs: Conduct an assessment of the risks posed by the colonial tunicate *Didemnum* and the transparent tunicate *Ciona* and develop strategies to contain and eradicate them. Continue work to contain and eradicate the club tunicate *Styela clava*.

Objective 1: Better understand the threats to the environment posed by invasive tunicates.

Actions:

- a. By September 2006, WDFW and DNR will conduct a risk assessment to determine the vulnerability and potential biological and economical impacts of tunicate invasions. This risk assessment should be consistent with the state's Early Detection and Rapid Response Plan.

Status: DNR contracted with the Skokomish Tribe to survey for *Ciona* in the lower Hood Canal to determine the extent and distribution of this species. WDFW has shifted work to next biennium contingent on funding

Objective 2: Develop and implement a long-range strategy to control and eradicate invasive tunicates - *Styela clava*, *Ciona* and *Didemnum*.

Actions:

- a. By September 2006, WDFW will work with the state agency caucus and TRAC to develop a long-term strategy to control and eradicate club tunicates.

Status: Shift work to next biennium contingent on funding.

- b. Starting in September 2006, WDFW and DNR will develop and implement management strategies, if appropriate, to control and eradicate non-native tunicates such as the transparent *Ciona* and colonial *Didemnum* tunicates.

Status: Ongoing

- c. Starting in September 2006, WDFW, DNR, and others will develop and implement a monitoring strategy to determine spread of the *Styela clava*, *Ciona* and *Didemnum* tunicates.

Status: Ongoing – requested additional resources to carry out monitoring.

- d. By September 2006, WDFW and Ecology will secure general NPDES permit to control, treat and kill all invasive species in general and specifically non-native tunicates.

Status: Ongoing

Objective 3: Identify and implement research needed to improve our understanding and control of *Styela clava*, *Ciona* and *Didemnum*.

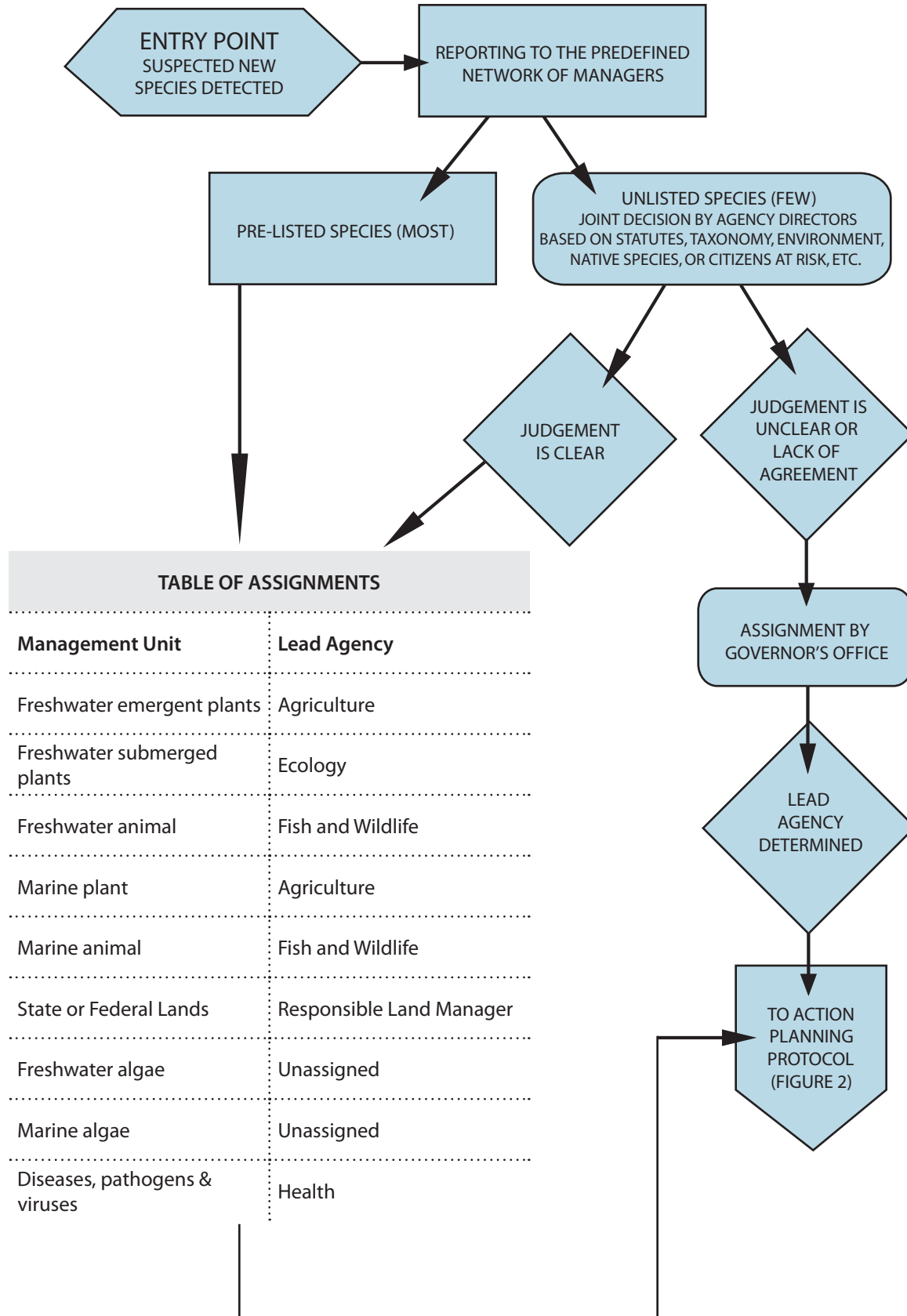
Actions:

- a. By September 2006, WDFW will develop a research plan to improve control and eradication of invasive tunicates:
- Identify and research treatment options.
 - Research dispersal and develop predictive models.
 - Research tunicate effects on biodiversity, food web; ecological functions.
 - Research environmental parameters where tunicates will survive and prosper.
 - Research the ecological range prediction for invasive tunicates.
 - Research the reproductive potential and modes.

Status: Not started

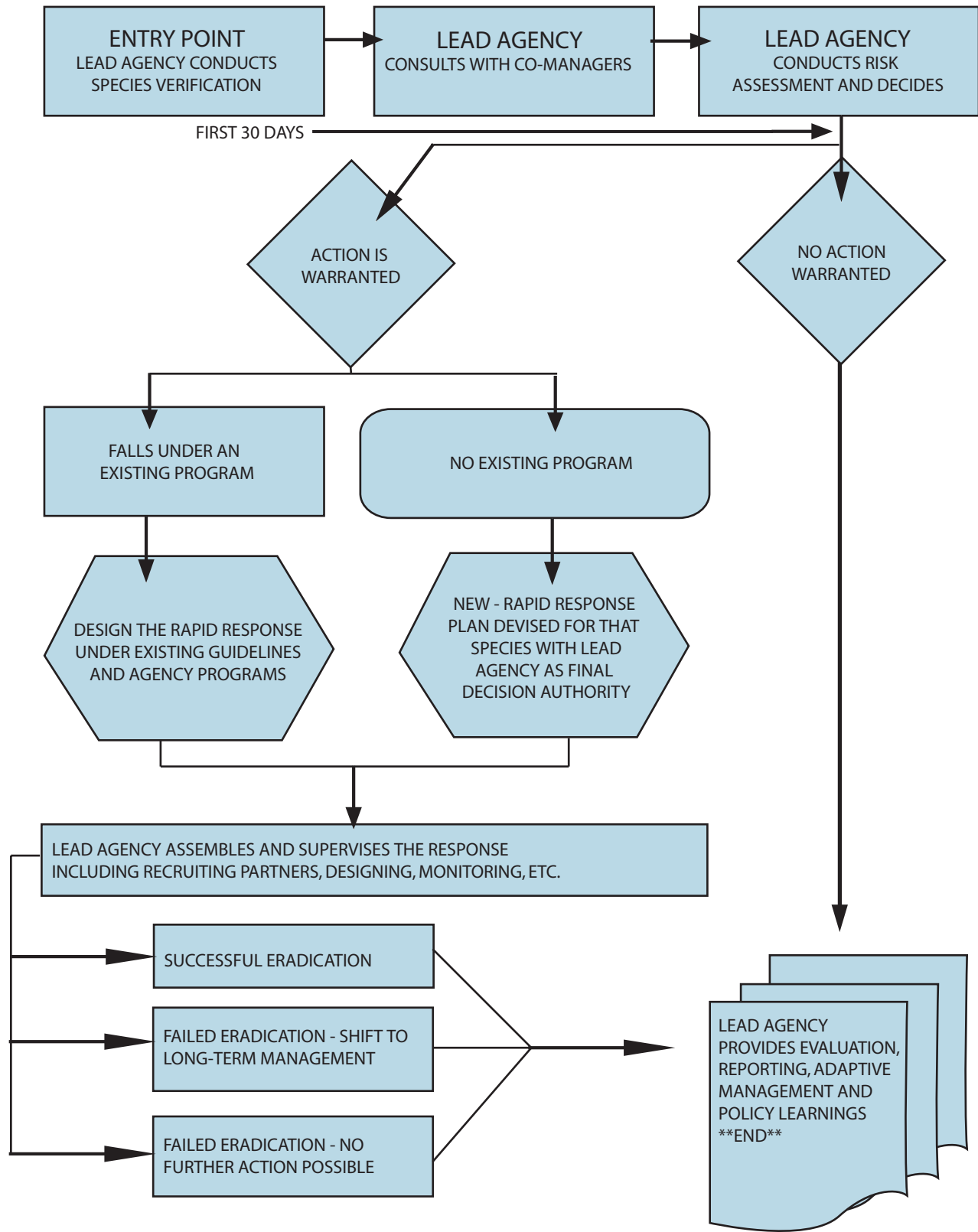
FIGURE 1

Lead Agency Determination for Rapid Response



Source: 2005 Early Detection and Rapid Response Plan for Aquatic Invasive Species in Washington State.

FIGURE 2
RAPID RESPONSE Action Planning Protocol



Source: 2005 Early Detection and Rapid Response Plan for Aquatic Invasive Species in Washington State.

APPENDIX 2: DEPARTMENT OF FISH AND WILDLIFE: RESULTS OF ERADICATING CLUB TUNICATES

WDFW *Styela clava* Response Progress Report
October 6, 2006

In April 2006 WDFW was provided with emergency funding for the purpose of surveying to determine the extent of *Styela clava* infestation, to make efforts to control the spread, and to determine the potential costs of eradication efforts. Three commercial diving organizations were contracted by Washington Department of Fish and Wildlife (WDFW) to remove invasive tunicates (*Styela clava*) from vessels and docks in three marinas (Blaine, Pleasant Harbor, and Neah Bay) where populations were previously identified. The first phase of the removal effort was completed June 30, 2006. A second phase will be designed based upon Phase 1 results and implemented between July 1, 2006 and June 30, 2007. During Phase 1 only a native species of *Styela* was found at Neah Bay. However, *S. clava* was found at two additional marinas adjacent to Blaine and Pleasant Harbor Marinas (Semiahmoo and Home Port).

Blaine Marina

WDFW contracted with The Washington Department of Ecology, who in turn contracted with Natural Resources Consultants, Inc. (NRC) to undertake the field aspects of the project. Fenn Enterprises conducted the dive aspect of the project for NRC.

A total of 4.5 diver team (two scuba divers/day) days of effort were expended during the May 2006 project. All of the docks and vessels in Blaine Marina were surveyed for *S. clava* and densities in numbers per square meter were estimated. A total of 522 vessels were checked and *S. clava* were found on 94 vessels. The number of *S. clava* on the infested vessels ranged from 1 to 693, average being 38.5. All the infested vessels were cleaned except one derelict vessel, El Primero, on dock G56-A. This vessel had one of the highest densities of *S. clava* observed ($>100/m^2$) but the metal hull of the vessel was in such poor condition that the divers believed the vessel could be threatened by any removal work. A total of 3,545 *S. clava* weighing 62 lbs were removed from 93 vessels (Table 1).

Infestation of *S. clava* on docks in Blaine was extensive. Densities were determined by an underwater visual estimate; they ranged from 0 to 120 per m^2 , averaging 8 per m^2 (Table 2). A total of 12,086 m^2 (77%) of dock bottom had some *S. clava* concentrations. The estimate does not include

sides of docks, hoses or pipes. Docks A-G had moderate concentrations ($<15/m^2$), docks I-L had no *S. clava* except on the ends of some of the finger piers and docks O-S had high concentrations ($>15/m^2$) of *S. clava*.

Three separate tests of removal of *S. clava* from docks by divers were conducted. The first test involved divers hand picking from only the bottom of finger dock S-6. The total time was 1.75 hours for two divers to remove 710 *S. clava* weighing 19 pounds. The average number of *S. clava* removed for the 42 m^2 finger was 16.8 m^2 . A second test involved using a pressure washer to clean all of the organisms off the bottom of finger dock R-12. All material was removed down to the bare concrete and allowed to sink to the bottom. A total of 19.5 m^2 of dock area was cleaned requiring 1.2 hours of diver effort. A third test also used the pressure washer and the divers cleaned both the bottom and sides of a larger finger dock, R-14. A total of 3.1 hours of diver time was required to clean 31 m^2 of area. Based on NRC's test removals, cost estimates to clean infested marinas were calculated (Table 3). If large-scale pressure washing is undertaken a vacuum hose will collect the tunicates as they are removed and they will be disposed of at an upland composting facility.

Semiahmoo Marina

As in Blaine Marina, Natural Resources Consultants conducted the invasive *S. clava* survey and removal project in Semiahmoo Marina. A total of 3.5 diver team (two scuba divers/day) days of effort were expended during the May 2006 project. All of the docks and vessels in Semiahmoo Marina were surveyed for *S. clava* and densities in numbers per square meter were estimated. A total of 211 vessels were checked and *S. clava* were found on 17 vessels. The number of *S. clava* on the infested vessels ranged from 1 to 20, average being five. A total of 82 *S. clava* weighing 2.1 lbs were removed from the vessels (Table 1). Because density was very low on the docks, all *S. clava* were removed from the docks. The divers removed 1,169 *S. clava* weighing 52 pounds resulting in 0.2 m^2 (Table 2). The jetty is approximately 1,500 m^2 (dock sides not included) and has a high concentration, approximately 26 m^2 , of *S. clava*. Based on NRC's test removals, cost estimates to clean infested marinas were calculated (Table 3). Contract hours had been completed, so the tunicates were not removed from the jetty.

Neah Bay Marina

WDFW contracted with Global Diving and Salvage, Inc. to remove and conduct density counts of *S. clava* at Neah Bay Marina. A total of 5.5 diver team (one surface supplied air diver/day) days of effort were expended during the May 2006 project. All vessels and docks were inspected in the marina resulting in no *S. clava* being found. Specimens collected from previous years thought to be *S. clava* were later identified as a native tunicate (*Styela montereyensis*). Global Diving and Salvage, Inc. departed from Neah Bay to assist the Skokomish Indian Tribe at Pleasant Harbor. The contract with Global was amended to fund additional work.

Pleasant Harbor Marina

WDFW contracted with the Skokomish Indian Tribe, along with Global Diving and Salvage, Inc., to conduct density counts and remove *S. clava* at Pleasant Harbor. All vessels and docks were inspected at the marina. A total of 11 diver team (two scuba divers/day) days of effort were expended for the Skokomish and eight diver team (one surface supplied air diver/day) days of effort were expended for Global at Pleasant Harbor during the May and June 2006 project. A total of 170 vessels were checked and *S. clava* were found on 29 vessels. The number of *S. clava* on the infested vessels ranged from 1 to 327, average being 33. All the infested vessels were cleaned except one, it left before we could clean it. A total of 917 *S. clava* weighing 18.14 lbs were removed from 28 vessels (Table 1).

The docks are heavily infested throughout Pleasant Harbor Marina. Erin Grey, a Ph D candidate from University of Chicago estimated the densities to be 58 m², using quadrants. Global and the Skokomish combined for removed 1,920 pounds of *S. clava*, cleaning approximately 5% of the marina (Table 2). Global, using one diver with surface supplied air averaged 10.3 m² of removal per hour. While the Skokomish two scuba divers averaged 9.2 m² of removal per hour. Based on both dive teams removals, cost estimates to clean infested marinas were calculated (Table 3).

Home Port Marina and Surrounding Private Docks

The Skokomish divers also spent two diver team days of effort at the private docks within Pleasant Harbor. At Home Port, a total of 72 vessels were checked and *S. clava* were found on 12 vessels, all of which were cleaned. A total of 533 *S. clava* weighing 11 lbs were removed from those vessels (Table 1). The number of *S. clava* on the infested vessels ranged from 3 to 208, average being 44.

The docks at Home Port Marina had a relatively low concentration of *S. clava* on them, 4 m² (Table 2). No *S. clava* was removed from the docks at Home Port (Table 3).

The surrounding area has 11 private and one Washington State Parks docks with 13 vessels at the time of the survey.

Out of the 13 vessels only four had *S. clava* (Table 1). The docks have a moderate concentration of 9 m² on them (Table 2). No vessels or docks were cleaned.

Summary

All invasive tunicates found on recreational watercraft at Blaine, Semiahmoo, Pleasant Harbor, private docks within Pleasant Harbor, and Home Port Marinas were removed except six during Phase 1 of this project. This should significantly reduce the risk of spread. However, tunicates still remain on the docks at Pleasant Harbor, Home Port, private docks within Pleasant Harbor, Semiahmoo and Blaine Marinas. Phase 1 provided estimates of the additional resources needed to complete the removal effort. Phase 2 will evaluate the effectiveness of the removal efforts conducted in Phase 1 and test new methods to remove tunicates from docks. Pressure washing is the superior choice when removing *S. clava* from docks where applicable but due to some docks undersides are made of exposed styrofoam therefore pressure washing could cause damage and should not be pressure washed (31% of Pleasant Harbor Marina, Home Port, and private docks within Pleasant Harbor.) At the present time the only other adequate removal method is hand picking. WDFW is conducting further surveys of marinas and distributing educational literature to boaters. No further removal activity will be undertaken until water temperatures drop and the tunicates are not reproducing.

Marina docks can serve as a nursery for invasive tunicates and other species. Species can move from a dock to boats and then be transported to other areas. Docks that retard the growth of marine species may significantly reduce the movement of invasive species from recreational watercraft. More frequent cleaning of watercraft, and taking additional care to not move highly infested watercraft to other areas could also reduce spread.

TABLE 1: Summary of Vessels

MARINA	# VESSELS SURVEYED	# VESSELS INFESTED	# VESSELS CLEANED	LBS REMOVED FROM VESSELS	COMMENTS
Semiahmoo	211	17	17	2.10	All vessels cleaned
Blaine	522	94	93	62.12	All vessels cleaned but one, too fragile
Neah Bay	200	0		0	No vessels infested
Home Port	72	12	12	11.00	All vessels cleaned
Pleasant Harbor	170	29	28	18.14	All vessels cleaned but one, it left
Area outside of PH	13	4	0	0	Vessels were not cleaned
Totals	1,188	156	150	93.36	

TABLE 2: Summary of Docks

MARINA	TOTAL AREA M ² (sides not included)	% OF MARINA CLEAN	LBS REMOVED FROM DOCKS	AVG. DENSITY M ²	COMMENTS
Semiahmoo	5,505	100	52	0.2	
Semiahmoo Jetty	~ 1,500	0	0	26	
Blaine	15,653	23	19	8	23% of marina had no <i>Styela clava</i>
Neah Bay	N/A	N/A	N/A	0	No <i>Styela clava</i> found
Home Port	1,087	0	0	4	
Pleasant Harbor	6,061	12	1920	58	
Area outside of PH	891	0	0	9	11 Private and one State Park
Totals	30,697	-----	1,991	15 Avg.	

TABLE 3: Cost Estimates to Clean Docks

NRC hand removal estimates does not include sides of docks.

Home Port Marina Total Area 1,587 m ²						
TEAM	M ² /HR	TOTAL HOUR	# DAYS	METHOD	COST/PER DAY	TOTAL
Skokomish	9.2	173	22	Hand	\$1,150	\$25,300
Global	10.3	155	20	Hand	\$2,800	\$56,000
NRC	12	133	23	Hand	\$2,670	\$61,410
NRC	10	N/A	N/A	Pressure Wash	N/A	N/A
Pleasant Harbor Marina Total Area 9,232 m ²						
TEAM	M ² /HR	TOTAL HOUR	# DAYS	METHOD	COST/PER DAY	TOTAL
Skokomish	9.2	1,004	126	Hand	\$1,150	\$144,900
Global	10.3	897	113	Hand	\$2,800	\$316,400
NRC	12	770	129	Hand	\$2,670	\$344,430
NRC	10-12	876	147	Pressure Wash/ Hand	\$2,670	\$392,490
Private Docks of Pleasant Harbor Total Area 1,291 m ²						
TEAM	M ² /HR	TOTAL HOUR	# DAYS	METHOD	COST/PER DAY	TOTAL
Skokomish	9.2	141	18	Hand	\$1,150	\$20,700
Global	10.3	126	16	Hand	\$2,800	\$44,800
NRC	12	108	18	Hand	\$2,670	\$48,060
NRC	10	N/A	N/A	Pressure Wash	N/A	N/A
Blaine Marina Total Area 15,653 m ² (dock sides not included)						
TEAM	M ² /HR	TOTAL HOUR	# DAYS	METHOD	COST/PER DAY	TOTAL
Skokomish	9.2	1,702	213	Hand	\$1,150	\$244,950
Global	10.3	1,520	190	Hand	\$2,800	\$532,000
NRC	12	1,305	218	Hand	\$2,670	\$582,060
NRC	10	1,566	261	Pressure Wash	\$2,670	\$696,870
Semiahmoo Marina Jetty Total Area ~1,500 m ² (dock sides not included)						
TEAM	M ² /HR	TOTAL HOUR	# DAYS	METHOD	COST/PER DAY	TOTAL
Skokomish	9.2	164	21	Hand	\$1,150	\$24,150
Global	10.3	146	19	Hand	\$2,800	\$53,200
NRC	12	125	21	Hand	\$2,670	\$56,070
NRC	10	150	25	Pressure Wash	\$2,670	\$66,750
Cost Estimate for <i>Styela Clava</i> Removal at all Marinas						
<i>Pressure washing is only applicable at 2.7 marinas</i>						
TEAM	M ² /HR	TOTAL HOUR	# DAYS	METHOD	COST/PER DAY	TOTAL
Skokomish	9.2	3,184	398	Hand	\$1,150	\$457,700
Global	10.3	2,844	356	Hand	\$2,800	\$996,800
NRC	12	2,439	407	Hand	\$2,670	\$1,086,690
NRC	10	N/A	N/A	Pressure Wash	N/A	N/A

APPENDIX 3: SKOKOMISH TRIBE: CIONA ASSESSMENT IN LOWER HOOD CANAL

Skokomish Fisheries Department

N. 541 Tribal Center Rd. Shelton WA 98584
(360) 877-5213

Project Title: *Ciona savignyi* PHASE 1 (presence/absence survey)

Date of Report: July 6, 2006

Project Funded by:
Washington Department of Natural Resources (DNR) via Interagency Agreement # 06-308 made between DNR and the Skokomish Tribe Fisheries Department.

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Phase 1 Summary
The initial phase of this two-part study was to determine where the invasive *C. savignyi* are present or absent within the lower Hood Canal. This included biological surveys of the Tahuya and Union areas. Work began on May 11, 2006 and was completed on June 30, 2006. In this short period, 22 dives were made and data was collected to determine abundance and population distribution (map 1).

Distribution of the invasive *C. savignyi* was concentrated east of the Great Bend (Bald Pt.), remaining constant toward Belfair. It seemed apparent during the first observations that high densities of *C. savignyi* were related to substrate conditions and freshwater influences from the Tahuya and Skokomish Rivers. After additional surveys, it was unreliable to correlate high densities with proximity to river deltas. The highest densities were found at transects 14 and 15 (map 1), more than three miles from the Tahuya influx. Substrate varied from rock, sand, gravel and cobble. Gravel areas seemed to be the most efficient substrate for the tunicates to set on, although many of the large mats were found on sandy substrate, attached to dead northern feather duster worm (*Eudistylia vancouveri*) tubes. Tunicate populations were observed in 19 of the 22 surveys with the highest densities located at depth ranging from 65 to 40 feet.

A large dead zone (map 1) was found on transect 16 and 17. The substrate had a jelly-like consistency ~3.5 feet deep. White patches of bacteria covered the bottom and extended to a depth greater than 65 feet, running the contour lines parallel to shore. This bacterium is related to an anoxic layer within the substrate. There were several dead fish species found from 65 feet to 35 feet. Dungeness crab mortalities were also observed from 62 to 50 feet. No living marine life was apparent until the 35 foot contour line. *C. savignyi* was the first species noted above the dead zone. Density and size were relatively small compared to other locations, but without any competition the population was very well established.

This data suggest that the *C. savignyi* population in southern Hood Canal is extremely well developed and established. Additional survey work is required to fully understand the distribution extent of these tunicates. Low current circulation and highly nutrient rich water seem to develop a growth promoting environment for these invasive tunicates.

Survey Methodology
Surveys were conducted using SCUBA. Each dive started at ~65 feet and ended at ~20 feet. Geoduck survey methodology was used to collect the density distribution data. This included a transect spool, which is 6-foot wide and 150-foot long, with every 20 feet marked with flagging tape. Tunicates were counted within the tape lengths, for an area total of 120 sq.ft; total area equaling 900 sq.ft. Substrate, depth, and other marine plants and animals (tables 1 and 2) were also recorded within each 20 interval.

Global Positioning System (GPS) was used to mark the beginning of the transect point at a depth of ~65 feet. Once the dive team reached the ~20 foot depth mark, topside crew marked the ending transect point. After a dive was completed, the survey team moved 0.5 miles parallel to shore. Compass headings were also taken at the initial drop in position.

TABLE 1. MARINE ANIMAL SPECIES OBSERVED DURING PHASE 1

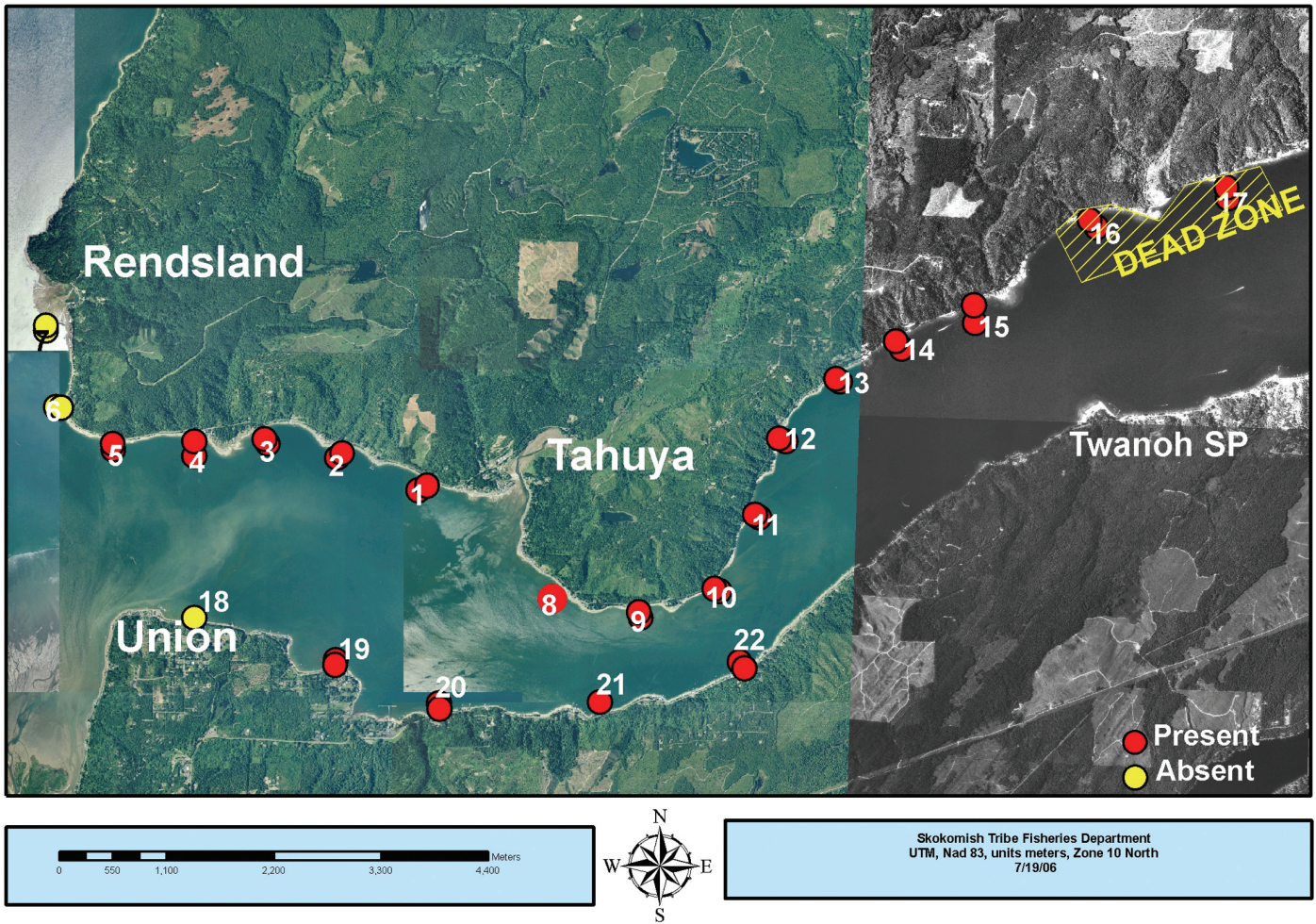
COMMON NAME	TAXONOMER	COMMON NAME	TAXONOMER
Burrowing anemone	<i>Pachycerianthus fimbriatus</i>	Pile perch	<i>Rhacochilus vacca</i>
False geoduck	<i>Panomya sp.</i>	English sole	<i>Parophrys vetulus</i>
Pacific geoduck	<i>Panopea abrupta</i>	Opal squid	<i>Loligo opalescens</i>
Plumed anemone	<i>Meetridium senile</i>	Sanddab	<i>Citharichthys sp.</i>
Heart cockle	<i>Clinocardium nuttalli</i>	Starry flounder	<i>Platichthys stellatus</i>
Horse clam	<i>Tresus spp.</i>	Moon snail	<i>Polinices lewisii</i>
Hydroids	UNK	Sunflower star	<i>Pycnopodia helianthoides</i>
Decorator crab	<i>Pugettia sp.</i>	Sun star	<i>Solaster sp.</i>
Dungeness crab	<i>Cancer magister</i>	Rainbow star	<i>Orthsterias koehleri</i>
Hermit crab	UNK	Sabellid tube worm	<i>Sabellid sp.</i>
Red Rock crab	<i>Cancer productus</i>	Short spined star	<i>Pisaster brevispinus</i>
California cucumber	<i>Parastichopus californicus</i>	Squat lobster	<i>Munida quadrispina</i>
Bay pipefish	<i>Syngathus leptorhynchus</i>	Spiny dogfish	<i>Squalus acanthias</i>

TABLE 2. MARINE PLANT SPECIES OBSERVED DURING PHASE 1

COMMON NAME	TAXONOMER
Eelgrass	<i>Zostera marina</i>
Laminaria kelp	<i>Laminaria sp.</i>
Red algae	UNK
Diatoms	UNK
Turkish towel	<i>Chondracanthus exasperatus</i>

MAP 1. PROJECT LOCATION

Ciona savignyi PHASE 1 Survey



APPENDIX 4: GRETCHEN LAMBERT: SURVEY RESULTS FOR THE PRESENCE / ABSENCE OF INVASIVE TUNICATES IN PUGET SOUND

Washington State 2006 survey for invasive tunicates

With records from previous surveys
Final report June 19, 2006

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In September 1998 and August 2000, the Washington Department of Natural Resources conducted surveys of a large number of harbors, marinas and natural areas for invasive marine species (Cohen et al. 1998, 2001). In August 2001 and August 2002 a number of sites on the Olympic Peninsula were surveyed by the Olympic Peninsula National Marine Sanctuary. Records of the nonindigenous ascidians from these and other surveys can be found in Lambert 2003.

During the past several years, a species of non-indigenous tunicate already known from the 1998 survey to be present in Washington (*Ciona savignyi*) has been recorded at additional sites (see Lambert 2003), indicating that it is spreading, and a new introduction (*Didemnum* sp. A) has appeared that was not recorded during the 1998 or 2000 DNR surveys though it was recorded by myself at Poulsbo Yacht Club October 1998 (not one of the DNR survey sites). The third species of concern, *Styela clava* (commonly referred to as the club tunicate), is currently known from only three sites but the data is 8 years old. These three species of non-indigenous tunicates are extremely abundant in other parts of the world, and have seriously impacted mussel and oyster farms, in some cases completely wiping out individual farms and driving the farmers out of business because their culture lines became so fouled that it smothered the bivalves. Thus before such a situation develops in Washington, it is imperative to conduct a new comprehensive survey of the major harbors and marinas of Washington to assess the current distribution of these 3 species and to determine if there are any additional introductions since the 1998 and 2000 DNR surveys.

Accordingly, such a survey was undertaken between April and June 2006 (WDFW contract #06-1197). The results are listed below **and in the accompanying Excel table** for the 3 relevant non-indigenous species of tunicates, plus an unusual sighting of *Ciona intestinalis*. Survey sites, dates and results are also listed for prior surveys.

SUMMARY (sites listed alphabetically for each species)

Styela clava

Blaine Marina, Drayton Harbor. Abundant especially on uncovered floats. Covered floats dominated by the anemone *Metridium senile*. Floats sampled 9/8/98, 9/7/01, 5/4/06.

Neah Bay floating docks, Olympic Peninsula: 7 preserved specimens of the native species *Styela montereyensis* collected 8/18/01 during the Olympic Coast National Marine Sanctuary survey for invasive species, and misidentified by myself as *Styela clava* January 2002. These specimens were reexamined June 2006, at which time the error in identification was discovered. Many of the larger individuals are very robust, with an unusually short stalk, causing them to resemble *Styela clava*. A second survey by OCNMS August 2002 yielded only *S. montereyensis* at Neah Bay (identified by myself). No *S. clava* were collected spring 2006 by divers conducting a careful search of the marina; only *S. montereyensis* (common) were observed on the floats. Pleasant Harbor Marina, Hood Canal. Abundant. 11/5/05, 2/21/06, 5/12/06.

Ciona savignyi

Breakwater Marina/Tacoma Yacht Club, Point Defiance Park, Tacoma near the ferry dock to/from Vashon Island. 5/19/06 common, widespread in the marina. Very abundant on a covered float 9/23/01.

Brownsville Marina 5/29/06. Present but not common. Brownsville Yacht Club close by: present but not abundant 9/10/98.

Des Moines Marina. Very abundant on covered floats 5/9/06, though not as solidly dense as on 9/1/98, 9/8/98, 4/9/01 and 11/20/04.

Edmonds Marina. Very abundant on covered floats 4/25/06. No change since last surveys 2/7/04, 9/26/04. Absent (not recorded) at DNR survey 9/8/98 or on pre-survey 8/23/98. First noticed July and Sept. 1999, very abundant on covered floats.

Elliott Bay Marina. On piling D66 and on G dock near shore 4/27/06. Last survey was 11/20/04, at which time *C. savignyi* was very abundant: everywhere with even slight shade, on

floats and sabellid worm tubes. Thus it is much less abundant now than 18 months ago. Absent at DNR survey 9/8/98 and pre-survey 8/28/98.

Gig Harbor Marina 5/19/06. Common on covered floats.

Port Orchard Marina. Common here and there—in clumps on a long rope, and suspended mesh bag 5/29/06.

Winslow Marina, Bainbridge Island. Common 5/12/06.

Ciona intestinalis

Port Orchard Marina 5/29/06. One individual on a long rope suspended from a floating covered dock ~1.5 m below water surface. This is only the second confirmed sighting in Washington state; the first was on a Smithsonian Environmental Research Center settlement plate (suspended at 3 m depth) retrieved August 2000 from the Bremerton Navy Yard just across the bay from Port Orchard and identified by myself.

Didemnum sp. A

Dabob Bay Taylor Shellfish long lines, buoys, raft, etc. 5/12/06. Some large colonies on water intake pipe and the anchor line for the raft, which have been in the water since last year at least. All other lines, and buoys, were deployed about January or February 2006 and have no tunicates.

Des Moines Marina. Abundant on several long ropes suspended from floats at D, J and M docks 5/9/06 but only at 2+ meters or more depth, not on shorter ropes. Thus, distributed throughout the marina, and apparently it has spread in the 18 months since first observed on 11/20/04 on a crab trap suspended at 4 m depth from a covered floating dock. A thorough search was conducted at that time but no other colonies were observed. The crab trap is now gone. Not recorded at DNR survey 9/8/98 or pre-survey 9/1/98.

Edmonds Underwater Park. On sunken wooden boat 9/26/04. Large colony, eradicated.

Longbranch Marina, Key Peninsula 5/21/06. A few very small colonies on sabellid worm tubes attached to a suspended crab trap at outer end of marina walkway. About 2 m below surface.

Port Washington Marina 5/29/06. Large colonies on pilings ~0.5 m below surface at a very low tide, thus about 3.5-4 m below surface at high tide.

Poulsbo—Liberty Bay Marina 5/12/06. Huge colonies at end of 2 long ropes (2+ meters depth) suspended from floats, one near shore and the other at the outer end of the longest walkway, thus widely separated from each other. This marina is about a mile further out into the channel from the Port of Poulsbo and thus has much better water circulation. Poulsbo

Yacht Club surveyed 10/3/98—a large colony of *Didemnum* sp. A at end of long rope.

Steamboat Island, Totten Inlet. 5/20/00. Present, collected by Claudia Mills.

Taylor Shellfish mussel rafts, Totten Inlet. Abundant, with mature brooded larvae, fouling the mussels and supporting structures 11/20/04. Also collected on 5/19/00 and 10/25/05.

Winslow Marina, Bainbridge Island. 5/12/06. Several large colonies on sabellid polychaete worm tubes at the end of a long rope (2.5-3 meters) suspended from floating dock at C46 slip.

Conclusions:

1. *Styela clava* has apparently colonized only two sites in Washington: Blaine Marina and Pleasant Harbor Marina; at both sites they are extremely abundant (hundreds of thousands). Due to a misidentification by myself, it was believed that they also occur at Neah Bay, but a reexamination of preserved specimens collected 8/18/01 (see above) showed them to be the native species *Styela montereyensis*. Live *S. clava* are being transported around Puget Sound, however, as evidenced by Larry Crockett's finding several live ones on a boat hull that was cleaned June 9, 2006 at Port Townsend that had just come from Pleasant Harbor. Thus there is the potential for this species to spread via hull fouling. Nevertheless, it is most likely that *S. clava* has never become established at Neah Bay.

2. *Ciona savignyi* and *Didemnum* sp. A have both spread since 1998 and also become more abundant. *Didemnum* sp. A is a significant fouler of mussel lines at the Taylor Shellfish farm in Totten Inlet, though Gordon King does not think it has affected the growth rate or survival of the mussels.

3. With the exception of sightings of a single *Ciona intestinalis* in 2000 and 2006 in and near Bremerton, apparently no new non-native tunicates have become established in Puget Sound and Hood Canal.

4. At all sites surveyed on Whidbey Island, including the Penn Cove Shellfish mussel farm, the salinity is very low because of the Skagit River outflow from the mainland. The mussels survive and thrive in this location but are not fouled by any tunicates; their only fouling problem is barnacles. Most tunicates do not survive at a salinity below 25 ppt (parts per thousand) and thus will probably never be a problem for Penn Cove Shellfish.

5. The May and June 2006 surveys of 41 sites indicate that no additional non-native species of tunicates have become established in Washington since the DNR survey of 1998.

Recommendations

1. Continued surveillance by WDFW of boat hulls by divers periodically for *Styela clava*, and removal of all individuals from fouled boats. Eradication of *S. clava* from Blaine and Pleasant Harbor if feasible; if not feasible to remove all individuals, then attempt to remove the largest ones perhaps twice a year. Breeding season for *Styela clava* is probably from about May or June to October or November. Individuals may spawn every day, thus it is important to minimize the number of gametes being released into the seawater.
2. Education of boat owners, marina operators and all aquaculture facilities (both shellfish and fish) for invasive tunicates—any of the above species and any new and different species. Report new sightings to WDFW.
3. Cooperation by all boat owners, and fish and shellfish farmers, to keep their boats, stock and gear clean and not move any infected stock or gear from one location to another in Washington until it is clean.

Complete results of all sites surveyed for *Didemnum* sp. A, *Ciona savignyi* and *Styela clava*

2006 SURVEYS -- 41 marinas and other sites

- 2/21/06 Pleasant Harbor Marina, Hood Canal ~ *Styela clava* abundant. Same as on 11/5/05.
- 4/22/06 Shilshole Marina, Seattle ~ All 3 spp. absent.
- 4/25/06 Mukilteo boat launch ~ Floats out of water for the winter.
- 4/25/06 Edmonds Marina ~ *Ciona savignyi* very abundant on covered floats. No change since last surveys 2/7/04, 9/26/04. Apparently absent 8/23/98, 9/8/98. First individuals observed July and September 1999; very abundant on covered floats.
- 4/27/06 Elliott Bay Marina ~ *Ciona savignyi* on piling D66 and on G dock near shore. Last survey was 11/20/04, at which time *C. savignyi* was very abundant: everywhere with even slight shade, on floats and sabellid worm tubes. Thus it is much less abundant now than 18 months ago. It was apparently absent 8/28/98, 9/8/98.
- 5/4/06 Bellingham marina ~ No tunicates of any species; salinity low (27-28 parts per thousand). Previously sampled 9/11/98; all 3 spp. absent.
- 5/4/06 Blaine Marina ~ *Styela clava* abundant especially on uncovered floats. Covered floats dominated by the anemone *Metridium senile*. Floats previously sampled 9/3/98, 9/11/98 and 9/7/01, *Styela clava* abundant.
- 5/9/06 Des Moines Marina ~ *Ciona savignyi* very abundant on covered floats, though not as solidly dense as on 9/1/98, 9/8/98, 4/9/01 and 11/20/04. *Didemnum* sp. A - abundant on several long ropes suspended from floats at D, J and M docks but only at 2+ meters or more depth, not on shorter ropes. Thus, distributed throughout the marina, and apparently it has spread in the 18 months since first observed on 11/20/04 on a crab trap suspended at 4 m depth from a covered floating dock. A thorough search was conducted at that time but no other colonies were observed. The crab trap is now gone.
- 5/12/06 Kingston Marina ~ All 3 species absent.
- 5/12/06 Port of Poulsbo floats ~ All 3 species absent. Water very turbid, full of sediment.
- 5/12/06 Liberty Bay Marina, Poulsbo ~ *Didemnum* sp. A Huge colonies at end of 2 long ropes (2+ meters depth) suspended from floats, one near shore and the other at the outer end of the longest walkway, thus widely separated from each other. This marina is about a mile further out into the the channel from the Port of Poulsbo and thus has much better water circulation. Poulsbo Yacht Club surveyed 10/3/98—a large colony of *Didemnum* sp. A at end of long rope.
- 5/12/06 Winslow Marina, Bainbridge Island ~ *Ciona savignyi* common. *Didemnum* sp. A Several large colonies on sabellid polychaete worm tubes at the end of a long rope (2.5-3 meters) suspended from floating dock at C46 slip.
- 5/18/06 Quilcene Marina ~ All 3 spp. absent.
- 5/12/06 Pleasant Harbor ~ *Styela clava* abundant. Low salinity surface layer 16 parts per thousand). Diver Chris Whitehead said layer was about 1 m. This layer was not present in April. If it persists it might kill off a lot of the float animals, though the *S. clava* still look healthy and no die-off was observed yet by the divers.
- 5/12/06 Dabob Bay ~ Taylor Shellfish long lines, buoys, raft, etc. *Didemnum* sp. A – some large colonies on water intake pipe and the anchor line for the raft, which have been in the water since last year at least. All other lines, and buoys, were deployed about January or February 2006 and have no tunicates.
- 5/19/06 Tacoma. Ole and Charley's Marina ~ All 3 spp. absent. Also absent 9/9/98.
- 5/19/06 Tacoma. Chinook Landing Marina ~ All 3 spp. absent.
- 5/19/06 Tacoma. Breakwater Marina/Tacoma Yacht Club, Pt. Defiance Park. ~ *Ciona savignyi* common.

5/19/06 Gig Harbor Marina ~ *Ciona savignyi* common on covered floats.

5/21/06 Zittel's Marina, Johnson Pt. near Olympia ~ All 3 spp. absent.

5/21/06 Boston Harbor Marina ~ All 3 spp. absent. Also absent 9/9/98.

5/21/06 Swantown Marina, Olympia ~ All 3 spp. absent. Low salinity.

5/21/06 Shelton Yacht Club ~ All 3 spp. absent. Also absent 9/9/98; and 11/20/04 when only the fuel dock float was examined; access to the main docks was locked that day and the office was closed.

5/21/06 Jarrell's Cove Marina, Harstine Island ~ All 3 spp. absent.

5/21/06 Fair Harbor Marina, Grapeview ~ All 3 spp. absent. Also absent 9/9/98.

5/21/06 Longbranch Marina, Key Peninsula ~ *Didemnum* sp. A - A few very small colonies on sabellid worm tubes attached to a suspended crab trap at outer end of marina walkway. About 2 m from surface.

5/29/06 Port Orchard Marina ~ *Ciona savignyi* common here and there—in clumps on a long rope, and suspended mesh bag. All 3 spp. absent 9/10/98. *Ciona intestinalis* – one individual on a long rope suspended from a floating covered dock, ~1.5 m below the water surface. This is only the second confirmed sighting in Washington state; the first was on a Smithsonian Environmental Research Center settlement plate (suspended at 3 m depth) retrieved August 2000 from the Bremerton Navy Yard just across the bay from Port Orchard.

5/29/06 Bremerton Marina ~ All 3 spp. absent.

5/29/06 Port Washington Marina ~ *Didemnum* sp. A – large colonies on pilings ~0.5 m below surface at a very low tide, thus about 3.5-4 m below surface at high tide.

5/29/06 Bremerton Yacht Club ~ Could not sample; entry denied by caretaker.

5/29/06 Silverdale ~ No tunicates – floats dominated by mussels, barnacles, anemones and sabellid tubeworms.

5/29/06 Brownsville Marina ~ *Ciona savignyi* – present but not common; no change since 9/10/98. Floats dominated by sabellid tubeworms and anemones.

6/9/06 Port Ludlow Marina ~ All 3 spp. absent. Also absent 9/10/98.

6/9/06 Port Hadlock marina ~ All 3 spp. absent. Also absent 9/10/98.

6/9/06 Port Townsend Boat Haven ~ All 3 spp. absent. Also absent 9/10/98 and 5/25/05.

6/9/06 Port Angeles Boat Haven ~ All 3 spp. absent.

6/9/06 John Wayne Marina, Sequim ~ All 3 spp. absent.

6/14/06 Langley marina, Whidbey Island ~ Low salinity (22 ppt at 1 m). All 3 spp. absent.

6/14/06 Coupeville float at end of pier, Whidbey Island ~ Low salinity (23 ppt at 1 m). No tunicates.

6/14/06 Penn Cove Shellfish LLC, Whidbey Island ~ Low surface salinity (23 ppt at 1 m, though 31 ppt at 6-7 m). No tunicates on mussel lines even at the bottom of a 6-7 m long string.

6/14/06 Oak Harbor Marina, Whidbey Island ~ Low salinity (20 ppt at 1 m). No tunicates.

Additional sampled marinas and other sites not mentioned before

Burton Marina, Vashon Island 9/23/01 ~ All 3 spp. absent.

Cap Sante Marina, Anacortes 9/11/98, 7/11/04 ~ All 3 spp. absent.

Cornet Bay, Whidbey Island 9/11/98 ~ All 3 spp. absent.

Dockton Park floats, Vashon Island 9/23/01 ~ All 3 spp. absent.

Everett Marina 9/8/98 ~ low salinity. All 3 spp. absent.

Neah Bay Marina 8/18/01, August 2002, spring 2006 ~ All 3 spp. absent.

San Juan Islands. Numerous surveys over the past 40 years, especially on San Juan, Orcas and Lopez Islands; none of the 3 invasive tunicate spp. considered in this report have been recorded. Further surveys on San Juan Island are planned for late June and July.

Seattle-Harbor Island 9/8/98 ~ low salinity. All 3 spp. absent.

Seabeck Marina, Hood Canal 9/10/98 ~ All 3 spp. absent.

Steamboat Island, Totten Inlet 5/20/2000 ~ *Didemnum* sp.
A present.

Steilacoom 9/9/98 ~ All 3 spp. absent.

Taylor Shellfish mussel rafts, Totten Inlet 11/20/04 ~
Didemnum sp. A abundant, with mature brooded larvae,
fouling the mussels and supporting structures. Also collected
on 5/19/2000 and 10/25/05.

Taylor Shellfish rafts, Shelton 11/20/04 ~ All 3 spp. absent.

Willapa Bay, various sites, May 2000 (Cohen et al. 2001) ~ All 3
spp. absent.

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