Predicted changes in the distribution of the non-indigenous tunicate *Styela clava* along the west coast of North America with emphasis on Canadian waters

Thomas W. Therriault, Leif-Matthias Herborg and Cathryn L. Clarke

Department of Fisheries and Oceans Canada
Pacific Biological Station, Nanaimo

Background

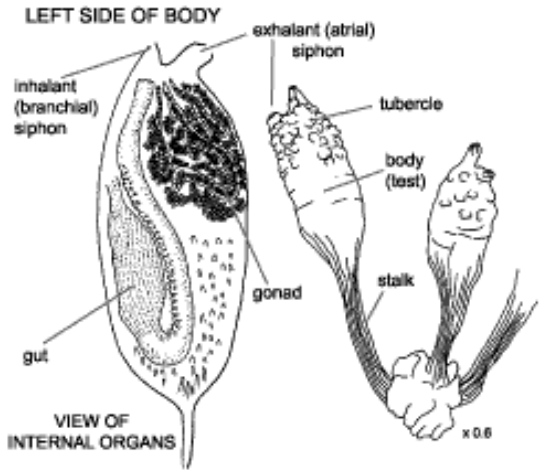
- Club tunicate, *Styela clava*, is native to Asia
- As with other non-indigenous tunicate species has dramatically impacted shellfish aquaculture, especially on the Atlantic coast of Canada
- This was one of five species considered in a National tunicate risk assessment

General RA Framework

- Both for the organism and potential parasites, pathogens or fellow travelers two rankings are determined to get a combined risk level
  - Probability of establishment
    - Arrive, survive, reproduce and spread
  - Consequences of establishment
- Uncertainty associated with each probability or ranking is identified

Styela clava

- A large, solitary tunicate that can grow to 16 cm
- Tunic is tough, brown and leathery which tapers to the peduncle
- Two short siphons possess four brown to purple stripes
- A sessile filter-feeder typically found attached to hard structures



Styela clava

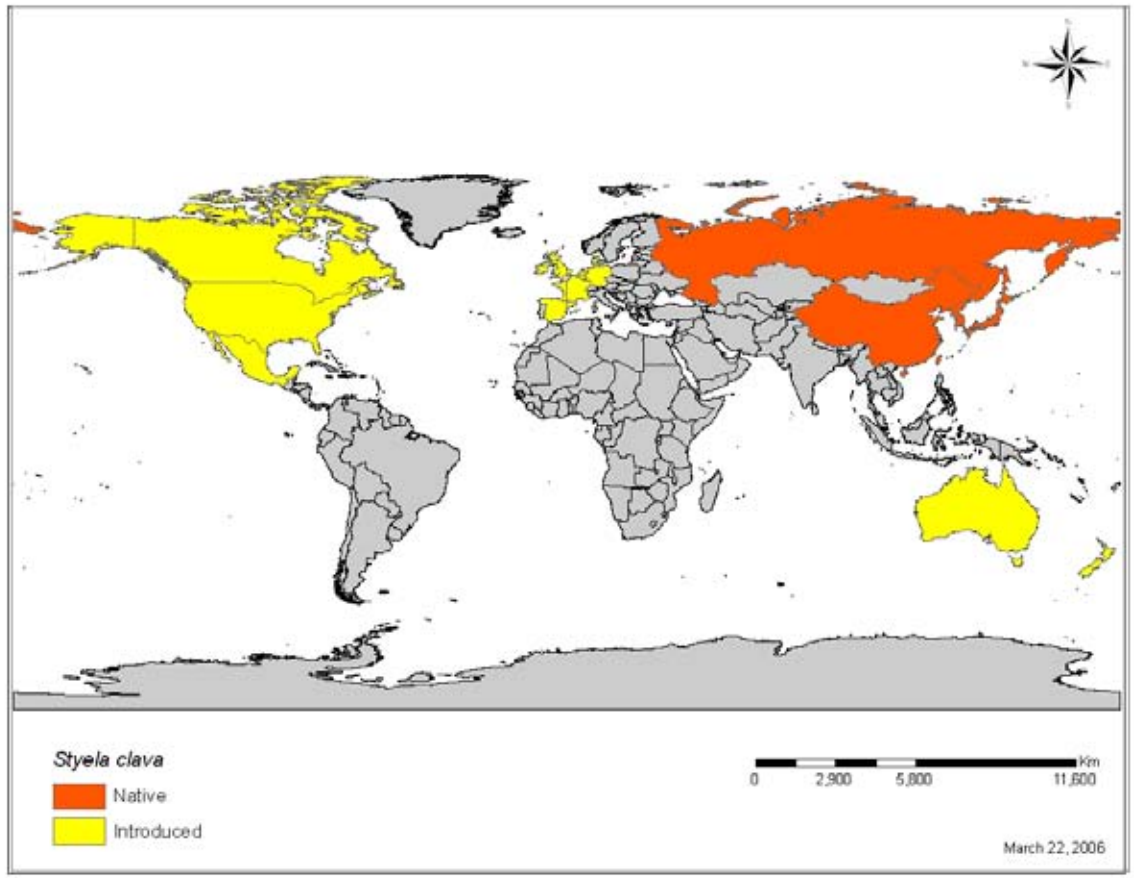
- Non-simultaneous hermaphrodite that is not self fertile with external fertilization
- Once mature, spawning can occur every 24 hours in response to light and temperature (above 15^{o}C)
- Larvae planktonic for 24-28 hours

Styela clava

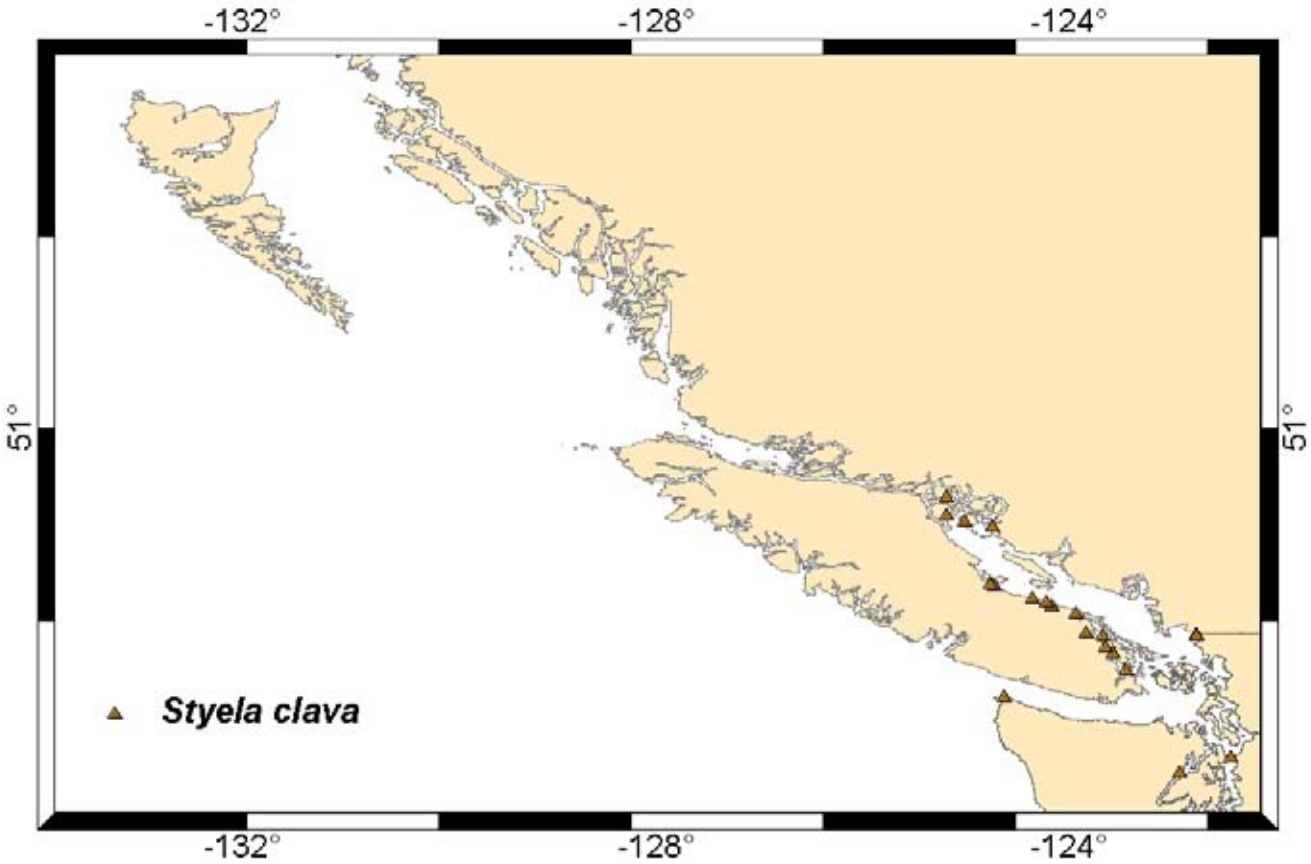
- Generally considered a temperate, cold water species with broad environmental tolerances
  - Temperature: 2°C to 23°C
  - Salinity: 20‰ to 32‰, temporary to 8‰
  - Depth: 15m to 25m, up to 40m
  - Preference for artificial structures and enclosed or semi-protected habitats

Current Global Distribution

Year	Place of earliest sighting	Reference
1933	Pacific USA	Abbott & Johnson, 1976
1953	England	Carlisle, 1954
1968	France	Coughlan 1969
1970	Atlantic USA	Berman *et al.,* 1992
1976	Australia	Holmes, 1976
1993	Pacific Canada	Lambert, 2003
1998	Atlantic Canada	MacNair, DFO, 2006, pers. comm.
2005	New Zealand	Biosecurity New Zealand, 2005a



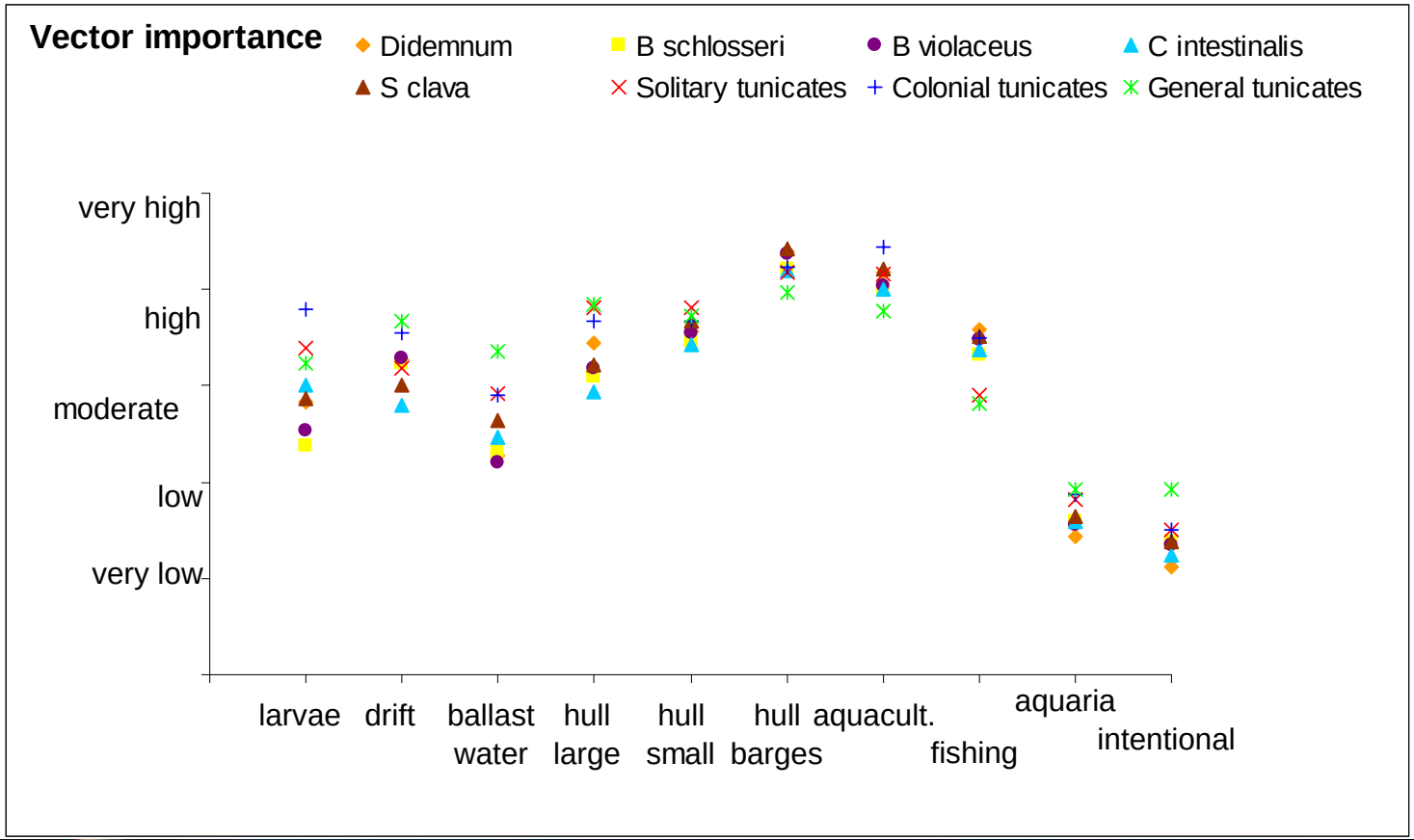
Pacific Canadian Distribution



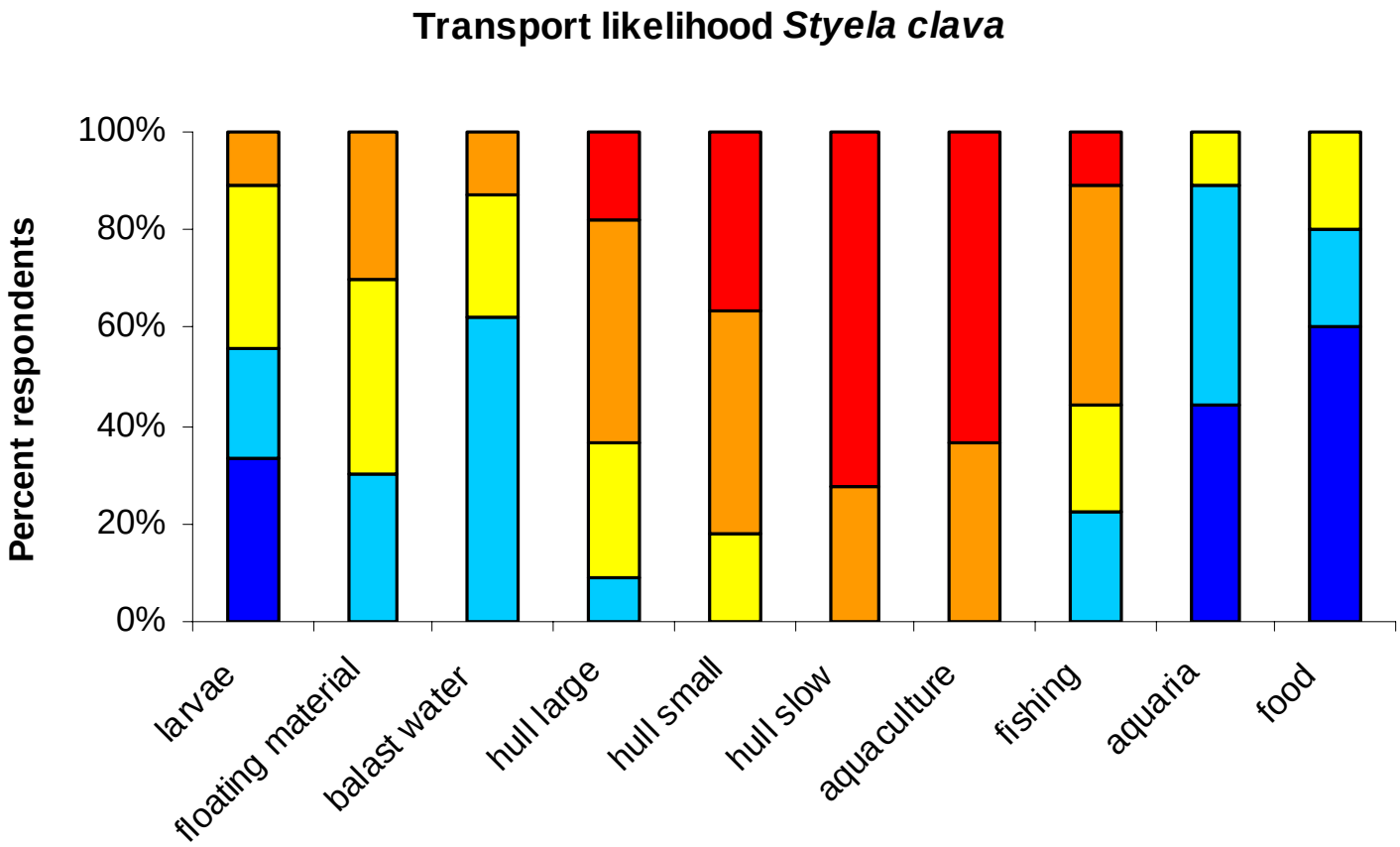
Expert Survey

- Survey was built using surveymonkey.com and e-mailed to 520 scientists and three mailing list
  - received 132 replies
- Asked to rate the likelihood of different transport vectors contributing to the spread invasive tunicates and associated uncertainty
- Asked to rate the impact level of invasive tunicates on a range of human and natural factors and associated probability of the impact

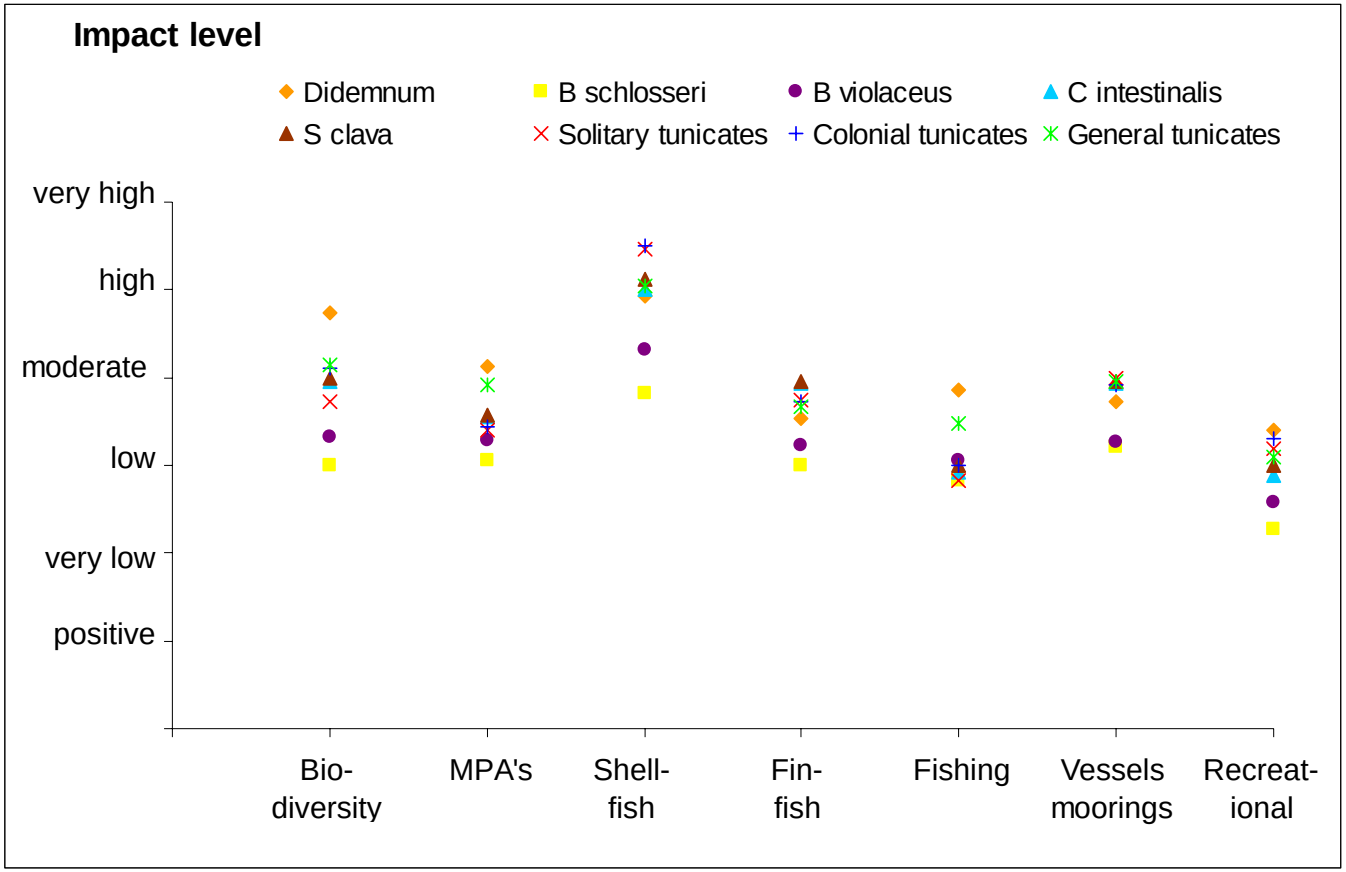
Expert Survey



Styela clava Experts



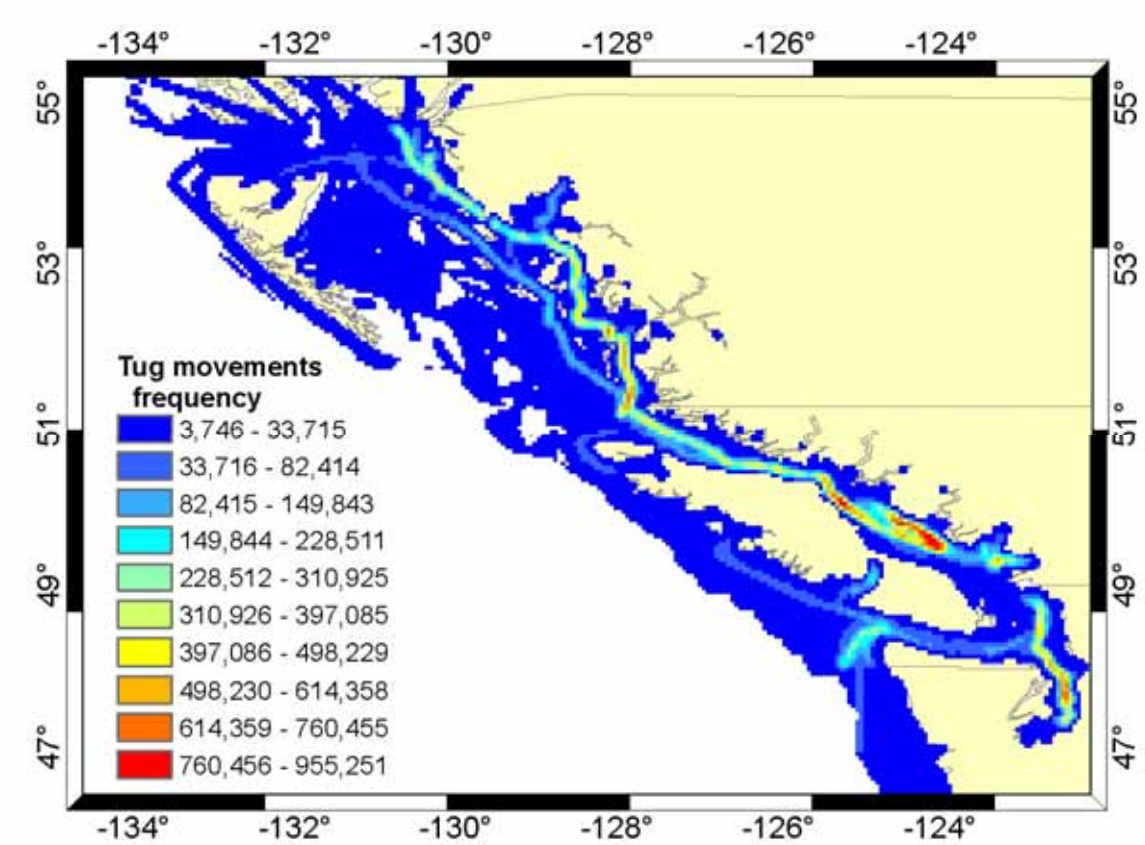
Expert Survey



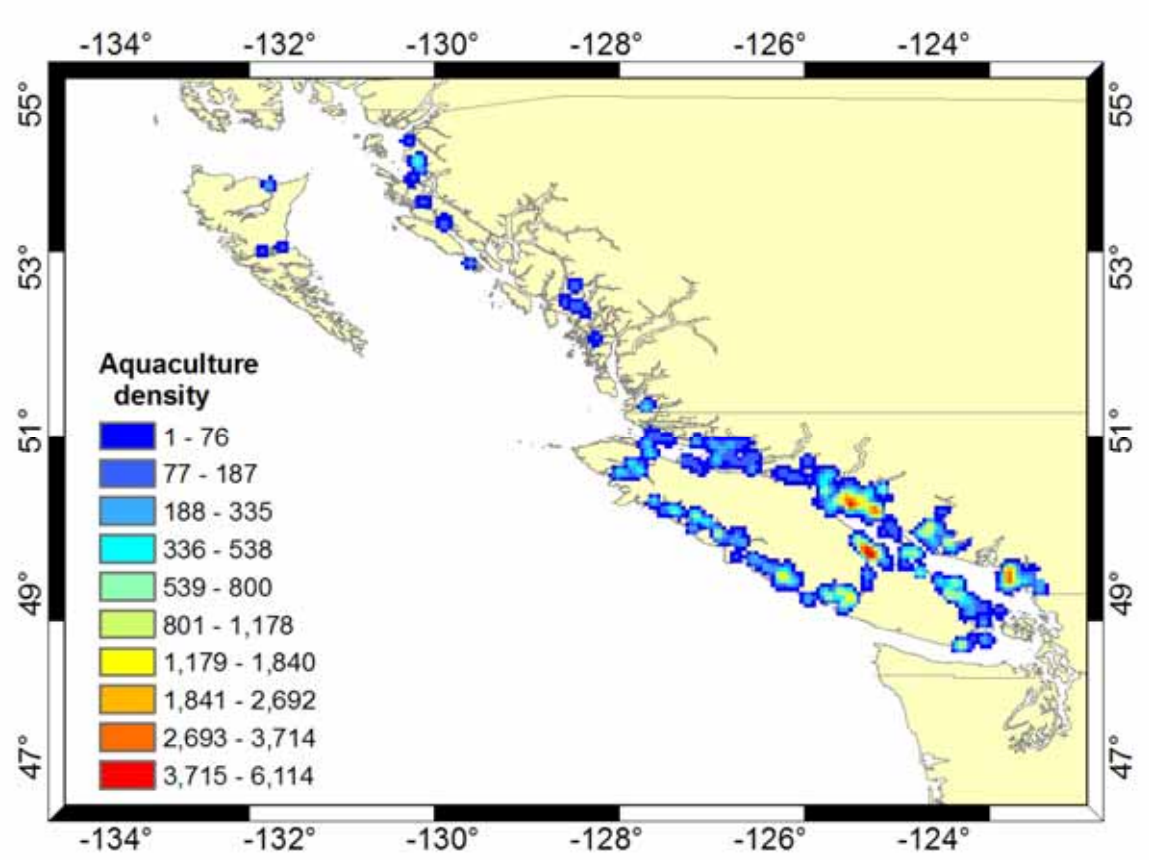
Major Dispersal Vectors

- Based on an expert survey and literature accounts, the most likely vectors for *Styela clava* included:
  - Hull fouling on slow moving vessels or barges
  - Transfers associated with aquaculture activities
  - Hull fouling on small, recreational boats

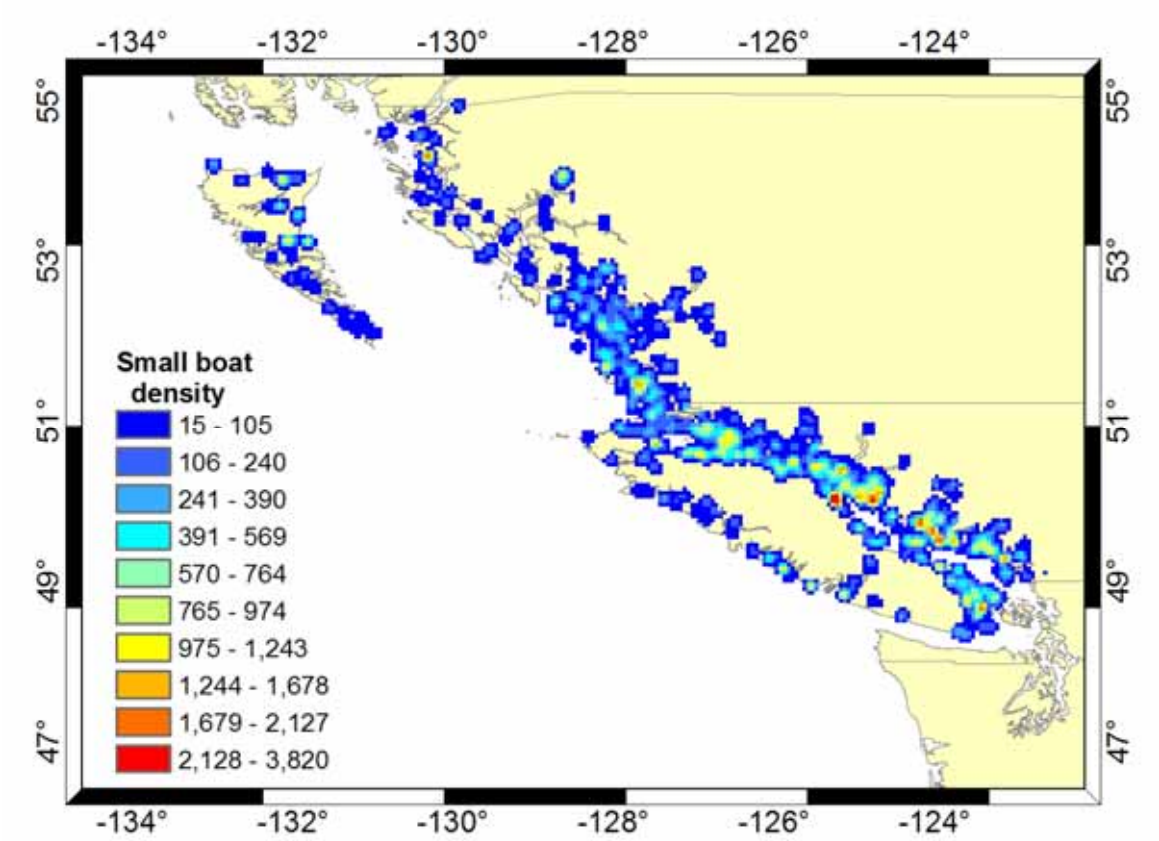
Tug/Barge Density



Aquaculture Density



Small Craft Density

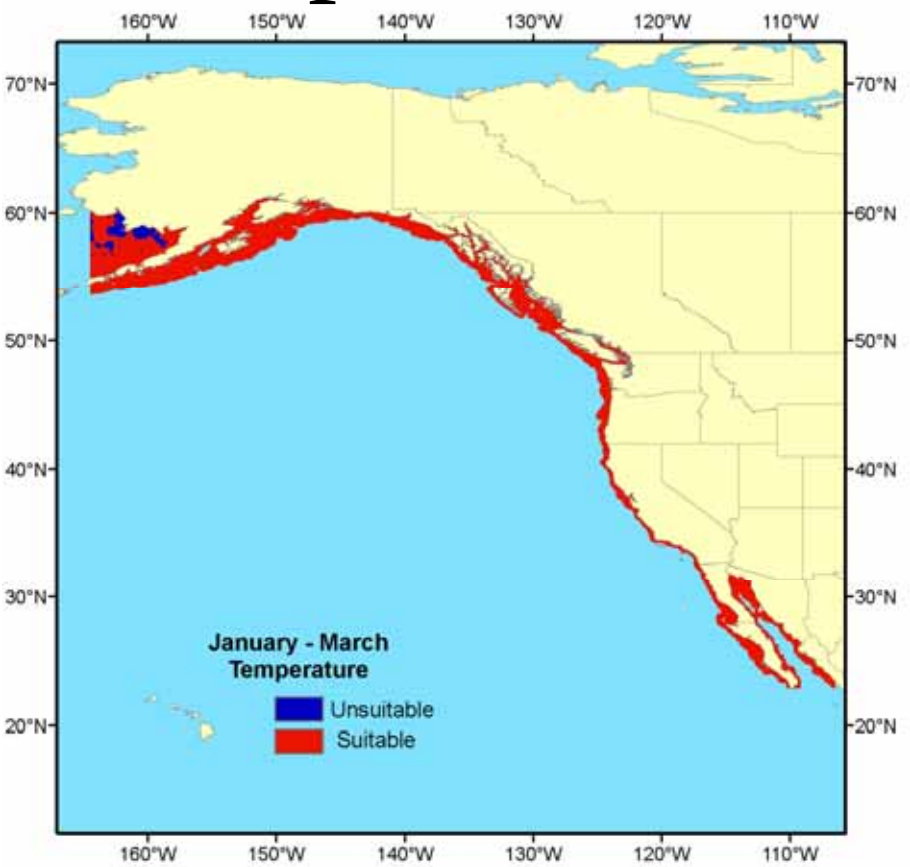


Environmental Constraints

- Where can *Styela clava* live in Canada?
  - Survive and Reproduce

- Environmental niche models
  - Simple models based on literature accounts e.g. temperature or salinity tolerances
  - More complex environmental niche models e.g. Genetic Algorithm for Rule-set Prediction (GARP)

Simple Predictions: Temperature



- For the other 3 seasons, virtually the entire area was determined to be suitable

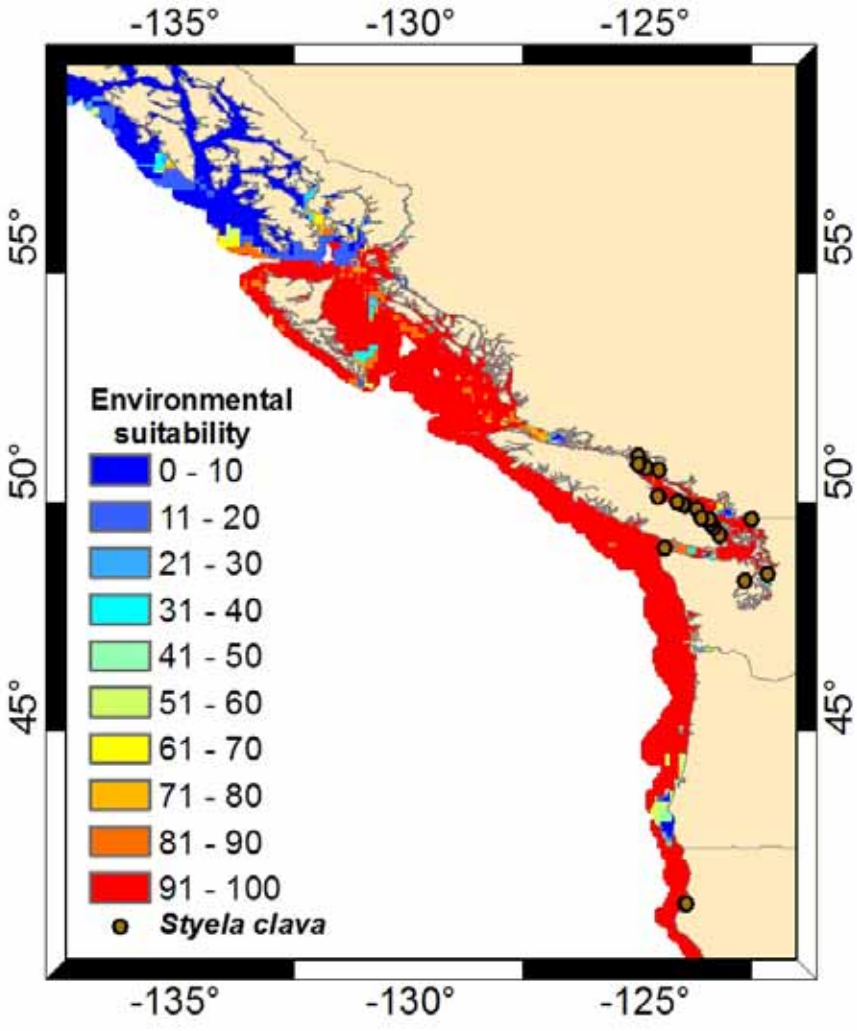
Simple Predictions: Salinity

- Almost the entire area was determined to be suitable based on salinity regardless of season

GARP Layers

- Seasonal Temperature (4)
- Seasonal Salinity (4)
- Annual Oxygen (1)
- Annual Chlorophyll a (1)
- Depth was bounded at 200m
- All environmental layers were tested for their contribution to model accuracy and only those that improved accuracy were used (here all)

GARP Model Predictions



Evaluating Environmental Predictions

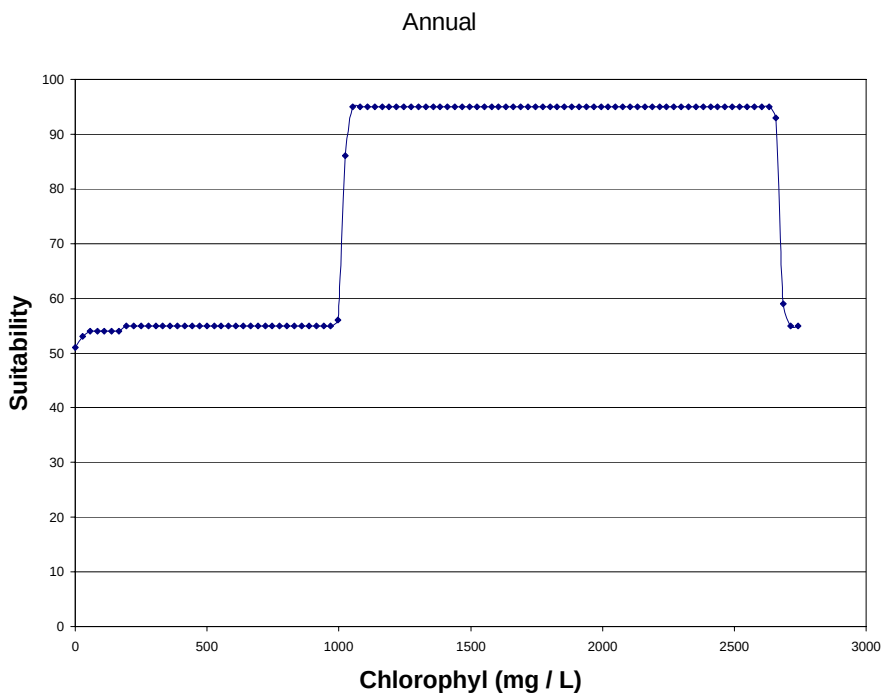
- Simple models based on literature accounts were relatively uninformative for predicting the distribution of *Styela clava*

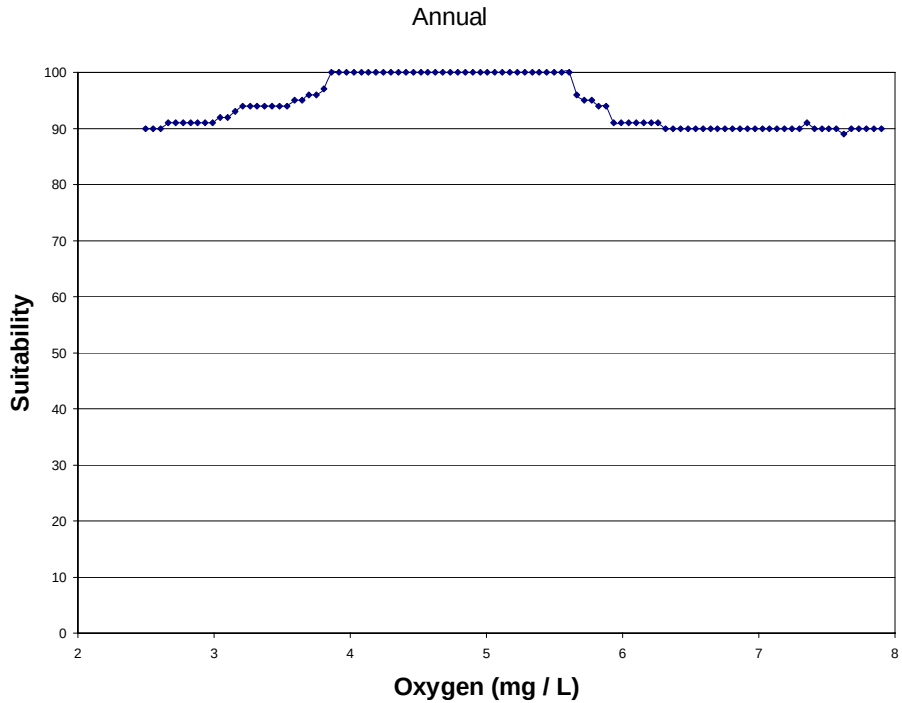
- Although inherently conservative, GARP modeling was much more informative for predicting suitable locations

Potential GARP Limitations

- GARP models were based on the KNOWN North American distribution along the Pacific coast
- If *Styela clava* is present at locations with significantly different environmental conditions then the distribution presented here underestimates the actual potential distribution

Environmental Suitability





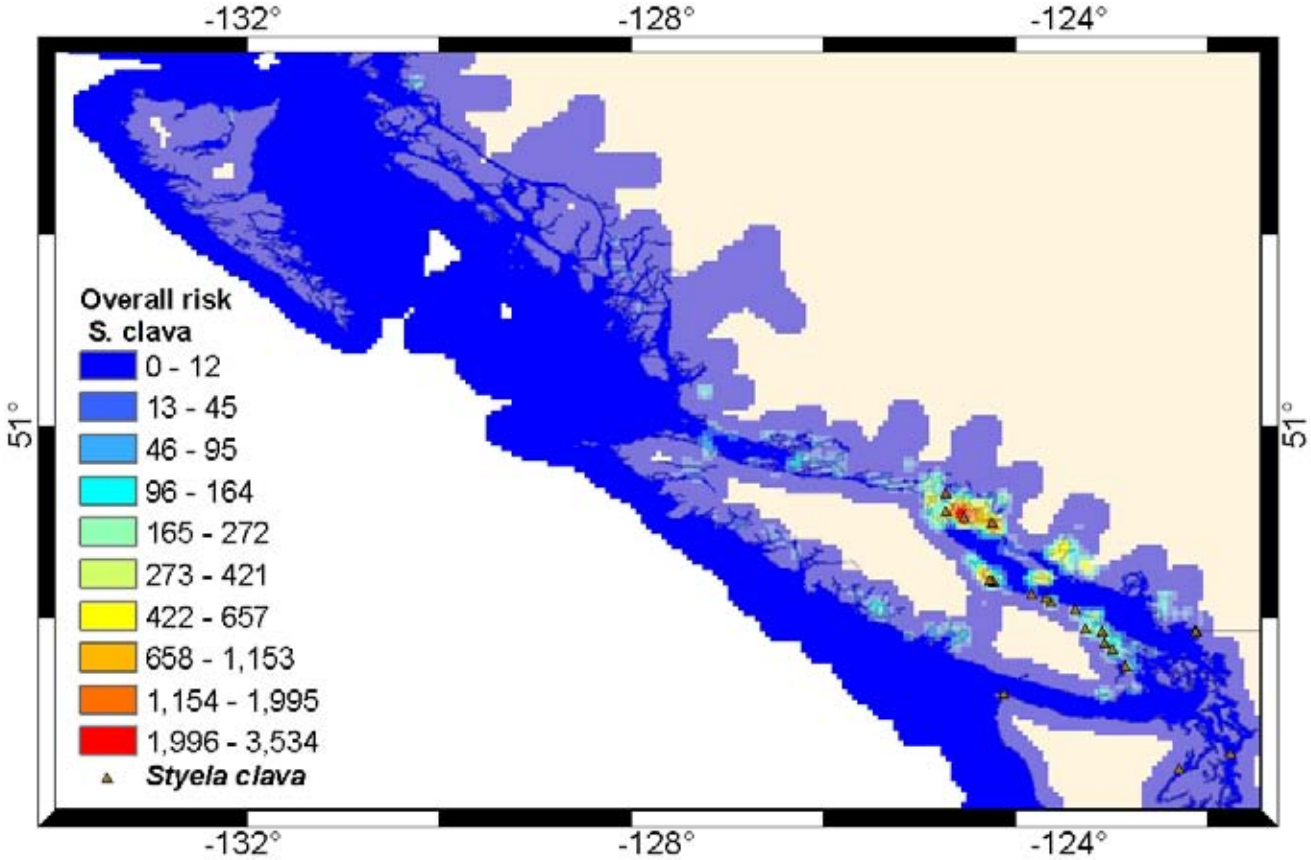
Environmental Suitability

	Salinity (‰)	Temperature (°C)
Jan-Mar	26.5 – 33.6	5.5 – 13.3
Apr-Jun	24.2 – 33.6	8.4 – 14.7
Jul-Sept	26.7 – 33.4	11.0 – 16.3
Oct-Dec	22.7 – 34.0	8.0 – 16.2

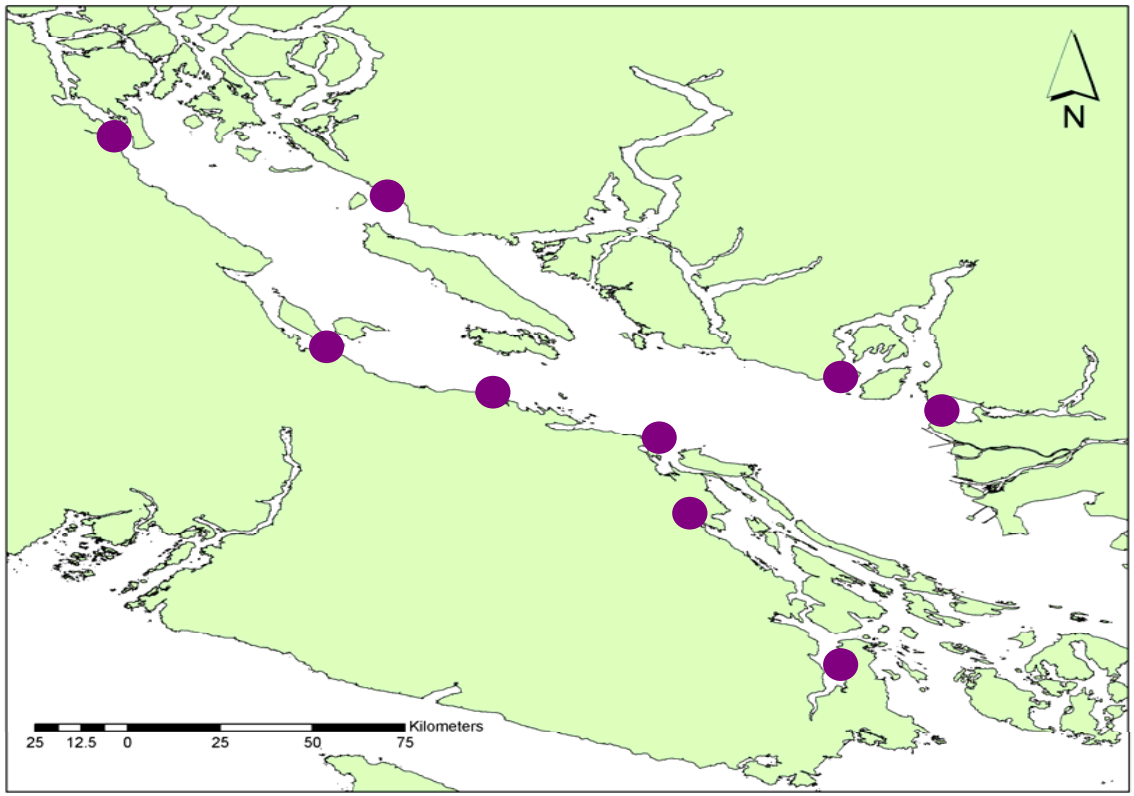
Potential Distribution

- Potential distribution is a function of potential vectors and suitable environments
- We combined the three major vector densities with GARP environmental predictions
- All density layers were standardized to range between 0 and 1

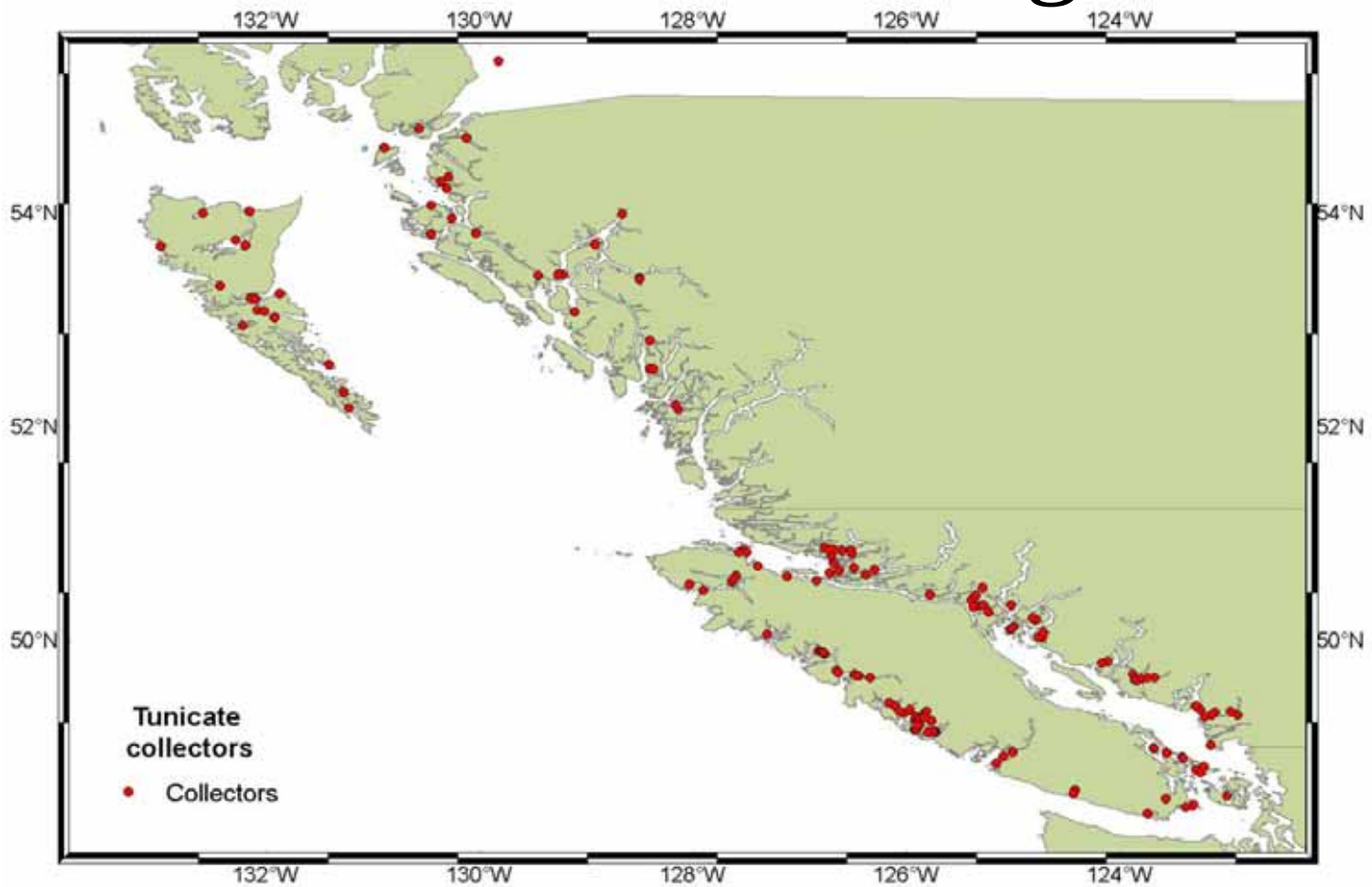
Potential Distribution



Subtidal AIS Monitoring – 2006



Subtidal AIS Monitoring – 2007



Informing Other NIS Activities

- The potential distribution of *Styela clava* as determined by vector density and GARP modeling can be used to inform other activities
  - Risk Assessments
  - Monitoring
  - Rapid Response Planning

Next Steps

- Quantify *actual* vector movement
  - associated with aquaculture-related activities
  - associated with small craft movements
- Use genetic information to identify the population structure of this non-indigenous tunicate and potential vectors responsible for this observed structure

Potential Consequences

- Based on an expert survey and literature accounts, the most severe impacts noted for *Styela clava* included:
  - Shellfish aquaculture
  - Biodiversity
  - Vessels, moorings or marinas

Aquatic Organism Risk Potential

Ecological or Genetic Consequence	Very High					
	High					
	Moderate					*Ecol.* (EC) *Ecol.* (WC)
	Low					*Gen.* (WC)
	Very Low					*Gen.* (EC)
		Rare	Low	Moderate	High	Very High
	Probability of Introduction					

Outreach and Communication

- The shellfish industry, recreational boat owners and marina operators need to be especially vigilant
- New sightings should be reported immediately
  - Phone: 1-888-356-7525
  - E-mail: AISPacific@pac.dfo-mpo.gc.ca

Acknowledgements

- Funding from DFO's Aquatic Invasive Species program and the Centre of Expertise for Aquatic Risk Assessment (CEARA)
- All the individuals who provided data, both environmental and species sightings
- Comments/suggestions from those at the Charlottetown peer-review meeting