Distribution of Non-indigenous Intertidal Species on the Pacific Coast of Canada

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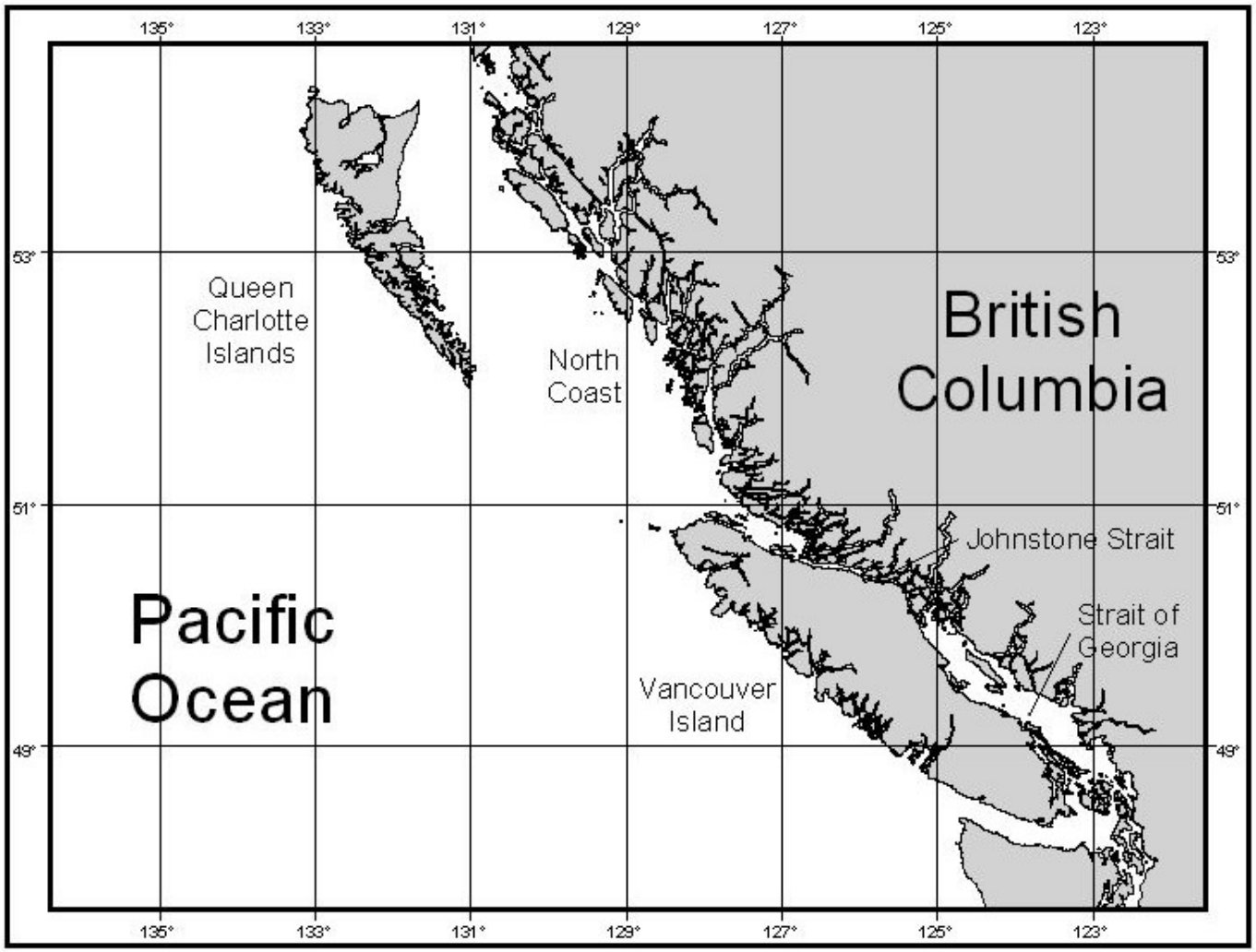
Introduction

- Non-indigenous species (NIS) are of concern globally
  - PICES WG on NIS
  - Canadian government programs to collect, synthesize and distribute data on NIS
  - Survey work to determine distribution and abundance of intertidal NIS
    - Strait of Georgia (Jamieson, Therriault)
    - Other areas of British Columbia

Objectives

- Provide updated information on distribution of intertidal NIS on the Pacific Coast of Canada

- Synthesize information on distribution, source and pathway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Queen Charlotte Islands
North Coast
British Columbia
Johnstone Strait
Strait of Georgia
Vancouver Island
Pacific Ocean

Legend and Data Sources

- White circles ○ are survey locations
- Yellow circles ● are collection records from:
  - Other survey databases (limited species)
  - Literature and public records
- Red circles ● are collection records from:
  - Exploratory intertidal clam surveys 1990-present
  - Exploratory NIS surveys 2006

Boundary Bay

- Sole location for:
  - *Crassostrea virginica*
  - *Crepidula convexa*
  - *Nassarius fraterculus*
  - *Nassarius obsoletus*
  - *Petricolaria pholadiformis*
  - *Spartina anglica*
- Primary location for:
  - *Urosalpinx cinerea* (Ladysmith)
  - *Neotrapezium liratum* (Ladysmith)
  - *Crepidula fornicata* (Victoria)
  - *Cecina manchurica* (Nanaimo)

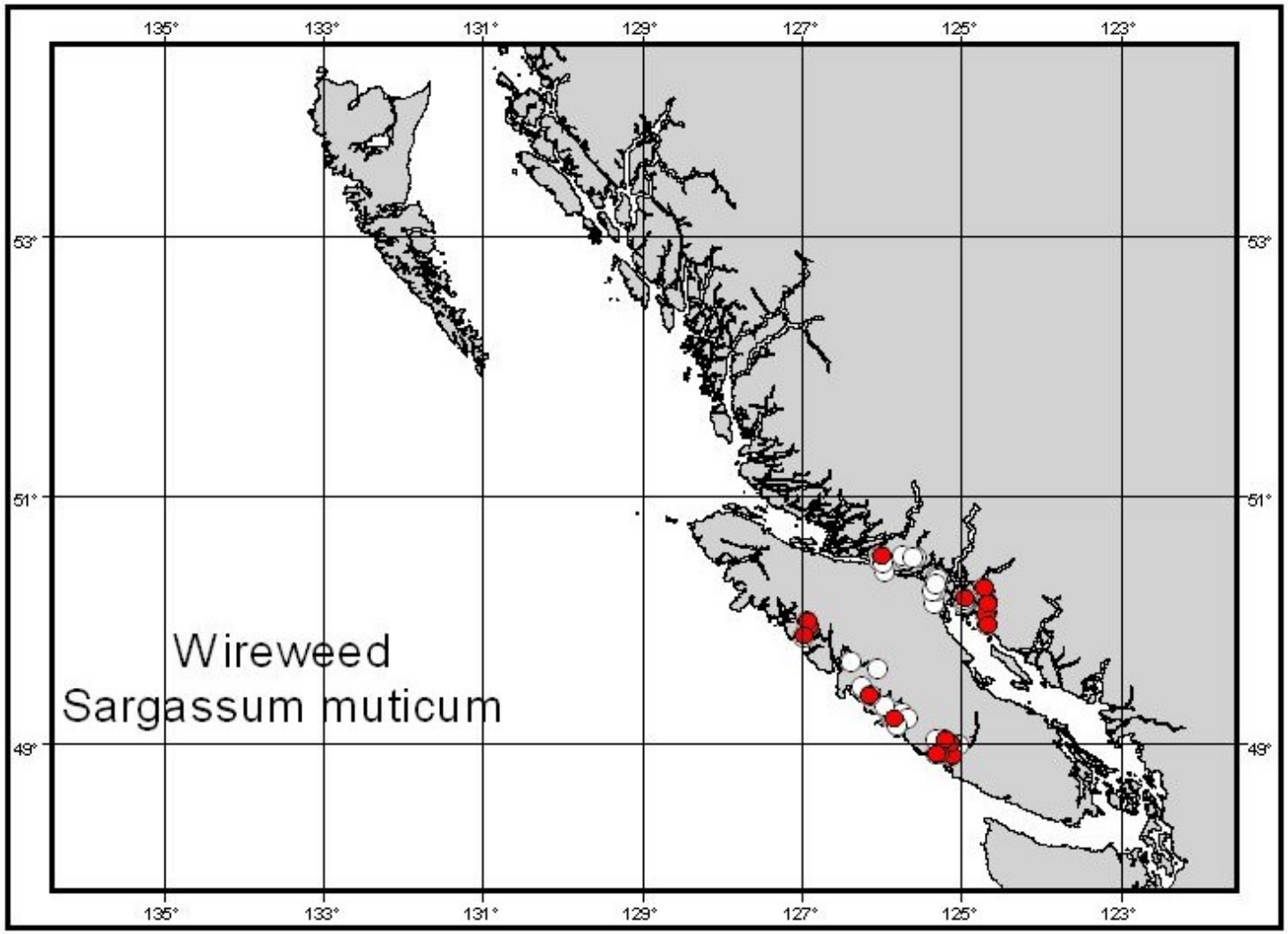
Intertidal NIS in BC – Plants / Algae

- Wireweed, *Sargassum muticum*
- Cordgrass, *Spartina alterniflora, S. anglica* and *S. patens*
- Dwarf eelgrass, *Zostera japonica*

Wireweed (*Sargassum muticum*)

Sargassum muticum

- Arrived with Pacific oyster seed
- Common in all South Coast areas
- Continuing to spread in North Coast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Wireweed
Sargassum muticum

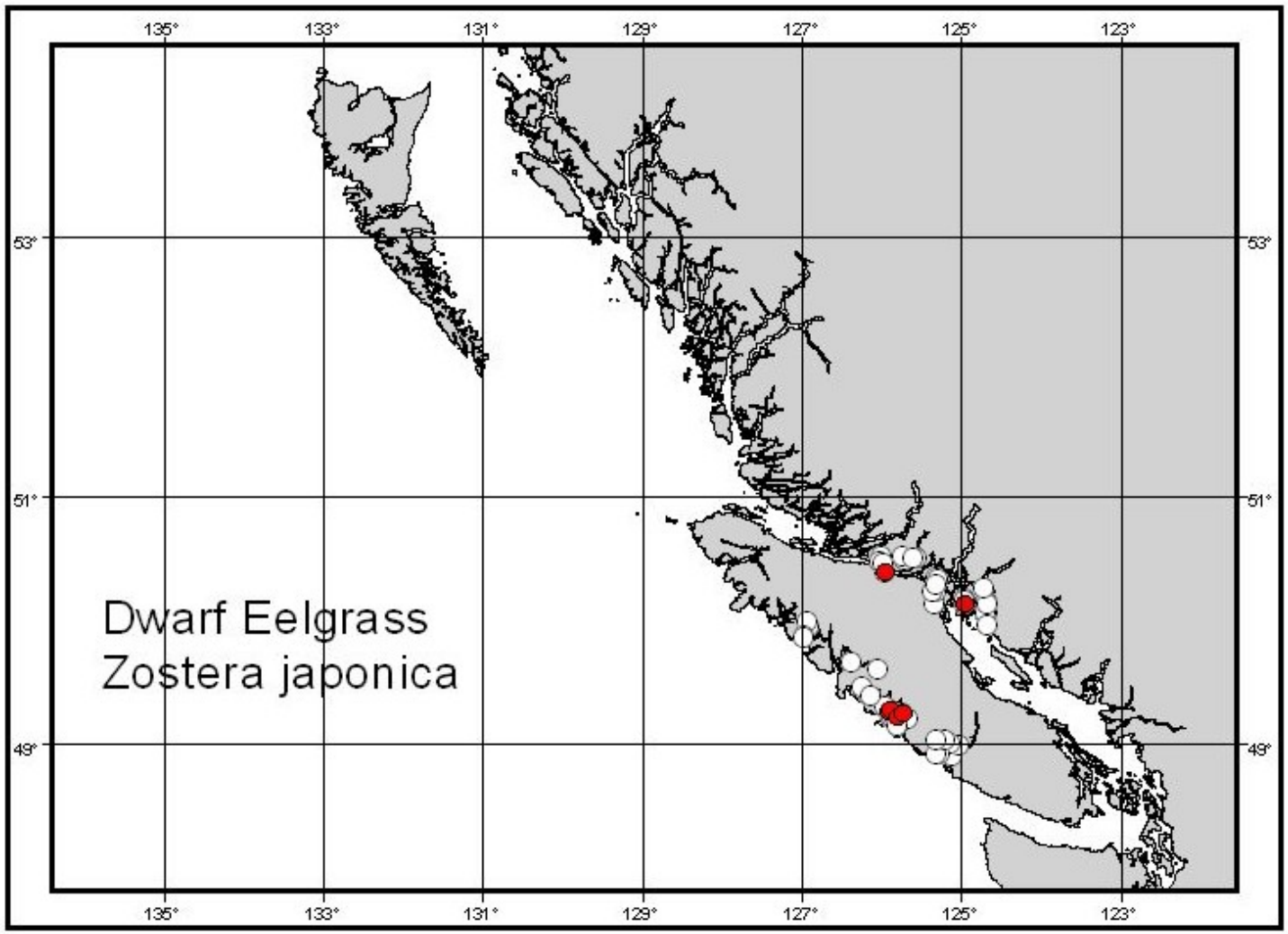
Cordgrass (*Spartina* sp.)

- Few records, possibly dispersal, possibly human mediated
  - Smooth cordgrass, *Spartina alterniflora*
    - Comox, Strait of Georgia
  - English cordgrass, *Spartina anglica*
    - Boundary Bay
  - Saltmeadow cordgrass, *Spartina patens*
    - Baynes Sound, Strait of Georgia

Dwarf Eelgrass (*Zostera japonica*)

Zostera japonica

- Arrived with Pacific oyster seed
- Dispersed from aquaculture locations
- Primarily Strait of Georgia, specific locations on WCVI and in Johnstone Strait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Dwarf Eelgrass
Zostera japonica

Intertidal NIS in BC – Gastropods I

- Japanese false cerith, *Batillaria attramentaria*
- Manchurian cecina, *Cecina manchurica*
- Convex slippersnail, *Crepidula convexa*
- Atlantic slippersnail, *Crepidula fornicata*
- Mouse-ear snail, *Myosotella myosotis*

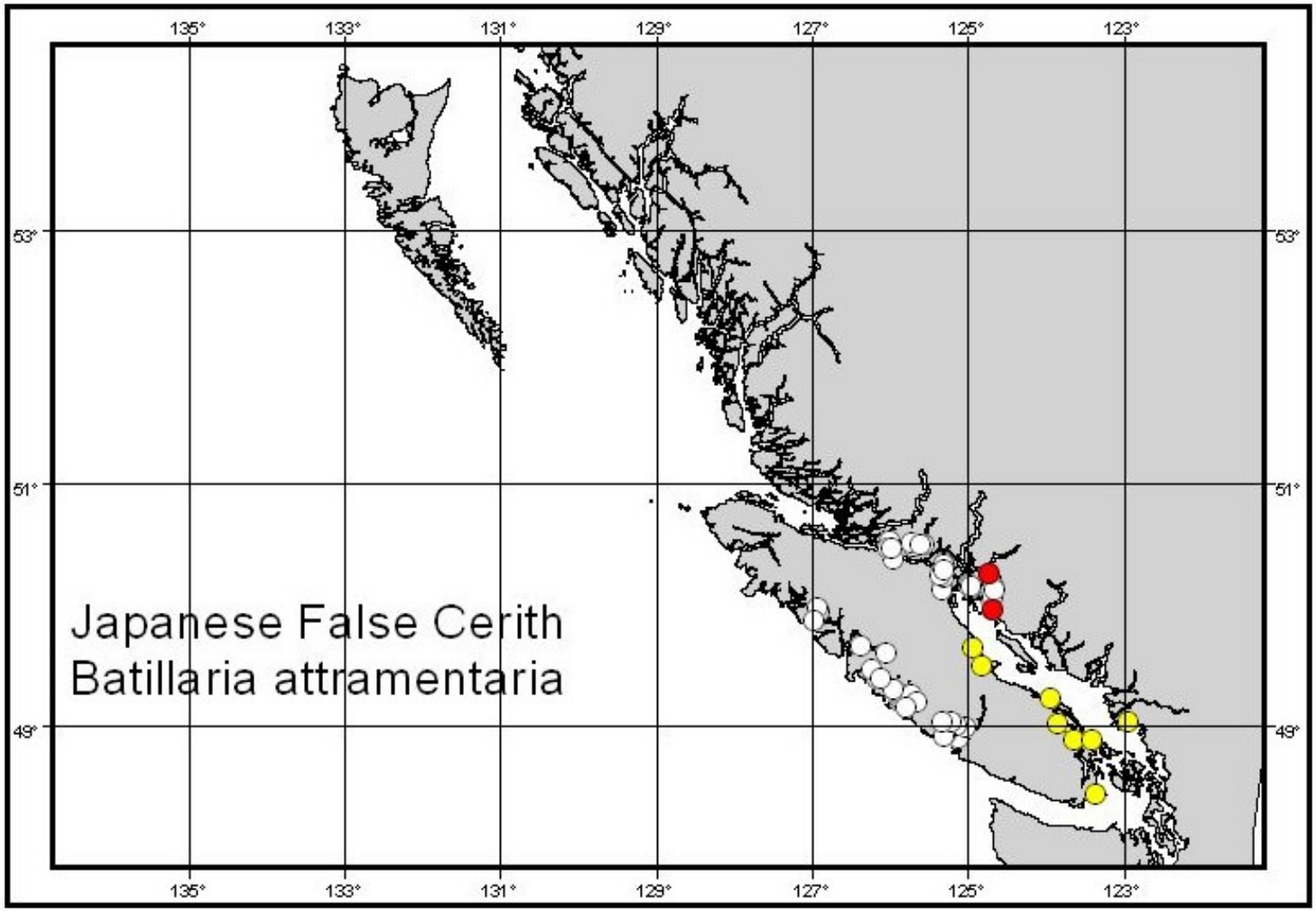
Intertidal NIS in BC – Gastropods II

- Japanese nassa, *Nassarius fraterculus*
- Eastern mudsnail, *Nassarius obsoletus*
- Japanese oyster drill, *Ocinebrina inornata*
- Atlantic oyster drill, *Urosalpinx cinerea*

False Cerith (*Batillaria attramentaria*)

Batillaria attramentaria

- Arrived with Pacific oyster seed
- Relatively few locations in Strait of Georgia, associated with oyster culture
- Dispersal limited by life history (benthic larvae)
- Collected in Pendrell Sound and Okeover Inlet in 2006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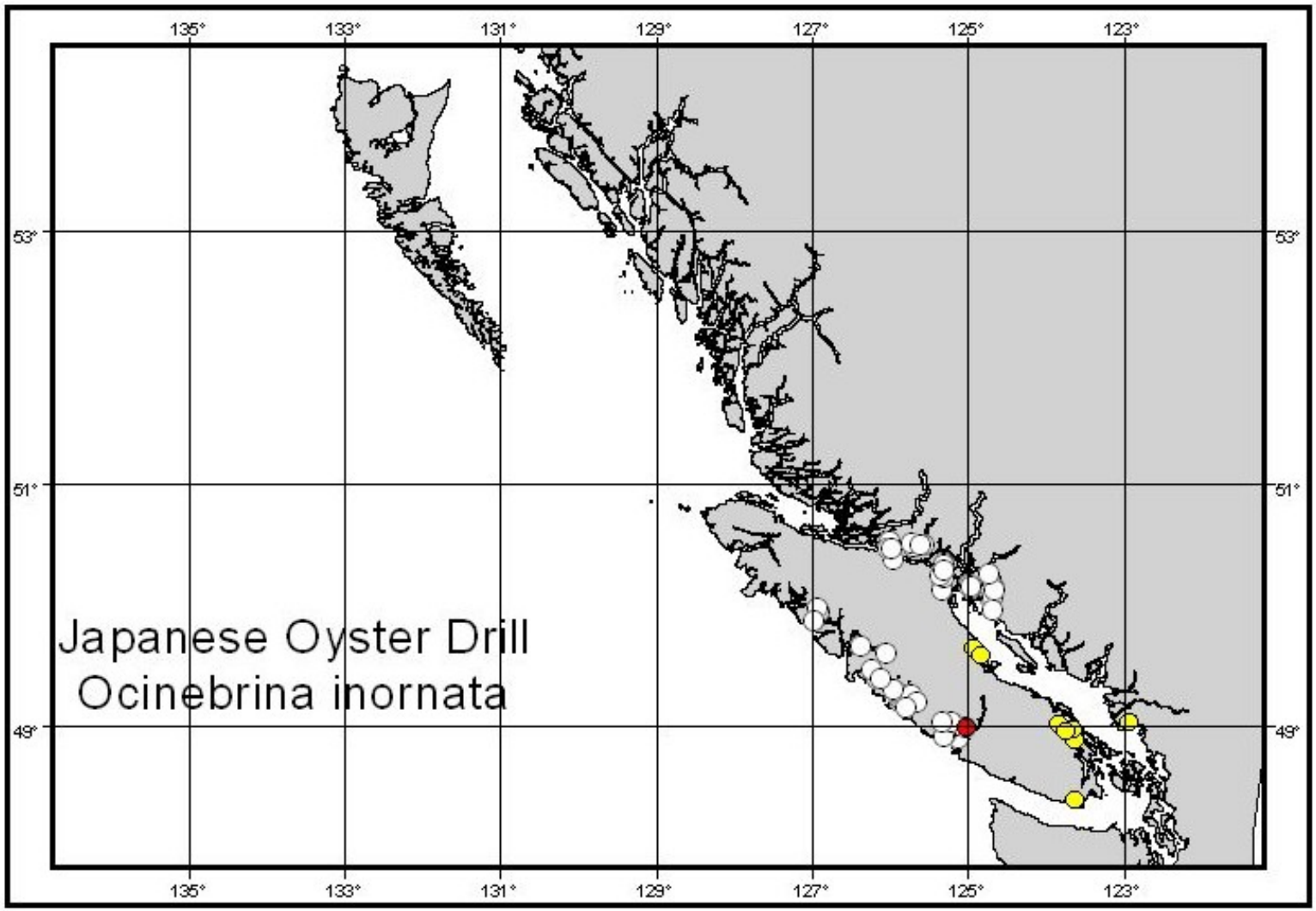
Japanese False Cerith
Batillaria attramentaria

Japanese Oyster Drill (*Ocinebrina inornata*)

Ocinebrina inornata

- Arrived with Pacific oyster seed
- Few locations, associated with oyster culture
- Drill Zone regulations in place to prevent spread
- Dispersal limited by life history (benthic larvae)
- Collected in Barkley Sound in 2006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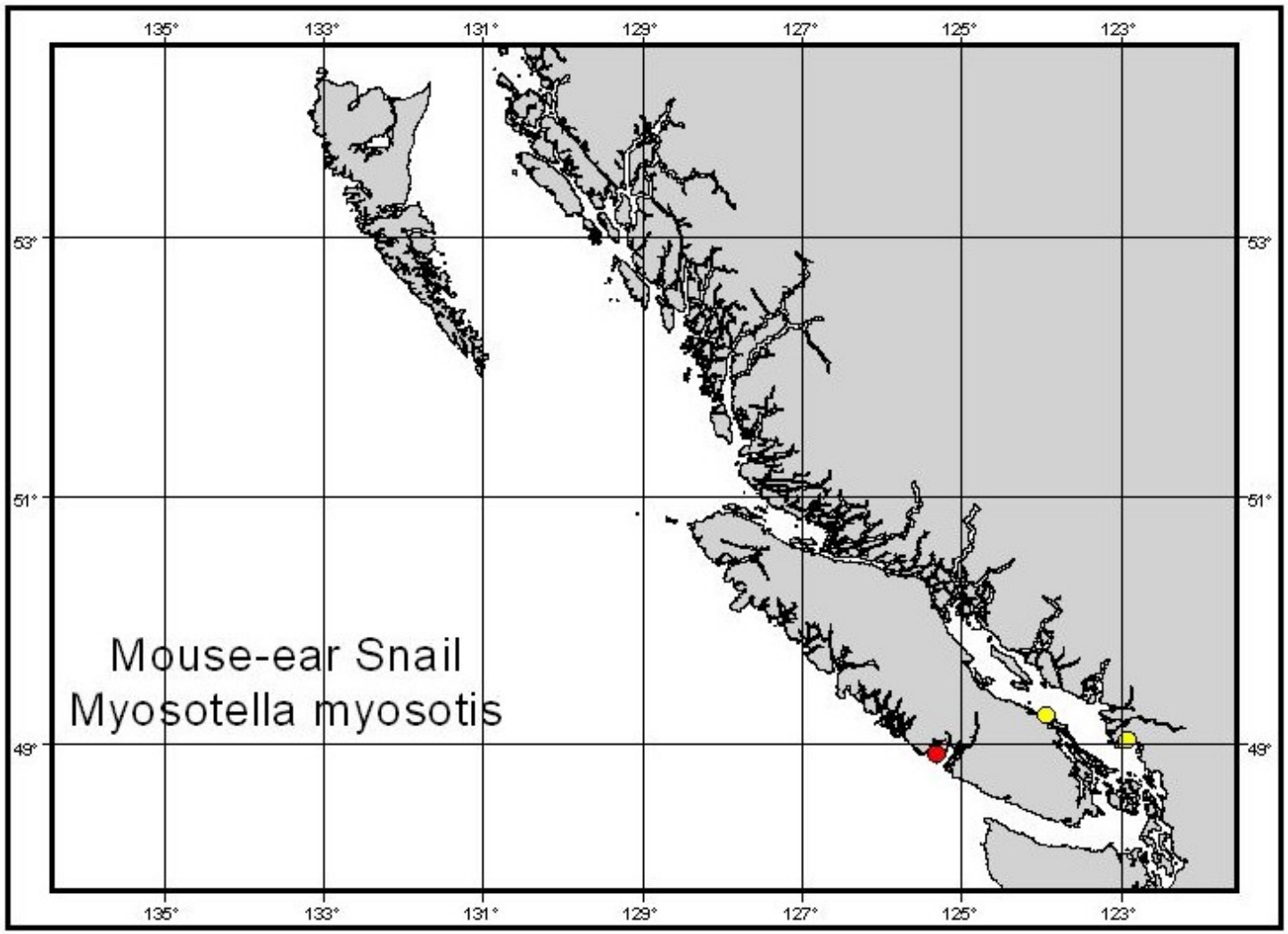
Japanese Oyster Drill
Ocinebrina inornata

Mouse-ear Snail (*Myosotella myosotis*)

Myosotella myosotis

- Possibly arrived with Atlantic oysters
- Known from Boundary Bay
- Recent records from Nanaimo
- Dispersal limited by life history (benthic larvae)
- Collected in Barkley Sound in 2006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Mouse-ear Snail
Myosotella myosotis

Intertidal NIS in BC – Bivalves I

- Pacific oyster, *Crassostrea gigas*
- Eastern oyster, *Crassostrea virginica*
- European flat oyster, *Ostrea edulis*
- Green mussel, *Musculista senhousia*
- Blue mussel, *Mytilus edulis*
- Mediterranean mussel, *Mytilus galloprovincialis*

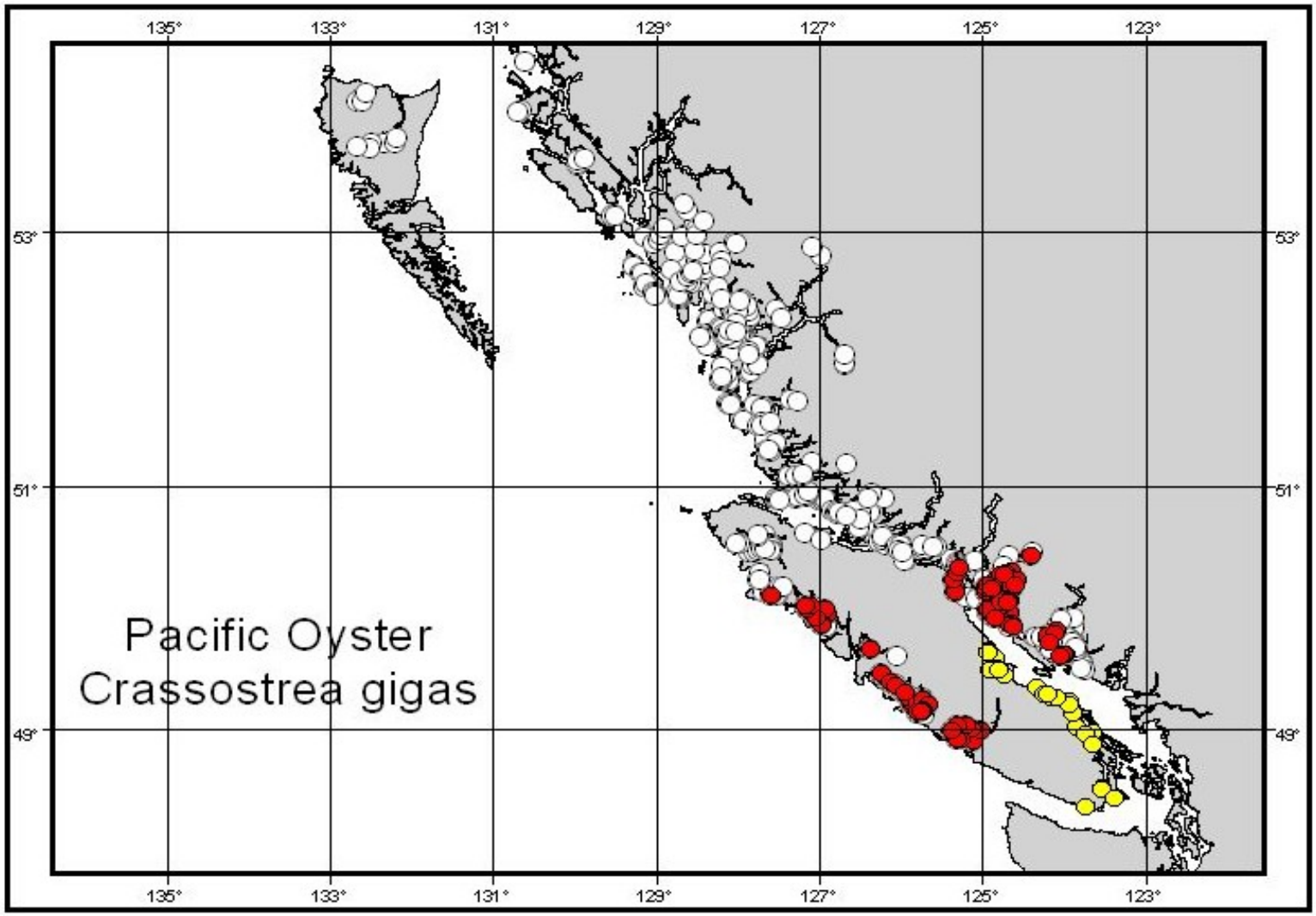
Intertidal NIS in BC – Bivalves II

- Softshell, *Mya arenaria*
- Quadrate trapezium, *Neotrapezuim liratum*
- Varnish clam, *Nuttallia obscurata*
- False angelwing, *Petricolaria pholadiformis*
- Manila clam, *Venerupis philippinarum*
- Naval shipworm, *Teredo navalis*

Pacific Oyster (*Crassostrea gigas*)

Crassostrea gigas

- Imported since 1920s for aquaculture to Strait of Georgia and WCVI
- Successful reproduction in Ladysmith Harbour, 1936
- Dispersed throughout Strait of Georgia and on WCVI north to Brooks Peninsula
- Dispersal limited by temperature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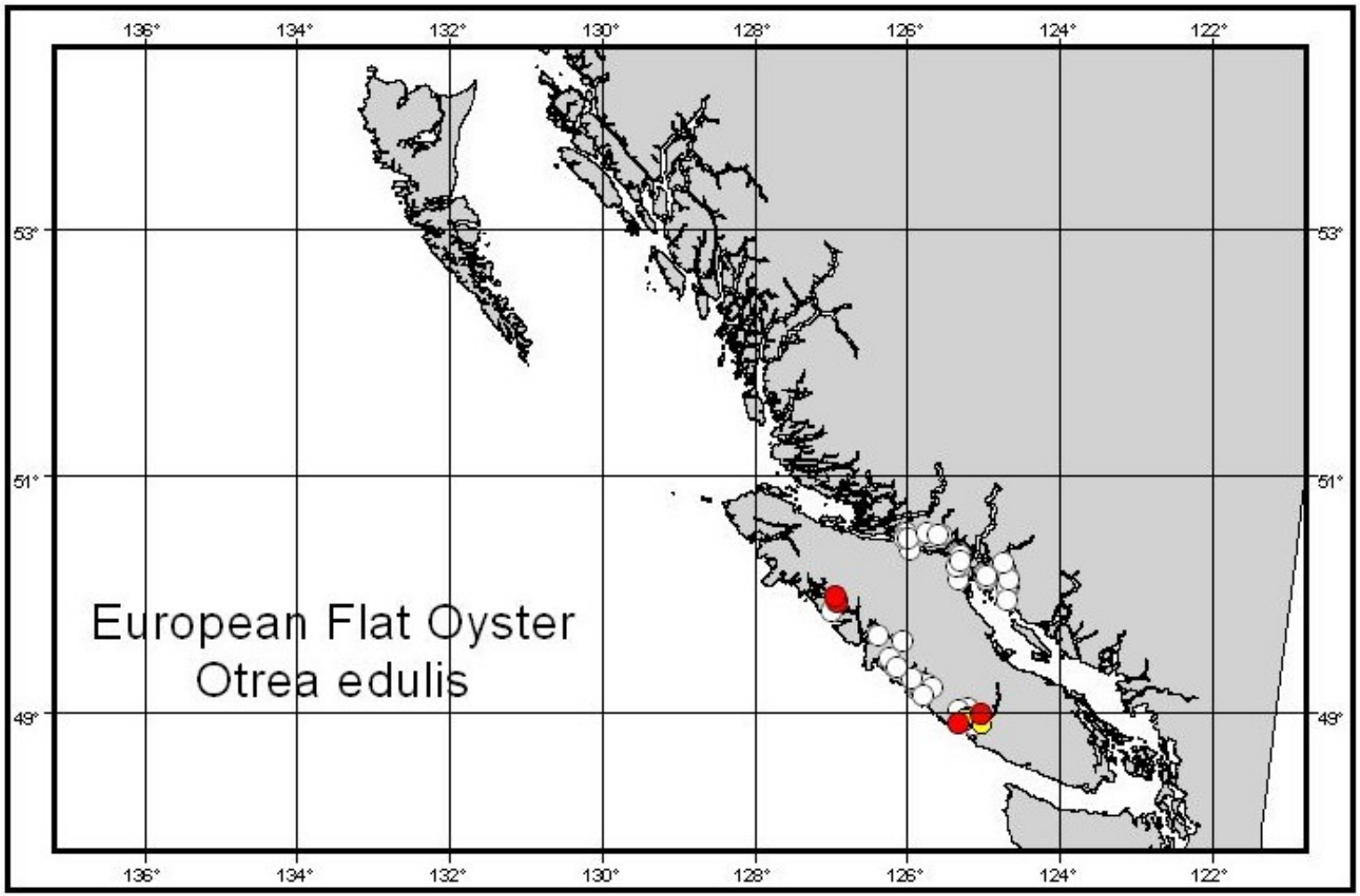
Pacific Oyster
Crassostrea gigas

European Flat Oyster (*Ostrea edulis*)

Ostrea edulis

- Imported for aquaculture in Strait of Georgia and WCVI
- Limited successful reproduction in Barkley Sound
- Deliberate introduction to several sites in Esperanza Inlet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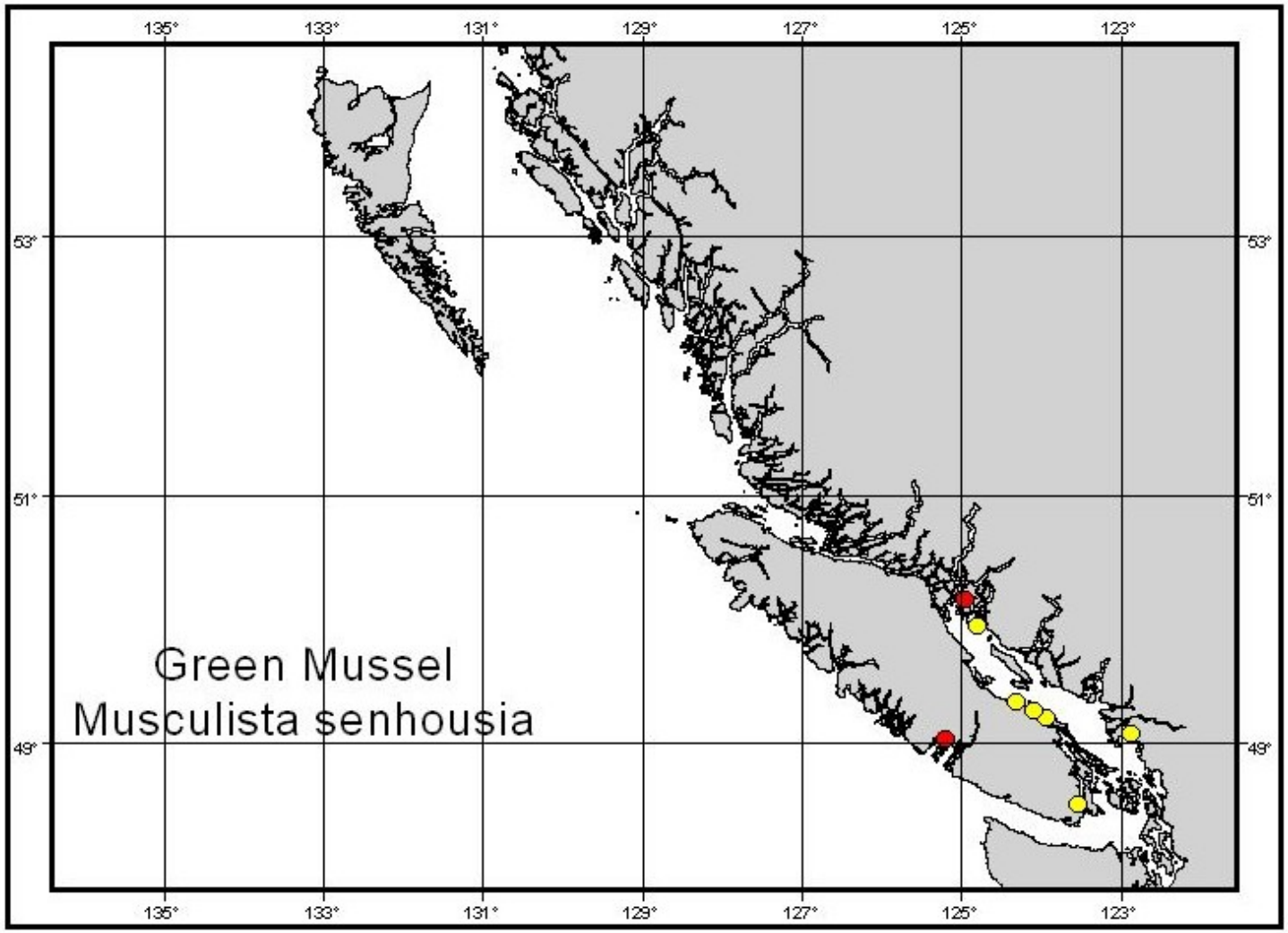
European Flat Oyster
Otrea edulis

Green Mussel (*Musculista senhousia*)

Musculista senhousia

- Known from Puget Sound since 1940s, arrived with Pacific oysters, no dispersal
- Collected in Strait of Georgia in 1990s
- Collected in Desolation Sound and Barkley Sound in 2006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Green Mussel
Musculista senhousia

Blue Mussels, *Mytilus* sp.

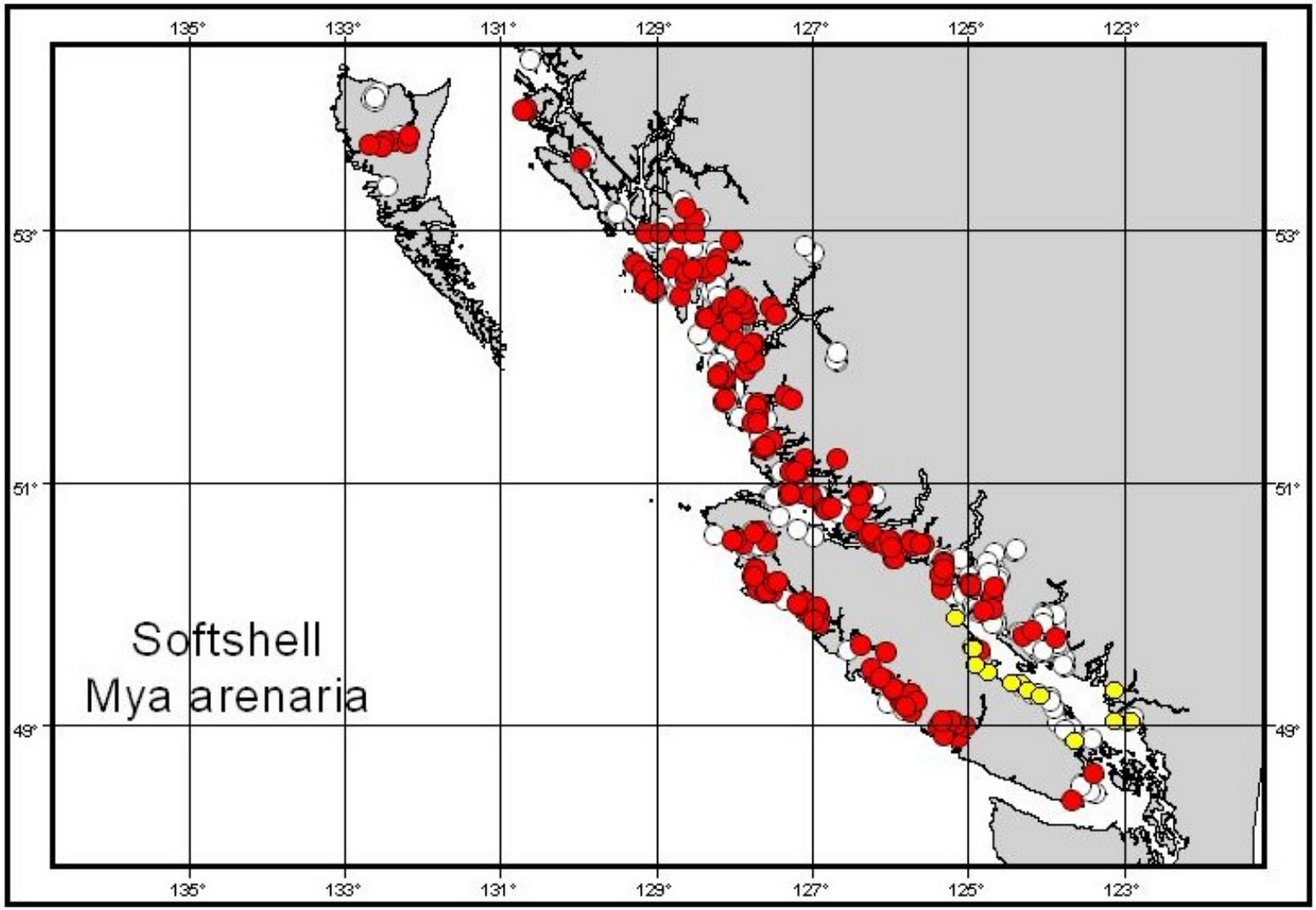
Mytilus edulis and *Mytilus galloprovincialis*

- Cannot be definitively distinguished from each other or native *Mytilus trossulus* in field
- Samples collected from each location for genetic analyses (pending funding)

Softshell (*Mya arenaria*)

Mya arenaria

- Brought to San Francisco Bay with Atlantic oysters
- Dispersed north, some deliberate introductions (*e.g.*, Willapa Bay, Washington)
- Dispersed through BC to Alaska, then south to Queen Charlotte Islands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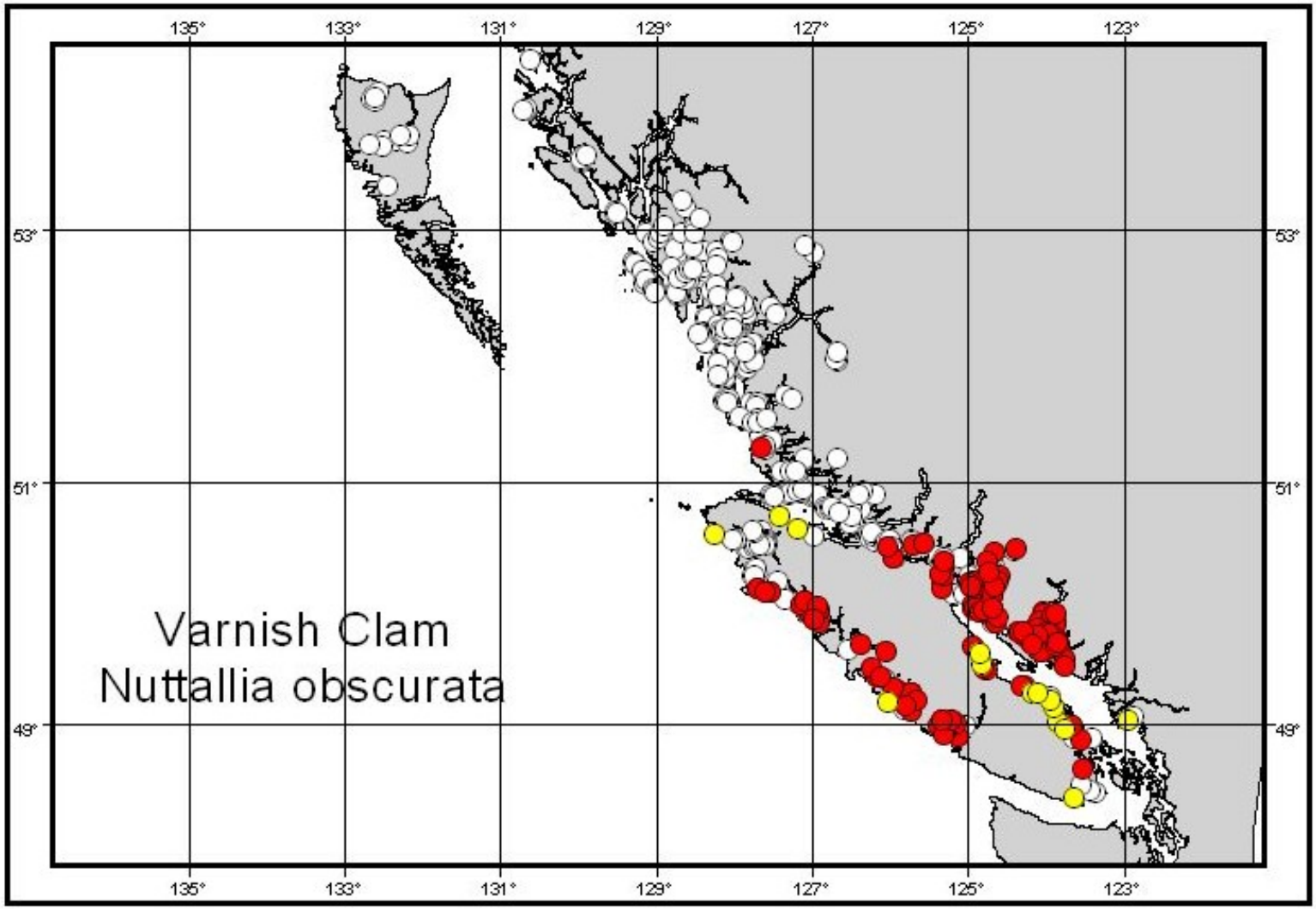
Softshell
Mya arenaria

Varnish Clam (*Nuttallia obscurata*)

Nuttallia obscurata

- Arrived late 1980s, ballast water introduction
- Nearly simultaneous appearance in Strait of Georgia and southern WCVI
- Dispersed north to tip of Vancouver Island
  - One record from North Coast
- Dispersal not complete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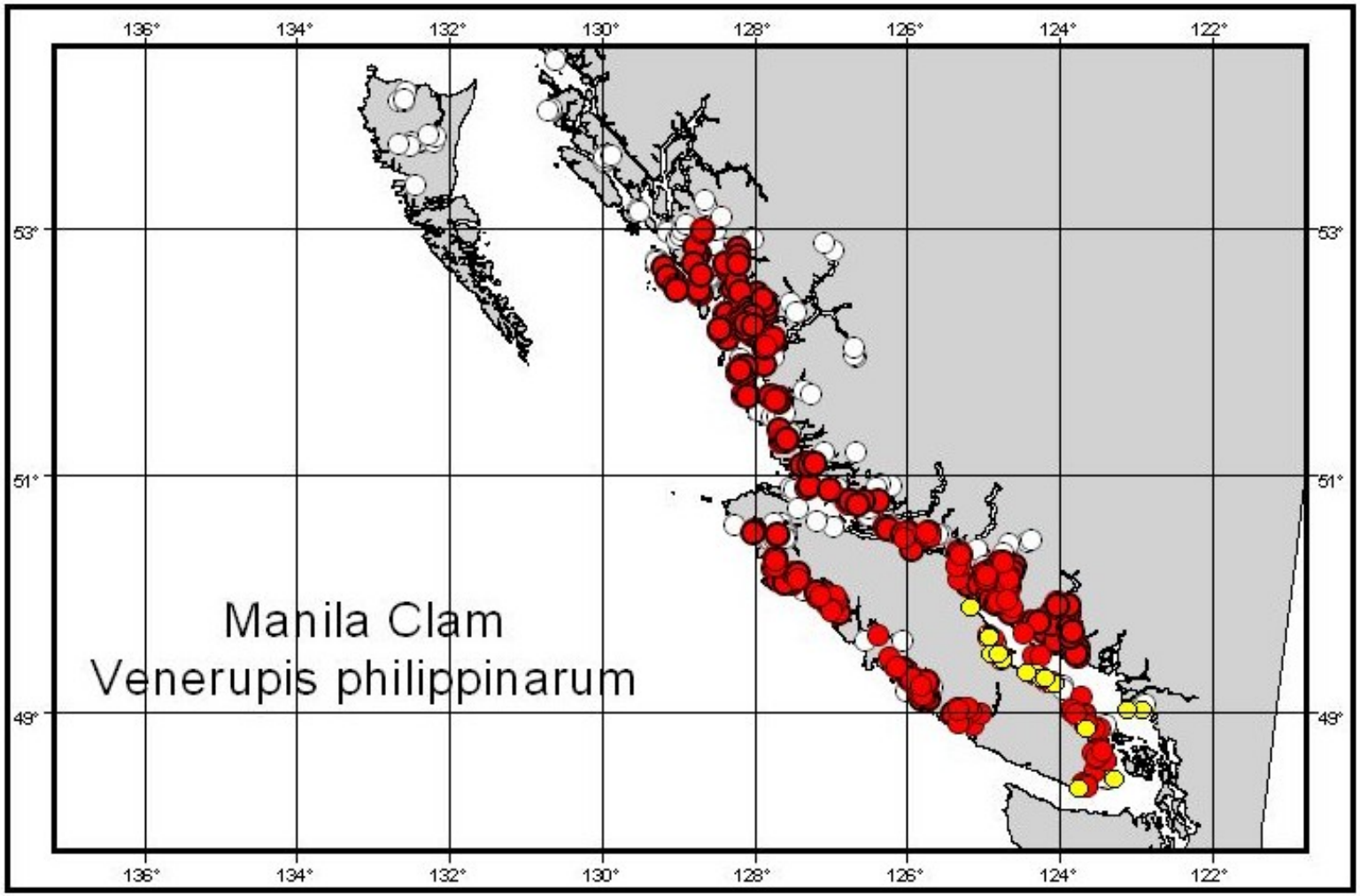
Varnish Clam
Nuttallia obscurata

Manila Clam (*Venerupis philippinarum*)

Venerupis philippinarum

- Came with Pacific oyster seed
- Found in Ladysmith Harbour in 1936
- Spread quickly, now basis of commercial fishery and aquaculture
- Dispersed into North Coast
- Dispersal limited by temperature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Manila Clam
Venerupis philippinarum

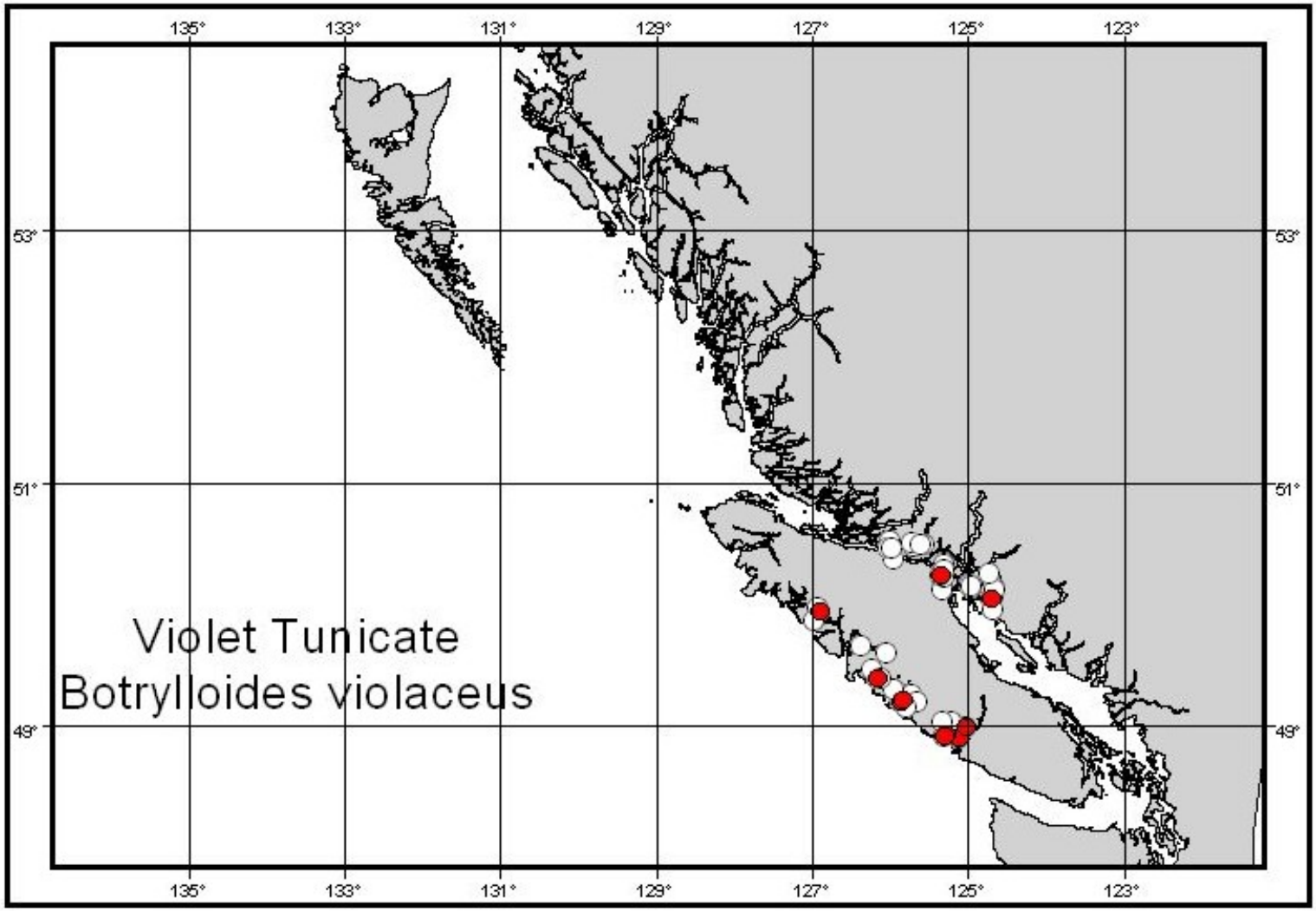
Intertidal NIS in BC - Others

- Violet tunicate, *Botrylloides violaceus*
- European green crab, *Carcinus maenas*

Violet Tunicate (*Botrylloides violaceus*)

Botrylloides violaceus

- May have been introduced with oysters or through hull fouling
- Found from Mexico to Alaska
- Cryptogenic, known in BC since at least 1990s
- Collected at low tide line or in oyster shell in 2006 surveys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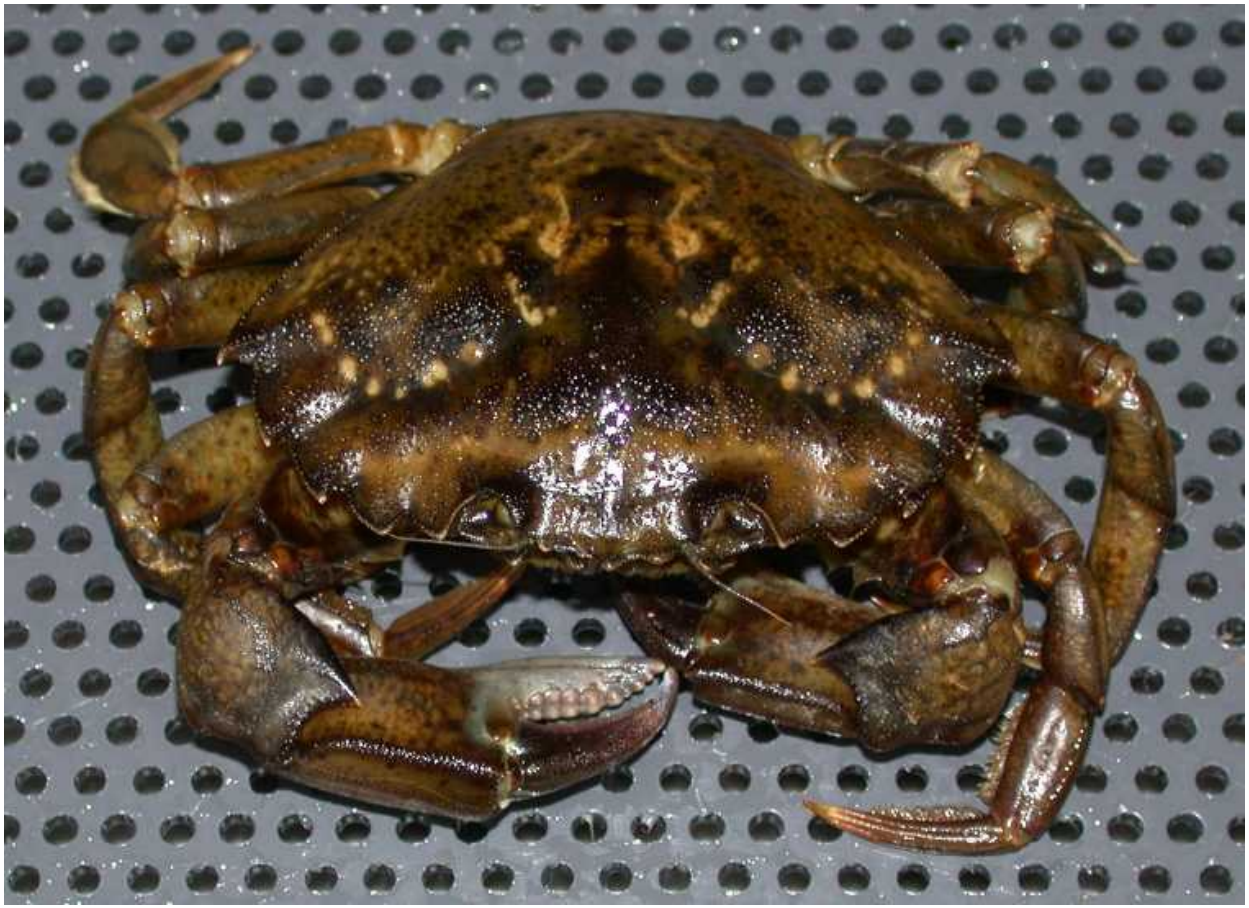
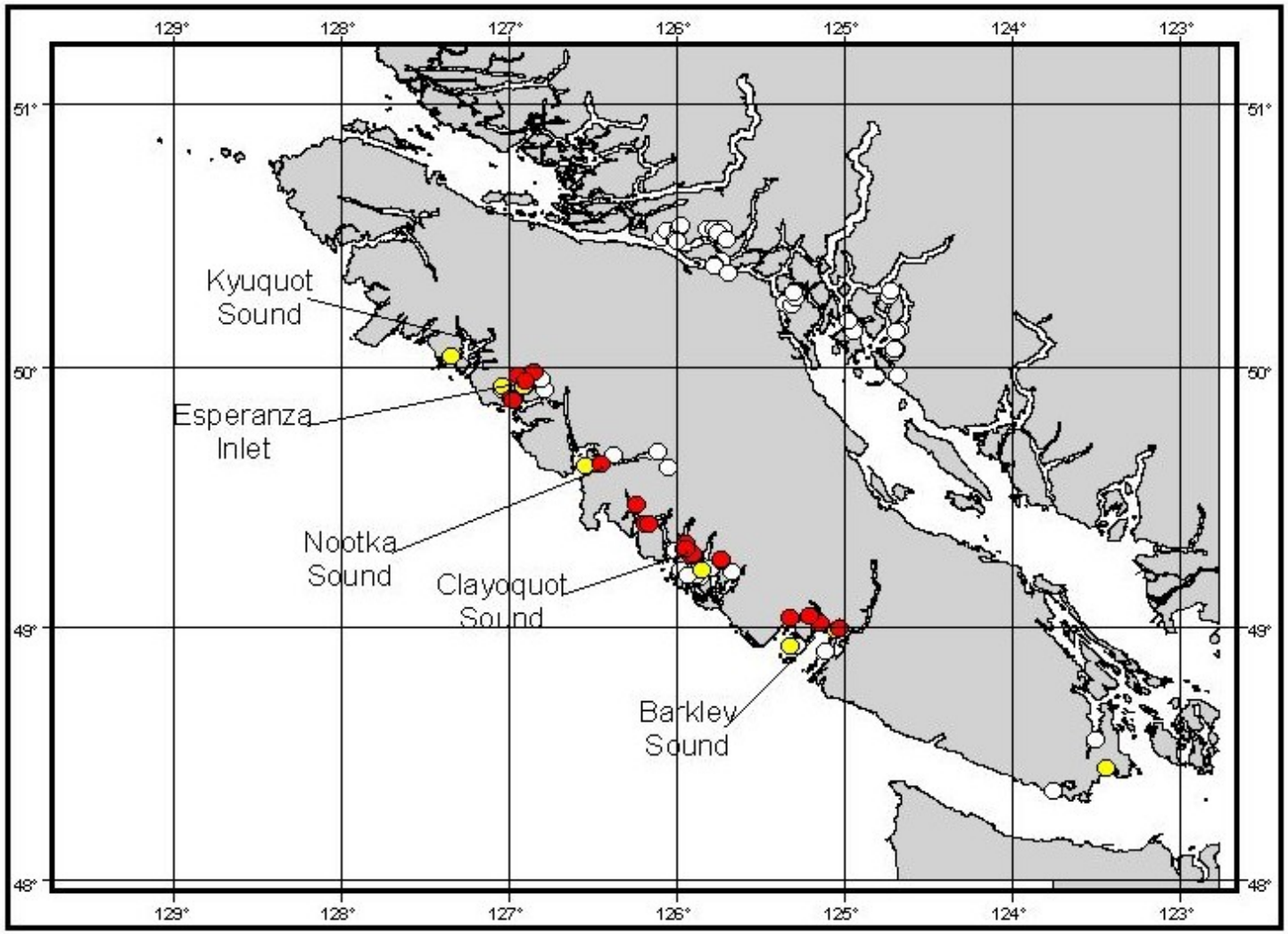
Violet Tunicate
Botrylloides violaceus

Green Crab (*Carcinus maenas*)



Carcnius maenas

- Arrived in San Francisco Bay in 1980s, likely ballast water introduction
- Dispersed north during strong El Nino episode in 1998
- Found on WCVI in 1999 (one year-olds)
- First survey in 2006
  - Collected on WCVI; not Johnstone Strait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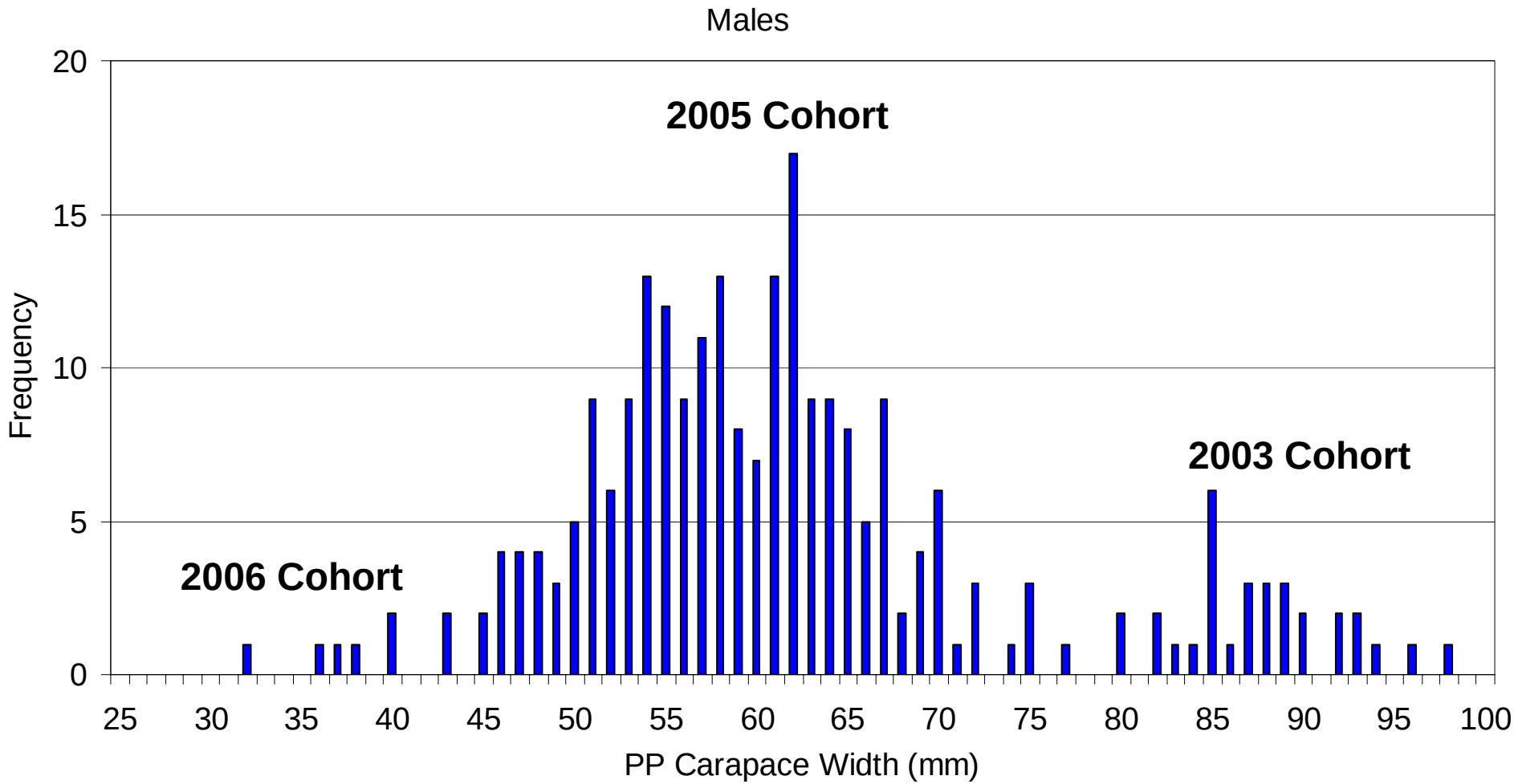
Kyuquot Sound
Esperanza Inlet
Nootka Sound
Clayoquot Sound
Barkley Sound

Green Crab Catch Rates by Sound

Sound	No. of Traps Set	Crabs/Trap-day
Barkley	162	1.72
Clayoquot	205	0.20
Nootka	30	0.03
Esperanza	118	0.46
Kyuquot	17	0.53


Males
2005 Cohort
2003 Cohort
2006 Cohort
Frequency
PP Carapace Width (mm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

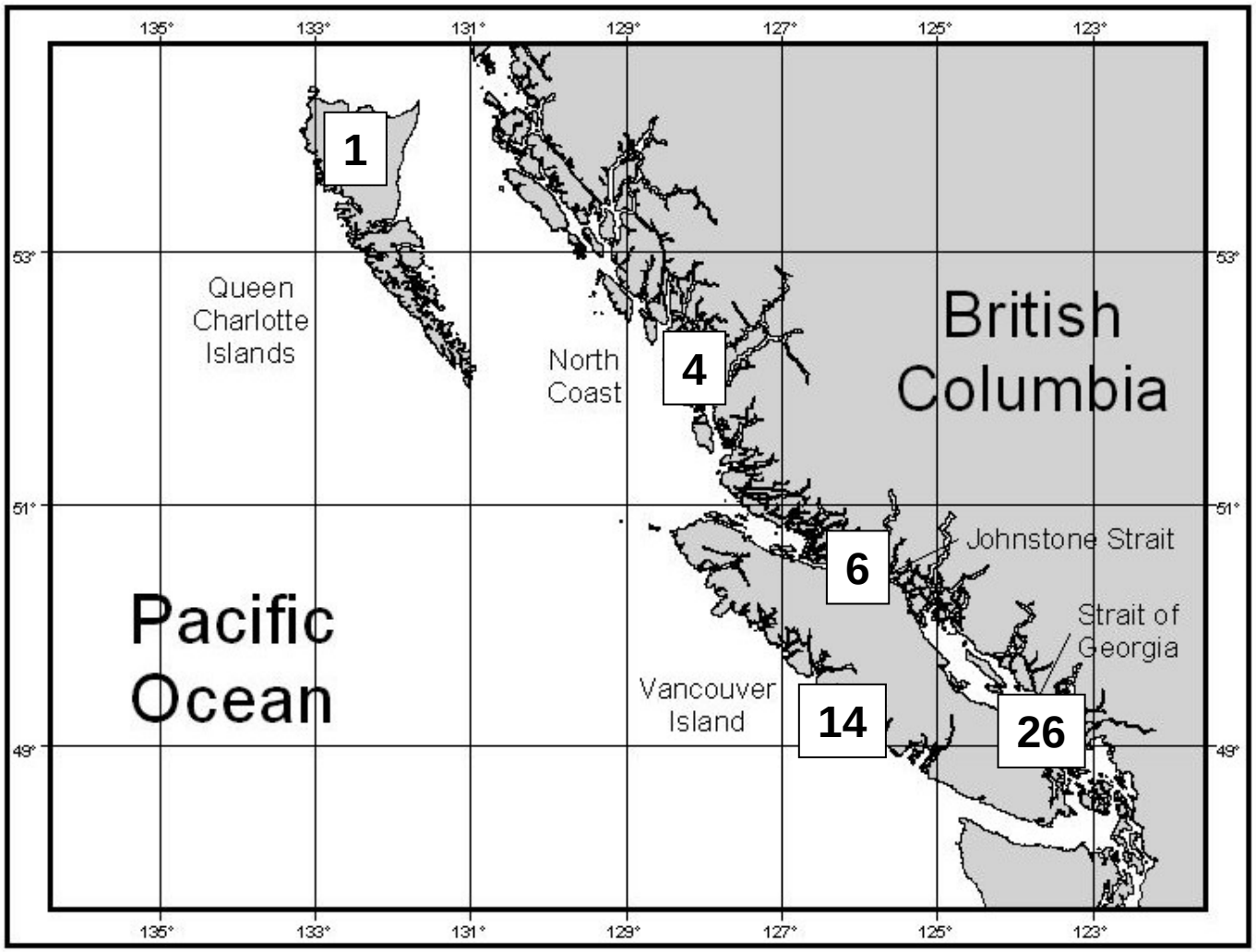
Intertidal NIS in BC – Not Established

- Topsnail, *Clanculus ater*
- Japanese rock-shell, *Purpura clavigera*
- Hoofsnail, *Sabia conica*

- Takenoshima shipworm, *Lyrodus takenoshimensis*
- Northern quahog, *Mercenaria mercenaria*

Number of NIS by Area

Strait of Georgia	26
West Coast Vancouver Island	14
Johnstone Strait	6
North Coast	4
Queen Charlotte Islands	1
Total Possible	28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Queen Charlotte Islands
North Coast
4
British Columbia
6
Johnstone Strait
Strait of Georgia
Pacific Ocean
Vancouver Island
14
26

Number of NIS by Origin

NW Pacific	13
North Atlantic	15
Total	28

Number of NIS by Area and Source

	Atlantic	Pacific
Strait of Georgia	13	13
West Coast Vancouver Island	5	9
Johnstone Strait	2	4
North Coast	1	3
Queen Charlotte Islands	1	0
Total Possible	15	13

Number of NIS by Pathway

Aquaculture (Hitch-hiker)	13
Natural Dispersal	5
Aquaculture (Intentional)	4
Fouling/Boring	4
Ballast Water	2
Total	28

Deliberate Dispersal Within BC

- Species transferred to previously uninhabited areas for aquaculture
  - Pacific oyster, *Crassostrea gigas*
  - Kumamoto oyster, *Crassostrea sikamea*
  - European flat oyster, *Ostrea edulis*
  - Mediterranean mussel, *Mytilus galloprovincialis*
  - Manila clam, *Venerupis philippinarum*
  - Japanese scallop, *Mizuhopecten yessoensis* hybrids

Conclusions

- NIS found throughout BC
  - Diversity greatest in Strait of Georgia
    - Highest density of aquaculture
    - Only aquaculture of Atlantic oysters
  - Diversity decreases with increasing latitude
    - Some species limited by temperature requirements
    - Aquaculture expanding into North Coast and QCI

Conclusions

- Most important pathway historically was aquaculture (intentional and unintentional)
  - Strict legislation in place to ensure that unintentional introductions prevented
  - However, still allow deliberate transfers to areas where not currently established
- Ship vectors currently of more concern

Other Considerations

- Where dispersal limited by life history, control of human vectors can limit spread
- Where dispersal limited by temperature requirements, projected climate change will allow broader distribution, particularly northward
- BC larval sources for green crab could allow dispersal through northern BC into Alaska in years of strong northward coastal currents