

**Appearance and rapid increase of
Acartia tonsa on the British
Columbia continental margin**

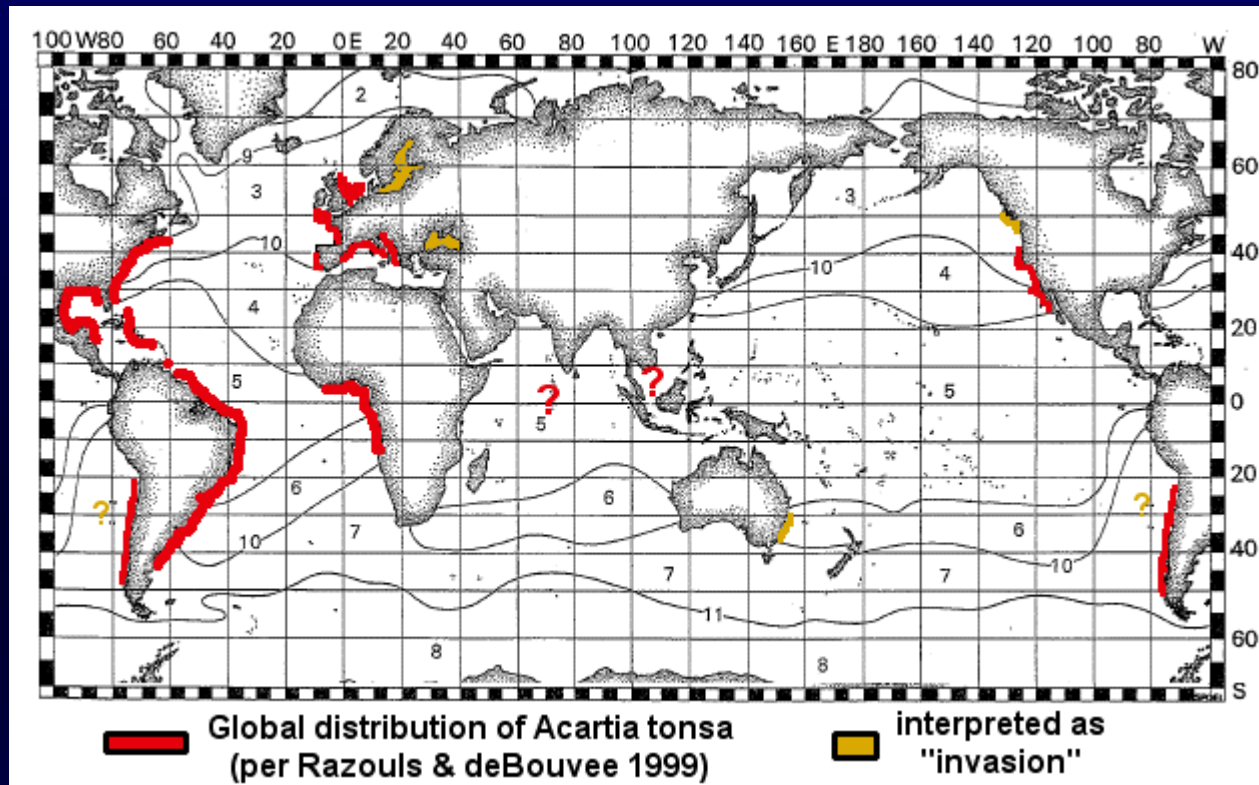


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Outline of our presentation:

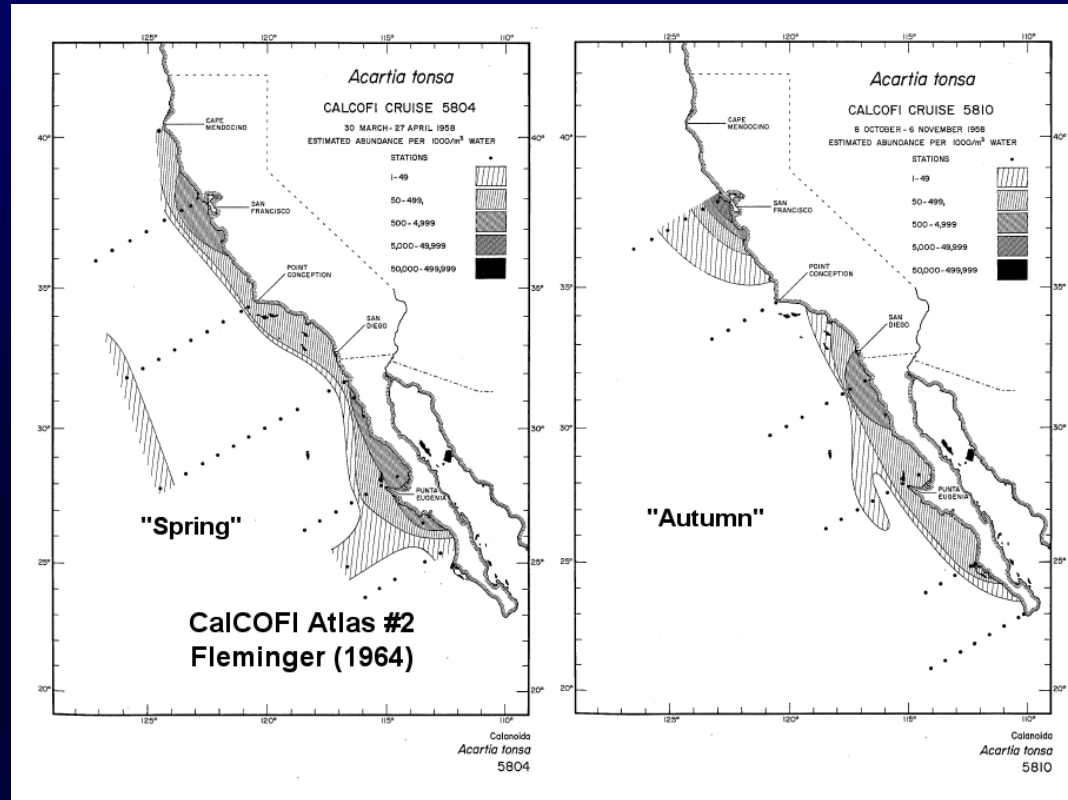
- **Background on *Acartia tonsa*:**
 - Global distribution
 - NE Pacific distribution
 - Life history & physiological traits that favor 'invasiveness'
- **Observations off British Columbia:**
 - 2004-2005 chronologies of *Acartia tonsa* & *A. longiremis*
 - Detailed spatial distributions
- **Interpretations:**
 - Was there a significant recent colonization?
 - Where did it come from and how did it spread (invasion or introduction)?
 - Effects on other zooplankton?

Background info: 1) Global Distribution



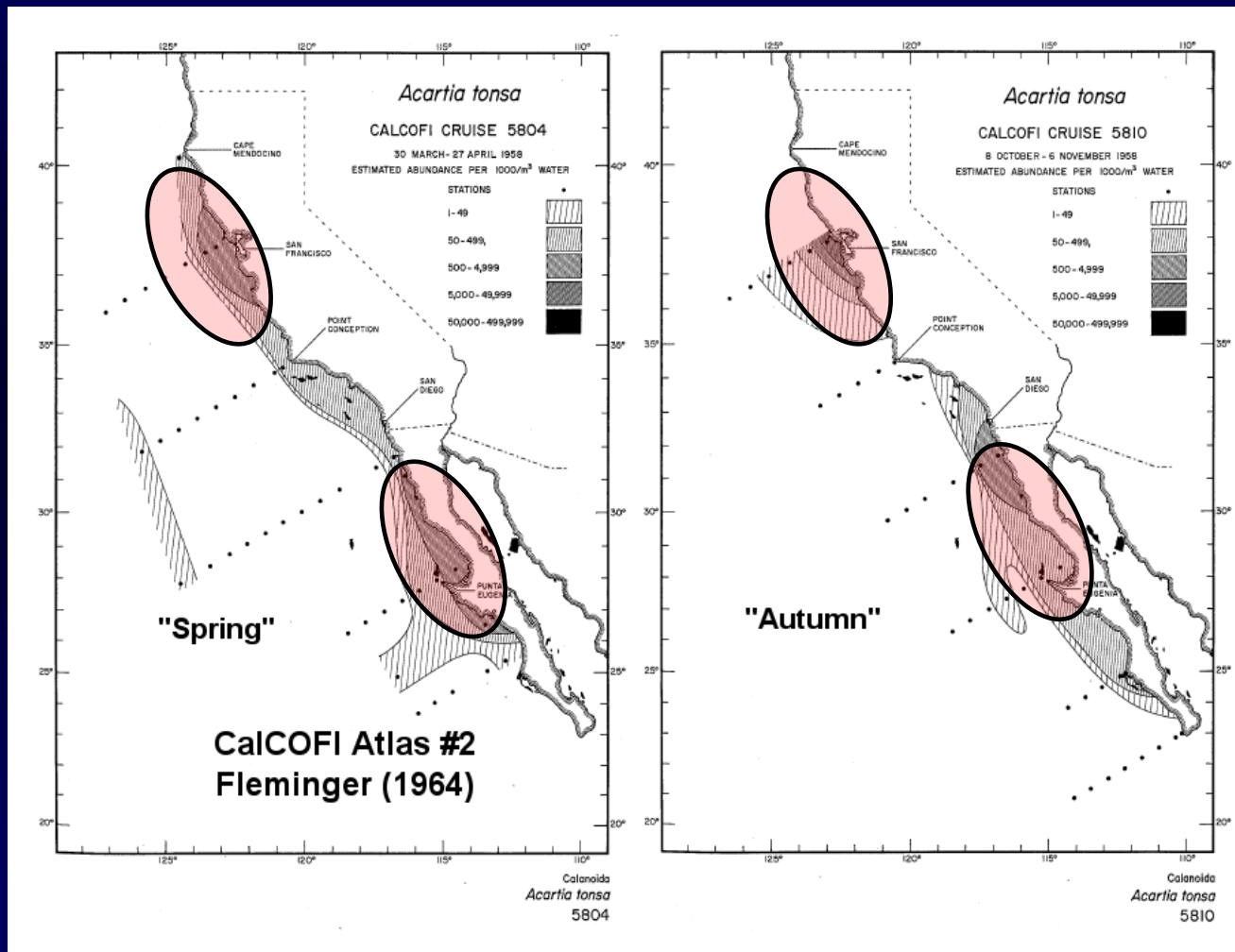
- Mid- & low-latitude ocean margins (especially estuaries)
- Both sides of Atlantic, east side of Pacific
- Some sites interpreted as “invasion/introduction”:
e.g. SE Australia, Baltic, Black, Caspian

2) NE Pacific Distribution



- Nearshore portion of California Current
- Centers off San Francisco Bay & northern Baja
- Appears off Oregon in 'warm' years (W. Peterson, pers. comm)
- NE Pacific genetically distinct from Atlantic?
(Caudill & Bucklin, 04)

Prefer areas with 'broad' continental shelf??



Physiology & Life History

Very broad salinity tolerance:

- **good for estuaries**
- **favors survival in ballast water?**

Occupies warm, food-rich near-surface habitat as nauplii and copepodites

BUT

Benthic diapause eggs:

- **tolerate low temperature, allow success in cold winter environments? (McAlice 1981)**
- **restrict year-round reproduction to coastal areas**

Morphology: a small copepod but a 'big' *Acartia*

(mesh = 1mm)

(Female)

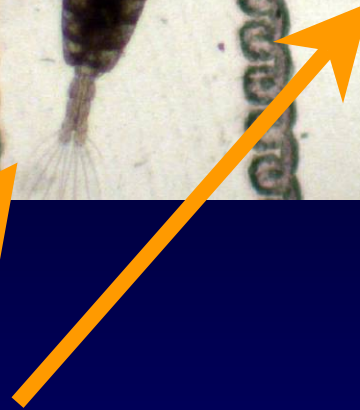
(Male)



A. tonsa

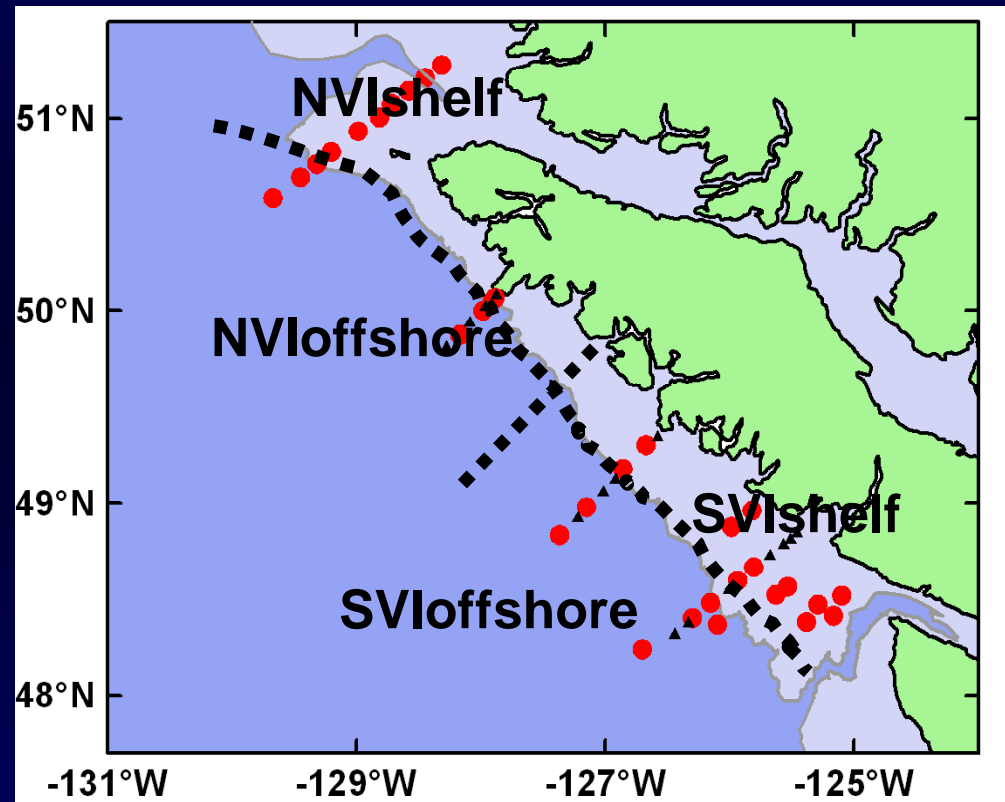
vs.

A. longiremis



Acartia spp. off Vancouver Island: Chronology from WCVI monitoring grid

- Vertical net hauls (red) + CTD casts along cross-shelf lines
- 2-3 full surveys per year + opportunistic extra lines & stations
- Four averaging regions:
 - ‘south’ vs ‘north’
 - ‘shelf’ vs ‘offshore’



Four *Acartia* species off BC:

Species	Usual rank in region (average g m ⁻²)	Where?	When?
<i>A. longiremis</i>	Highest ⇒ #2	Continental margin & seaward	Summer
<i>A. hudsonica</i>	Lower (limited range)	Inner shelf only	Summer
<i>A. danae</i>	Lowest	Mid-Outer shelf	Winters: 'warm' & El Niño
<i>A. tonsa</i>	Absent ⇒ #1	Mid-Outer shelf	Summers of 2004 & 2005 (both warm)

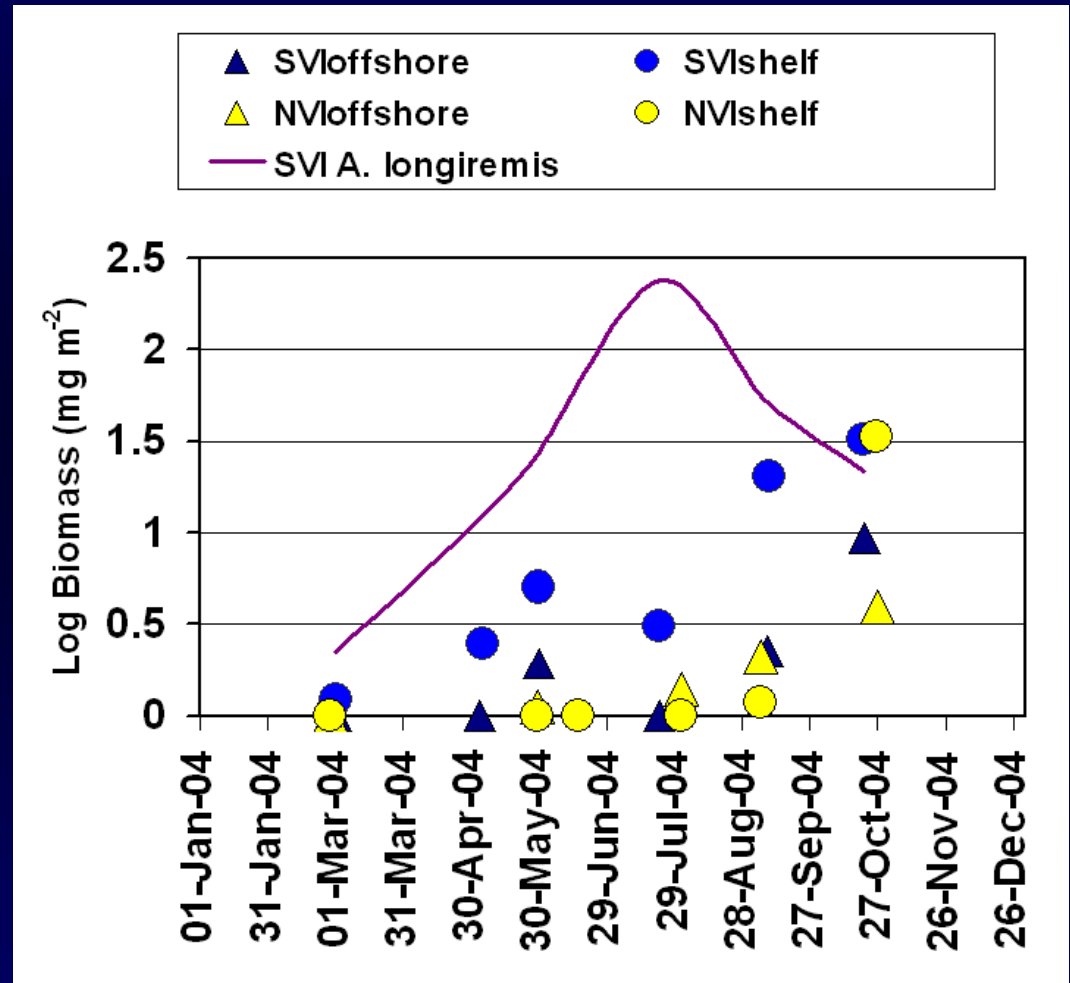
***A. tonsa* chronology off Vancouver Island:**

Pre-2004:

- **Undetected 1979-1991**
- **Present 1992-1993 (but only at trace levels = 0 or 1 per net tow)**
- **Undetected 1994-2002 (including during strong 1997-98 El Niño)**
- **Reappeared in 2003 (more abundant than 1992-93, but still lower than the other 3 *Acartia* spp.)**

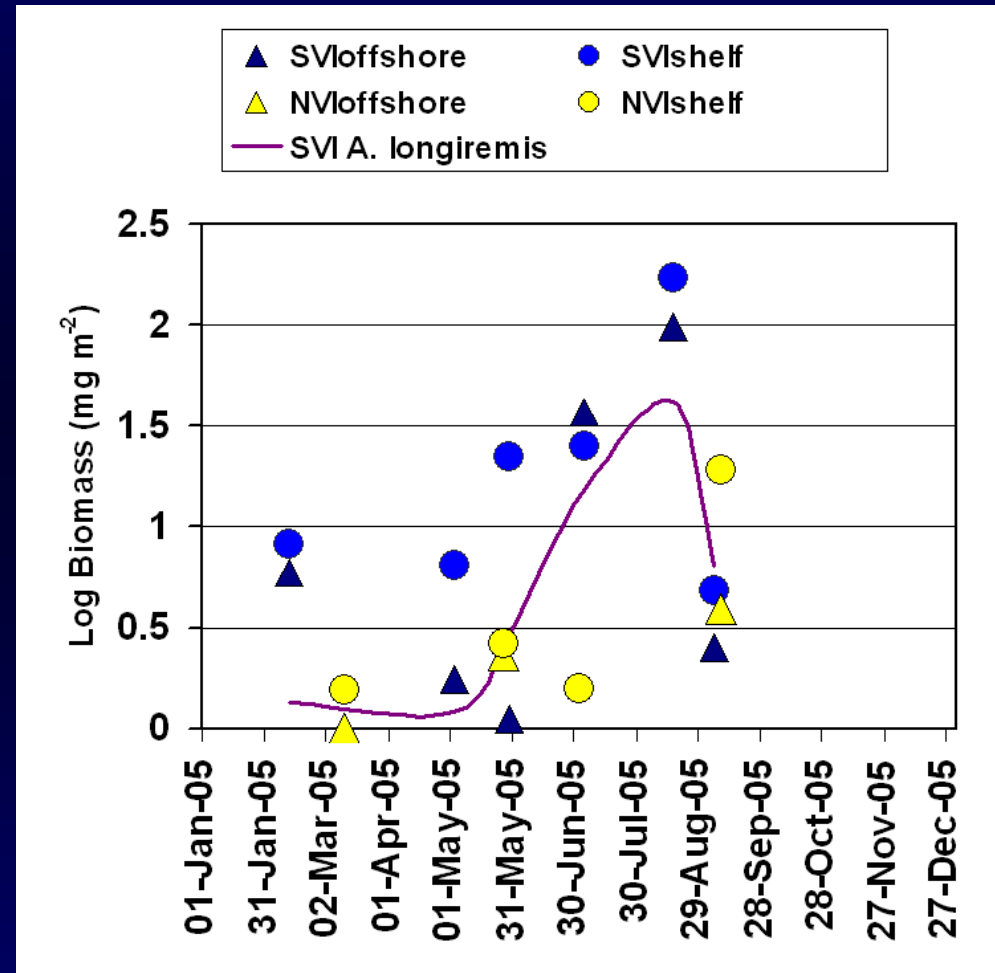
Recent chronology off Vancouver Island: 2004

- *A. tonsa* (symbols) starts year with low biomass in all regions
- Exponential increase through summer and autumn, earliest on SVI shelf
- *A. longiremis* (line & the usual dominant species) declines at end of summer & is passed by *A. tonsa*



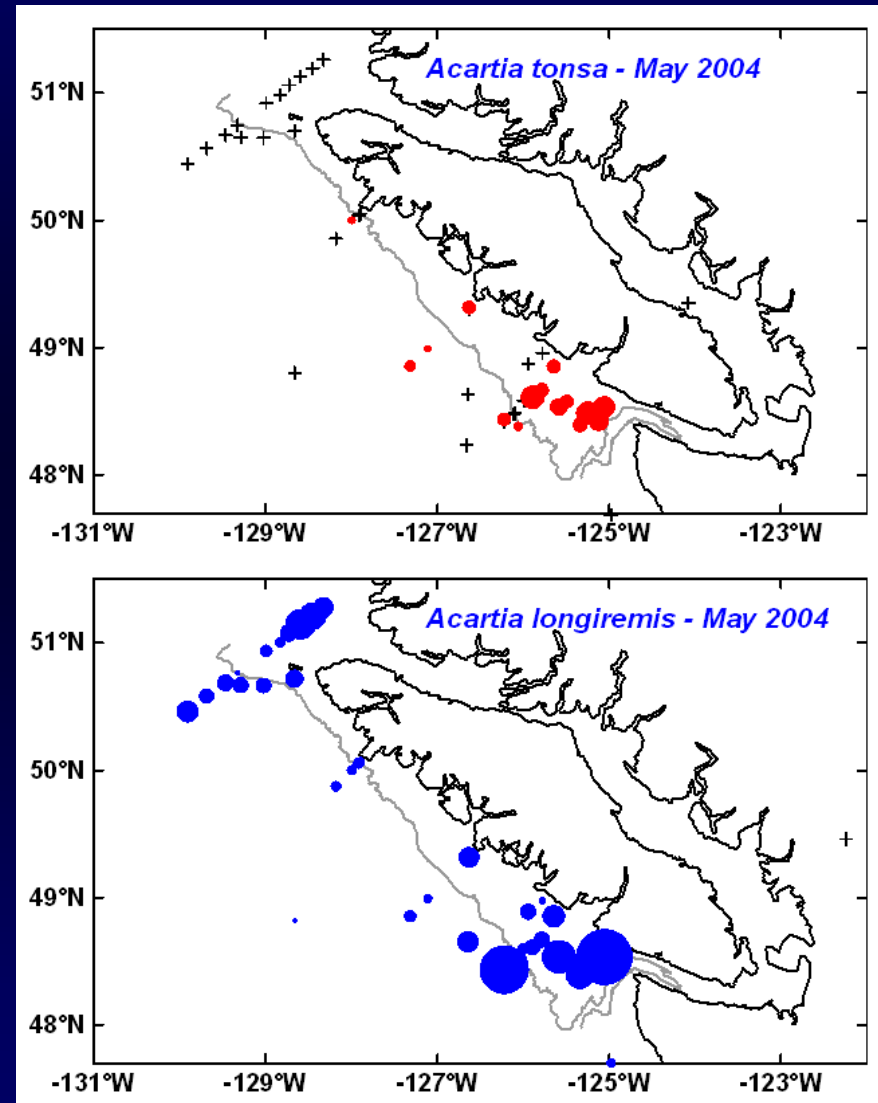
Recent chronology off Vancouver Island: 2005

- *A. tonsa* starts year with high SVI biomass
- $> A. longiremis$ for much of the season
- Decline in SVI in September, especially in recent upwelled water



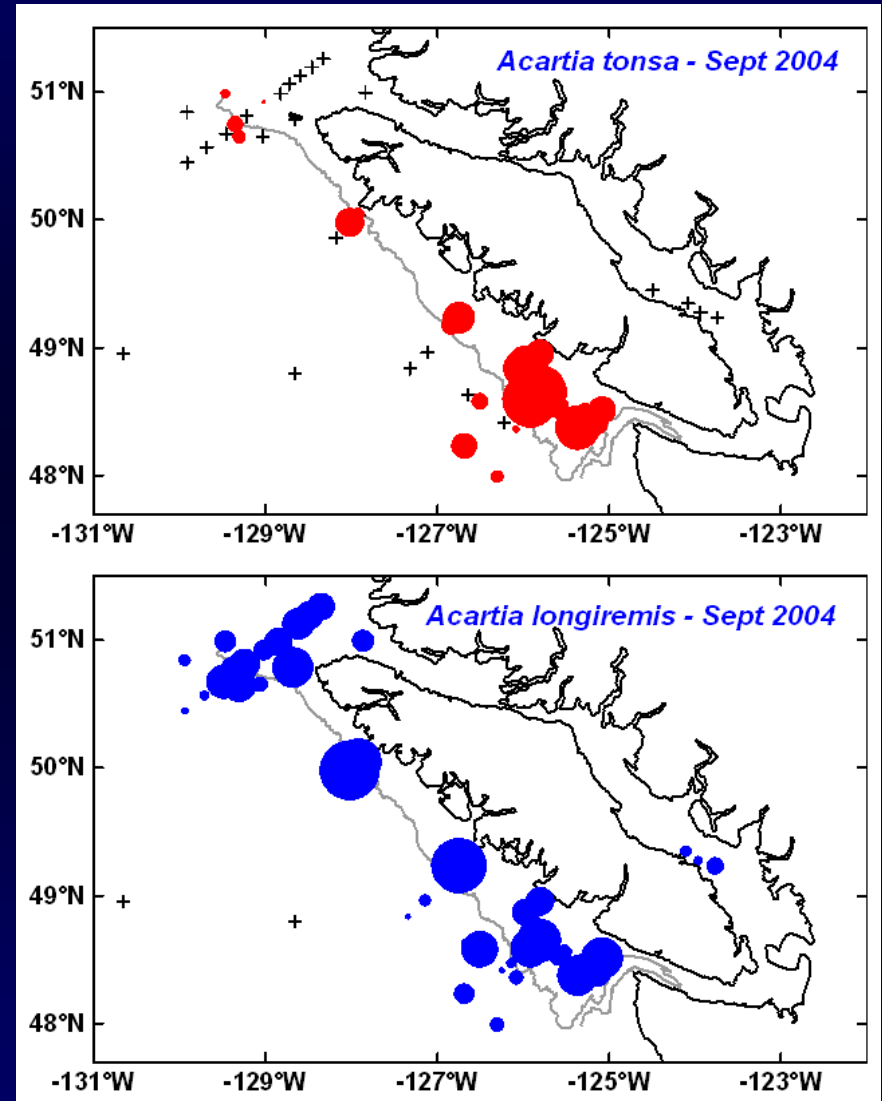
Detailed spatial distributions: May 2004

- *A. tonsa*:
Present south to mid Vancouver Island.
Absent NVI and Strait of Georgia.
- *A. longiremis*:
More abundant than *A. tonsa*,
More widely & evenly distributed, both alongshore and cross-shore.



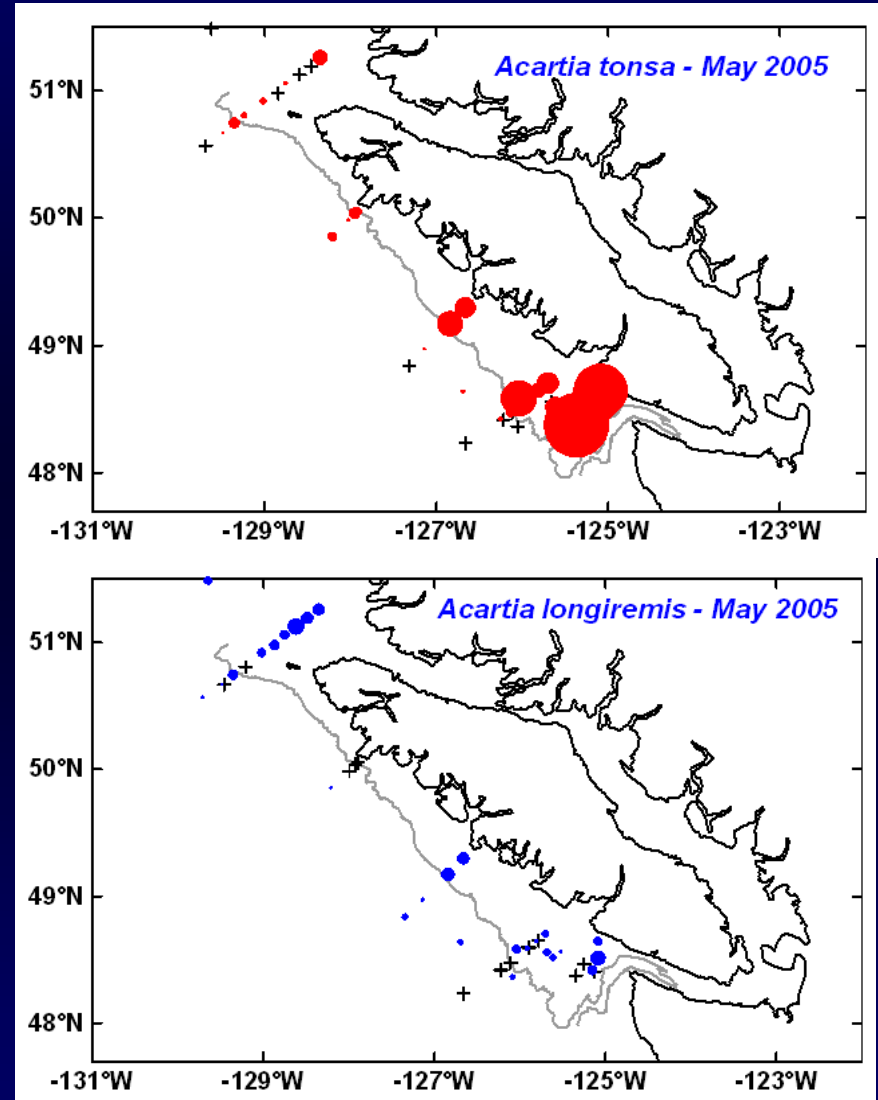
Detailed spatial distributions: Sept 2004

- *A. tonsa*:
Big increase from May
Present both SVI & NVI,
Highest SVI outer shelf.
Absent in Strait of Georgia
- *A. longiremis*:
More evenly distributed,
both alongshore and
cross-shore.
SVI ~ same as May
NVI > May
(Less growth where *A. tonsa* is most abundant??)



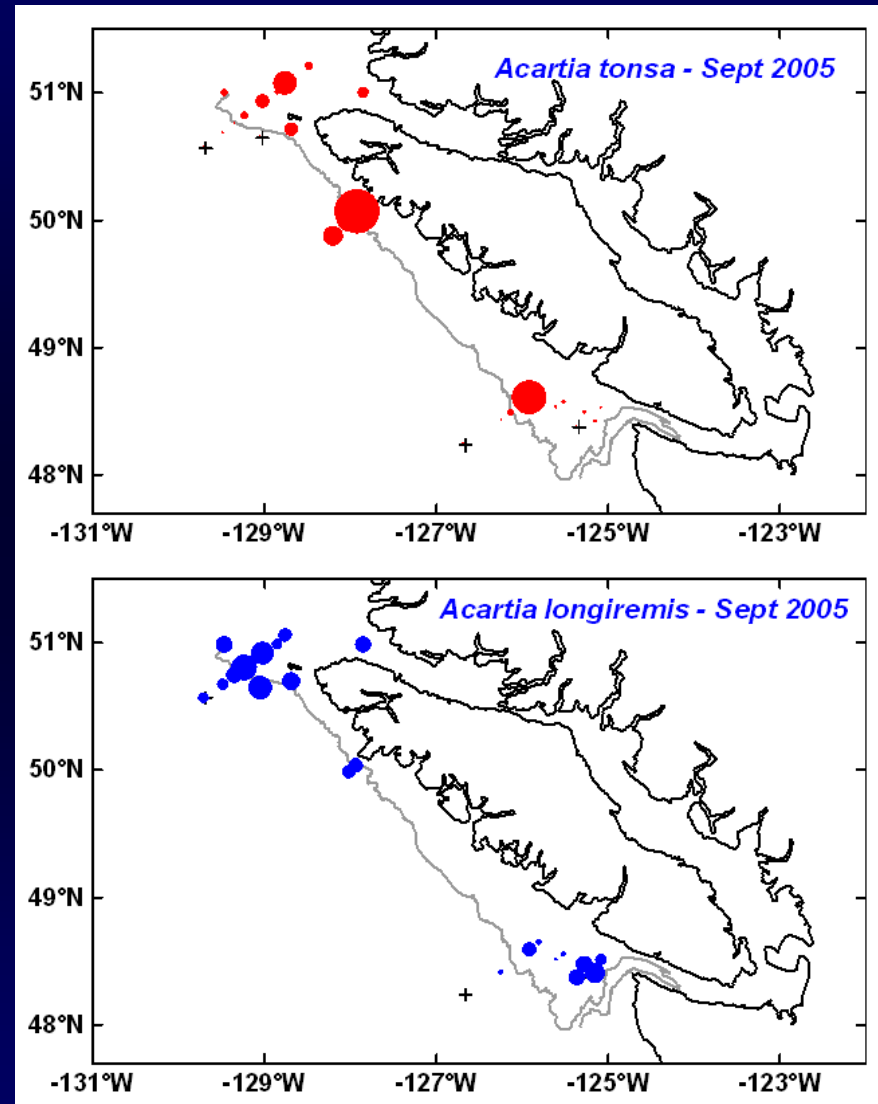
Detailed spatial distributions: May 2005

- *A. tonsa* distribution & biomass similar to September 2004
- *A. longiremis* evenly distributed, but everywhere much lower than in 2004



Detailed spatial distributions: Sept 2005

- *A. tonsa* increased off northern Vancouver Island, declined off SVI
- *A. longiremis* remains lower than in 2004, and low where *tonsa* highest



Interpretations:

Q1: Has *Acartia tonsa* recently and successfully colonized the BC continental shelf?

A1: Definite YES.

1979-1991: Undetected

1992-1993: Present at a few sites at trace levels

1994-2002: Undetected

2003: First broad occurrence at multiple stations

2004: 100-fold exponential increase in all outer coast regions

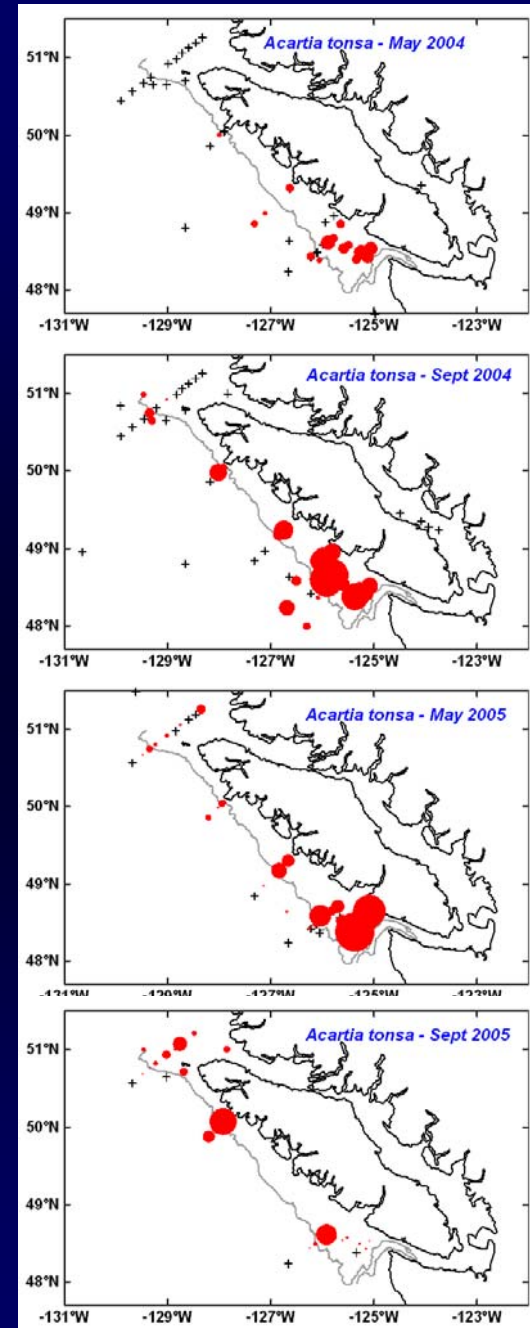
2005: Maintains high abundance in south, expands northward, and appears in Strait of Georgia

Interpretations:

Q2: How did *A. tonsa* get here and where did it come from?

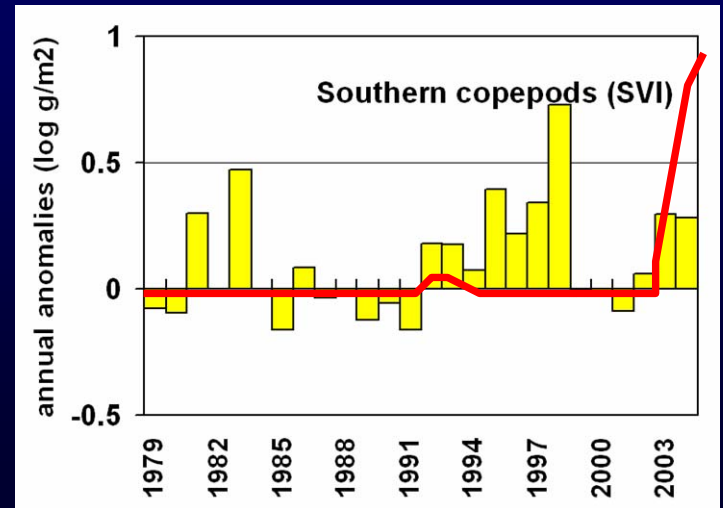
A2:

- Spatial pattern suggests south to north advection/dispersion along the BC shelf.
- Probable source = California (need to confirm by genetics)
- Did not originate & spread from inner coast ports (Vancouver or Seattle).
- Probably not a point source introduction via ballast water, (but perhaps broadly introduced offshore where ships' tanks are flushed?)



Interpretations:

Q3: Why different years (and later) than the northward range extensions by other 'southern' origin zooplankton taxa (*Paracalanus*, *Clausocalanus*, *Ctenocalanus*, *Acartia danae*)???



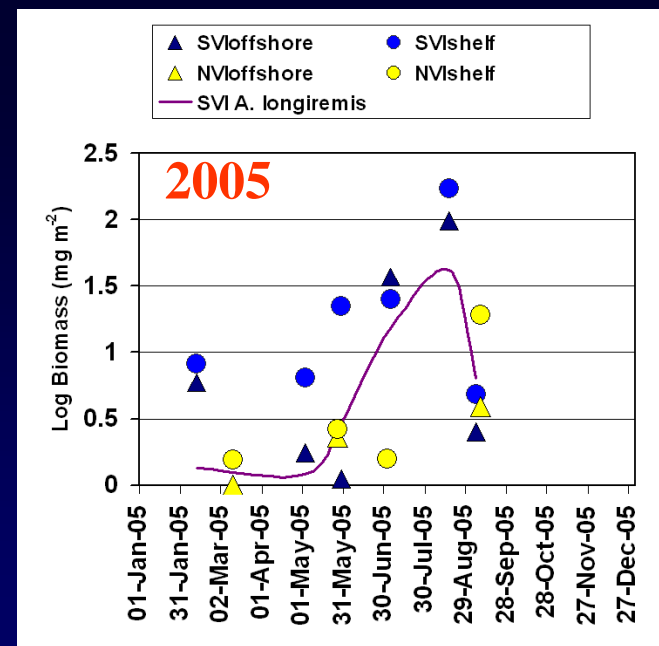
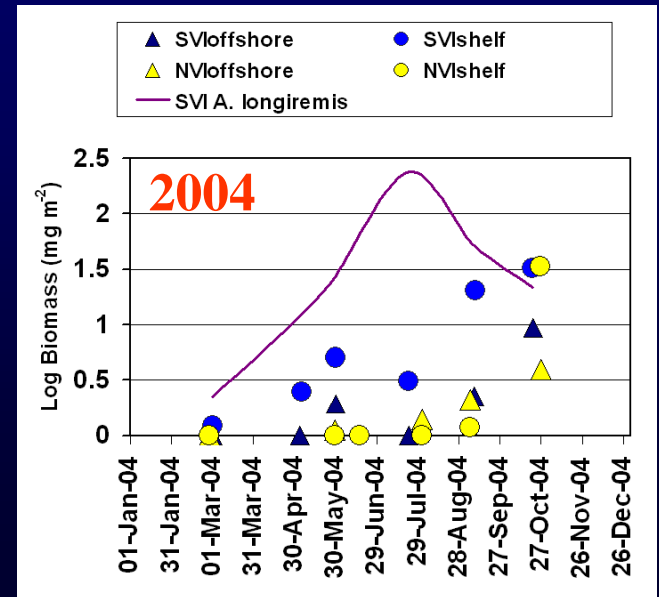
A3: A PUZZLE. One possibility: Circulation patterns since 2003-2005 may have favored on-shelf retention, or survival of demersal eggs. For example, *Centropages* (another copepod with demersal resting eggs, but preferring cool water) has also done well 2003-05

Interpretations:

Q4: Is *A. tonsa* out-competing 'native' zooplankton species?

A4: MAYBE.

- *A. tonsa* has expanded both spatial and seasonal ranges
- Now leveling off at biomass similar to the native *A. longiremis*.
- Despite broad overlap in both distribution and timing, *A. longiremis* shows some evidence for decline at places and times when *A. tonsa* is most abundant.
- Sept 2005 declines off SVI affected many zooplankton taxa, not just the *Acartia* spp.



Interpretations:

Q5: What made *Acartia tonsa* a successful colonizer?

A5 (BIOLOGY):

- **Tolerance of warm and stratified summer water column during the growing season.**
- **Over-wintering as dormant eggs on/in sediments**

+

A5 (CLIMATE):

- **Warm summers in 2004 and 2005 (Is the post 98 cool regime over ALREADY??)**
- **Circulation patterns that favor retention on the shelf???**
- **Epibenthic hypoxia reduces mortality of benthic eggs???**

Interpretations:

Q6: What will happen next??

A6: UNKNOWN. Possibilities include:

- Gradual replacement of *Acartia longiremis* or other resident species??
- Expansion shoreward into the Strait of Georgia and Puget Sound??
- Southward (or shoreward) range contraction if/when the BC outer continental shelf becomes cooler??

D. LaCross

THE END

IOS Plankton Productivity



Or maybe not?