Temporal and spatial analysis of chlorophyll-*a* measurements within the Strait of Georgia, BC

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Background

- Phytoplankton plays an important role in the marine food web
- Cushing's (1990) match-mismatch hypothesis

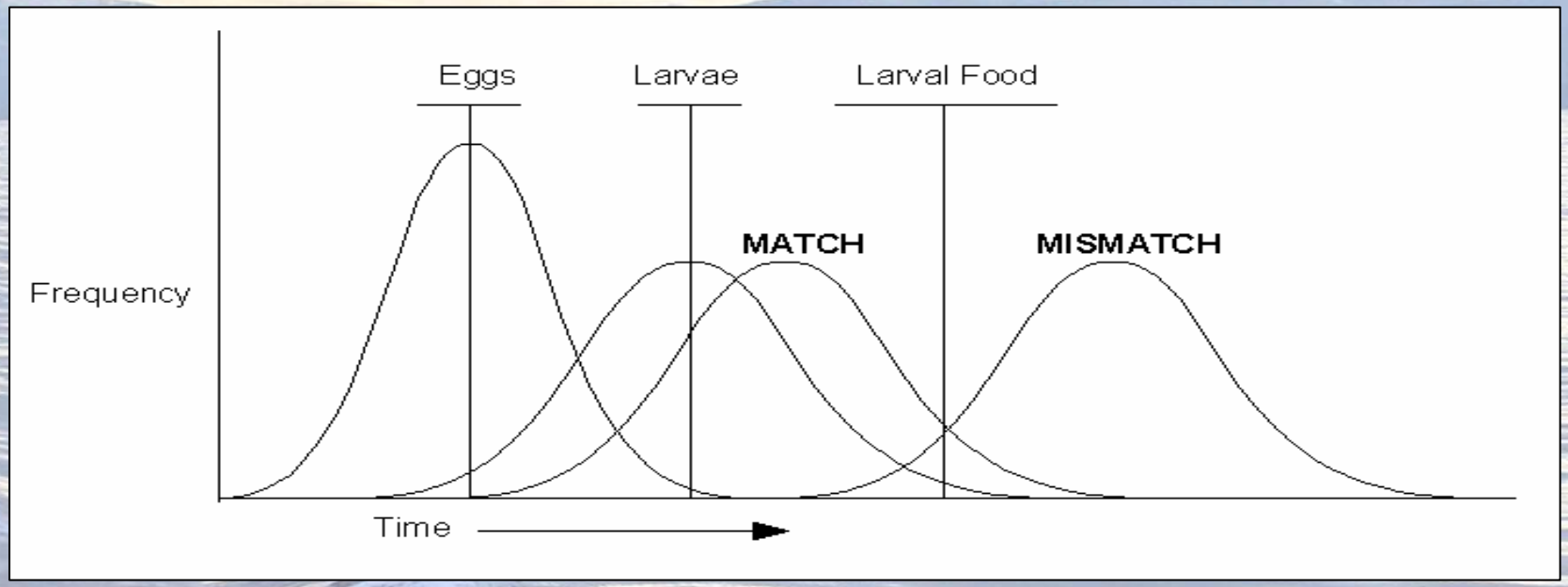


Image Source: Cushing (1990)

Background

- Examples of Cushing's (1990) hypothesis:
  - Strait of Georgia, 2005, salmon (DFO, 2007)
- Satellite imagery provides information regarding the timing and extent of the spring bloom
- In the Strait, need ground data for validation of chlorophyll *a* (chl-a)
  - Proxy for phytoplankton

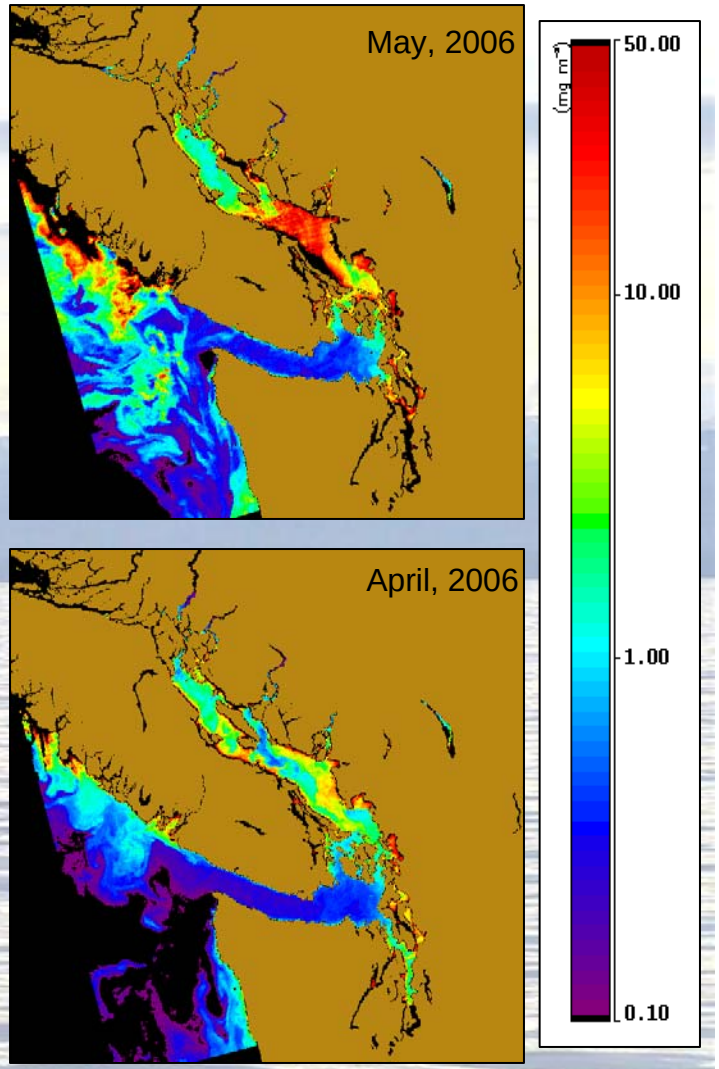
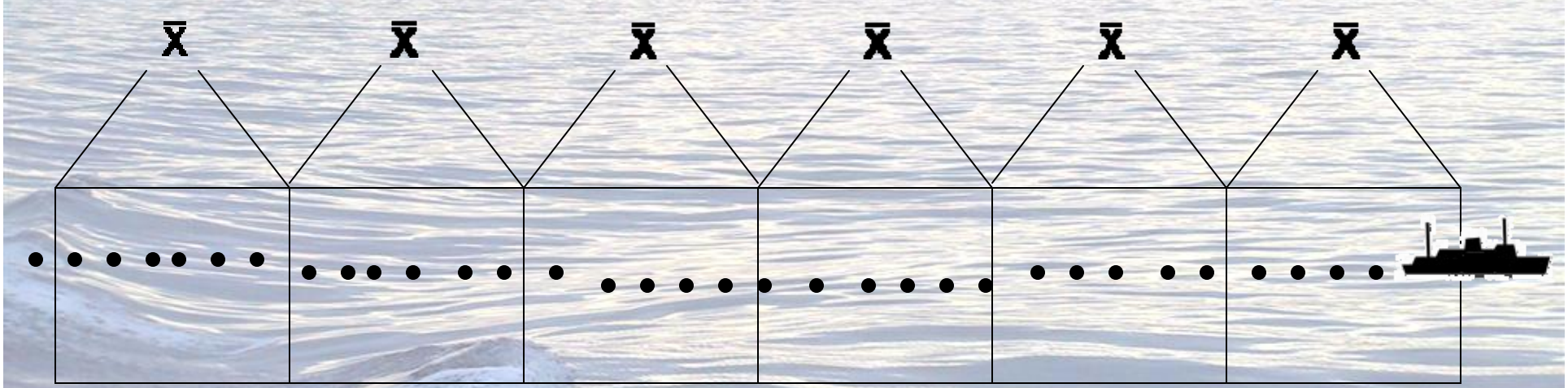


Image Source: Komick & Costa, (submitted)

Background

- Previously, punctual ship or buoy data used for validation
- Emergence of Ships-of-Opportunity (SOOP) with flow-through fluorometer
  - high spatial and temporal resolution data
- Most studies use the mean of points within the pixel to validate the satellite image

➢No variance check!!!

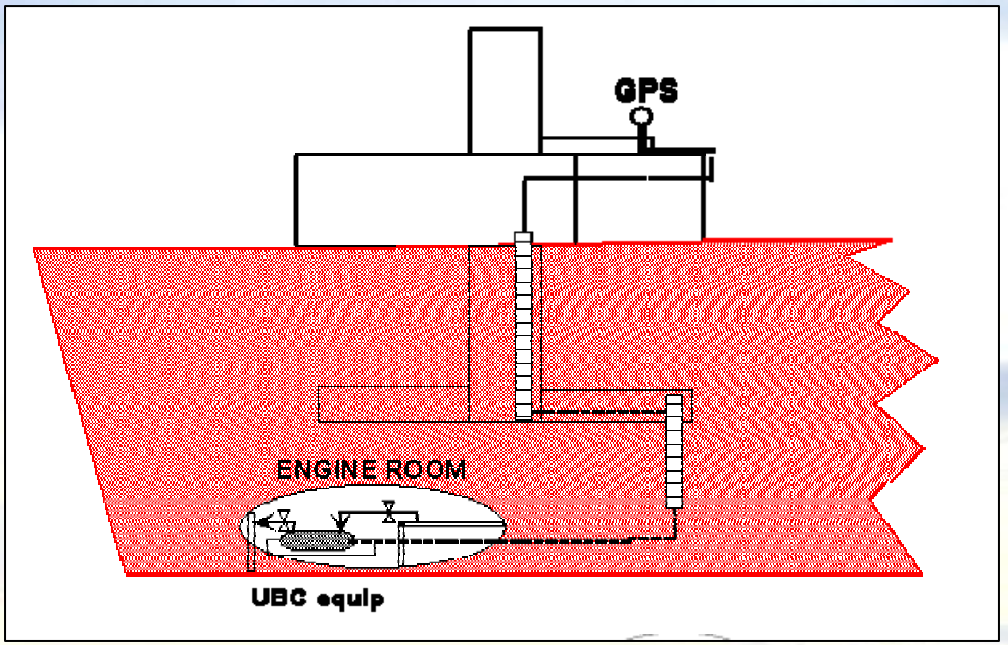


Objective

- To investigate the spatial and temporal variability of chl-*a* means measured by a flow-through fluorometer installed on a ship-of-opportunity (SOOP)
  - We used data acquired in the Strait of Georgia, which represents a very dynamic environment, with regard to variability of chl-a in both space and time.
  - We hope that our results will be illustrative of other coastal waters and as such, provide guidelines for using SOOP data to validate chl-a estimates from ocean colour satellites.

Methods

- STRATOGEM Data
- BC Ferry
  - Duke Pt - Tsawwassen
  - 8 runs/day
  - 30 sec. intervals
  - 200-300/run



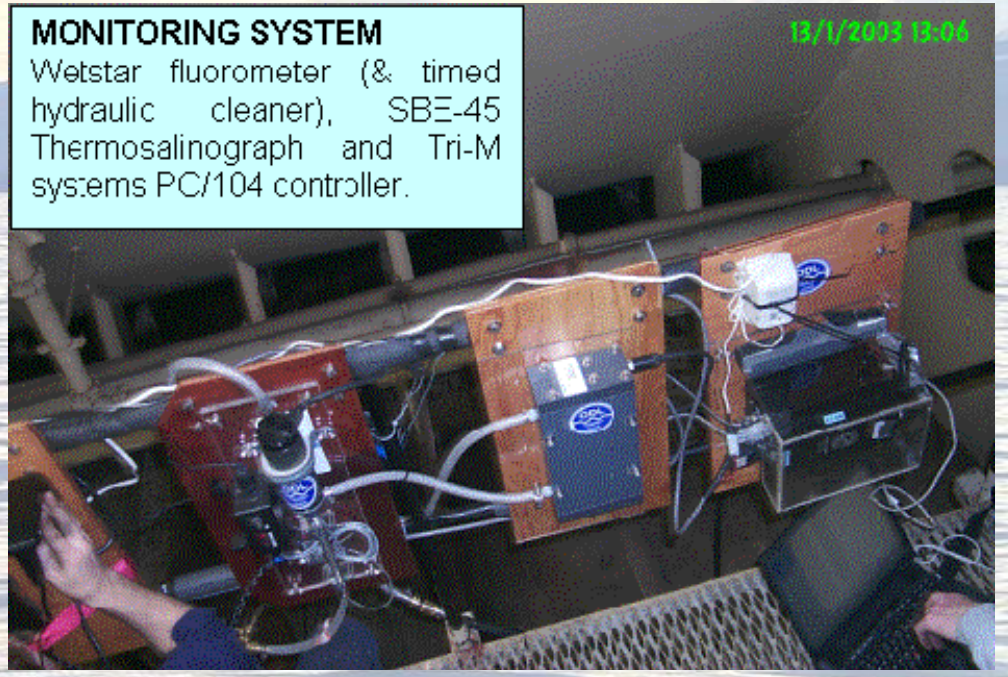


Image Source: STRATOGEM

Study Area

- 10 stations, 1100 m hypothetical pixel
- 12:45-3:15 pm (PST)
- For each station:
  - Mean
  - Variability characterized using CV
- Winter/fall
- Spring/summer

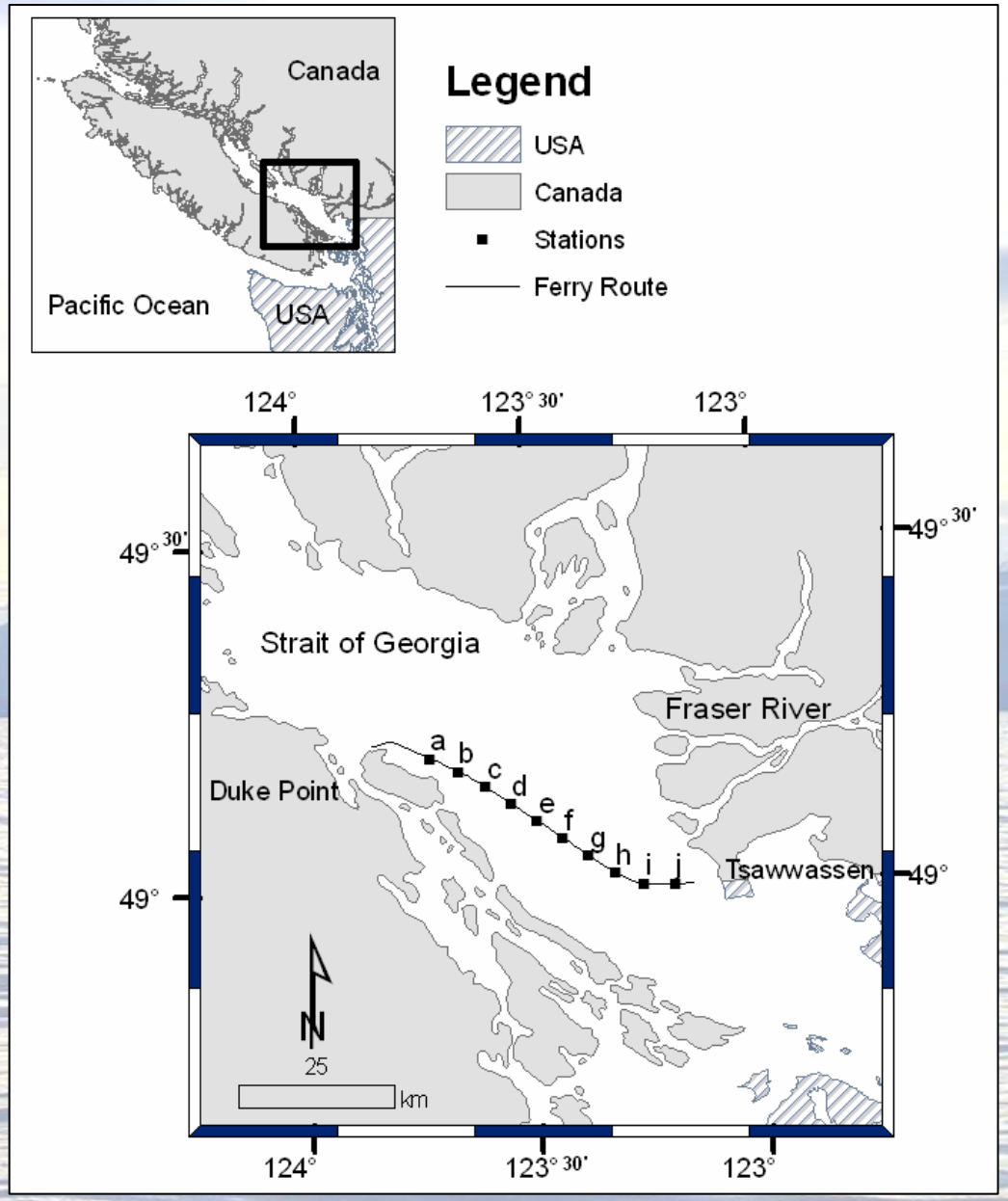
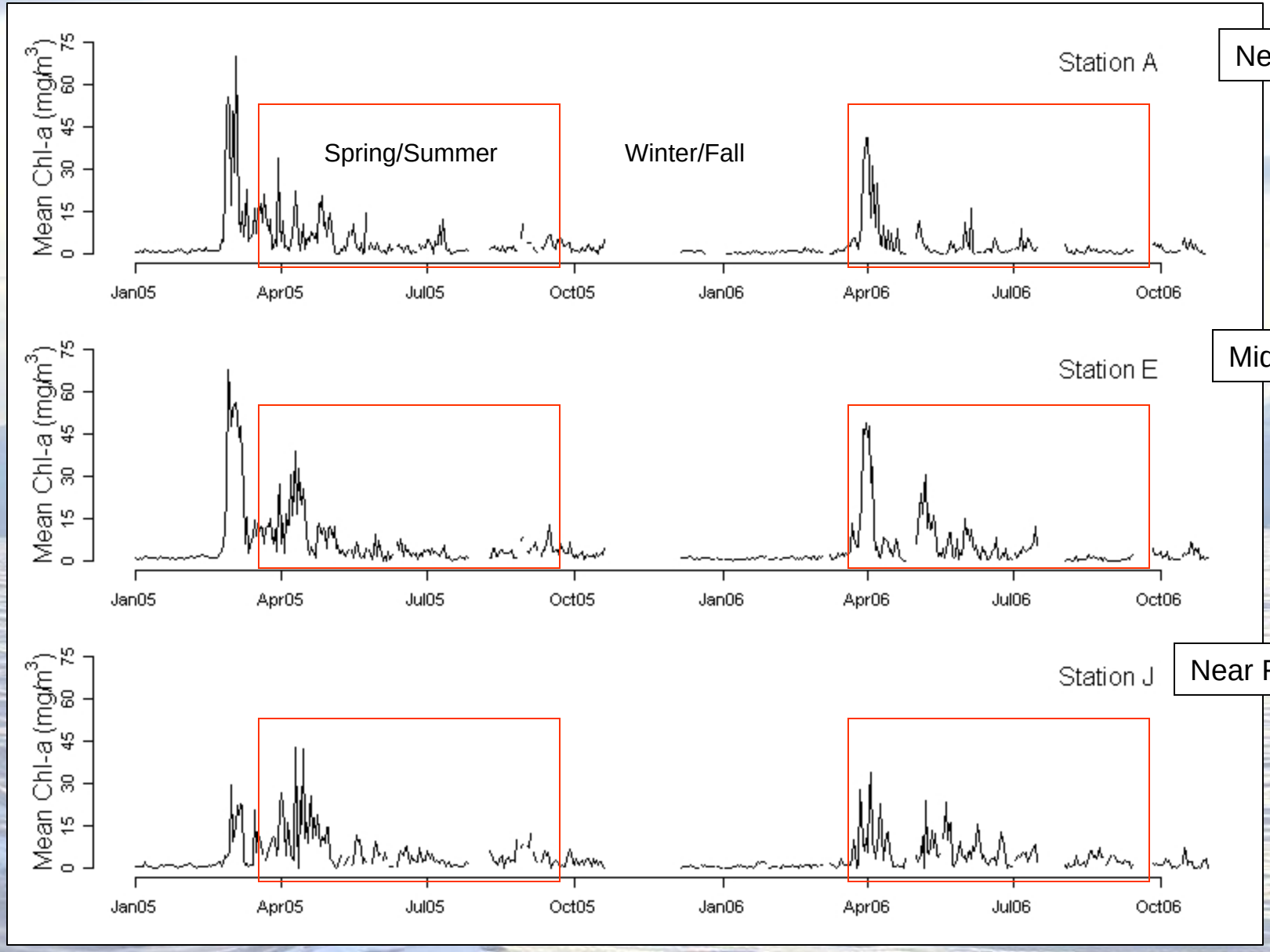


Image Source: Modified from Komick & Costa, (submitted)

Methodology

- Define the variability of the mean
  - Spatially
  - Temporally
- Variability analysis:
  - Mean and CV distribution – Illustrates the variability of the mean within a station~ hypothetical pixel
  - Mann Whitney U test – Defines the significant differences between station CV distributions (seasonally and spatially)
  - Define threshold of background variability in CV

Results - Means

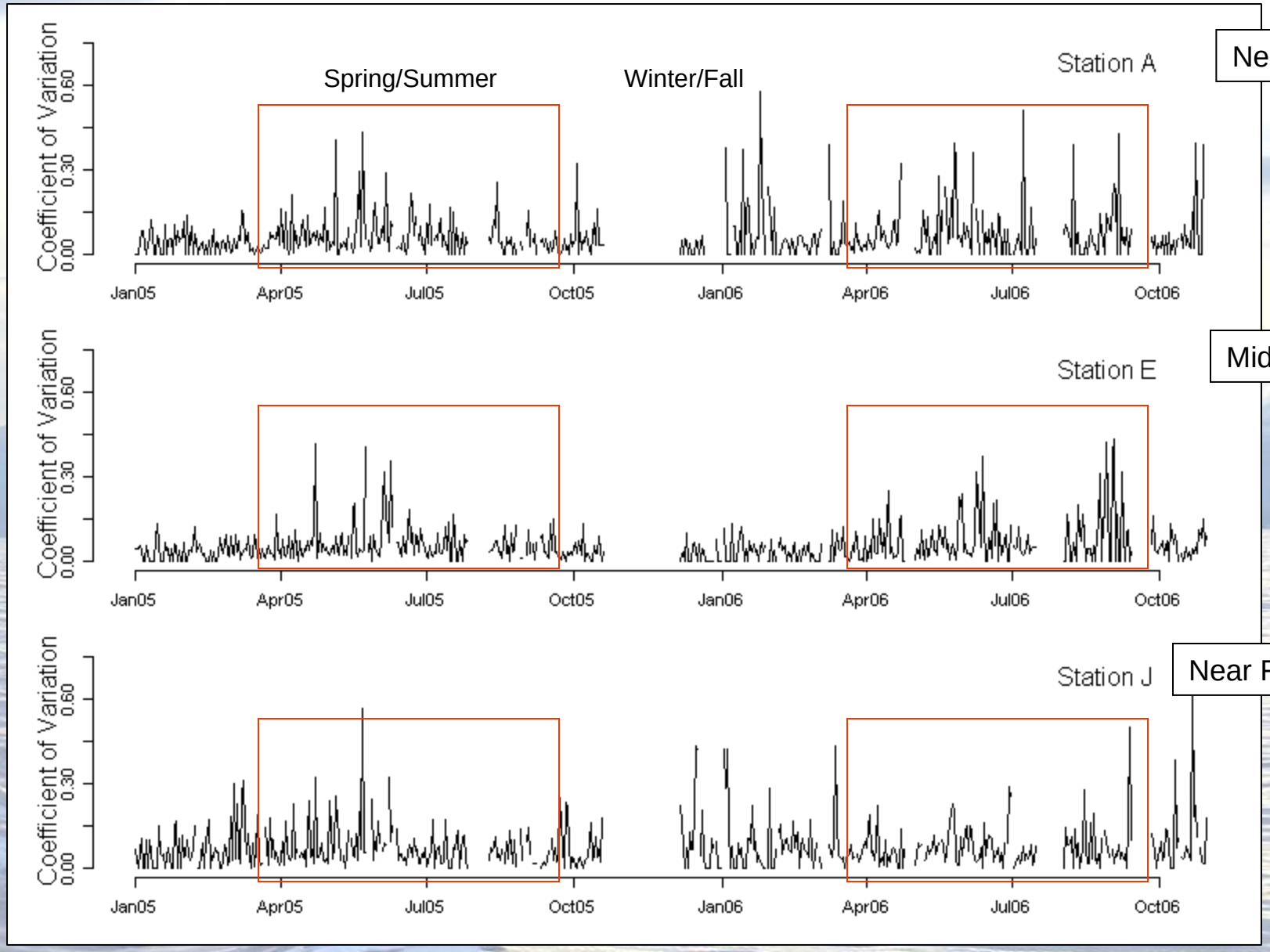


Near Nanaimo

Middle of Strait

Near Fraser River

Results - CVs



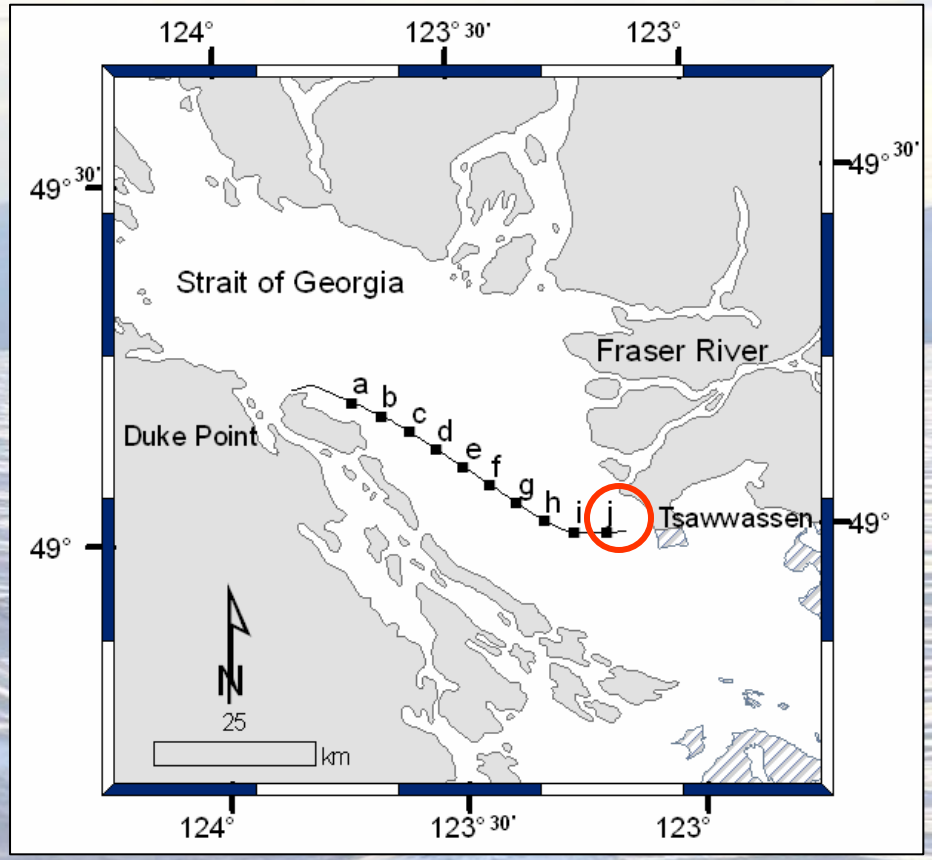
Near Nanaimo

Middle of Strait

Near Fraser River

Results - Seasonal

- Mann Whitney U test
  - Cross seasonal differences in CV distributions



Station	*p*-value
A	0.00
B	0.00
C	0.01
D	0.00
E	0.00
F	0.00
G	0.00
H	0.00
I	0.00
J	0.45

Results - Spatial

Significant differences in the distributions of CV's between stations

Stations E, G & H

- Heterogeneous waters

Stations C, E, H & J

- Heterogeneous waters

Spring / Summer

	A	B	C	D	E	F	G	H	I	J
A										
B	0.04									
C	0.53	0.14								
D	0.99	0.05	0.54							
E	0.88	0.03	0.44	0.90						
F	0.12	0.73	0.29	0.10	0.07					
G	0.01	0.47	0.02	0.01	0.00	0.22				
H	0.00	0.25	0.01	0.00	0.00	0.11	0.68			
I	0.08	0.61	0.26	0.07	0.04	0.93	0.23	0.09		
J	0.08	0.71	0.24	0.07	0.04	0.89	0.28	0.12	0.95	

Winter / Fall

	A	B	C	D	E	F	G	H	I	J
A										
B	0.42									
C	0.14	0.02								
D	0.22	0.77	0.00							
E	0.06	0.34	0.00	0.47						
F	0.82	0.50	0.08	0.30	0.08					
G	0.55	0.13	0.39	0.06	0.01	0.41				
H	0.07	0.01	0.60	0.00	0.00	0.03	0.19			
I	0.68	0.20	0.33	0.08	0.02	0.46	0.98	0.17		
J	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.00	

Results

Spring/Summer

- G & H
- Heterogeneous due to high CV

Winter/Fall

- H & J
- Heterogeneous due to high CV, whereas E is due to low CV

Percentage results with CV > 0.11, defined to be non-background variability.

Station	Summer/Spring (%)	Winter/Fall (%)
A	19.2	11.0
B	19.5	10.3
C	17.4	10.5
D	18.6	4.6
E	18.2	4.6
F	22.9	8.8
G	24.6	10.1
H	24.9	13.0
I	17.6	12.3
J	19.4	21.5
Mean	20.23	10.7

Summary

- Mean varies seasonally, spatially and annually
- CV variability is the highest:
    - Spring/summer
        - Middle of the Strait where means are highest
        - Possible front of freshwater plume
        - Biological fronts (Parsons *et al.*, 1981)
    - Winter/fall
        - Closest to the Fraser plume where means are lowest, but not in the summer
        - Further Investigation

Implications

- Main point - Caution is required when using SOOP mean data for validating satellite imagery.
  - At certain times the mean may be representative, however, the variance should be assessed

Image Source: Google Images

Future Research

- Compare chl-a estimates from MODIS-Aqua satellite images to ferry data within the station locations

- Is the mean representative?
  - Would minimum or maximum chl-a values be more representative for different times?

Acknowledgements

- STRATOGEM Project
- NSERC USRA
- SPAR Lab
- Spectral Lab

References

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