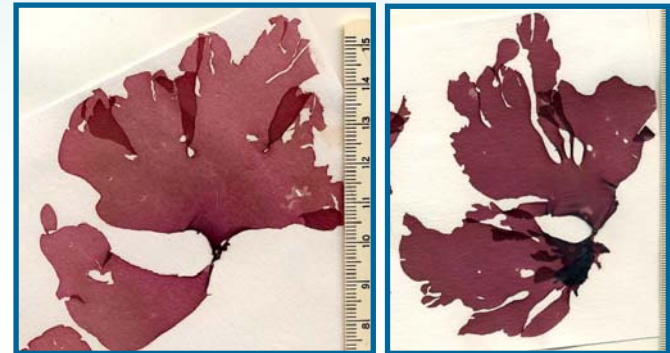


Macroalgal  
Systematics &  
Biodiversity in the  
Age of DNA  
Barcoding: a  
Biological  
Renaissance

By Gary W. Saunders  
CEMAR, UNB

# A Primer on Macroalgae

- Macroalgae are difficult to identify
  - Life histories can be complex with heteromorphic (cryptic) stages
  - Simple morphologies
  - Excessive levels of Phenotypic Plasticity
  - High levels of convergence
- DNA identification commonplace & necessary tool



# Our Place in CBLN

- Previous research in our lab has uncovered dozens of cryptic (overlooked) species in Australia
- Commonly assumed that the Canadian Flora was 'done'
- Decided to test this assumption as part of contributing to CBLN
- Completing an exhaustive floristic account of the Canadian macroalgae

MASSIVE



TASK



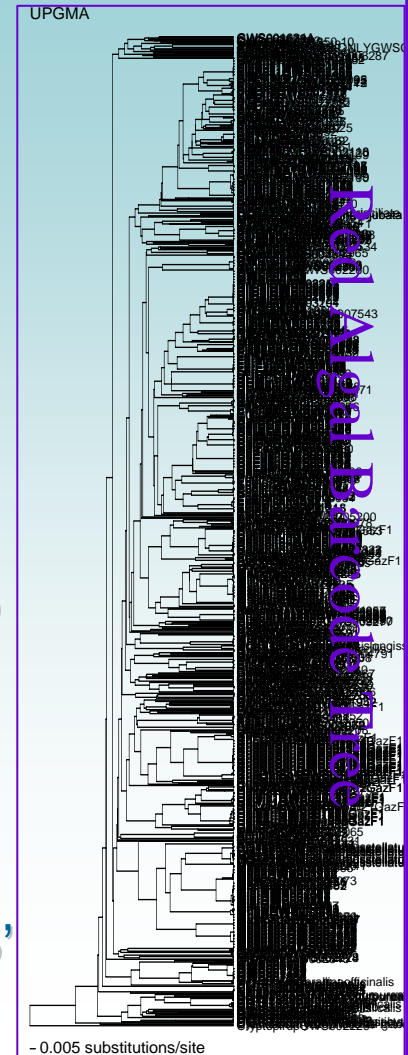
# Method to the Madness

- Collect twenty to thirty isolates for each species emphasizing:
  - varying morphologies
  - divergent habitats
  - geographical range
- Generate 5' *cox1* sequence & cluster plants together in folders in Herbarium based on genetic species group
- Go back & complete alpha taxonomy (new species or new record?)



# Big Picture Barcode Summary

- To date ca. 2300 macroalgal *cox1-5'* sequences generated spanning many of the families & orders of red & brown algae
- For most species 2-20 isolates studied
  - Observed intraspecific divergence = 0-3 bp (0-0.4%)
- Interspecific divergences generally >30 bp (4.5%), with the exception of a few closely related species pairs
  - displayed ca. 1% divergence
  - species diagnosis was unequivocal with *cox1-5'* or exciting evolutionary tales have surfaced



# Canadian Flora Summary - Red

- e.g., new species/records (36 total)
  - Ceramiaceae: *Ptilota* (2 novel entities), *Scagelia* (1)
  - Rhodomelaceae: *Odonthallia* (1), *Rhodomela* (1)
  - Schizymeniaceae: *Schizymenia* (1)
  - \*Dumontiaceae (currently 12): *Constantinea* (2), *Dilsea* (2), *Farlowia* (2), *Weeksia* (1), *Pikea* (4)
  - \*Kallymeniaceae (15): *Callophyllis* (2), *Euthora* (1), *Pugetia* (3)
  - \*Phylloporaceae (9): *Coccotylus* (1), *Mastocarpus* (6), *Petroglossum* (1), *Stenogramme* (2)
  - Solieriaceae: *Sarcodiotheca* (1)
  - Liagoraceae: *Nemalion* (1)
  - Corallinales: *Corallina* (1)
- Examples of 'new' records for BC = 6 total
  - *Colaconema proskaueri*, *Farlowia conferta*, *Isabbottia ovalifolia*, *Leptofauchea pacifica*, *Mazzaella flaccida* & *Mazzaella volans*
  - Northern extensions of species boundaries - global warming?  
simply overlooked?

Current  
ca. 500  
+ 8.5%

*Dilsea californica*: a single plastic species widely distributed along the coast of North America from sheltered to exposed habitats



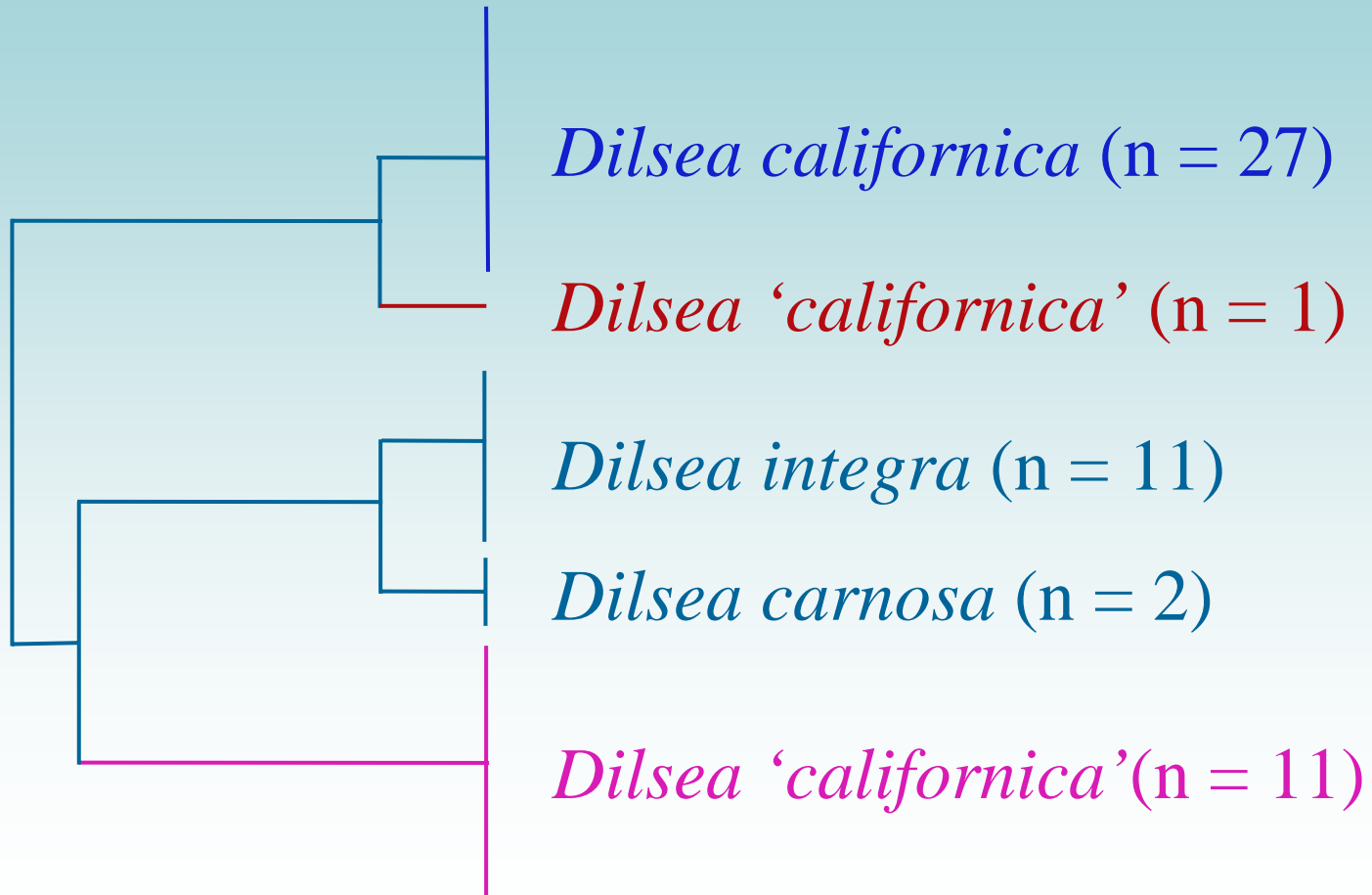
Exposed

Intermediate

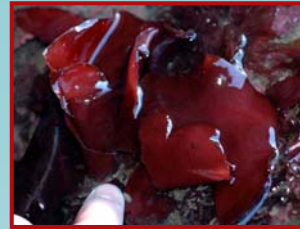
Sheltered



# *Dilsea* Barcode Results



# Ecological & Biogeographical Patterns



*Dilsea sp.*

*Dilsea sp.*



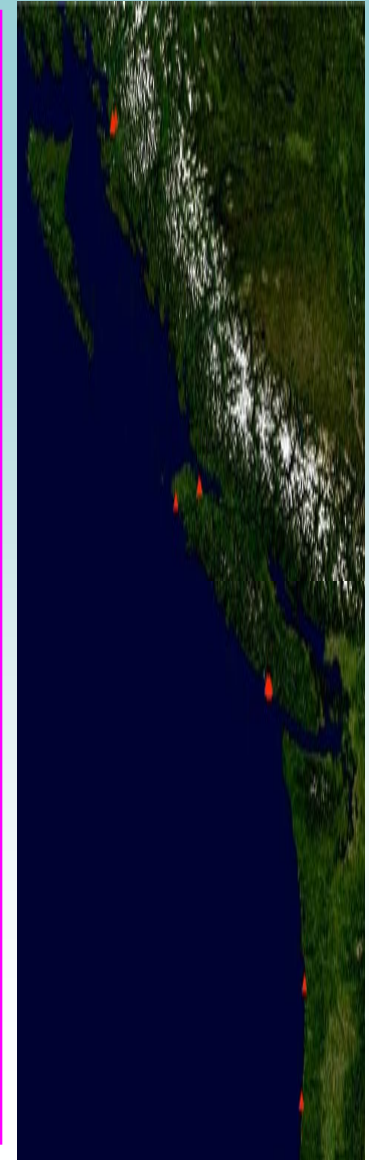
Exposed

Intermediate

Sheltered

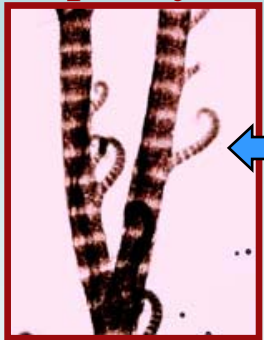


*Dilsea 'californica'*



# Biodiversity (morphological species concept), e.g. *Ceramium* spp.

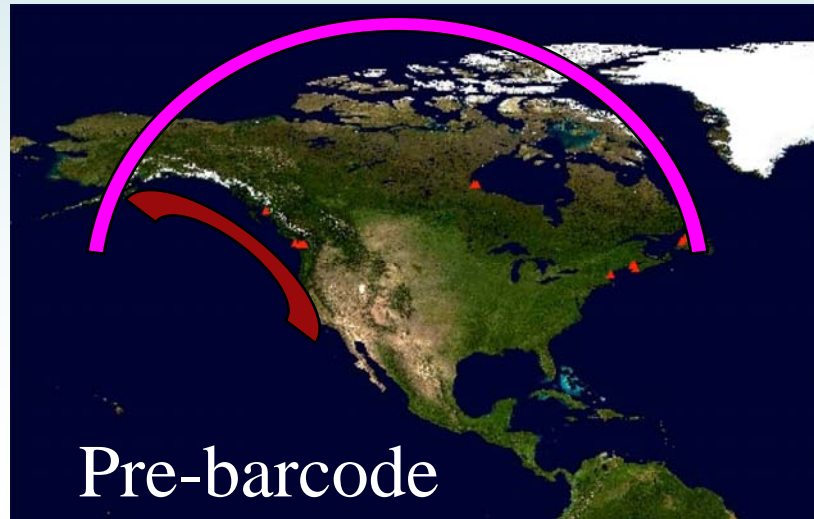
Pacific  
*C. pacificum*



*C. virgatum*



Atlantic cosmopolitan  
*C. virgatum*



HOWEVER...

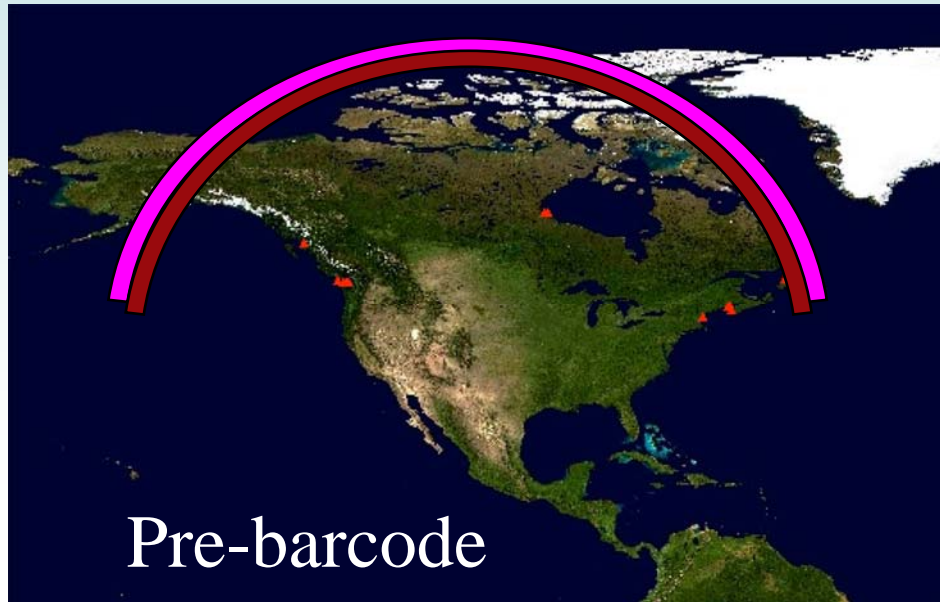


# Hypothesis: two cosmopolitan species with distinct morphologies

*C. pacificum*



*C. virgatum*



Pre-barcode

# *Ceramium* Barcode Results

Pacific  
*C. pacificum*



Atlantic  
*C. virgatum*



Separate species in the Atlantic versus the Pacific overlapping in the features traditionally used to distinguish between them...

# Phylogeography *Corallina* spp.



*C. vancouverensis*

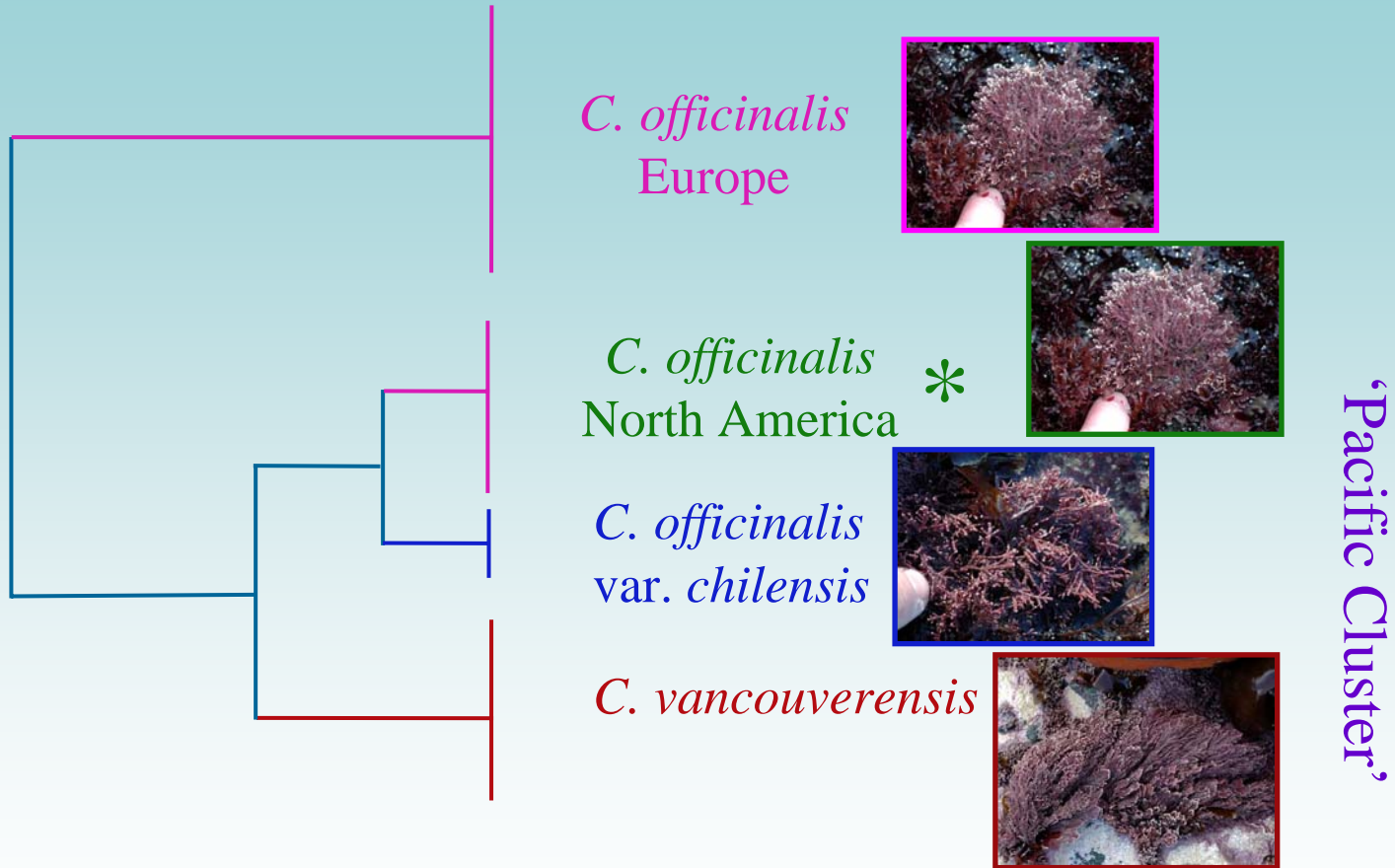


*C. officinalis*  
var. *chilensis*



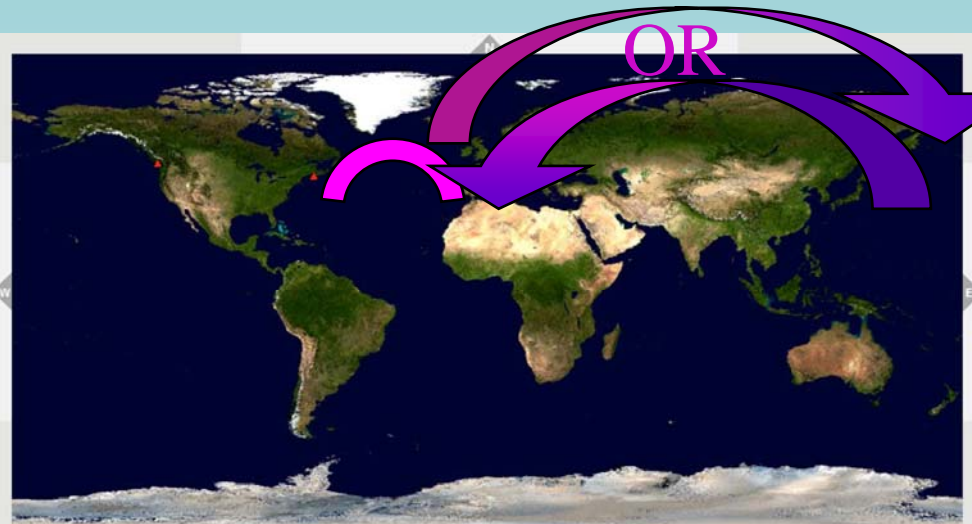
*C. officinalis*

# Corallina Barcode Results

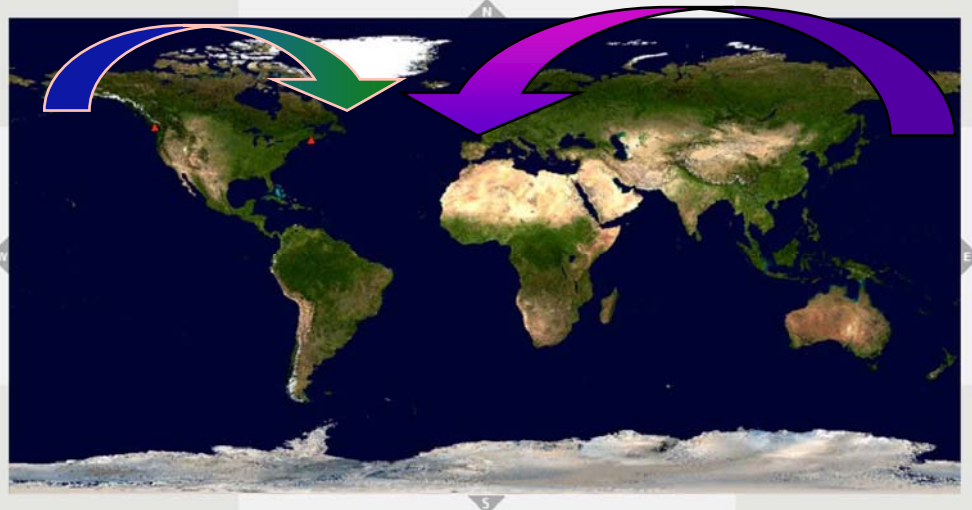


North American populations of *C. officinalis* represent a novel species closely related to Pacific species and not European *C. officinalis*.  
Perspectives on the phylogeography change with this new knowledge.

# Phylogeography of *Corallina* in the Northern Hemisphere



Before barcode: *Corallina* originated in Atlantic; reached Pacific & speciated; or speciated in Pacific with a population reaching the Atlantic across Europe & Asia.



After barcode: speciated in Pacific with two separate migrations and speciations into the Atlantic, **one** very recent.

## ■ Conclusions:

- Current biodiversity estimates for algal genera are inaccurate for most regions
  - This impacts on our ability to:
    - infer accurate phylogenies
    - infer past events (phylogeography; biogeography)
    - to assess algal species for their industrial and economic potential
    - to recognize & identify invasive & nuisance species
- DNA barcoding holds great promise for resolving cryptic species & for establishing distributional limits:
  - We are completely changing our current views on biodiversity & biogeography in the Canadian Flora
  - Anticipate that similar results will be uncovered for macroalgal floras everywhere
  - It is a great time to be an algal systematist!

# Acknowledgments

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