Australian National Algae Culture Collection: Biodiversity, pigments and bioproducts

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Australian National Algae Culture Collection ANACC

•CSIRO National Biological Collections: Algae – a living collection

•1000 strains of more than 300 microalgae species

•unique Australian biodiversity, sourced from the tropics to Antarctica, marine and freshwater microalgal classes

•isolation of new strains from Australia's biodiversity

Formerly CSIRO Collection of Living Microalgae
http://www.cmar.csiro.au/microalgae

•strain characterisation: taxonomic identification, chemical & molecular, growth parameters

Algal Culture Facility

•Controlled environment rooms and cabinets: secure AQIS QC5.2

ANACC
Australian Quarantine
Inspection Service
AQIS QC5.2 Facility

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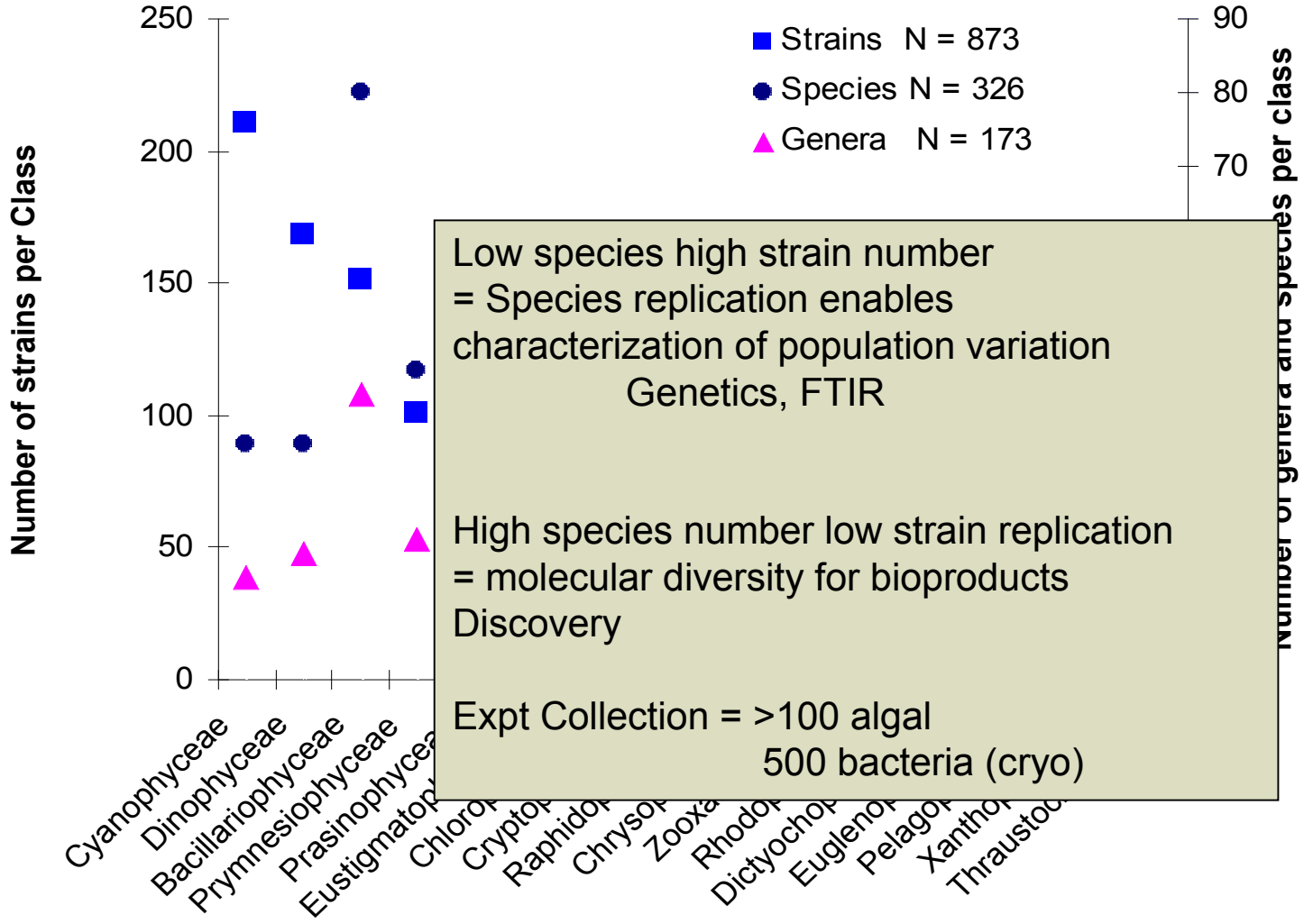
CSIRO

Algal Culture Facility – AQIS QC5.2

Number of Extant Genera, Species & Strains in CCLM Grouped by Class

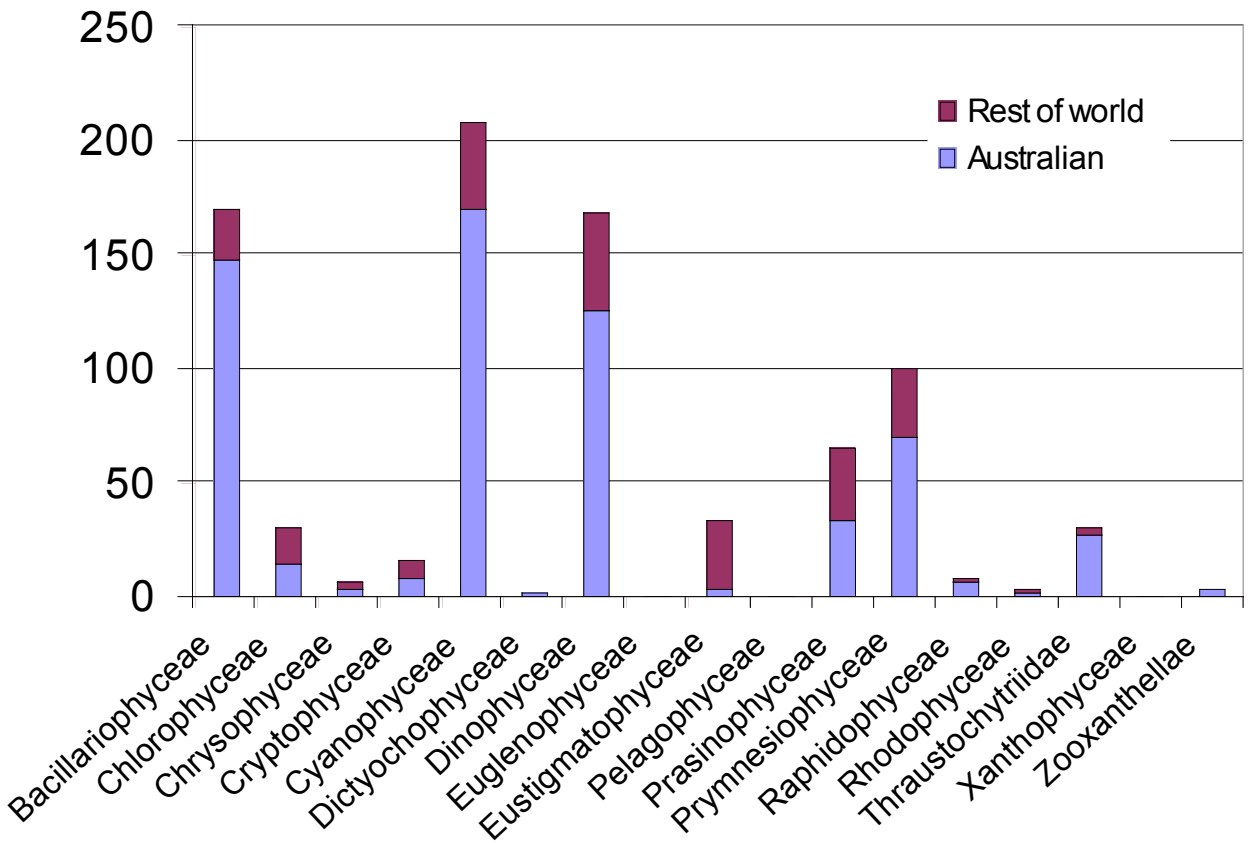


Low species high strain number
= Species replication enables characterization of population variation
Genetics, FTIR

High species number low strain replication
= molecular diversity for bioproducts Discovery

Expt Collection = >100 algal
500 bacteria (cryo)

Number of Strains in ANACC



Australian National Algae Culture Collection

CSIRO Microalgae Supply Service

We supply high quality microalgae starter cultures and complementary technical advice to the aquaculture industry as well as for research, education and other industrial applications throughout Australia and internationally.

All cultures are grown under controlled environment conditions. Selected strains are axenic (bacteria-free).

Orders are dispatched via courier to ensure arrival in the best possible condition.

www.csiro.au

For more information, strain list, or to place orders, contact:

Ms Cathy Johnston, Manager, Microalgae Supply Service
GPO Box 1538, Hobart, Tasmania 7001, Australia
Phone 61 (0)3 6232 5316 Fax 61 (0)3 6232 5471
e-mail: cathy.johnston@csiro.au
http://www.cmar.csiro.au/microalgae/

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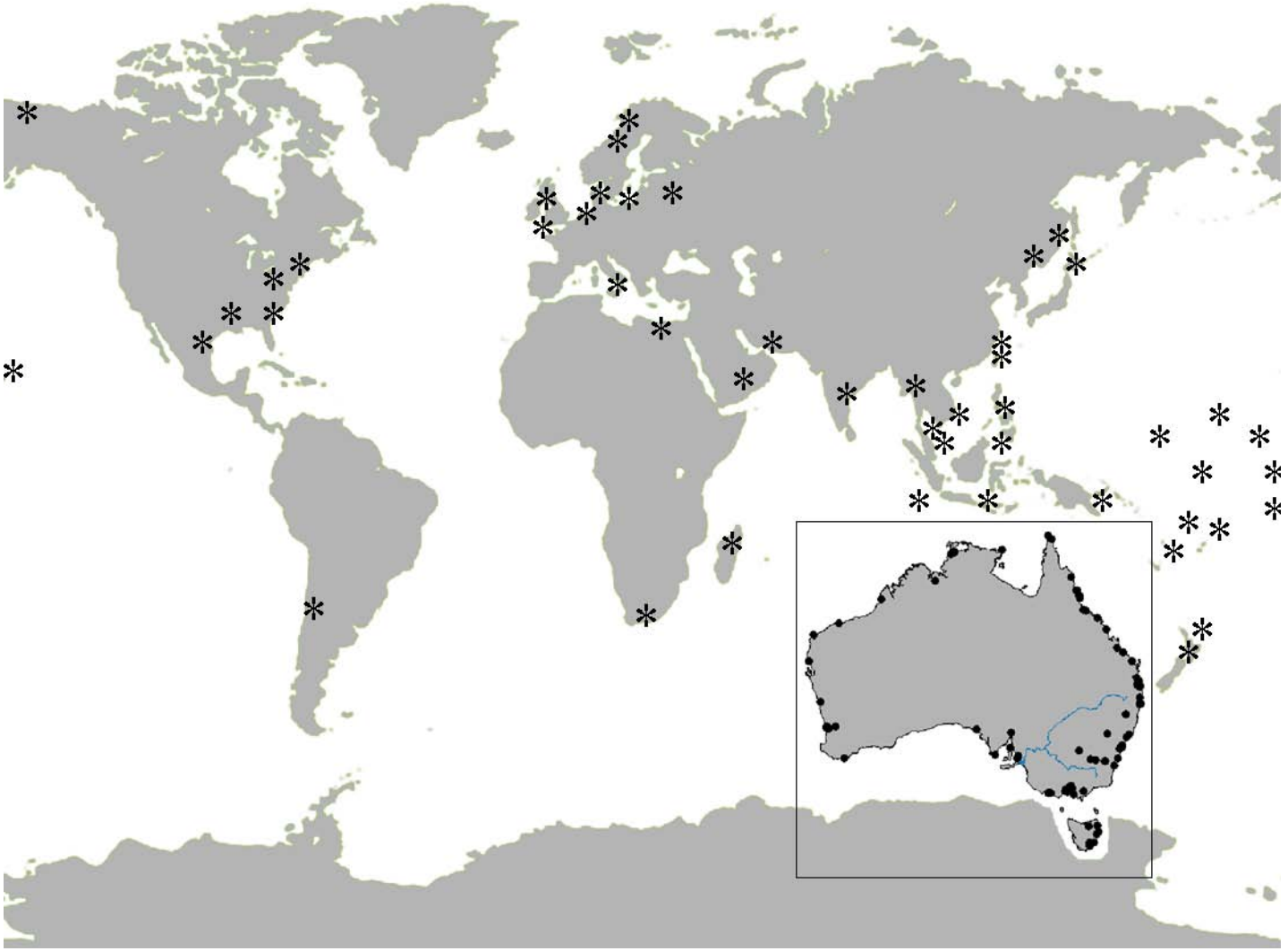
Microalgae Supply Service: locations supplied



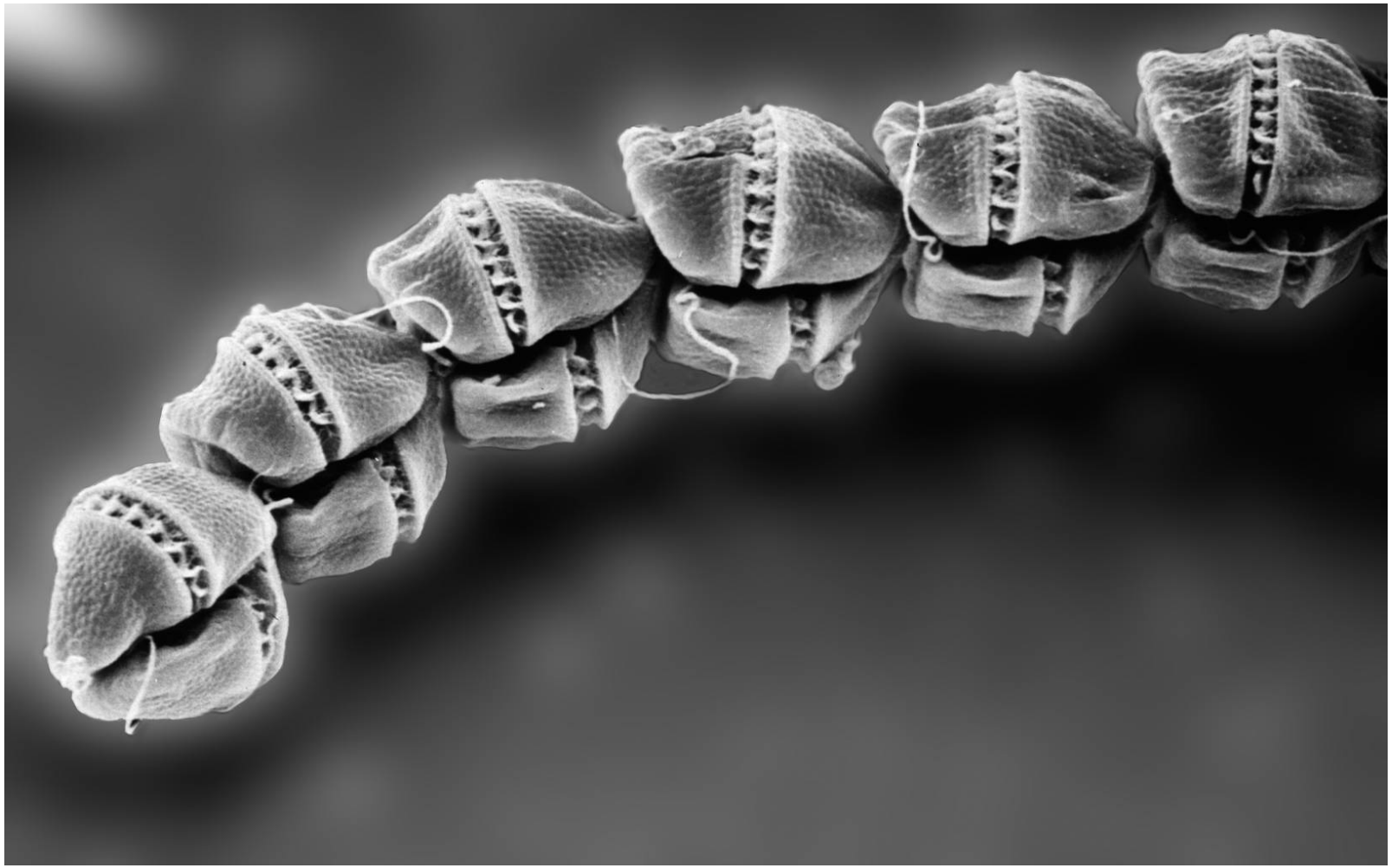
Pigments

1960s: **Dr Shirley Jeffrey**, biological mapping of Australia's oceans, development of pigment signatures

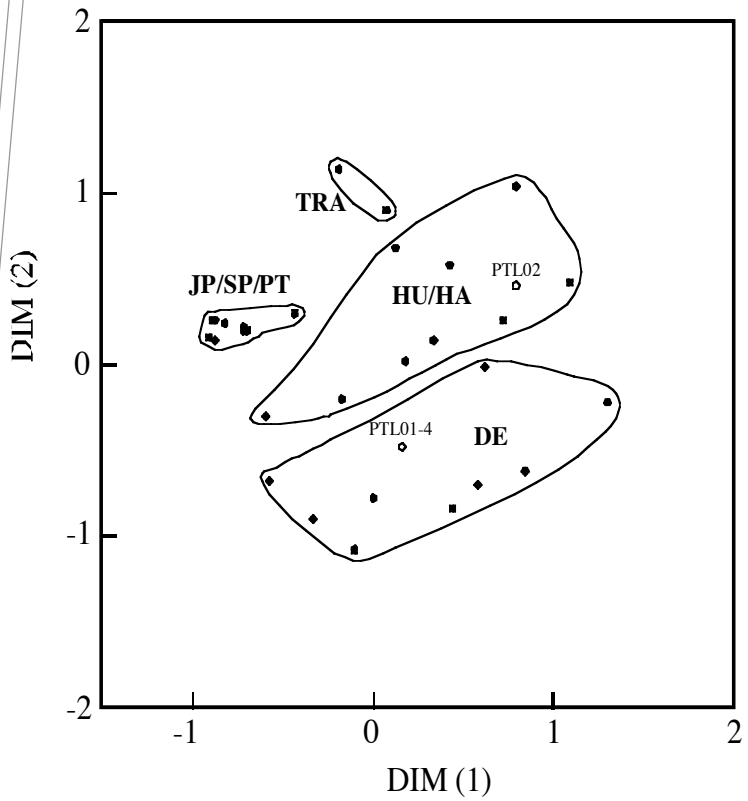
1990s: SCOR / UNESCO

- cultures for pigment standards
- chemotaxonomy
- composition of phytoplankton

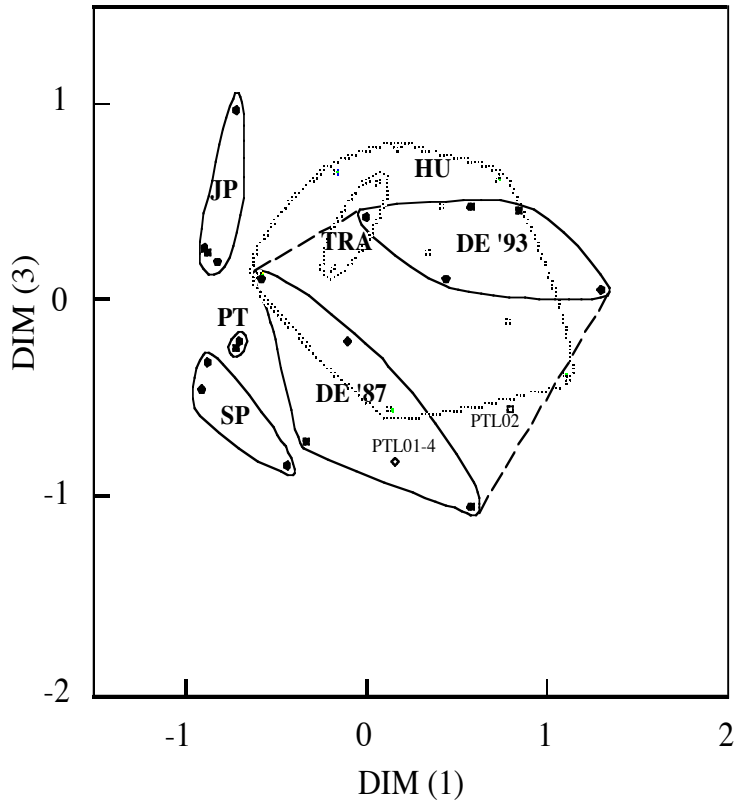
Diversity of Australian and global populations: *Gymnodinium catenatum* (Dinophyceae)



Diversity of Australian and global populations: *Gymnodinium catenatum* (Dinophyceae)



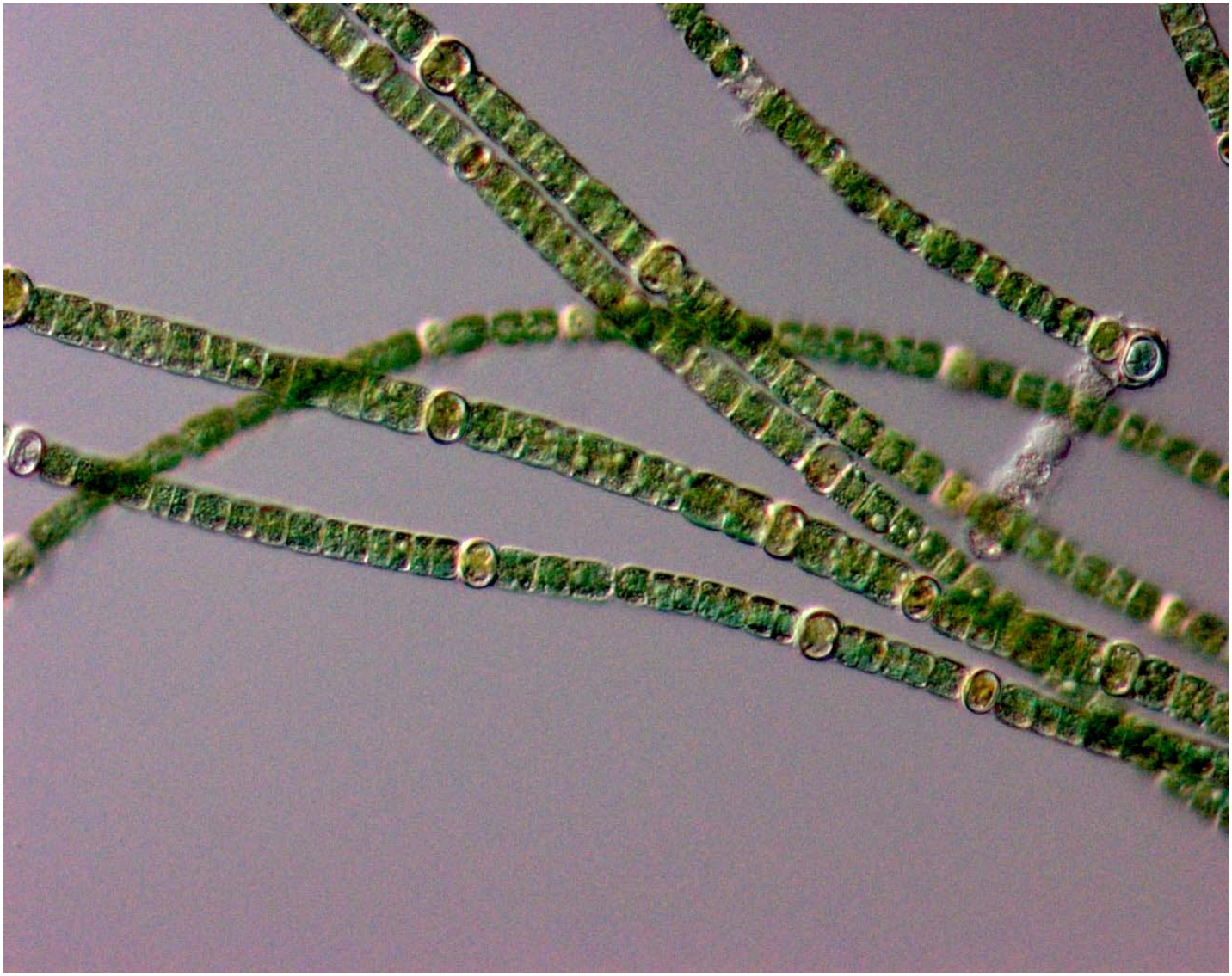
Plot of first and second dimension of the three-dimensional MDS analysis of *G. catenatum* strains.
Region /population clusters (bounded by solid line)



Plot of the first and third dimension of the three-dimensional MDS analysis of *G. catenatum* strains.
G. catenatum clusters bounded by solid or shaded lines.

Bolch et al. 1999, J. Phycol. 35, 356-67, Blackburn et al. 2001 Phycologia, 40, 78-87,

Diversity of Australian and global populations: *Nodularia* (Cyanobacteria)



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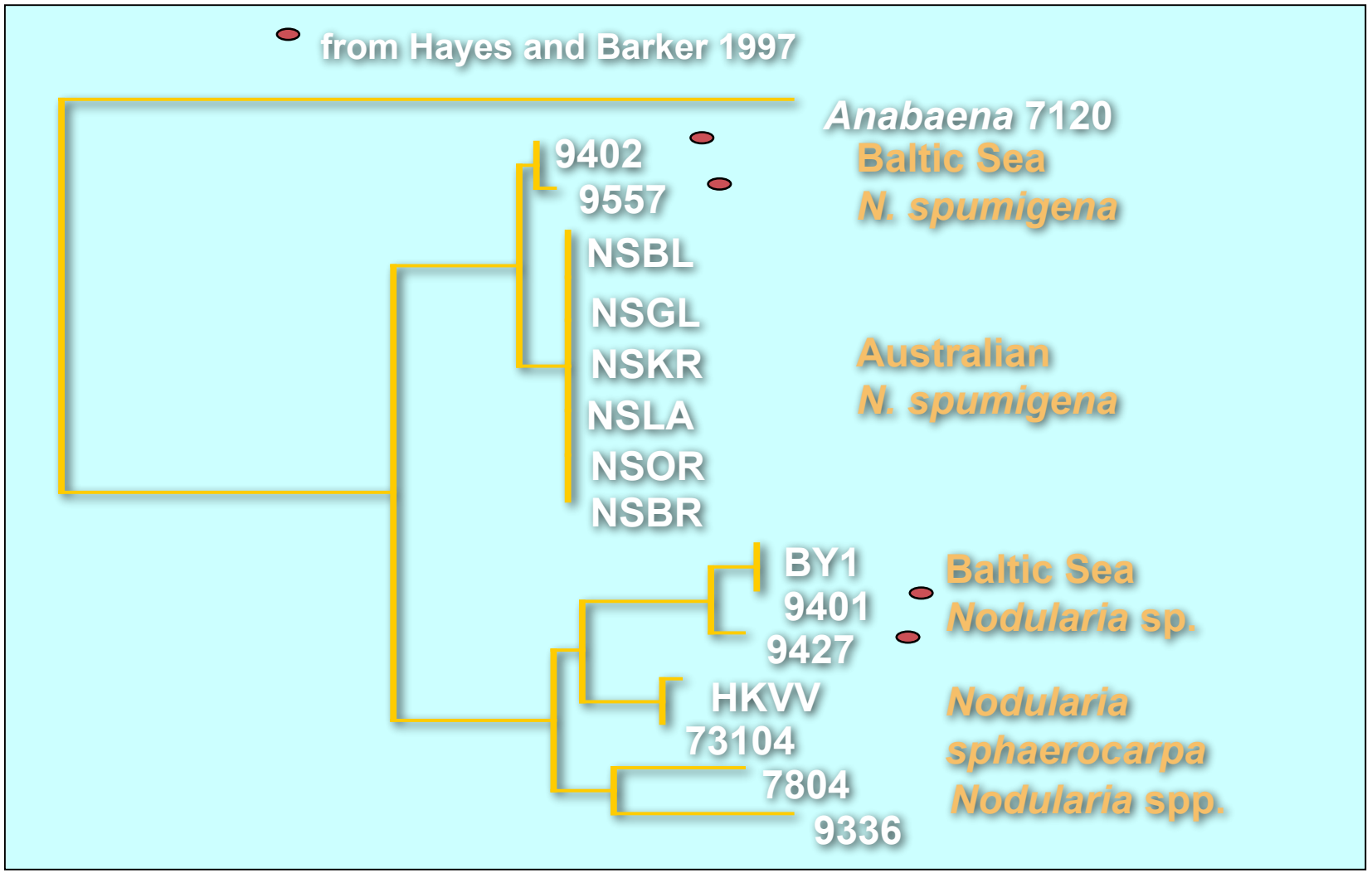
Nodularia genetic relationships: *cpcBA*-IGS



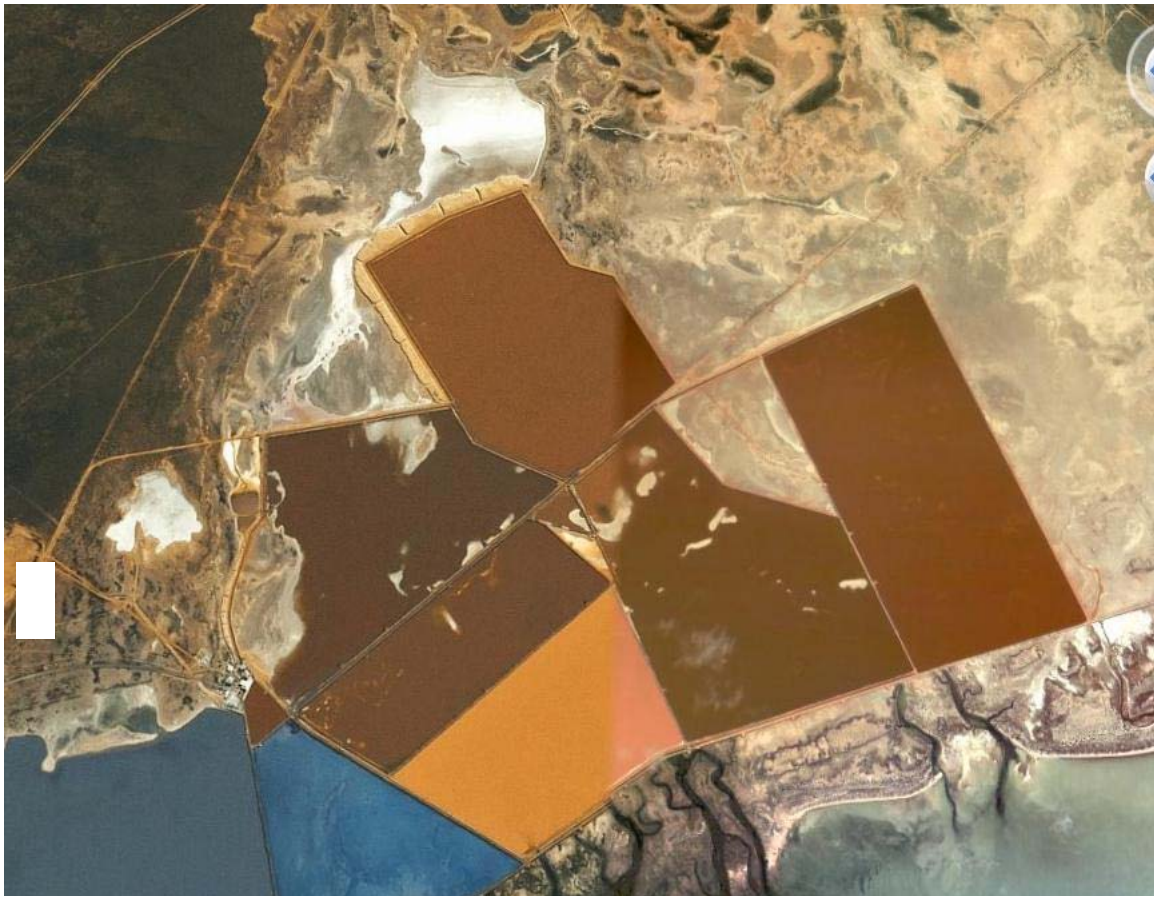
Bolch et al. 1999, J. Phycol 35, 339-55

Nodularia global populations

- Correlation of the hepatoxin nodularin with carotenoids:
  - Louise Schlüter et al. (DHI, Denmark and Norwegian University of Science and Technology) and Jameson and Blackburn (CSIRO Australia) Biochemical Systematics and Ecology 2008, 36, 749-57
- *N. spumigena* and *N. sphaerocarpa*:
  - 4-ketomyxol-2'-fucoside and 1'-O-methyl-4-ketomyxol-2'-fucoside: latter most important diagnostic pigment for toxic *N. spumigena,* Baltic Sea
- Relationship between carotenoids and the toxin nodularin:
  - Light intensity
  - Stage of growth
- Relationship between Australian strain and carotenoids / toxins not so clear
- Global population differences
- More studies of this type needed!

Australian algae industry

Cognis algae ‘lakes’, Whyalla, South Australia (also Western Australia)



Largest global producer natural β-carotene; Nutraceuticals; food / feed colorants

Dunaliella salina

Since early1980s

Energy Transformed Flagship
Biodiesel from Algae: Strain selection and optimisation

- **Bioproducts:** New Australian endemic algal strains for biodiesel, other biofuels and co-products, including **high value pigments**.

- New Australian industry for biodiesel from algae: coupling Australian endemic microalgae – selected for biomass and/or oil production along with co-products – with technologies developed by CSIRO to optimise:
  - algal growth, biomass and / or oil production
  - utilising flue gas, enhance solar energy conversion and CO_2 uptake

Commercial Feasibility

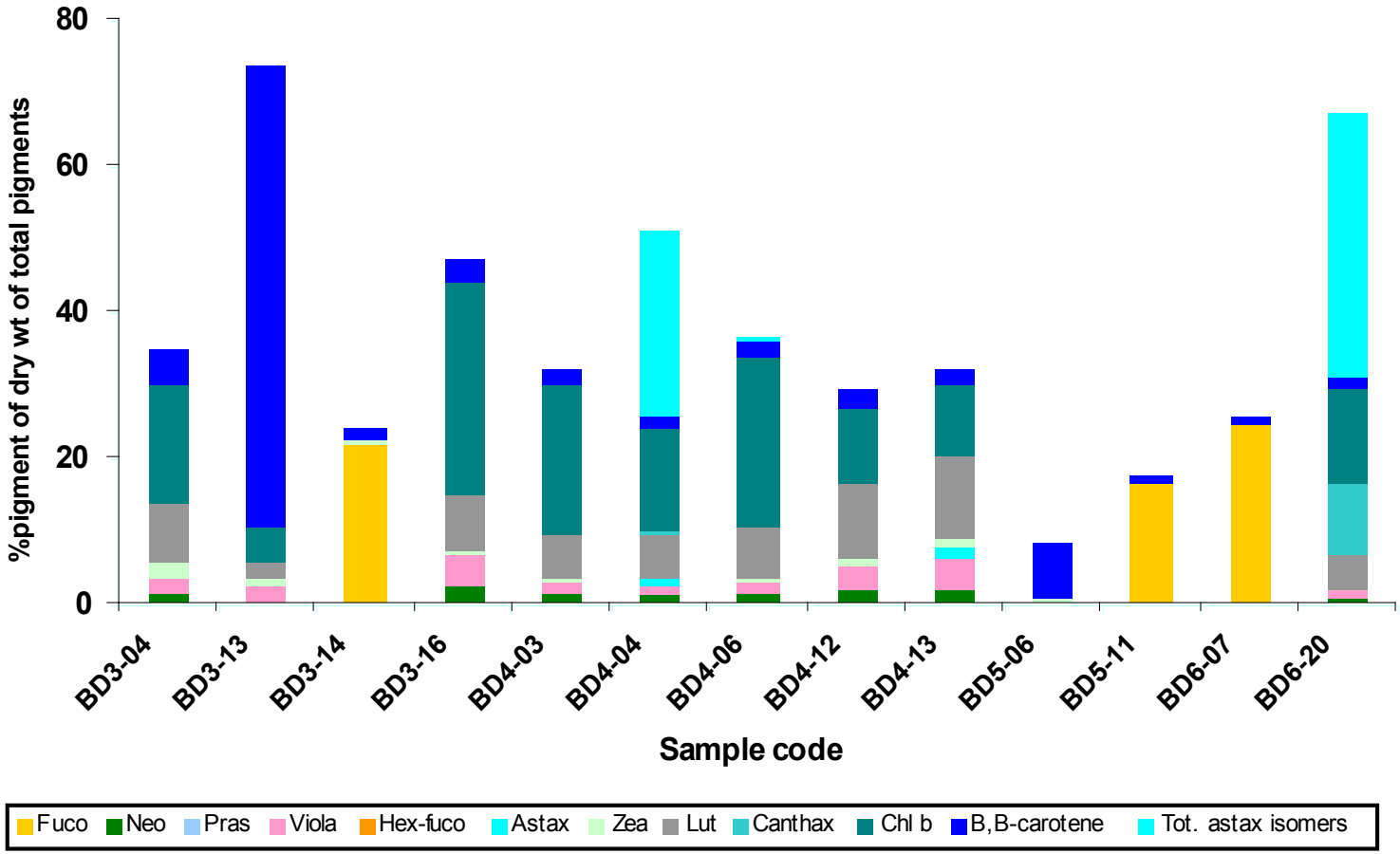
- We are piloting a microalgal biorefinery in which:
  - Production of ***Carotenoids*** looks to be the key now
  - Rank order (in terms of potential revenue earned):
    - **Carotenoids** (~75% of potential revenue!)
    - **Protein**
    - **Polyunsaturated fatty acids** (PUFA)
    - Biodiesel
    - Animal feed
    - Acrylic acid
- This ranking may change, so we must look now at:
  - Markets for ***carotenoids, protein, PUFA and biofuels***
  - Potential revenues and costs for each of the above
  - Species of microalgae that are best for the above

Carotenoids

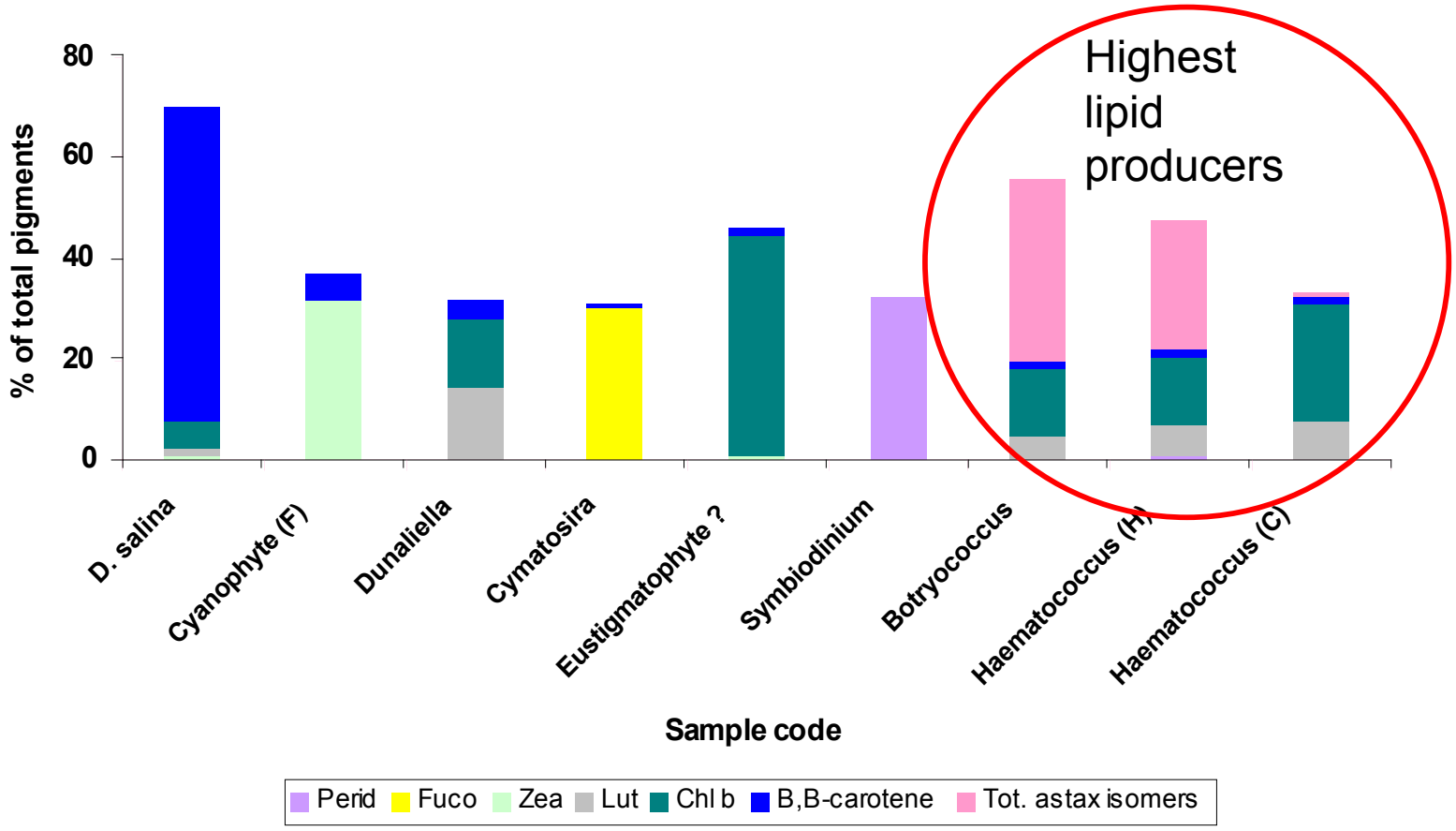
- Small number have found commercial application, including:
  - **β-carotene** US$**242** million worldwide in 2004
  - **Astaxanthin** US$**234** million worldwide in 2004
  - **Canthaxanthin** US$**148** million worldwide in 2004
  - **Lutein** US$**139** million worldwide in 2004
  - **Zeaxanthin**
  - **Lycopene**
  - *Others*
- Mainly used as ***food dyes***, as ***feed additives*** in aquaculture and to enhance the pigmentation of ***chicken and egg yolks***.
- Stringent regulations on synthetic dyes in the food sector
  → R&D on carotenoids from microalgae as food additives.
- Applications in the ***cosmetic industries*** (Borowitzka, 1988; Benemann, 1992; Johnson and Schroeder, 1995).

Potential co-products: Pigments

ANACC strain characterisation: pigments



High pigment producing strains



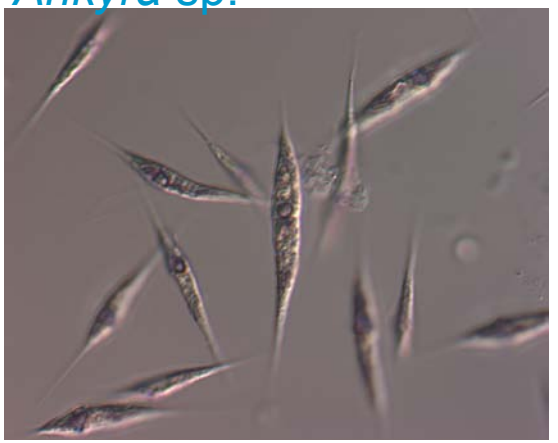
Pigment biodiscovery

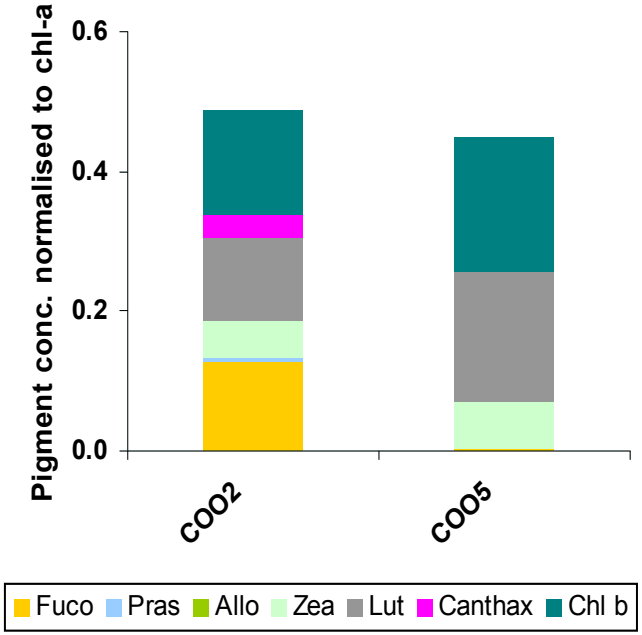
Coorong, South Australia – August 2007

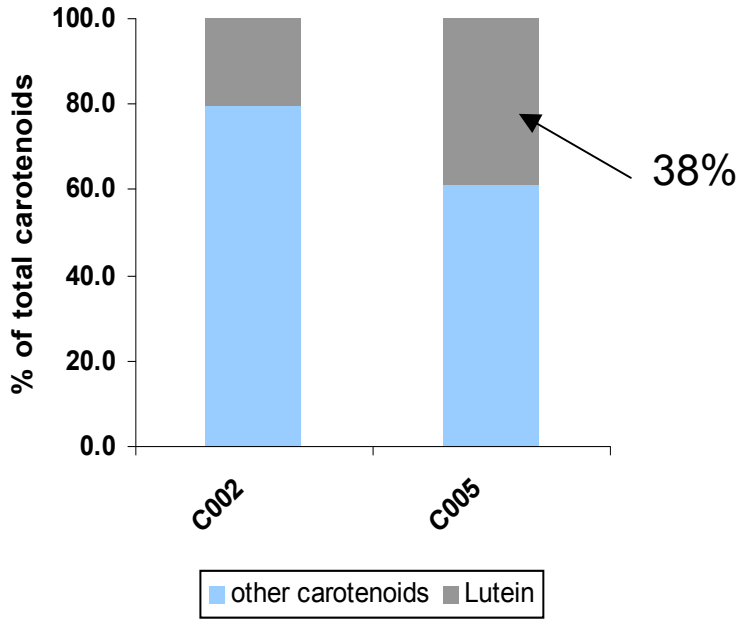
Surface salinity ranged from 53 – 116

C002 -77 and C005 - 116

Ankyra sp.







The future: Combined technologies / bioremediation / multiple bioproducts

Speciality chemicals

Biodiesel

Protein meal

Fermentation to alcohols

CSIRO Marine and Atmospheric Research
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Thank you

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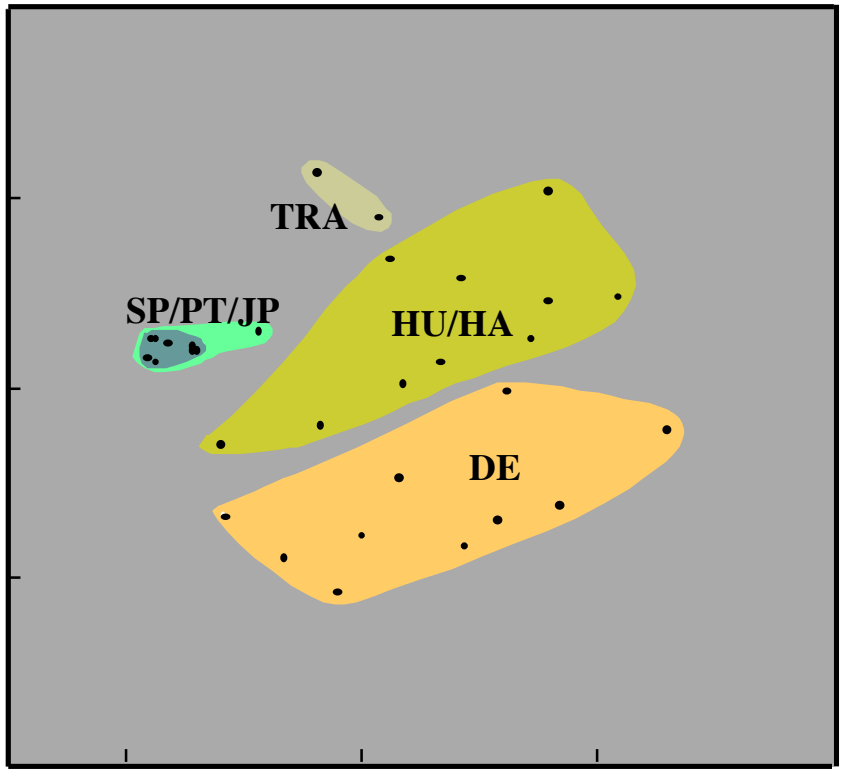
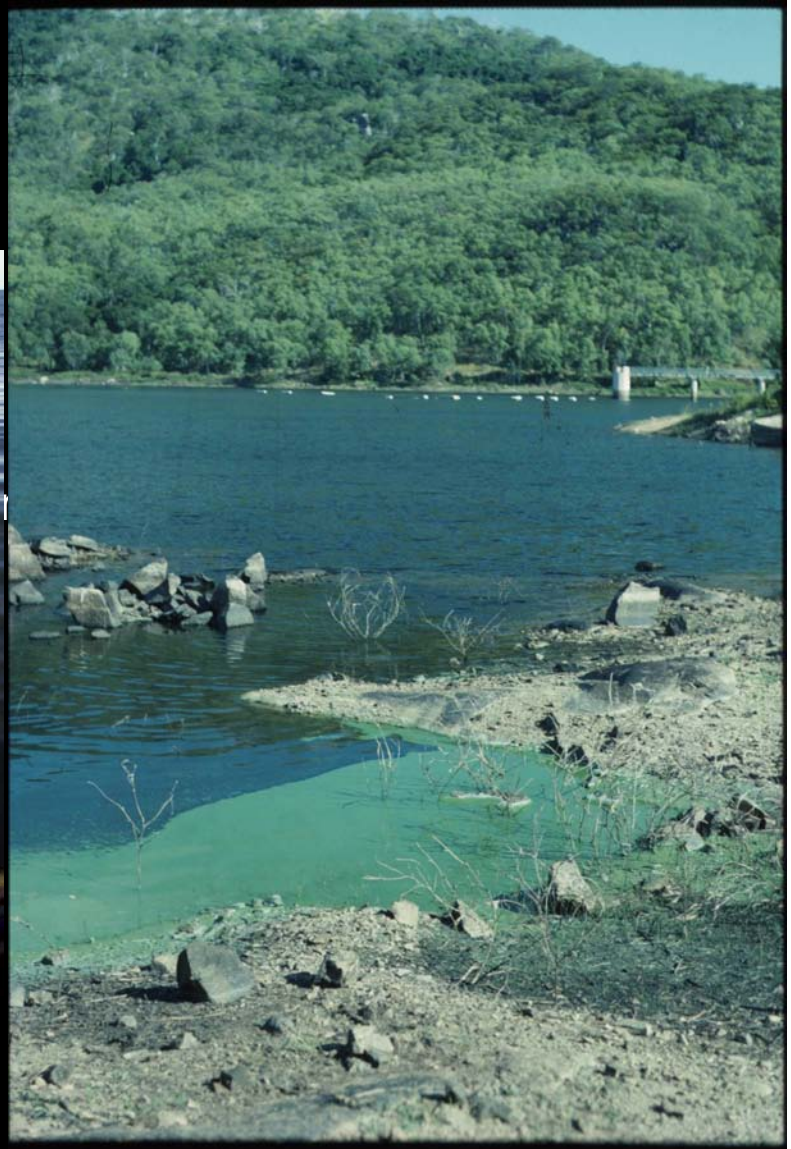
This is an example of a Section Divider slide Arial Regular, 44pt

3D MDS analysis of *G. catenatum* RAPD fingerprints



Algal Production: a challenge!
However algae produce high biomass in nature (algal blooms)

Dinoflagellate bloom, eastern Tasmania



Cyanobacterial bloom, Queensland