IMOS Integrated Marine Observing System

State and Trends of Australia's Oceans | Report

3.3 *Tripos* dinoflagellates as indicators of Australian marine bioregions

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Summary

While the distributions of a large number of the total of 50+ Australian *Tripos* dinoflagellate species have remained remarkably stable over the past 60-80 years, we identified a group of 8 rare tropical species that deserve careful attention in monitoring for range expansions, changes in seasonality or incursion of deep tropical waters.

Key Data Streams

Ships of Opportunity

National Reference Stations

Australian Ocean Data Network

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Rationale

Dinoflagellates belonging to what used to be referred to as the genus *Ceratium*, now redesignated *Tripos*, are widespread in marine waters, particularly outside the polar waters. The genus exhibits an amazing morphological diversity, with >77 species and numerous varieties and forms documented globally, and with numerous regional taxonomic monographs (**Figure 1**). Many studies hint at the potential of using *Tripos* species as water mass indicators to detect environmental change, which has been quantitatively explored for the North Atlantic (Dodge & Marshall, 1994) and the Mediterranean Sea (Tunin-Ley, Ibanez, Labat, Zingone, & Lemée, 2009). Previous comprehensive *Tripos* surveys of Australian species include Wood's (1954) dinoflagellate monograph of 71 taxa. These early studies produced the first conclusive biological evidence for what is now called the Leeuwin Current, which occasionally transports dinoflagellates from the Indian Ocean all the way to the west coast of Tasmania. Huisman (1989) focused on *Tripos* in 7 years (1979-1985) of net samples from Bass Strait (32 taxa). In adjoining Indian Ocean waters, Taylor (1976) characterized 56 *Tripos* taxa. In the period 1978-1984, as part of a series of CSIRO Division of Fisheries & Oceanography cruises, Hallegraeff and co-workers (1984) reported *Tripos* species from New South Wales coastal waters, East Australian Current eddies, the Coral Sea, North West Shelf and Gulf of Carpentaria. Here we summarise *Tripos* species in Australian tropical, subtropical, temperate and Southern Ocean environments.

Methods

Observations since 2007 were based on 614 Integrated Marine Observing System (IMOS) National Reference Station and 4263 Continuous Plankton Recorder samples from the Australian and Southern Ocean Continuous Plankton Recorder Surveys, and the phytoplankton and zooplankton samples from the IMOS National Reference Stations (Eriksen et al., 2019). Historical records of *Tripos* were obtained from the Australian Phytoplankton Database (8818 records) (Davies et al., 2016). All data were sourced from the AODN (https://portal.aodn.org.au/; see the datasets IMOS National Reference Station (NRS) - Phytoplankton Abundance and Biovolume", "IMOS - AusCPR: Phytoplankton Abundance", and "The Australian Phytoplankton Database (1844 - ongoing) - abundance and biovolume").

Results and Interpretation

Tripos in Australian waters exhibit a striking species richness, with most offshore sample locations containing 5-10 species. *Tripos* is best collected by phytoplankton or zooplankton nets, such as the surface to 100 µm drop nets in the Coral Sea, which also catch deep "shade" species (Sournia (1982). Tunin-Ley et al. (2009) in the Mediterranean Sea determined that a minimum sample volume of 70 L was needed for a sound estimate of *Tripos* species richness. The traditional bottle sampling of phytoplankton is insufficient.

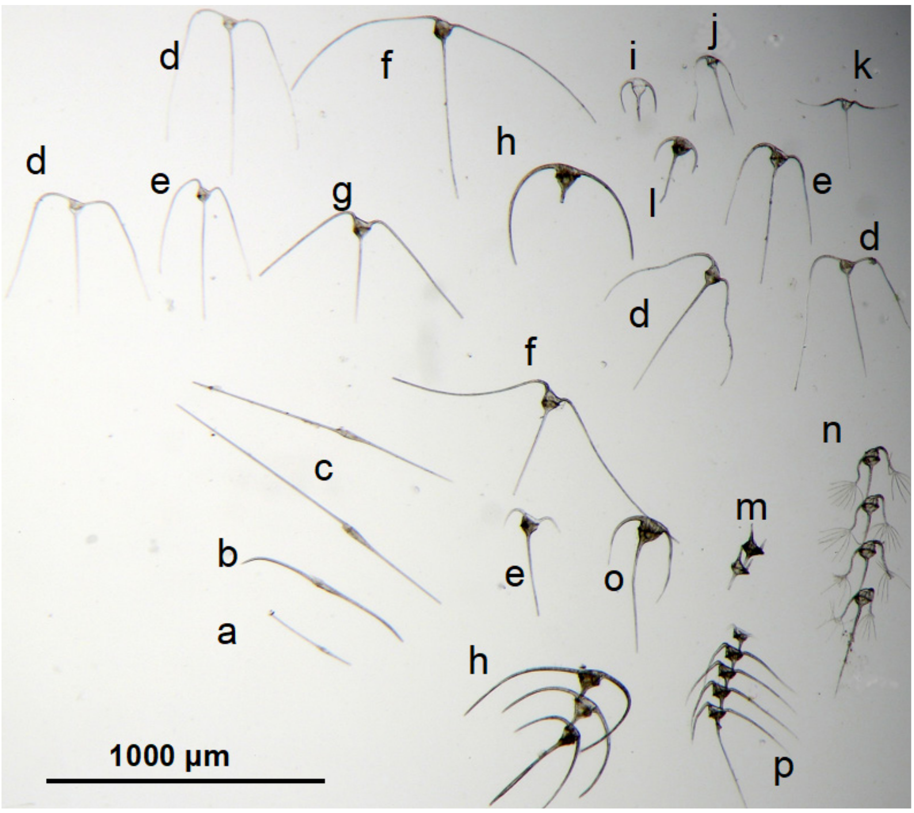

Figure 1. A selection of Tripos dinoflagellate species from the Port Hacking station off Sydney, Australia, hand-picked, sorted and photographed on the same scale (1000 µm). a. *Tripos fusus*; b. *T. falcatus*; c. *T. biceps*; d. *T. trichoceros*; e. *T. macroceros*; f. *T. carriensis*; g. *T. massiliensis*; h. *T. lunula*; i. *T. symmetricus*; j. *T. claviger*; k. *T. patentissimus*; l. *T. muelleri*; m. *T. candelabrus*; n. *T. ranipes*; o. *T. muelleri var. atlanticus*; p. *T. vultur. Micrograph* J. Uribe-Palomino.

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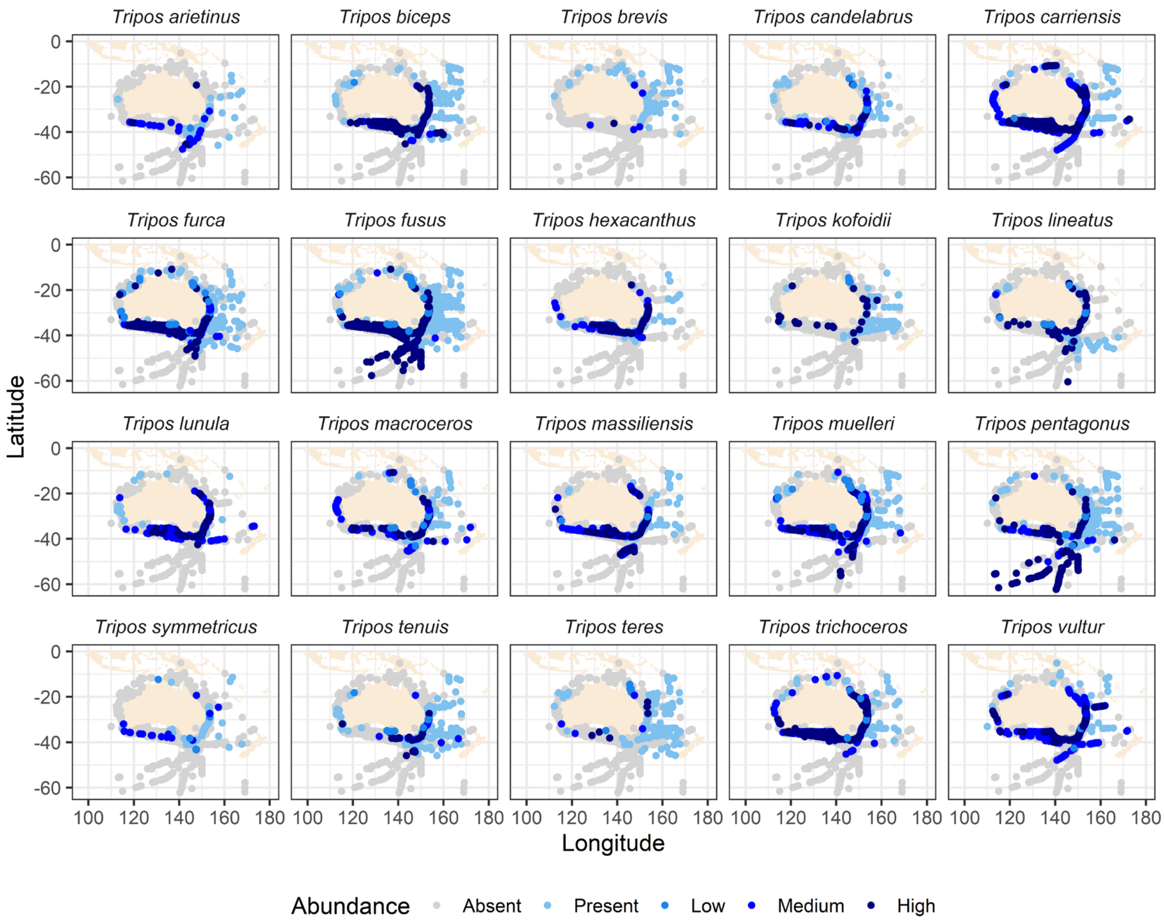

Figure 2. Collation over the period 1940-2019 of Australia-wide distribution records of 20 Tripos species.

Some apparent decadal shifts in Australian distribution patterns (**Figure 2**) simply reflect the fact that Wood's sampling focus was on the East Coast of Australia, while IMOS sampling covered the entire region.

The majority of *Tripos* species exhibit broad temperate to subtropical to tropical temperature preference (10-25°C), which essentially covers all Australian waters. This limits the use of *Tripos* indicator species in the Australian region. This is well demonstrated by the distributions of *Tripos carriense, T. falcatus, T. furca, T. fusus, T. gibberus, T. hexacanthus, T. limulus, T. massiliense, T. muelleri, T. platycornis,* and *T. ranipes*, which have remained remarkably stable in Australian waters over the past 60-80 years (**Figure 3**, **Figure 4**). It is noted that some species which are used as warm-water indicators in the North Atlantic (e.g. *T. hexacanthus*, 7-30°C, but "prefers higher temperature") are not necessarily diagnostic for warm waters of the Australian region (**Figure 4**). Similarly, Tunin-Ley et al. (2009) observed some strictly warm-water species such as *T. digitatus* in winter in the Mediterranean Sea.

Using the strict definition of stenothermal tropical species, agreed to by both Dodge & Marshall (1994) and Taylor (1976), we identified a restricted group of warm-water species including *T. belone, T. cephalotus, T. dens, T. digitatus, T. gravidus, T. incisus, T. paradoxides, and T. praelongus* (**Figure 5**).

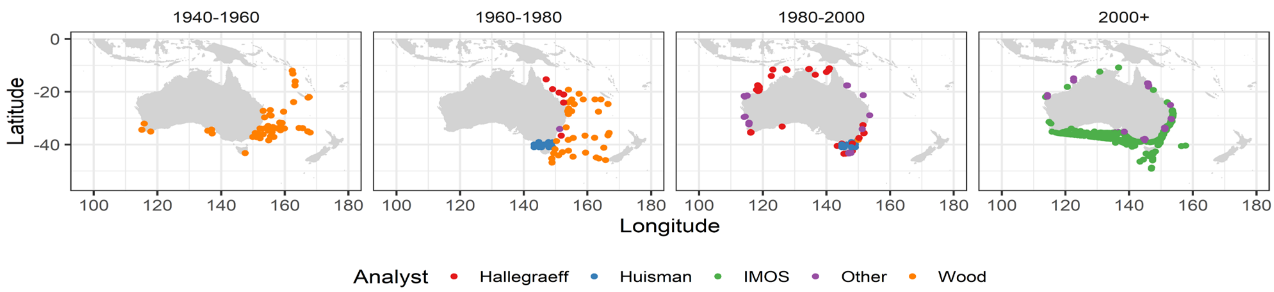

Figure 3. Sixty+ years of Australian distribution records of the widespread Tripos furca reflect temporal shifts in sampling efforts.

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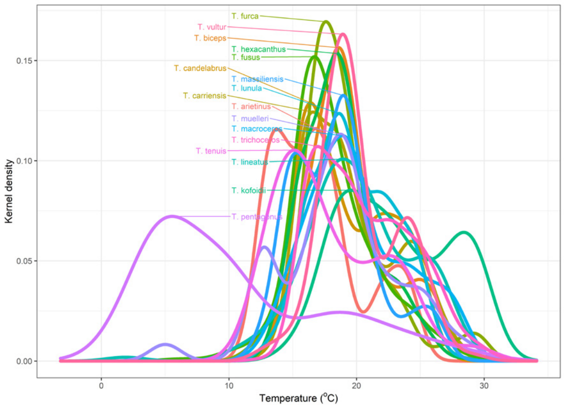

Figure 4. Thermal preferences of *Tripos* species estimated from IMOS data using kernel density. The temperature which gives the highest kernel density value is the Species Temperature Index (STI) and is a measure of whether a species prefers warm or cold water.

These tropical species are commonly encountered off Sydney (*T. digitatus, T. gravidus*), and more rarely down to Eden and Batemans Bay (*T. praelongus,* Sept 84) or Bass Strait (Huisman 1989: *T. gravidus, T. paradoxides*), but have occasionally been observed as far south as King Island (*T. cephalotus*, August 84) and even Tasmania off Maria Island (*T. gravidus* Sept 84) and the Huon River (*T. gravidus* Dec 2013, Nov 2018). These comparatively rare tropical Australian *Tripos* species are probably carried south on the East Australian Current and deserve careful attention in monitoring for future range expansions, changes in seasonality (**Figure 6**), or signs of upwelling/incursion of deep tropical waters (Sournia, 1982).

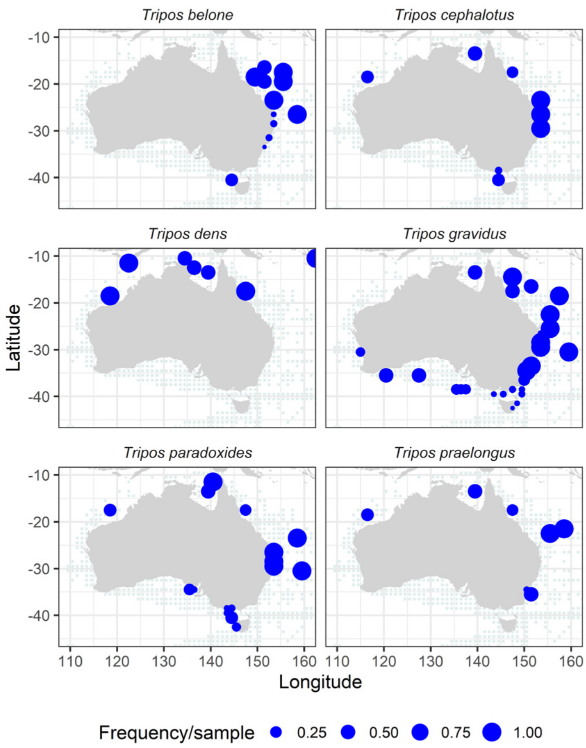

Figure 5. Australian distribution records of 6 stenothermal warm-water *Tripos* species.

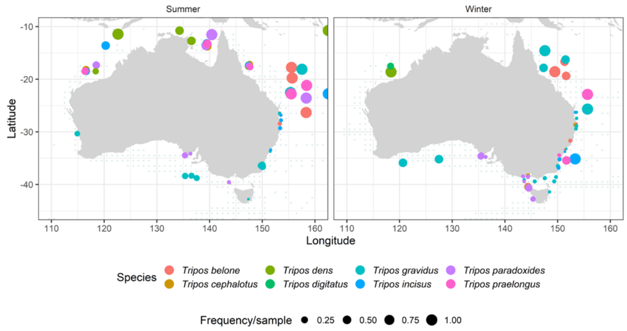

Figure 6. Seasonality of stenothermal warm-water *Tripos* species reflects upwelling in the Coral Sea, East Australian Current activity in summer, and Leeuwin Current activity in winter, as first postulated by Wood 1954.

Implications for people and ecosystems

Phytoplankton have been used successfully to increase our knowledge of the extent of water mass circulation by acting as indicator species. The ability to monitor changes in the extent and persistence of changes in water mass circulation relies heavily on long-term biological time-series, with sufficient taxonomic resolution to provide quantitative evidence of species range shifts or thermal niches (Buchanan, Swadling, Eriksen, & Wild-Allen, 2013; Eriksen et al., 2019). *Tripos* is a valuable indicator in this regard, but it is only through the careful curation of historical datasets, and species level data that these lines of evidence can be utilised. Shifts in species ranges due to changes in environmental conditions in the pelagic environment can have impacts on the food availability for higher trophic levels, potentially affecting the commercial and recreational fisheries that depend upon these food resources. Now that we have a validated dataset on *Tripos* from the 1940s to the present, the next step will be to derive indicators of change that are robust to the different sampling methods and focal regions.

Acknowledgements

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Data Sources

IMOS National Reference Stations.
http://imos.org.au/facilities/nationalmooringnetwork/nrs/

IMOS Ships of Opportunity.
http://imos.org.au/facilities/shipsofopportunity/

Australian Phytoplankton Database available through the AODN.
https://portal.aodn.org.au/search?uuid=75f4f1fc-bee3-4498-ab71-aa1ab29ab2c0

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References

Buchanan, P. J., Swadling, K. M., Eriksen, R. S., & Wild-Allen, K. (2013). New evidence links changing shelf phytoplankton communities to boundary currents in southeast Tasmania. ***Reviews in Fish Biology and Fisheries***. doi:DOI 10.1007/s11160-013-9312-z

Davies, C. H., Coughlan, A., Hallegraeff, G., Ajani, P., Armbrecht, L., Atkins, N., . . . Richardson, A. J. (2016). A database of marine phytoplankton abundance, biomass and species composition in Australian waters. ***Scientific Data, 3***. doi:10.1038/sdata.2016.43

Dodge, J. D., & Marshall, H. G. (1994). Biogeographic analysis of the armored plankton dinoflagellate ***Ceratium*** in the North Atlantic and adjacent seas. ***Journal of Phycology, 30***(6), 905-922. doi:10.1111/j.0022-3646.1994.00905.x

Eriksen, R. S., Davies, C. H., Bonham, P., Coman, F. E., Edgar, S., McEnnulty, F., . . . Richardson, A. J. (2019). Australia's long-term plankton observations: the Integrated Marine Observing System National Reference Station network. ***Frontiers in Marine Science, 6***(Article 161), 17.

Hallegraeff, G. M., & Jeffrey, S. W. (1984). Tropical phytoplankton species and pigments of continental shelf waters of north and northwest Australia. ***Marine Ecology Progress Series, 20***(1-2), 59-74. Retrieved from <Go to ISI>://A1984TT15600007

Huisman, J. M. (1989). The genus *Ceratium* Dinophyceae in Bass Strait and adjoining waters Southern Australia. ***Australian systematic botany, 2***(4), 425-454. Retrieved from <Go to ISI>://ZOOREC:ZOOR12600052147

Sournia, A. (1982). Is there a shade flora in the marine plankton? ***Journal of plankton research, 4***(2), 391-399.

Taylor, F. J. R. (1976). ***Dinoflagellates from the International Indian Ocean Expedition: A report on material collected by the R.V. "Anton Bruun" 1963-1964***. ***Bibliotheca Botanica, 132,*** 1-234.

Tunin-Ley, A., Ibanez, F., Labat, J.-P., Zingone, A., & Lemée, R. (2009). Phytoplankton biodiversity and NW Mediterranean Sea warming: Changes in the dinoflagellate genus Ceratium in the 20th century, ***Marine Ecology Progress Series, 375***, 85-90.

Wood, E. J. F. (1954). Dinoflagellates in the Australian region. ***Australian Journal of Marine and Freshwater Research, 5***((2)), 171-351. Retrieved from <Go to ISI>://ZOOREC:ZOOR09100014862