Forum Phycologicum

Newsletter of the

Phycological Society of Southern Africa

Vol. 78 - Bumper Issue

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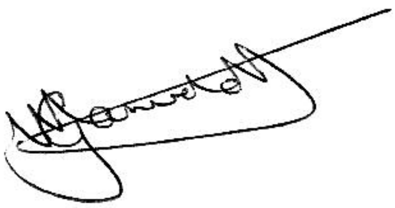
From the Editor

Welcome to yet another edition of the PSSA newsletter. For a number of reasons there was no March edition this year. This has meant, however, that I was able to produce a bumper issue this time round due to a number of submissions that were held over till now. It just so happens that this is also my last edition as Newsletter Editor, having been in this portfolio for nearly 11 full years (starting in January of 2002) and seeing my way through 30 issues as editor.

Like all previous issues, this issue comprises submissions from both members of the Society as well as invited authors. The spread of articles hopefully caters for all tastes. I am particularly proud to bring you the featured article on *How Spotted Beans, Elephant Trunks and Velvet Sleeves can serve as navigational tools*. Although longer than is usual for a featured article, I am confident that it will be well received because it bears so many elements (biogeography, history, natural science, social science, etc.) that would be of interest to both the scientific and the casual reader.

As an outgoing comment, I would like to take this opportunity of thanking you all for your continued support over these past many years. It has been great fun and I will miss communicating with you in this way. I am confident though that the incoming editor (Tommy Bornman) will find his experiences equally rewarding.

Best regards
Gavin



Synarthrophyton patena
epiphytic on *Gelidium capense*

News and Reviews

1. 2012 Members' Publications

On the following pages are just some of the PSSA Members' Publications over the past six months.

The Seaweeds of Angola: The Transition Between Tropical and Temperate Marine Floras on the West Coast of Southern Africa

Anderson RJ, Bolton JJ, Smit AJ, da Silva Neto D

The seaweed flora of Angola is relatively poorly known. Most of the 124 records listed for the country come from a 1974 British Natural History Museum expedition to the central and southern parts of that country. Previous biogeographic studies treated the Angolan seaweed flora as a whole and grouped it with those of certain West African islands as transitional between a Tropical West African seaweed flora (essentially extending from Senegal to Gabon) and temperate floras to the north and south of this truly tropical region. In the present study a total of 99 species and subspecies of seaweeds was collected from the intertidal zone and shallow sublittoral zones at five sites in the north of Angola and four sites in the south. The biogeographic distributions of our records were examined and compared with the temperate flora of Namibia to the south and the flora of Ghana to the north (as an example of a well-studied Tropical West African flora). Multivariate analyses of our presence/absence records showed differences between northern and southern sites (cluster analysis [Jaccard, average linkage] and detrended correspondence analysis). All Angolan sites were clearly different from floras of south, central and northern Namibia, which are considered to be strictly temperate in nature. Northern Angolan sites grouped more closely with Ghana than with southern Angolan sites. Distribution patterns within Angola are discussed in relation to monthly sea surface temperature data that were processed for this region. We conclude that the overall affinities of the Angolan seaweed flora, as represented by our collections, are Tropical West African, but with a well-developed temperate element in southern

Angola (from about 13° S) comprising mainly cooler-water species from the Benguela Marine Province of Namibia and western South Africa. Our collections add about 45 species to the Angolan seaweed flora, raising the total number of species to around 169. This total approaches that of Ghana which, with about 200 species, is considered to have the richest seaweed flora in Tropical West Africa.

African Journal of Marine Science (2012) 34(1): 1–13

South African kelp moving eastwards: the discovery of *Ecklonia maxima* (Osbeck) Papenfuss at De Hoop Nature Reserve on the south coast of South Africa

Bolton JJ, Anderson RJ, Smit AJ, Rothman MD

Historical and recent evidence is documented to demonstrate that the eastern limit of the major kelp-bed forming seaweed *Ecklonia maxima* has moved c. 73 km eastward along the south coast of South Africa since 2006, after remaining unchanged for almost 70 years. A significant population has established at Koppie Alleen, De Hoop Nature Reserve, which has been monitored from 2008 to 2011. It is hypothesised that the eastward spread is limited by aspects of the inshore water temperature regime, and recent evidence suggests that gradual cooling along this coast may have caused the change in distribution. It seems likely that if a cooling trend continues along the South African south coast, kelp beds and their associated species will move farther eastward in future decades, affecting the ecology and livelihoods along this coast.

African Journal of Marine Science (2012) 34(1): 147–151

The Mauritian Seaweed Flora: Diversity and Potential for Sustainable Utilisation

Bolton JJ, Bhagooli R, Mattio L

The world seaweed industry is currently worth over US$7.4 billion, and the potential for increased seaweed use exists in many countries. The species diversity of seaweeds in Mauritius has been extremely well documented in comparison with many local islands and regions, largely due to the work of the Danish phycologist Dr F. Boergesen, published from 1940-1957. The recorded seaweed flora is currently 435 species (59 brown algae, 108 green algae and 268 red algae), which is more than have thus far been recorded in either Kenya or Tanzania, and many more than for any other similar islands in the Indian Ocean. The world seaweed industry is growing rapidly, particularly the aquaculture sector, and possibilities for sustainable seaweed utilisation in Mauritius are discussed. Most seaweed culture for human food occurs in temperate regions, and current successful industries in tropical environments, especially the culture of *Eucheuma* / *Kappaphycus* for carrageenans, are in developing countries with low average incomes, often involving the importation of non-indigenous species. Possibilities exist in the aquaculture of seaweeds including in integrated systems for bioremediation and/or as animal feed, as well as the potential for utilisation of abundant species as feed or fertiliser or in small value-added industries. As an example, the worldwide uses of *Sargassum*, perhaps the most abundant local genus, are discussed.

University of Mauritius Research Journal (2012) 18A: 6–27

***Heydrichia cerasina* sp. nov. (Sporolithales, Corallinophycidae, Rhodophyta) from the southernmost tip of Africa**

Maneveldt GW, van der Merwe E

A new species of *Heydrichia* (Sporolithales), *Heydrichia cerasina* sp. nov., is described, found only on pebbles in the low intertidal zone along a 10 km stretch of the South African south coast from Cape Agulhas to Struisbaai. The species is characterized by the following suite of features that distinguish it from the other two species of *Heydrichia* found in South Africa: (1) unusual cherry-red colour when freshly collected; (2) uniformly warty growth form; (3) relatively thin

crust (up to 1400 mm thick); (4) tetra/bisporangial sori comprised of mostly single sporangial chambers; and (5) unbranched spermatangial structures distributed on the floor, walls, and roof of the mature male conceptacle. The species appears to be most closely related to *Heydrichia homalopasta* from Australia. This study has affirmed that the distribution of spermatangial structures within male chambers is a feature that cannot be used to separate *Heydrichia* from *Sporolithon*, the only other genus in Sporolithales, although features of thallus construction and tetra/bisporangial continue to distinguish the genera. A key to the southern African species from the order Sporolithales is provided.

Phycologia (2012) 51(1): 11–21

2. **KELP**

In parallel perfection,
a water ballet's synchronicity,
through narrow gullies
stems of kelp snake their way,
on and on, a dance
of lethal attraction
on the road
to death and decay.
Giant seaweed
like so many placentas
torn from the womb of the sea,
between glowing yellow stones,
their rubbery wrappings
adorning the shore,
as the sea, moving to and fro,
gently moans.
The salty tomb of afterbirth,
like felt trees
upside down,
the cradle of tiny life.
On nature's dinner table:
insects and crustaceans,
a decadent meal,
on which scavenging seagulls thrive.

Marion de Vos
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This poem submitted by Marion de Vos was first published in her book HEARTSCAPES [Marion's autobiography can be Googled]. Marion is thrilled to write about nature, and South Africa is one of her favorite inspirations.

3. Polyamines in *Ecklonia maxima* and their effect on plant growth (Thesis abstract)

Kelpak®, a seaweed concentrate (SWC) prepared from the brown seaweed *Ecklonia maxima* (Osbeck) Papenfuss, improves overall plant mass and fruit yield in a variety of crops. The main active principals isolated from Kelpak® are cytokinins and auxins. Although these compounds are partly responsible for the growth promoting effect observed with Kelpak® application, they do not fully account for the complete effect of Kelpak® treatment. For this reason the focus has turned to polyamines (PAs) which are found in all cells of plants, animals and microorganisms, including eukaryotic algae. Polyamines also have growth promoting effects in plants. A study was carried out to investigate the PA levels in *E. maxima* and Kelpak® through a biennial cycle and to investigate if the PAs present in Kelpak® may have an effect on root growth, alleviating nutrient deficiency and the transport and accumulation of PAs in plants.

Ecklonia maxima is commonly referred to as sea bamboo but also as "trombas" which is Portuguese for elephant trunks (see featured articles) (image: Gavin W. Maneveldt).

To determine the amount of PA in the stipes, fronds and SWC prepared from *E. maxima*, samples were collected monthly over a two-year period (June 2009 - June 2011). Extracts were benzoylated and quantified using a Varian HPLC. Putrescine concentrations ranged from 15.98-54.46 $\mu g.g^{-1}$, 6.01-40.46 $\mu g.g^{-1}$ and 50.66-220.49 $\mu g.g^{-1}$ DW in the stipe, fronds and SWC, respectively. Spermine concentrations ranged from 1.02-35.44 $\mu g.g^{-1}$, 1.05-26.92 $\mu g.g^{-1}$ and 7.28-118.52 $\mu g.g^{-1}$ DW in the stipe, fronds and SWC, respectively. Spermidine concentrations fell below the detection threshold. This is the first report of PAs being detected in a SWC. The seasonal pattern established for the stipe, frond and SWC followed the same trend over a biennial cycle. Polyamines accumulated in the seaweed tissue during periods of active growth and as a stress response elicited by rough wave action. This PA trend was similar to the cytokinin trend reported by Mooney and van Staden (1984) for *Sargassum heterophyllum* which suggests that PAs play an important role in the hormone cascade during active growth.

Routine monthly screening of Kelpak® carried out in the Research Centre for Plant Growth and Development indicated that Kelpak® consistently resulted in more rooting in the mung bean bioassay than the IBA control. The potential root promoting effect of PAs was investigated. Individually applied PAs did not increase rooting in the mung bean bioassay, but a synergistic relationship was observed between Put (10^{-3} M) and IBA (10^{-4} M). When applied together, rooting increased significantly above Put (10^{-3} M) and IBA (10^{-4} M) applied separately. The Put-auxin combination produced a similar number of roots to those treated with Kelpak®. It is possible that the PAs present in Kelpak® have a synergistic effect with auxins present in Kelpak® to promote root development and growth.

Several physiological effects of Kelpak® and PAs on plant growth were investigated in a series of pot trials. Kelpak® significantly improved the growth of P- and K-deficient okra seedlings and masked the detrimental effects exerted by P- and K-deficiency. The application of PAs (10^{-4} M) significantly improved the seedling vigour index (SVI) of okra seedlings subjected to N-deficiency. The statistical difference was attributed to the N-containing growth regulators and polyamines being degraded and metabolized by the okra seedlings. Polyamine application did not alleviate P- and K-deficiency but increased root growth significantly in seedlings receiving an adequate supply of nutrients. It is likely that the additional PAs supported auxin-mediated root growth.

A pot trial with okra plants was conducted to establish if the PAs in Kelpak®, applied as a soil drench or foliar application, are absorbed and translocated in a plant. Plants were also treated with Put, Spm, Spd to establish if PAs can be absorbed and translocated. Once the fruit had matured, plants were harvested and the endogenous PA content quantified by HPLC in the roots, stems and fruits. Applying PAs as a soil drench was not as effective as a foliar spray at increasing the PA content in the different plant parts. Kelpak® treatment (0.4%) did not contribute more PAs in any plant part. Spermidine concentrations were higher, in the various plant parts, than Put or Spm, irrespective of the mode of application. The application of Put, Spd and Spm increased Spd concentrations in the roots. Considering that Spd is the main PA produced in the roots and that exogenously applied PAs are readily converted to Spd, it seems evident that Spd is the preferred PA for long-distance transport in plants.

The cytokinins and auxins in Kelpak® play an important role in stimulating growth in plants. It is, however, the totality of different compounds in Kelpak® that gives it its unique growth stimulating ability. Polyamines, occurring within the seaweed contribute to this activity, having an active role in root production and thus increased plant growth.

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Reference

Mooney PA & van Staden J (1984) Seasonal changes in the levels of endogenous cytokinins in *Sargassum heterophyllum* (Phaeophyceae). *Botanica Marina* 27: 437-442.

4. Seaweed diversity in the Mozambique Channel: an expedition to Europa Island

The Eparses Islands (or Scattered Islands) are a group of five coral islands administrated by France (TAFF: Terres Australes et Antartiques Françaises). Four of them are situated in the Mozambique Channel and from North to South are are Glorieuses, Juan de Nova, Bassas, and Europa; Tromelin is situated to the north-east of Madagascar (Fig. 1). These islands are uninhabited except for militaries, and no infrastructure exists except for the military camps.

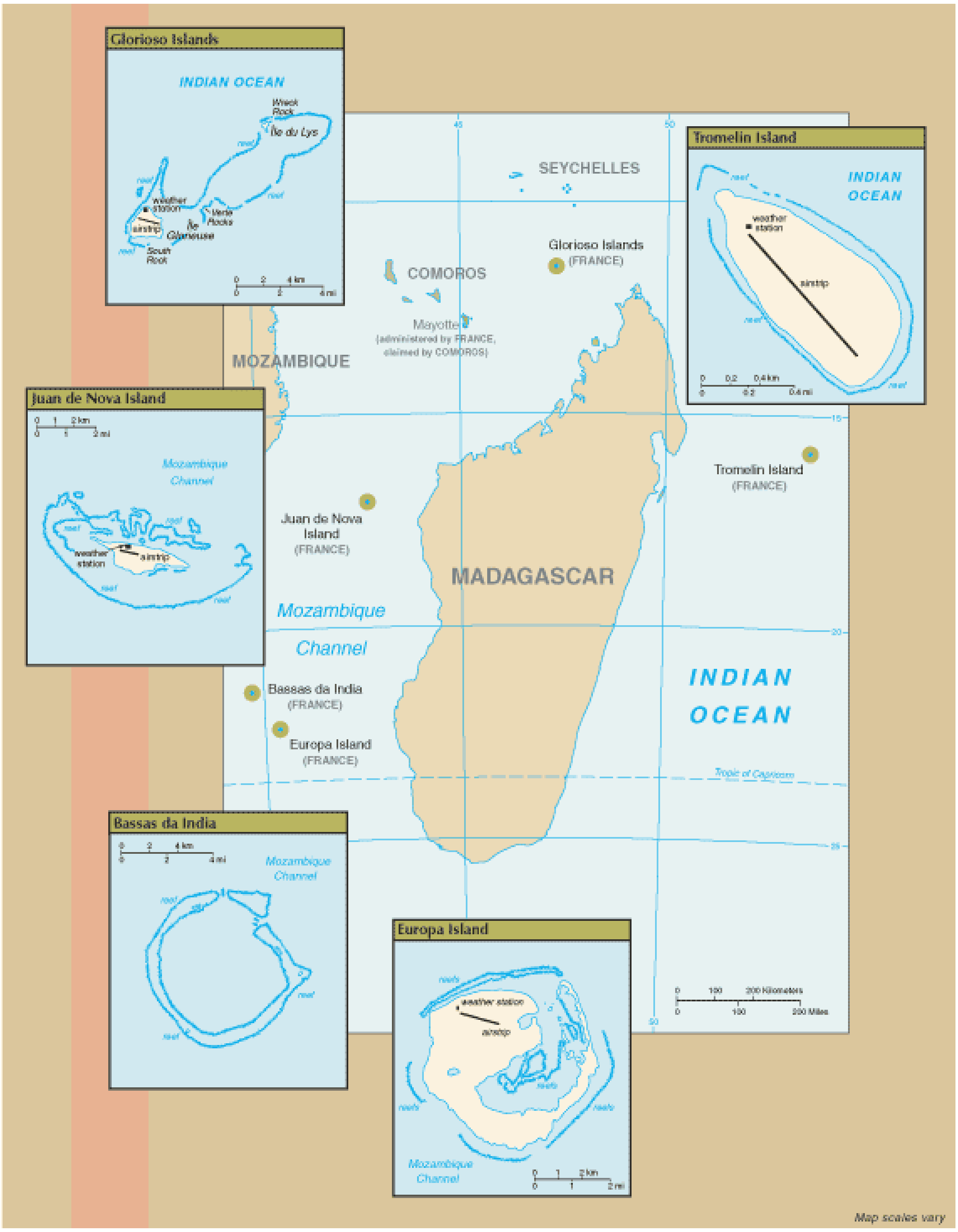

Figure 1. Location of the Eparses Islands around Madagascar (image: Wikipedia).

Knowledge of the coral reefs of the Eparses Islands is very low or non-existent because of their limited accessibility. The islands are to be declared marine protected areas (MPAs) and as such a management plan is to be established that requires fundamental knowledge of the habitats and communities associated with the surrounding coral reef ecosystems. Faced with gaps in our knowledge and to meet the needs of the mangers, the BioReCIE program was designed to focus on the scattered islands located within the Mozambique Channel and is aimed at:

1) Increasing our knowledge of the Eparses Islands through biodiversity inventories of the algae, cnidarians, molluscs, crustaceans, echinoderms and fish. Data will be recorded in a database and combined with a Geographic Information System (GIS) to provide the essential tools for developing a management plan.
2) Establishing a baseline study of fish communities (diversity, density and biomass) in order to obtain variables for estimating the state of the fish resources at each island.
3) Looking for potential indicators of disturbance for optimized environmental monitoring over the long term (e.g. fishing, coral bleaching, etc.).

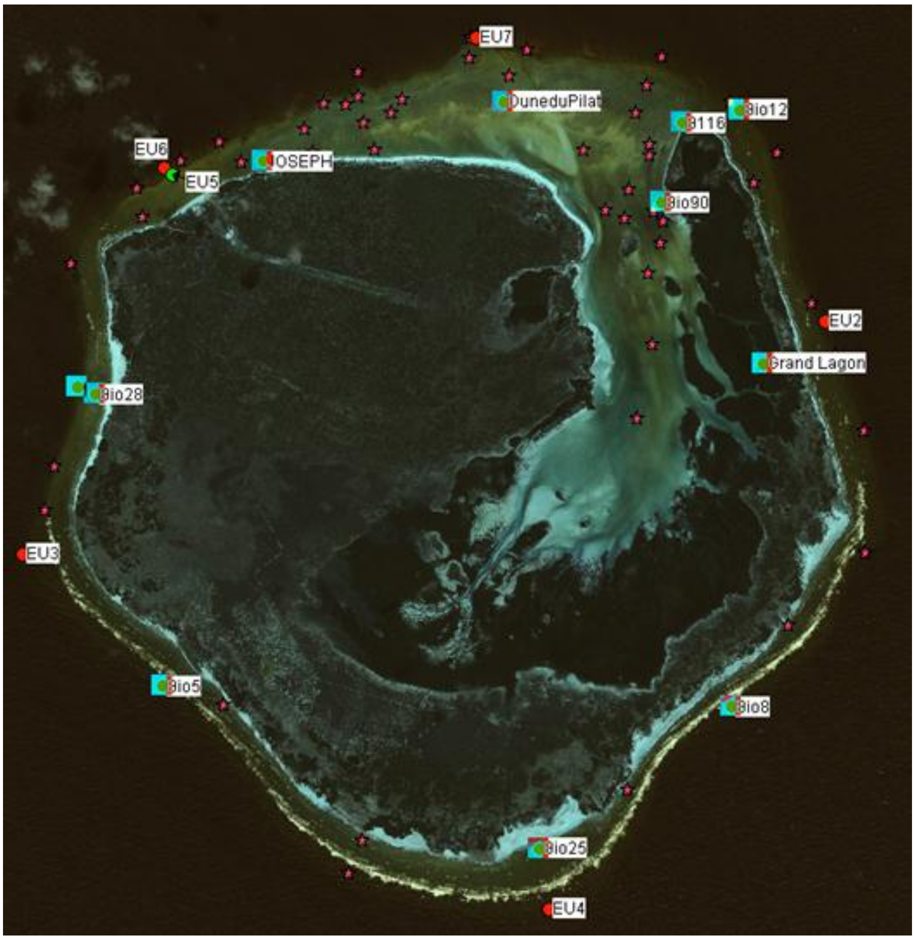

Figure 2. Collection sites during the expedition to Europa Island.

The first field expedition of the program was carried out from 5-16 November 2011 at Europa Island, situated between southern Madagascar and southern Mozambique (Fig. 1). Among the 13 participating scientists, two phycologists (Mayalen Zubia from Arvam, Reunion Is. and Lydiane Mattio currently based at the University of Cape Town, Cape Town, South Africa) boarded the 28 meter-long sailing yacht *Antsiva* at Tulear (Toliara, Madagascar) for a two day sailing trip across the Mozambique Channel.


Figure 3. Lydiane Mattio (left) and Mayalen Zubia (right) sorting through samples at Europa Island.

Samples were collected from a total of 17 sites around the island (Fig. 2) during 6 days by two teams: a SCUBA-diving team; and a "reef" team snorkeling in the shallows at low tide. Sampling sites were pre-determined from satellite images in order to represent as many of the different coral reef habitats as was possible. Three to four collecting baskets from each of two deep and two shallow sites were sorted each day (Fig. 3), resulting in a total of about 700 specimens representing two duplicate collections of 350 specimens. Preliminary identifications were made while sorting and pressing the specimens at Europa Island. Formalin, ethanol and silica gel subsamples were kept for later microscope examination and DNA analyses.

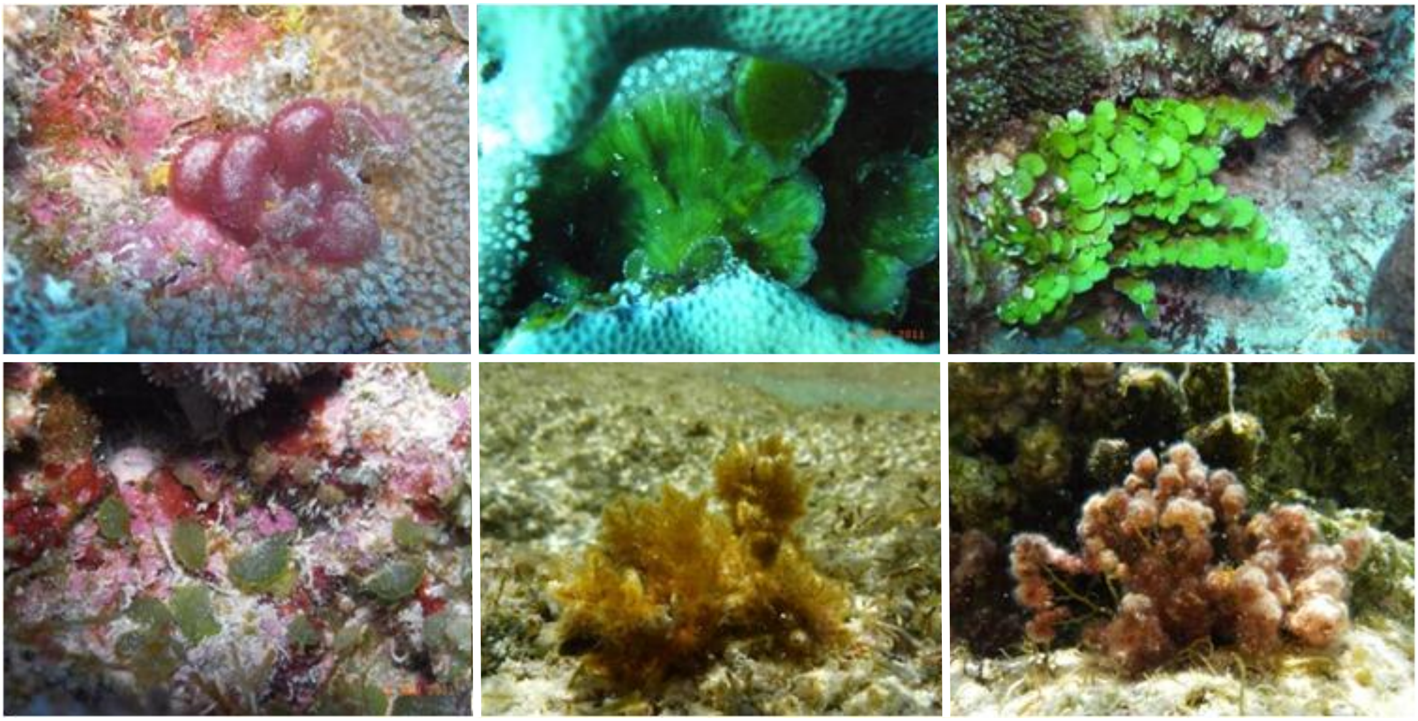

Figure 4. A selection of algae sampled from Europa Island.

In order to complete the algal specimen identifications, a workshop was held at the University of Cape Town (Botany department) from the 10-15 June 2012 (Fig. 5). Participants included Prof. Olivier De Clerck (Phycology group, University of Gent, Belgium), Prof. John J. Bolton (Botany Dept., University of Cape Town), Prof. Robert J. Anderson (Seaweed Unit, Dept of Agriculture Forestry and Fisheries), Prof. Gavin W. Maneveldt (Dept of Biodiversity & Conservation Biology, University of the Western Cape), Dr. Mayalen Zubia and Dr. Lydiane Mattio. By the end of the workshop, most of the algal material was positively identified with the exception of a few samples that will be sent to other experts for identification and/or sequencing. The resulting species lists accounted for 134 species (11% browns, 24% greens and 65% reds), 10% of which may be new to science. The main collection will be deposited at the herbarium of the National History Museum in Paris (PC) and will serve as the reference collection. A duplicate collection will be deposited at the Museum of Reunion Island. The final results will be examined within a biogeographical context and the data later submitted for publication. This publication will serve as the reference for the island, since no algal species list is yet available for this locality.

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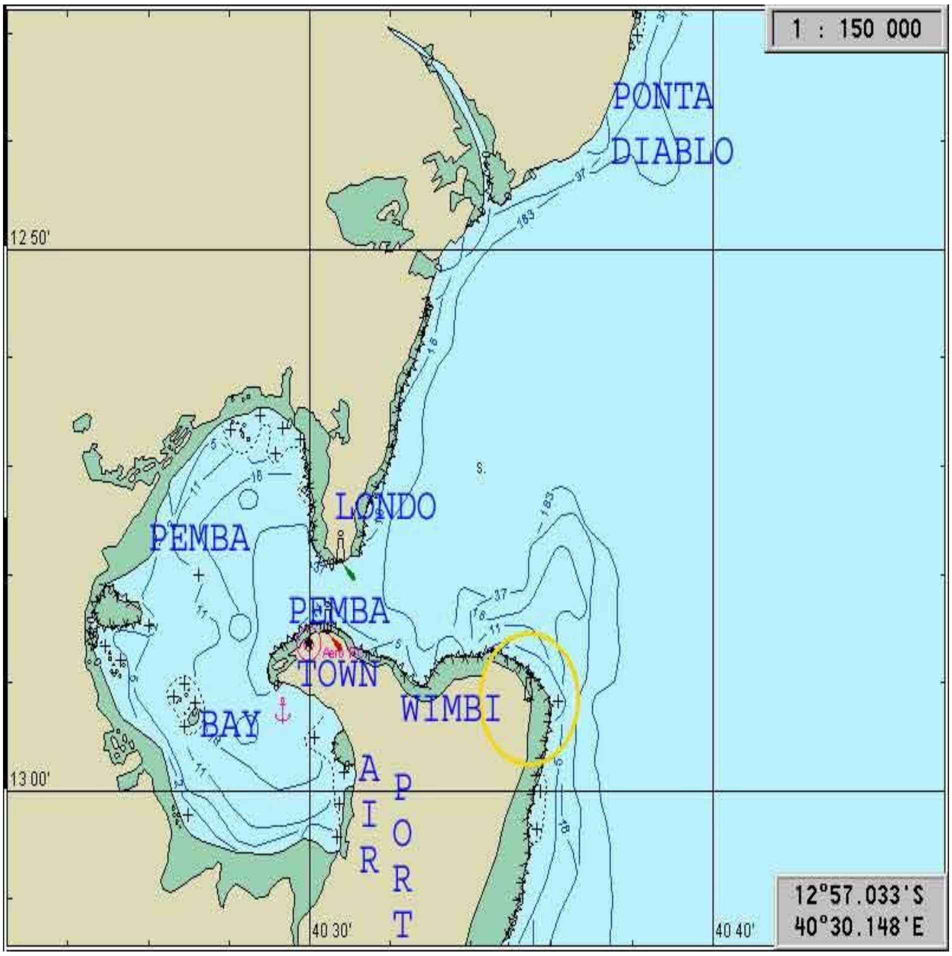
5. Searching for seaweeds in Pemba, northern Mozambique

The phycology group at the University of Cape Town is increasingly involved in research on seaweed diversity in the Western Indian Ocean. This interest has been greatly augmented since the end of 2010 by the arrival of Post-Doc Lydiane Mattio. Lydiane has worked extensively on the taxonomy of *Sargassum* in the Pacific, and is starting to sort out the taxonomic difficulties in *Sargassum* in the Indian Ocean. *Sargassum* is the most abundant seaweed in many tropical inshore habitats, and there are around 100 names available for Western Indian Ocean species, although several of those names are synonyms and the real diversity probably doesn't exceed 10 to 15 species.

The University of Cape Town provided funding for a trip to Pemba, northern Mozambique, ca. 300 km south of the Tanzanian border, which included travel for a team of 5, the authors plus Prof



Map of the Pemba region (image: www.fanigalore.com).

Salomao Bandeira (marine botanist at the Universidade Eduardo Mondlane in Mozambique) and an MSc student of Prof Bandeira, Manuela Amone. The idea was to spend a low spring tide period around Pemba, collecting as many species of seaweeds as possible. Daily trips to the extensive intertidal reefs in the area were planned, with diving collections if possible. There are daily direct flights from OR Tambo International Airport to Pemba, which is difficult to reach by road.

Pemba is a remarkable place, largely due to its bay. This is described in tourist literature as "the third largest inland bay in the world" (difficult to verify), and has a small mouth (about 2km wide), a kidney shape, an area of 375 square km and a uniform depth of 25 metres. The town itself has some tourist facilities, but has yet to be generally discovered, although there is an atmosphere around the town, which suggests that it may happen soon. We met groups of Europeans in restaurants who describe themselves as "investors". There are new hotels being built, and a natural gas industry is about to start offshore. We were hosted by CEPAM (Centre for Coastal and Environment Research) about 10km from the centre of town. This excellent facility was built in 2008, and includes a full range of laboratories and offices, a large auditorium, refectories, student dormitory and houses for visiting scientists. It is right on the coast, a couple of hundred metres from an expansive reef. CEPAM has seven boats of various sizes that are available for use by visiting scientists. The facility is run by the Director (Hermes Pacule) who has a staff of 36, including 7 junior staff, scientists who work on topics such as fish, invertebrate / plant diversity, aquaculture, oceanography and informatics. Their brief includes work on the sustainability of marine and coastal ecosystems, integrated management of marine biodiversity (including endangered species) and marine restoration. CEPAM has an impressive aquaculture setup, shown to us by their aquaculture scientist Goncales Bernabé, which was built with the assistance of the AquaPemba Company that is linked with HIK Abalone Farm in Hermanus, South Africa. AquaPemba is carrying out fish (kob) aquaculture trials in the bay, and there are trial mariculture investigations going on with other species that include crabs. We are very indebted to CEPAM for the use of their excellent facilities, and would recommend it to anyone wishing to carry out research in tropical marine environments. Apart from possibly high travel costs, it would be a perfect venue for a PSSA congress!

We were joined in our collecting and assisted throughout by Ezidio Cuamba, who has the marine botanist portfolio at the Institute. Ezidio was extremely helpful and full of enthusiasm throughout the collection, study and preparation of the specimens. Most mornings were spent collecting on various nearby reefs. There is a rather high tidal range around Pemba (4m [mean high spring tide] and 2.8m [mean high neap tide]). This means that the lagoon behind the reef empties at low spring tide, which tends to leave a long walk of up to 2km out to the reef itself. The walk is made more difficult by large populations of small black sea urchins (*Echinometra mathaei*) underfoot. According to Richmond (2011), "population outbreaks (of this species) are possibly due to removal of fish predators caused by overfishing". There is certainly enormous collecting activity of seafood at low tide around Pemba, including local women wading almost up to their necks in the sandy shallows, feeling for molluscs with their feet. Much the quickest and safest way to walk out to the reef is to follow the trails known by the locals. The small black urchins are not collected, but the much rarer white-spined urchin *Tripneustes gratilla* is opened on the beach, and the delicious roe spooned into a bowl for later consumption. The team also benefitted from the bounty of the sea, either buying fresh fish from roadside fishermen, or in one case bartering for large spiny lobsters directly on the shore (involving an excellent deal which cost a mask and snorkel).

Manuella and Ezidio collecting algae.

The countryside around Pemba is rural, with large impressive baobab trees dotting the landscape, surrounded by cashew nut trees and farmland growing mostly millet and cassava. Bakeries are open at all hours, selling delicious fresh-baked Portuguese rolls, and at night the roads are lined with people socializing. The atmosphere is friendly and relaxing.

Diving collection proved a little tricky, as our first attempt using a recommended local dive charter was aborted when the outboard engine failed a couple of hundred metres from the shore. Luckily CEPAM again came to our aid, and we had a fascinating trip in one of their smaller boats across the bay mouth, with a shallow dive on the open coast the next day. Local fishermen use traditional dhows and outriggers, and some are expert paddlers, with one single paddler in the open sea almost keeping up with our powered boat. One fisherman was collecting by snorkeling in the bay while pulling his outrigger on a rope behind. On the dive at 3-4m

The reef crest with women collecting seafood at Marringanha.

depth were large beds of *Sargassum* with some interesting understorey seaweeds.

Fishermen with the morning's catch, Murrebue.

At the end of the trip, John Bolton was asked to give a seminar, which he presented on seaweed biogeographic patterns and uses in the region. He initially thought it would be given just to the CEPAM scientists, but the audience proved to be quite a lot larger. The new University of Lurio was set up in 2006 to service the three most northerly Provinces of Mozambique, and a satellite campus at Pemba (Cabo Delgado Province) is even more recent. There are currently around 250 students at the Pemba campus. Almost the entire third year cohort (ca. 60 students of Biological Sciences, Engineering and Information Technology) were bused in to attend the lecture, accompanied by staff including the University Rector. The lecture was skillfully translated concurrently by Salomao Bandeira, and the students listened diligently, carefully taking notes throughout. At the end there was around 40 minutes of questions, with many students from the different disciplines showing great confidence in asking very relevant questions.

The collections yielded about 300 specimens of around 122 species. We made herbarium specimens in triplicate where possible, leaving a set at CEPAM, a set for the herbarium at the Universidade Eduardo Mondlane in Maputo, and a set for UCT. Silica gel specimens for molecular taxonomic work will be sent to experts on particular groups around the world. In the coming months we will confirm identifications (where possible, as the seaweed flora of the Western Indian Ocean is still surprisingly poorly known). We now have collections from a 'transect' across the Mozambique Channel, from Pemba to Europa Island (see previous article in this issue) to northern Madagascar. Collections in northern Madagascar were made by Lydiane during a field trip of two weeks, just after the Pemba trip. About 160 species were collected from a wide range of different habitats. We intend in the near future to analyze biogeographical patterns across this region.

Reference

Richmond MD (2011) A Field Guide to the Seashores of Eastern Africa and the Western Indian Ocean Islands. Sida/WIOMSA. 464pp.

Lydiane collecting in the *Sargassum* bed, north of the mouth of Pemba Bay.

Some of Pemba's marine life.

Acknowledgements

We would like to thank Prof Salomao Bandeira for his willingness to be a partner in this project, and his expert assistance throughout in making the trip a success. Also to CEPAM and its Director, Hermes Pacule, for their generous help in providing the perfect facilities that made the trip a success. Many thanks are also due to Ezidio Cuamba for his excellent work as a member of the seaweed team, and to the other staff at CEPAM for their assistance. We would like to acknowledge the University of Cape Town top-up funding for collaboration with partners in the global South for funding this investigation.

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Except for the map (first image), all photographs were taken by either John, Lydiane or Rob.

Featured Articles

Searching for the mysteries of multicellularity using algal genomics

The volvocines provide an excellent model for studying the evolution of multicellularity and cell differentiation. Extant members of this lineage provide a spectrum of developmental complexity, including unicellular members (e.g. *Chlamydomonas*), colonial forms without cell differentiation (e.g. *Gonium*) and those with incomplete (e.g. *Pleodorina*) and complete germ-soma (GS) differentiation (e.g. *Volvox*) (Figure 1). An analysis of extant members (Kirk, 2003) suggested that 12 major but readily achievable steps evolved sequentially *en route* to multicellularity. The culmination of these steps resulted in a major evolutionary transition– the development of multicellularity. Phylogenetic analyses of the volvocine algae provided details of their genetic relationships, however, these relationships do not in all instances concur with the sequence of Kirk's 12 steps (Herron *et al*., 2009). Of key importance is the development of cellular differentiation into germ and soma or the development of division of labour (GS-DOL). The development of GS-DOL may have occurred independently in three separate volvocine lineages (Herron and Michod, 2008; Herron *et al*., 2009) which gave rise to three modern lineages with different mechanisms of differentiation, these include; (i) *Astrephomene*, (ii) *Volvox globator*, *Volvox barberi* and *Volvox rousseletii* and (iii) a lineage which now consists of *Pleodorina* and the remaining *Volvox* species.

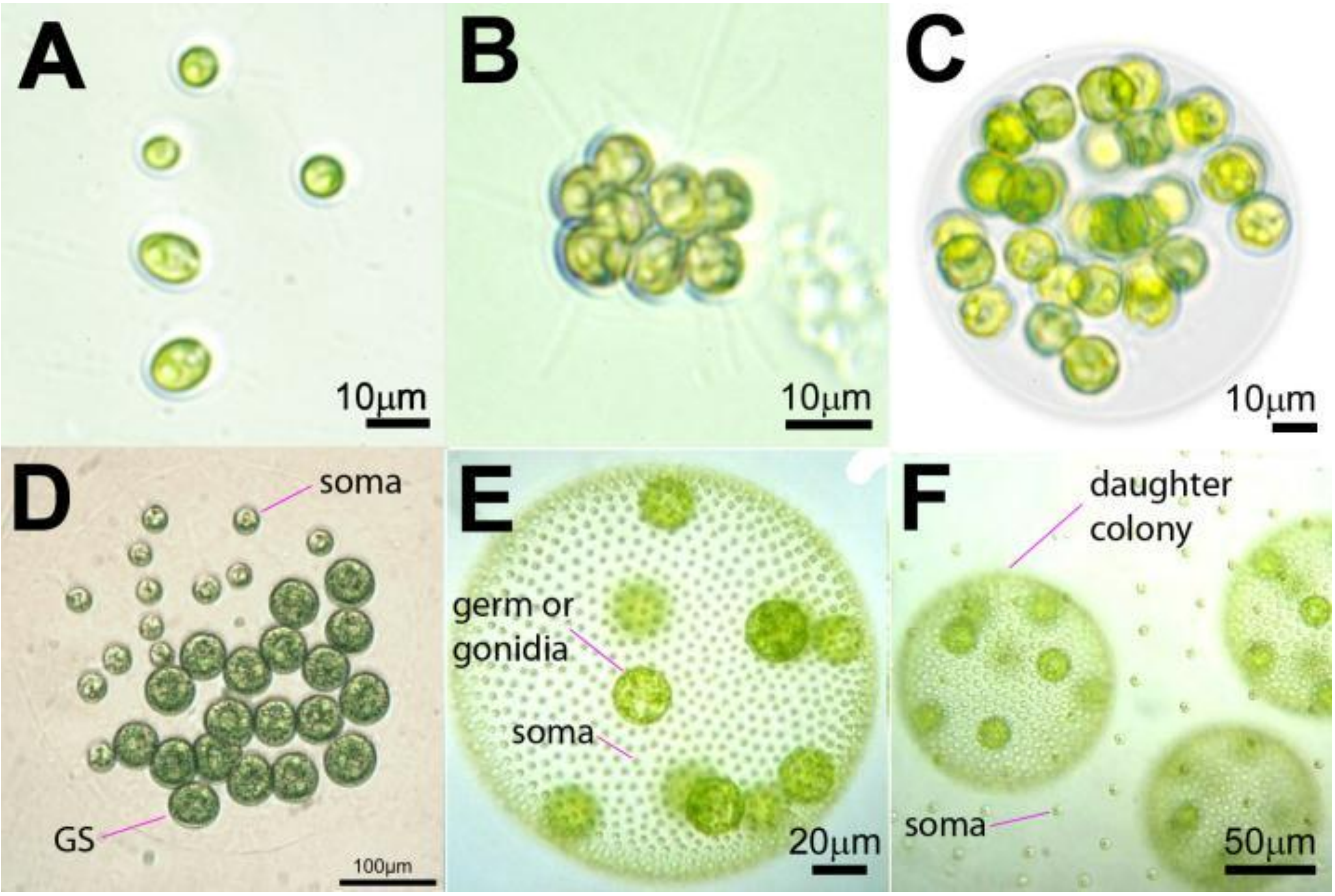

Figure 1. Examples of asexual haploid forms of volvocine species varying in cell number, colony volume, G-S DOL, and proportion of somatic S cells. A: *Chlamydomonas reinhardtii*, a unicell; B: *Gonium pectorale*, a flat or slightly curved sheet of 8-16 undifferentiated GS cells in a single layer; C: *Eudorina elegans*, a spherical colony of up to 64 GS cells; D: *Pleodorina starrii*, a spherical colony with GS cells and terminally differentiated S cells; E & F: *Volvox carteri*, juvenile and adult, respectively – with several thousands of S cells and up to 16 G cells called gonidia. Panel F is just a portion of an adult colony showing small S cells on the outside of the sphere and daughter colonies (with their own G and S cells) on the inside ready to hatch.

Although the third lineage gave rise to the fully differentiated *Volvox* species such as *Volvox carteri*, which develops germ/soma division upon gonidial maturation, it also gave rise to *Pleodorina*, which undergoes division at a later stage in the life-cycle from somatic cells, resembling how unicellular volvocine members asexually reproduce (Nishii and Miller, 2010).

Amongst the volvocines some organisms either possess key traits of multicellular complexity or are lacking in certain features - both conditions can provide useful insights. The genome sequences of *Chlamydomonas reinhardtii* and *Volvox carteri* were recently compiled (Merchant *et al*., 2007; Prochnick *et al*., 2010). However, sequencing of one of the simplest relatives and one of the more complex volvocines does not provide sufficient detail as multicellularity arose in the volvocines in a step-wise fashion. Further genome sequencing of key organisms is hoped to provide clarity into the genetic and genomic underpinnings of certain major developments. The organisms *Pleodorina starrii*, *Gonium pectorale*, *Astrephomene gubernaculifera* and *Tetrabaena socialis* have thus been selected for genome sequencing. *Pleodorina starrii* was selected as it possess only partial GS-DOL and comparison between the genome of *P. starrii* and in particular *V. carteri* may identify genetic differences involved in the developed of complete GS-DOL. *Gonium pectorale* forms a multicellular colonial organism, with a cell wall that is transformed into an extracellular matrix (ECM) with some cells possessing rotated basal bodies. *Gonium* does not possess: GS-DOL; complete inversion of the embryo; anterior-to-posterior polarity; or other features found in the larger volvocines and is therefore important for investigating the development of these early traits. *Astrephomene* appears to have developed partial GS-DOL independently from other larger and more complex volvocines. It is unclear if this trait is symplesiomorphic (derived from shared ancestry) or was derived convergently (homoplasy). The genus *Tetrabaena* represents one of the simplest multicellular forms within the volvocines as it possesses a transformed cell wall, but is without basal body rotation, embryonic inversion, incomplete cytokinesis or organismal polarity. Uncovering the genetic and genomic basis for these differences will contribute greatly to our understanding of multicellularity evolution.

To investigate the molecular basis for the transition to multicellularity in the volvocines, a collaborative project between the Universities of Arizona, Witwatersrand and Tokyo, and Kansas State University has been developed. The aim is to sequence the complete genomes of key members like *Pleodorina starrii*, *Gonium pectorale*, *Astrephomene gubernaculifera* and *Tetrabaena socialis* with a combination of ABI 5500XL, Illumina and 454 platforms. Sequencing will be performed at the Agricultural Research Council - Onderstepoort Veterinary Institute (Illumina) and at the University of Stellenbosch (ABI). The advances in sequencing technology now allow for a rapid and cost effective means for sequencing whole genomes. These advances will be applied to the volvocine algae, which represent perhaps the best lineage for investigating one of the most critical developments in the history of life.

References

Herron MD & Michod R (2008) Evolution of complexity in the volvocine algae: transitions in individuality through Darwin's eye. *Evolution* 62(2): 436-451.

Herron MD, Hackett JD, Aylward FO & Michod RE (2009) Triassic origin and early radiation of multicellular volvocine algae. *PNAS* 106(9): 3254-3258.

Kirk D (2005) A twelve-step program for evolving multicellularity and a division of labor. *Bioessays* 27(3): 299-310.

Merchant SS *et al*. (2007) The *Chlamydomonas* genome reveals the evolution of key animal and plant functions. *Science* 318(5848): 245-250.

Nishii I & Miller D (2010) Volvox: Simple steps to developmental complexity? *Current Opinions in Plant Biology* 13(6): 645-653.

Prochnick SE *et al*. (2010) Genomic analysis of organismal complexity in the multicellular green-alga *Volvox carteri*. *Science* 329(5988): 223-226.

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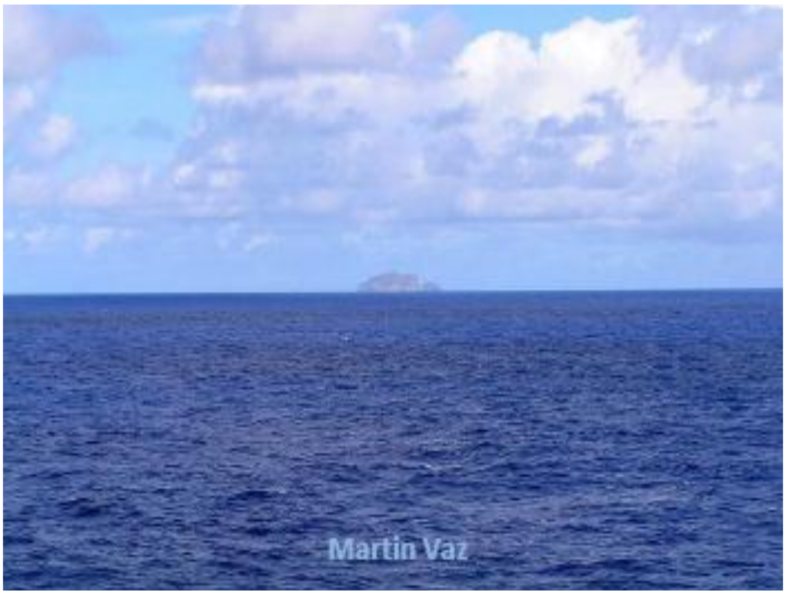
In the middle of the South Atlantic, without GPS, VHS or Radar

How Spotted Beans, Elephant Trunks and Velvet Sleeves can serve as navigational tools

Some 740 nautical miles east of Brazil, dusk was fast approaching on this 28th of June. The ocean sailors were racing for the Cape of Good Hope. The fleet of eight ships, all state of the art, was still in a tight formation and had just passed the volcanic island of Trindade. Before darkness would set in they would just be able to detect the sister island of Martin Vaz on the horizon. Weather permitting, this would be the last sightings of land for the next month. Steering south east, the ships were entering the emptiest ocean in the world, the South Atlantic.



The island of Martin Vaz (image: birdholidays.co.uk).

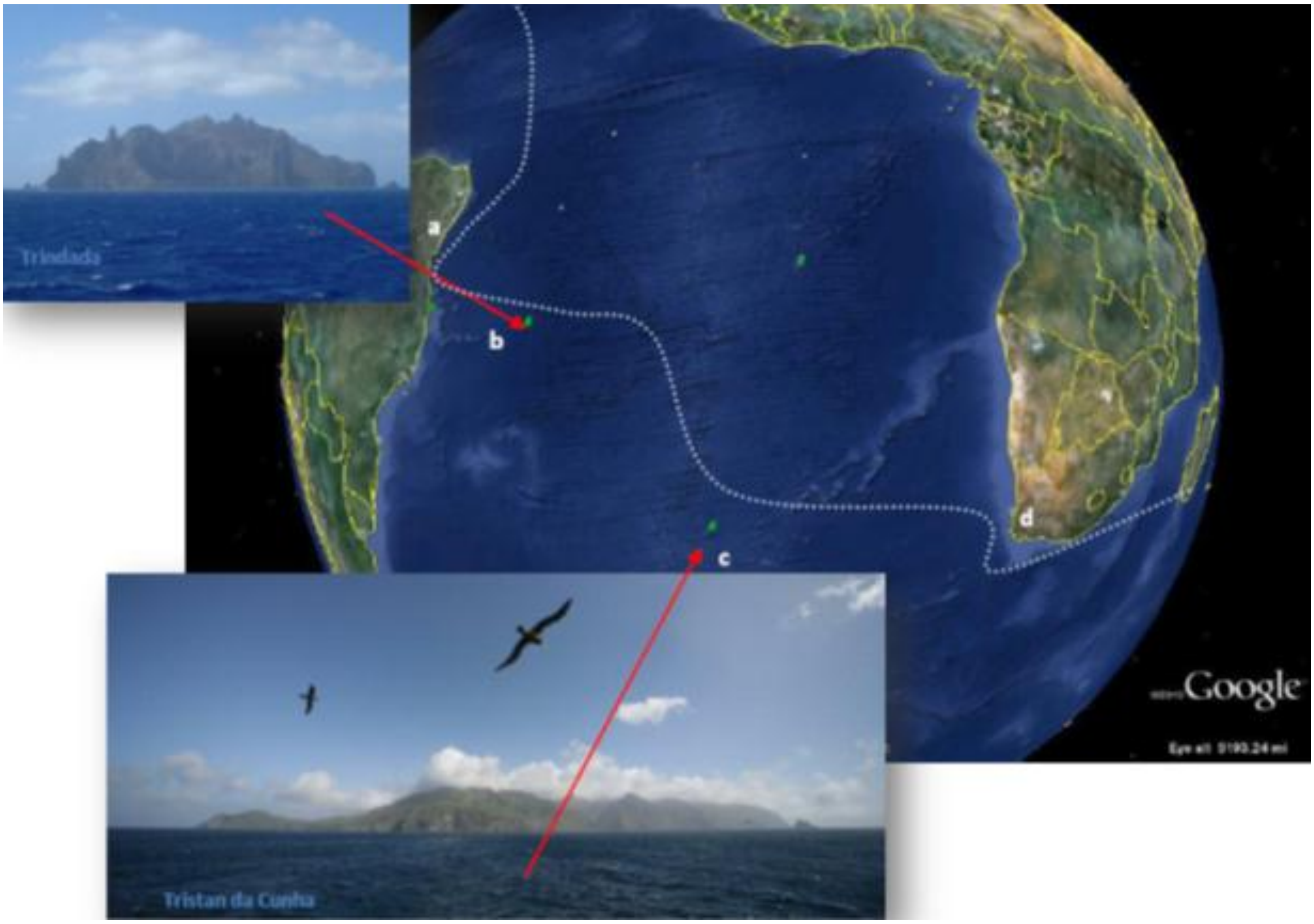
Imagine yourself on board, heading for mid ocean. You are not concerned. You recognize the island of Martin Vaz as a speck on your computer screen with a dotted line towards South Africa, your point of destination. Departure from Europe seems long ago, but so far it has been exciting, from being silently becalmed to howling storm conditions, from waters as glass to endless troths and foaming crests of waves. The wild region ahead promises much more, but your Global Positioning System (GPS) precisely pinpoints your coordinates in decimal seconds of latitude/longitude, to within a few meters. Even in bad weather, with no visibility and poor satellite reception, your radar gives your relative position. You have confidently punched in your next waypoints, micro-waved your meal and have just received an email that you are about to read by the overhead light in your comfortable bunk bed.

Now, imagine that your generator has stopped working. In fact, all your electrical power has vanished. Even your backup battery and your emergency beacon have been depleted. It's dark! You have no GPS, no radio, no radar, no smart phone, no computer, and you have just entered the loneliest place on earth! Could you survive, let alone make Cape of Good Hope some 3000 miles away?

That June 28th none of the eight ships had electrical power. How did these sailors manage and survive? To find the answer we need to go back in time to the 16th century because we know from records that this fleet passing Martin Vaz was the Dutch fleet of the Admirals Neck and van Warwijck sailing to the Indies in 1598. Luckily the navigators on each of these ships kept detailed ship journals. Let us consult three of those here, recorded by the Dutchmen Pietersz, Jolinck and Ceulen to get a glimpse of how they managed to survive without electrical power.

The three navigators were all 'mates', second in command, on board the sailing ships *Amsterdam*, *Vriesland* and *Mauritius* respectively[1]. Their skills sharply contrast against our 21st century electronic background. Not only did they not have GPS and other gadgets, they had no viable method of determining longitude. Similar to other ancient mariners of the 16th and 17th century, they were asked to navigate their ships safely around South Africa to the lucrative trade in India, the Indies and far beyond.

[1] The fleet of van Neck and Warwijck departed the Netherlands 1 May, 1598: the Mauritius, Holland and Gelderland (each 400 ton), Utrecht (260 t), Zeeland (360 t), Amsterdam (500 t), Vriesland (240 t), Overijssel (90 t).



The route taken from Europe to the Indies (images: Google; confluence.org; birdholidays.co.uk).

Navigation in the South Atlantic had started in the summer of 1488 when the Portuguese explorer Bartholomew Diaz had rounded the bottom of Africa. Over the next century and aided by a monopoly that granted them half the world[2], the Portuguese discovered and named many islands in the South Atlantic. It is a proper homage to these brave navigators that many of these islands still carry the same names even today. After each voyage the confidential sailing instructions were refined and only after the Dutchman Jan Huygen van Linschoten was able to publish these in his '*Itinerario*', did the rest of the world have an insight into these pilot guides[3].

From Europe, ships were to sail to the coast of Brazil, then sail south along the coast to pick up the counterclockwise ocean current (a) and steer east for the barren rocks of Trinidade and Martin Vaz some 740 nautical miles from the coast of Brazil (b). Continuing in a SE direction towards the Mid South Atlantic they were to turn due south once there. Eventually they would cross the Tropic

[2] This was the Treaty of Tordesillas that gave Spain one half and Portugal the other half of the known world. Signed into law in 1494 by the Spanish pope Alexander VI who was the second pope of the Borgia family. The world was divided 370 leagues to the west of Cape Verde Islands. As a consequence today, all of Central and Latin America speaks Spanish, except Brazil where Portuguese is spoken because its most eastern point can be found on the Portuguese side of the Tordesillas equation.

[3] The Dutchman Jan Huygen van Linschoten (1563-1611), was the first to lift the veil of secrecy of the Portuguese sailing instruction, in a series of publications based on his experiences in employ of the Portuguese that began with his outward journey of 1583. By this time the Netherlands was in war with Spain, which had annexed the Portuguese crown in 1580 assuming both halves of the Tordedillas pie. Van Linschoten's Nautical Directory, partly based on the 1550 'Roteiro' by Diogo Afonso pilot of the Portuguese crown, was first published in 1595. From that point on, in Dutch or in translation, the 'Linschoten Itinerario 'were found on board all ships to the Indies for a long time to come, and the sailing instructions were often quoted in ship journals.

'Rabos Forcados' - *Frigate* Birds (*Fregata minor*): 85-105 Length, 205-230 Wingspan, 1-1.6 kg (image: camacdonald.com).

'Small white seagulls'. Broad Billed Prions (*Pachyptila vittata*) which only breed on Tristan da Cunha; 28 cm Length, 61 cm Wingspan, 170-235 grams (image: pelagicodyssey.ca).

of Capricorn. This latitude was determined with some accuracy with the aid of the sun and stars and their on board instruments: the quadrant, backstaff, and astrolabe together with their declination tables[4]. Once there, in the loneliest place on earth, on vast waves under enormous skies, we can read that Pietersz, Jolink and Ceulen indeed headed in a S to SSE direction in a safe, empty ocean 'channel' towards the islands Tristan da Cunha (c) and the latitude of Cape of Good Hope (d).

Coming from the north, the 1598 fleet had been approaching the most remote island group in the world, some 2100 miles from Argentina, 2000 miles from Antarctica and 1750 miles from the coast of Africa (Its position is 37˚04' Lat S. 12˚19'W.). Heading south, without longitude, how then did these ancient mariners know whether their ships were east, west or on top of these dangerous rocky shores of Tristan da Chunha[5]?

We are fortunate indeed that not just 'our' 1598 journals, but so many other late 16th and early 17th century Dutch ship journals have survived. Together, these remarkable records written by the mate on board, who was tasked to keep such logs, give us an insight of their navigational skills. They took into account compass heading, speed, leeway and drift. This 'dead reckoning' position was combined with a fairly accurate latitude determination, through sun and stars observations. Even the compass variation was an aid[6]. But, there was much more. The smallest details in their environment mattered to them and were recorded with precision. Not in the least because they knew that their journals may benefit their fellow mates on the next fleet[7].

Let's look over the shoulder of our three mates. On July 17th 1598, Jabob Pietersz (mate on the ship Amsterdam)[8] noted in his journal:

"I reckon to be NW or N of the Islands of Tristan da Cunha at 32˚55 S … we saw 2 big birds with hanging tails that the Portuguese call Rabos Forcados and a few small white seagulls"[9]

Pietersz was some 350 miles to the NW of Tristan da Cunha and may well he had observed two Frigate Birds and the small white Broad Billed Prions which only breed on these islands[10]. But,

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4 Establishing latitude through the use of a quadrant, cross staff or astrolabe was remarkably accurate to within minutes of a degree of arc. (Only after the invention of the sextant in 18th century were mariners able to calculate with higher precision).

5 Longitude remained elusive until the invention of a reliable time piece in the mid 18th century. At the end of the 16th and 17th century a linear relation was pursued between the earth axis and an assumed magnetic axis, i.e. between True and Magnetic bearings.

6 Today we know that the earth's nonlinear magnetic field swerves around the globe and even moves over time. But the 16th century sailor had one benefit that we no longer have today: At the very bottom of the African Continent, True North coincided with Compass North. The Portuguese called this point the Cape of the Needles, Cabo da Agulhas. Sailing from the mid Atlantic towards the cape the variation would lessen thus affording a longitudinal position. Even out of sight of land, ships knew when to steer E-NE towards the Indies. Today Cape Agulhas as 25˚ W variation.

7 Jacob Pietersz, mate on the ship Amsterdam compared in his journal on the 26th Juli 1598 his findings on compass variations around Cape of Good Hope with those in the 1595 journal of Claes Janszoon mate on the Mauritius [LV Tweede Deel II, p133). He would have fully expected that his own journal would in turn serve a fellow mate on the next voyage. This constant updating also resulted in Dutch cartography became the best at the time.

8 Jacob Pietersz was mate on the Amsterdam until Januari 4th 1599, there after he was first mate and then skipper on the Utrecht. Jolinck replace Pietersz on the Amsterdam. [LV Tweed Deel I CIV]

9 LV Tweede Schipvaart deel II, p 131. Jabob Pietersz the mate of the Vriesland . ***17** item den 17en dyto nae mijn gissing nw wel zon n.van den eylanden van Tristan de Chuha op ZB 31 gr 55 of 32 m...en wij sagen 2 groote vogelen met hangend steerten van de Portugesen Rabos Forcados genaempt.. een weinich ontrent 2 oft 3 handvol croos gelijkc snaren met ziet sulk tuich wel in den Canael van Engelant"*

10 Blight, Whoeler 2008 http://www.marineornithology.org/PDF/36_2/36_2_191.pdf

eyes were not just towards the sky. All things mattered, and he continued:

"... and [we] saw a little seaweed, about 2 or 3 handfuls; like strings similar to the English Channel".

These two observations exemplify how the ancient mariners were in constant tune with their environment. They literally lived in and among their natural environment where their entire ship could fit in a single wave valley, where every half hour speed, direction and drift were observed and calculated, where sun rise, noon and sunset were heightened navigation periods during the day and where all night the stars were meaningful. In an empty ocean 1 or 2 birds and a handful of seaweed mattered.

Equally Pietersz' journal illustrates his apparent comfort with a lack of precision in such descriptions. This ease of data collection we observe in many journals appear to have been the result of a long established confidence that such pieces would help a later puzzle. Equally, such general observations show that he and his crew had been on an alert for a more distinctive natural phenomenon that served as a navigational beacon. Which unequivocal navigational tracks had they hoped to find?

Mate Pietersz' reference may well have been the European *Chorda filum* or possibly *Himanthalia Elongate* found in the English Channel, that would look from a distance like a moving deck somewhat like the *Macrocystis pyrifera* found in the South Atlantic (images: algaebase.org).

Himanthalia elongata

Chorda Filum

Macrocystis pyrifera

Closing in on Tristan da Cunha, Pietersz had consulted his sailing instructions and Linschoten's Itinerario[11]:

"To know if you are close to the islands, you will see the following signs namely:

Spotting a number of birds flying together meant that the sailors where close to the Islands (image: pelagicodyssey.ca).

IF you see some birds, five and the five flying together, then you are getting close [to the islands]. From that point a number of birds will follow you, the Portuguese call them 'Feigions' tinted with white and black spots, so they are easily recognizable. At that point the islands are directly south of you."[12]

Thus, on July 18th 1598, Pietersz simply knew he was in the proximity of Tristan da Cunha when he wrote:

"18. Early afternoon; Sunday; we saw small spotted birds ..."

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[11] In his journal, Pietersz refers to the Linschoten sailing instructions on the 26th of July158 [LV Tweede Deel II p 132]

[12] *"Om te weten oft ghy dicht by de Eylanden zijt, soo sult ghy 't by dese teyckenen comen te weten, als ghy sommighe Voghelen siet, vijf ende vijf te samen vlieghen, so ismen daer by, ende van daen voor aen sullen u volghen etlicke Voghelen van de Portugesen Feigions ghenaemt, zijn van witte ende swarte vlecken beplackt, so datse hier om seer goet te kennen zijn; met dese Eylanden z. ende n. over een zijnde, soo sult ghy in de Zee vinden dryven, ende genaemt vande Portugesen Sargasso gheheeten, is by naest ghelijck het Wier datmen by Wieringhen in Hollandt vint."*

Turtle Dove/Starling" may well have been any of five South Atlantic Storm Petrels (*Hydrobatidae Oceanitidae*) that may be found in the region. The earliest sailors did not need a new vocabulary for species in distant oceans and lands. Their fellow mates, experienced sailors all, easily recognized their descriptions having the same reference points. The small birds referenced by Jolinck are the common European 'Turtle Dove' (*Streptopelia turtur:* 24-29 cm length; 47-55 cm wingspan; 85-170 gram) and by Ceulen as the common European starling (*Sturmus vulgaris*: 20-23 L; 31-40 W; 60-96 gr). Today we do know that the Grey-Backed Storm Petrel does not stray far from north of Tristan da Cunha, that the White Faced Storm Petrel (*Pelagodroma marina*) breeds on these islands, and that the Black-Storm Petrel has a much wider distribution. Difficult to distinguish from a White Bellied Storm Petrel (*Fregetta grallaria*) or a Grey Backed Storm Petrel (*Oceanites nereis*: 16-19 cm L; 39 cm W; 34 gr) all of the storm petrels would easily fit the description of a small European Turtle Dove or Starling in the 16th century.

Even four hundred years later Storm Petrels remain enigmatic. Strictly found in open seas and difficult to detect, hard to distinguish, nocturnal when visiting their nests in remote locations that are only partially known, all these factors ensure that we still have much to learn. These elusive Storm Petrels are only observed close to inhabited shores when a storm has blown them off course earning their name as they have signaled through the ages that a storm often shortly follows their sightings (image: 10000birds.com).

The brevity understates the importance, until we remember that on board a 16th-17th century vessel paper, ink, and time were scarce commodities. Each journal entry was critical. A single sentence spoke volumes[13].

Pietersz' entry for the 18th of July was monumental and he was not the only one that deemed the sighting important. In the next few days July 19th and the 21st in the wake of the *Amsterdam*, but over the horizon, Jolinck (mate on board the ship *Vriesland*) and Ceulen (mate on the *Mauritius)* also made careful notes in their journals as the latter had just estimated to be just some 480 nautical miles NNW of Tristan da Cunha[14].

" 19. the same day I saw 3 or 4 small grey birds sitting on the water as big as Turtle Doves and also 2 or 3 spotted birds with white and grey spots, that the Portuguese called 'feionis' and are very recognizable."[15]

"21. Tuesday [July 1598]. We saw a mix of small birds looking like starlings and big birds with black and white spots. We also saw big black ravens with white beaks, that the Portuguese write is a clear sign of being close to the islands Tristan da Cunha."[16]

Even though these small birds were difficult to distinguish from each other, they fit into the navigation equation as 'starlings' and 'turtle doves' because they served as a useful comparison to the much bigger Cape Petrel, which in turn were humbled in size compared to an albatross or Giant Northern Petrel. Cape Petrels became the navigation beacon to look for not just because they loved to follow ships, but because there can be no doubt to their identity whether described as a 'White-Grey-spotted bird' by the Dutch, or as a 'Pickled Bean Bird' by the Portuguese.

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[13] There are many such examples throughout the journals in the 16th and 17th century. For example an entry 11 years later for the 15th of June 1609 from Juet second mate on board the Half Moon. "we had a great storm and spent overboard our fore-masts." One sentence describing a night of terror and survival. Ink was precious.

[14] One degree error in latitude calculation represents 60 nautical miles. On a pitching deck a half degree of arc was not uncommon.

[15] Journal Heyndrick Dirrecksen Jolinck on board the Vriesland until Januari 4th 1599 when took position on the Amsterdam: " *desin dito sach ik 3 ofte 4 kleijne voegelges graue siende op het watter sitten ende waren van een grootе als een tortelduive end enoch 2 ofte 3 van die bonte voegeltgies met witte ende grauwe plecken die de Portugesen feionis noemen ende sijn seer kenbaer"* Linschoten V. Tweede, Deel V, p 34-36

[16] *"21 Dinstaaechs. wijs sagen vrij een deel vogejelne als starren end bonte vogelen met suart en witte placken .. wij sagen oock van die grote svarte ravenmet witte becken daer die poortegisen schrijven een teiken te sijn van dicht bij die eilanden van Crijstan die cunno tee wesen als men die eerst gewaer wort ick sache oock den 21 dach al ."*. [Tweede Schipvaert der Nederlanders naar Oost Indie, deel II, p 57 J.Keunig,1940 nijhoff].

Daption capensis, the Cape Pigeon. The Portuguese named the bird after a common sailor's food item: 'feijão carioca' (Spanish: frijol pinto) meaning "speckled beans". Also called 'Cape Petrel': 34-42 cm Length, wingspan of 80-90 cm; 440 grams. Straying not far North of Tristan da Cunha in winter and spring, it is easily recognizable (Image: wildimages-phototours.com).

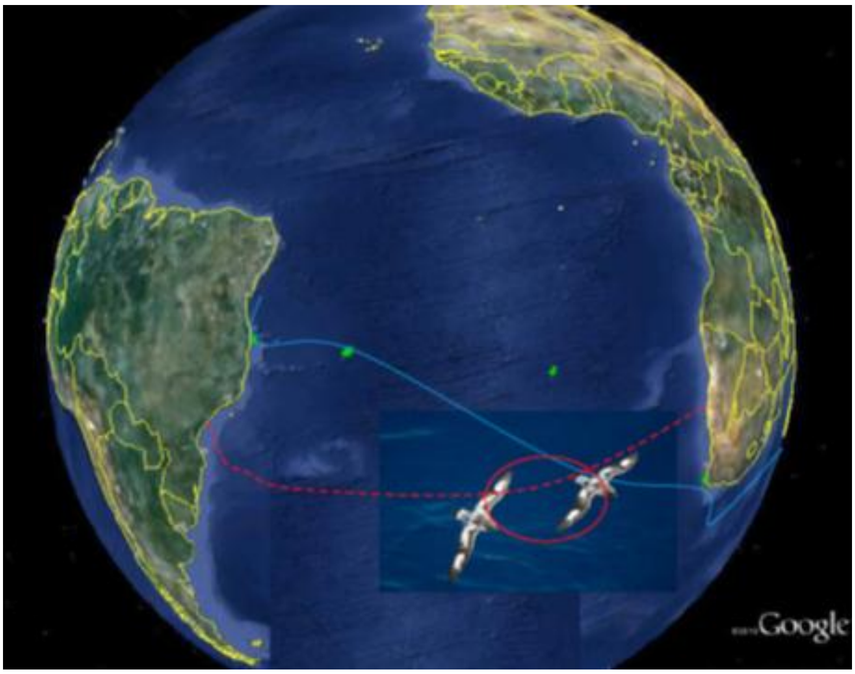
Cape Petrels are much bigger than Storm Petrels, but 'small spotted birds' compared to the Wondering Albatross, (110-135 cm L; 250-360 cm W; 6-11 kg) or the Tristan native Sooty Albatross (84-89 cm L; 203 cm W; 3 Kg) (image: manchesterbirding.com).

or the black Northern Giant Petrel (80-95 L, 152-210 Wingspoan; 3.5 kg) that can be found just north or Tristan da Cunha (image: www.kentos.org.uk).

material if one consistently aims towards rounding South Africa along a given South Easterly course. When Pietersz, Jolinck and Ceulen first observed Cape Petrels, the last land they had seen (the island group of Trindade and Martin Vaz), had been some 1800 miles sailing back to the North West and 18 days earlier. For them Cape Petrels were a welcome and important notification that the islands of Tristan da Cunha were not far. And if the islands were not far, the 'Spotted Bean Bird' also afforded a broad longitudinal position in relation to the Cape of Good Hope.

The 16th-17th century journals refer to other birds, again perhaps as an exercise in filling a future puzzle, but after sighting the two distinctive Cape Petrel and/or White Chinned Petrels, in combination with a latitude calculation, we can read in most ships journals a course alteration from South East to due East and Cape of Good Hope. They had arrived in familiar waters.

Today we do know that the Cape Petrel has a circumpolar distribution, with a habitat around breeding islands[17]. Four hundred years ago the ancient mariner did not yet know this and assumed a certain distribution 'radius' around land and the islands such as Tristan da Cunha. Later observations by sailors, such as in 1887, determined that the Cape Petrel could be found mid ocean generally south of Latitude35˚S or higher[18]. Thus while we know today that Cape Petrel sightings can only represent an approximate 'Latitude line' that curves north along the coasts of the continents, the difference in perception is and was not

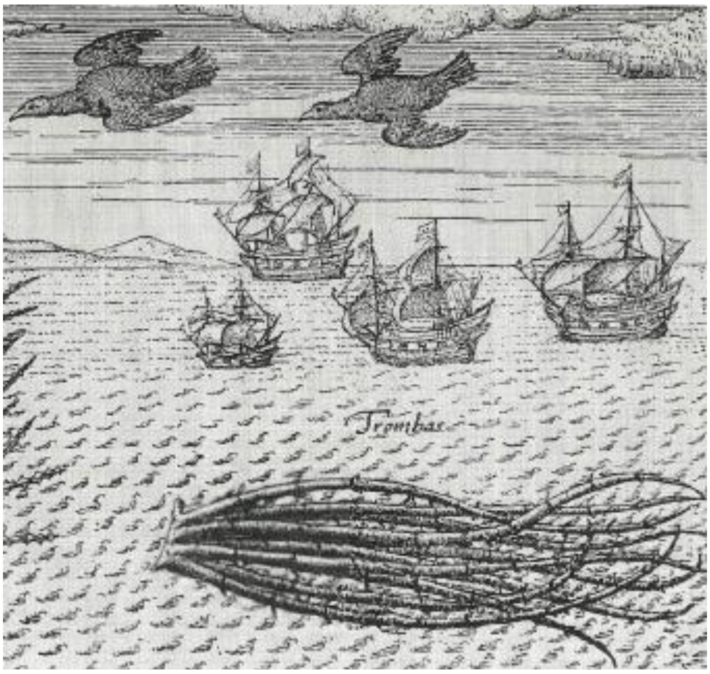


The Cape Petrel has a circumpolar distribution (images: Google).

[17] S. Marchant & P.J. Higgens (1990) Handbook of Australian, New Zealand & Antarctic Birds. Vol. I p 391-402.

[18] In 1887 bird watchers could read " the well-known Cape Pigeon (*Daption capensis*) is usually met with in the Atlantic near Latitude 35˚S.,or 'off the River Plate as it is termed in the vernacular" The Auk Journal of Ornithology, Volume IV, Foster New York, 1887.

The 'black bird with the white beak' that Ceulen observed in 1598 can only be the distinctive White Chinned Petrel (*Procellaria aequinoctialis*: 51-58 cm length; 134-147 cm; 1390-1280 gr). In the South Atlantic, this distinctive pelagic bird offered a confirming latitude range similar to the Cape Petrel of 30-35 ˚S. An even more consistent beacon as it remains year-long on these latitudes. During its breeding season it can be found especially around its nests such as on Tristan da Cunha which lies some 420 miles further south of this 'latitude line' 30˚. In 16th century navigational terms such sightings represented approximately 4 days sailing from danger (image: galleryofbirds.com).



Depiction of a Dutch Fleet (1595) with birds and Trombas (Published in 1598. 'Eerste Shipvaart Cornelis Houtman'. Lins. VII, vol I p.208).

The above illustration of an earlier fleet demonstrates that mates paid close attention to the sky and the water surface, because their experience and sailing instructions assured them that their environment would soon offer another distinctive beacon. Having observed Cape Petrels, and in the proximity of Tristan da Cunha they would start looking for the most easily recognizable seaweed in the world. The Portuguese had labeled these "Trombas", elephant trunks, at once showing their early global reference world. The Dutch adopted the Portuguese name but always described its meaning as a '*bazuin* with roots' referring to the ancient musical instruments easily translated in English as 'trumpets'.

Linschoten's sailing instructions informed sailors that they might first see some 'Trombas' among other seaweed and that these early Trombas could disappear possibly for 600 miles. However, sailing on the latitude of the Cape of Good Hope, these 'Trombas' would eventually reappear in quantity and at that point it was a sure sign of being close to the Cape of Good Hope:

"When you find the Trombas you are 120-160 miles of the Cape. These weeds are longish and look almost like big trumpets."[19]

There is no doubt that these 'Trombas' are today's kelp '*Ecklonia maxima*', also called 'sea bamboo'. Ideal as a navigational beacon, indigenous only to South African waters, these 'navigation buoys' were mentioned in journals for decades.

Our mates Ceulen and Jolinck would see them first on the 27th of July 1598[20],

"… we twice saw Trombas those are long things of about 2 fathoms as thick as an arm …"

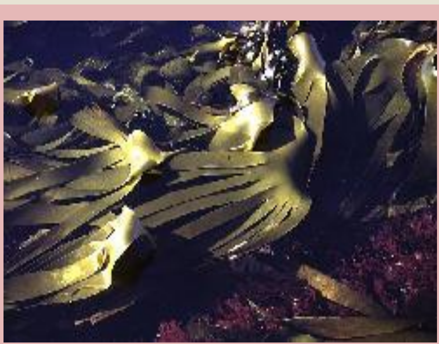
"After the night I saw Trombas floating. Those are long things like 'basuine' with roots and I was asked by the merchant for my estimated position ... which after calculating the variation was 160 miles [of Cape of Good Hope]."

[19] *"alsmen dese Trombas vint, soo ismen maer 30 ofte 40 mylen vande Cabo de Bona Esperança; Dese Riet struijcken zijn lanckachtigh, by naest van fatsoen als Basuynen."* The Dutch mile of the time equates to app. 4 nautical miles today.

[20] LV Tweede Schipvaert der Nederlanders naar Oost Indie, deel II, p 57 ; "27. Den 27 [juni 1598] geschoten 34-50 wijs sagen trombes tot 2 mael toe drijven dat sijn lange dingen van een vaem ofte 2 ende soe dick als sijn arm omtrent "Deel V p 37 J.Keunig,1940 nijhoff cornelis jansz Ceulen.

A 'bazuin', the ancient horn trompet (images: algaebase.org; pc-nijkerk.nl).

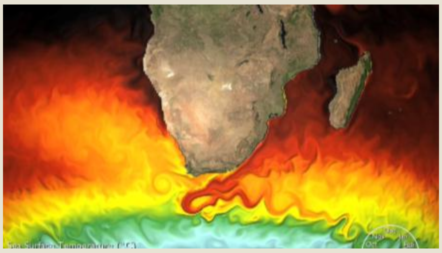
TROMBAS. *Ecklonia maxima*, grows only on South Africa's west and south coast. We know that it does not have 'roots' but that microscopic male and female gametophytes produce male and female gametes that fuse to produce a fertilized zygote. This tiny beginning of the bamboo kelp produces first a 'hold fast', an 'anchor' that grows to looks like roots. Stipe and primary blades follow. *Ecklonia maxima* absorbs nutrients across its entire surface and benefits from the nutrient-rich ocean up-swells produced by the Benguela and Agulhas currents. These 'Trombas' can grow up to a foot per day in ideal conditions. Their hollow stipes and apex contain a self-produced gas that acts as a floating device allowing them to reach for the ocean surface and towards sunlight. In quantity they form a canopy that allows them to outcompete other seaweeds by dominating the light resource growing up to 30 feet in length and can live for over 5-6 years. It appears that they are sensitive to water temperature are not known to grow well in water below 18 degrees Celsius, which around South Africa are waters quickly beyond 30 feet deep and thus they are only found in shallow coastal waters. We know that they don't voluntarily give up their spots, but succumb to deep ocean currents and wave action that 'uproot' the kelp. Their photosynthesis continues even when floating.



Laminaria pallida in its natural habitat (image: Gavin W. Maneveldt)

There are other kelp in South African waters which grow in deeper waters such as the split fan kelp *Laminaria pallida*, depicted in the 16th century publication of the above mentioned journals. But, it was the *Ecklonia maxima* that represented the recognizable longitudinal 'buoys' in the water. These TROMBAS remain enigmatic even four centuries after the ancient mariners regarded them as important. There is still much to learn regarding the distribution and habitat of *E. maxima*.

Laminaria pallida depicted in the early journals (1595 fleet: Eerste Shipvaart Cornelis Houtman'. Lins. VII, vol I p.7).



To a great extent this has to do with the complexity of the waters west of South Africa. A warmer Indian Ocean spills into the South Atlantic through the Agulhas current meeting counter clockwise forces of the South Atlantic gyre and Benguela currents. Different ocean depths, wind forces, upper and lower currents and upwelling can be found close to shore. Eddies, rings, retro-flows and counter currents are offshore. Combined with seasonal differences the innumerable variables help ensure that for this important resource there is enough to research for generations to come (image: noaanews.noaa.gov).

So important was the kelp that not just mates, but also skippers would record them in their own journals. Staying on board the same 1598 fleet, Jolincks' own skipper, Jan Cornelisz May, and Rijer Corneliz of yet another ship of the fleet, the *Utrecht*, mentioned in their journals on the same day:

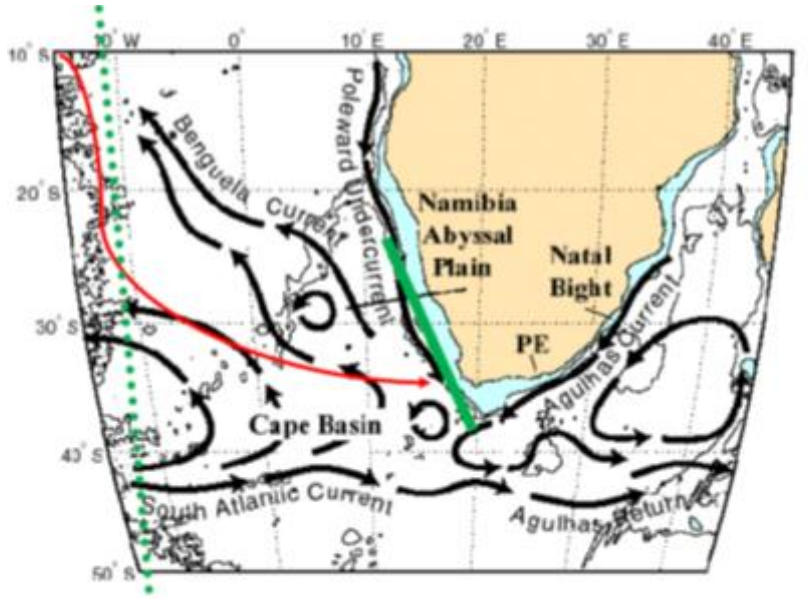
"… we saw some Trombas floating, of which it is said that it is a sure sign to be some 120-160 miles of Cabo da bona Speranse but we have seen them some 400-400 to the west already."[21]

"… took our course East and in the afternoon had height of 34 degrees and 56 minutes. In the evening we saw trombas floating of which the Portuguese write is a sign of Cabo de Bona Speransa."[22]

[21] 1598 Tweede Deel IV, p 126 . Journael Jan Cornelisz May, schipper Vriesland Den 27 [juli]. was die wijnt noort nort west ende waide seer stijf. Na die middach sagew ij eenige trombes drijven, hetwelck men seydt een seker teken te wesen van die Cape de bona Speranse 30 ofte 40 mijlen van lant, maer wij hebben se gesien wel 100 ofte 110 mijlen van het landt door die westelijke stroom die wij daer hadden.

[22] Op desen 27 hebben wij de windt gehadt van den westen noort westen ende nort westen met harde coelte. Onse cours genomen oost, des middachts de hochte gehadt van 34 graden 56 menuyten; tegen den avondt saghen wij trombas drijven daer de Poortegijsen af schrijfen teijkenen sein van de Cabo de Bona Speransa ..." 1598 Tweede schipvaart deel V Lin L, p 7 stuurman Reijer Conrelisz, p17.27 juli.

The next day Skipper Cornelz estimated to be some 120 miles from the Cape.



The old journals appear to give early empirical evidence that *E. maxima*'s maximum range is the longitude of Tristan da Cunha (image: wfdac.whoi.edu).

As was the case with birds, by continuously recording natural phenomena, a familiarity was created where pieces became over time a puzzle with distinct recognition points. In combination with other observations, Trombas were helpful. Sailing with an average speed of 4-5 knots, coming from the North West in an empty ocean the first handful of 'regular' seaweed had probably washed north from the islands of Tristan da Cunha as it was usually observed with stormy weather.

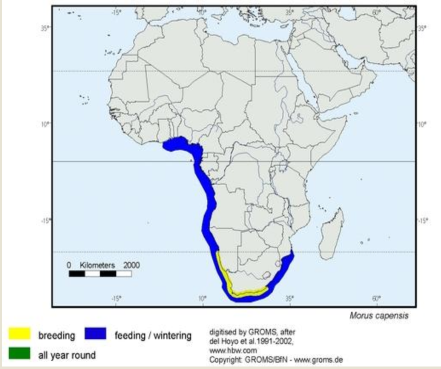
Without defining what 'regular seaweed' was, this was still meaningful as it made sailors search the water surface even more. A possible rare early observation of 'Trombas' in the proximity of the Tristan da Cunha may have followed. From journals we learn that this 'Tristan kelp' was smaller in length to the typical robust Trombas found closer to shore. As such, the old journals appear to give early empirical evidence that *E. maxima*'s maximum range is the longitude of Tristan da Cunha and that at this time the kelp is also at the end of its life span. Floated far from its natural habitat, sightings of *E. maxima* after Tristan da Cunha followed a trek of no sightings for another 600 miles. This would suggest that *E. maxima*'s buoyancy is insufficient for it to 'retro float' on the South Atlantic current back towards South Africa. Perhaps a calculation of distance traveled and the speed of water surface (by wind, currents and Coriolis Effect) would give us a time range for its floating life span.

For the ancient mariner, even rudimentary information of first and second sightings afforded two approximate longitudes. The first sighting of feeble Trombas [dotted green line] was followed by a second meridian when they saw the newly 'uprooted', long and vibrant Trombas, consistently seen between 120-160 miles off the coast [solid green line]. This latter 'longitudinal' line represented 1 to 2 days sailing before entering Table Bay and so close to a possible lee shore, the shout of "Trombas!" ensured a supreme alertness on board.

Whether the decision had earlier been reached to make landfall or to continue sailing around South Africa, after some 3 to 4 months sailing on sun and stars alone, most Dutch skippers preferred to put some land bearings under their equations. Again, South Africa offers a unique and most distinctive view: Table Mountain, which, provided there was clear visibility, would start appearing over the horizon soon after the sightings of robust Trombas.

Soon after the sighting of robust Trombas, Table Mountain would start to appear on the horizon (image: joshushund.com).

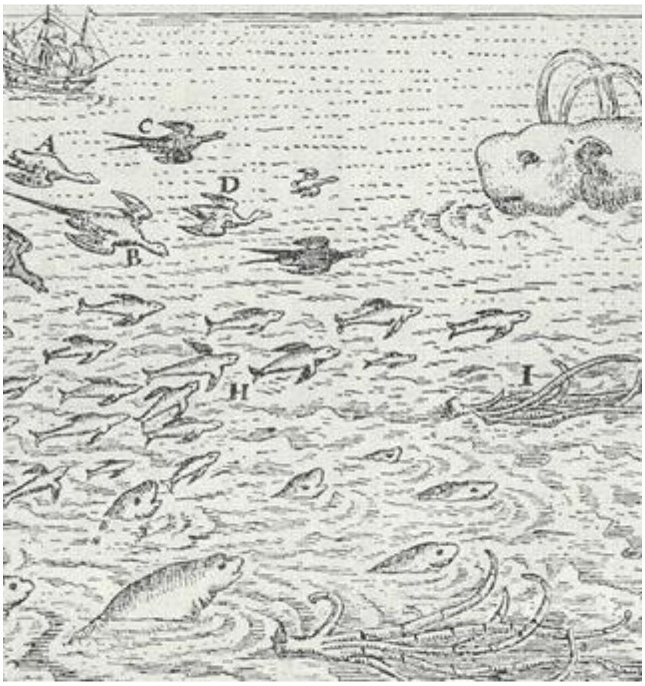
Velvet Sleeves, Mangas de Velludo, Jan van Gent, Cape Gannet (*Morus capensis*: 84-94 cm, 171-185 wingspan, 5-6 pounds) is not known to fly more than 100 km off the coast of South Africa (images: redbubble.com; planetofbirds.com).



And if there was no visibility, the ancient mariner had yet one more aid in his navigational arsenal that did not require sun or stars. We already have seen that for a natural phenomenon to be useful as a navigational tool, it had to be distinctive. The 'Spotted Bean Bird' and the 'Elephant Trunk kelp' served such purposes. Close to land nature offers its most beautiful beacon yet.

The Portuguese called them '*Mangas de Velludo'*, "Velvet Sleeves"[23]. Later the Dutch would refer to them as Jan van Gent and the English as Cape Gannet, but there never was any doubt about this large magnificent bird with its velvety feathers. Sighting the Cape Gannet meant landfall was imminent. Today we know that the Cape Gannet strays not further from the coast of South Africa than a day sailing for the 1598 fleet, a most perfect longitude for all those approaching Table Mountain.

The ancient mariner used *all* his senses and never felt to be in an 'empty' ocean. Looking up in the sky for clouds and other weather signs they would take on board knowledge of birds. The constant dead reckoning navigation required looking at the sea for their chip board with its knotted rope and they would at the same time observe seaweed, fish, mammals and the color of the water. They would smell and taste the salinity of the water, and would quite literally feel the different motion of waves in different seas and oceans. Their knowledge of sun and stars is enviable today. It was not a single phenomenon that was their focus; it was the totality of information where each puzzle piece mattered. They took action with the distinctive, and recorded the rest in the conviction that such information would make a difference to others.



All natural phenomena mattered in 16-17th century navigation as this rendering in a 1598 publication illustrates (Eerste Shipvaart Cornelis Houtman'. Lins. VII, vol I p.52).

Each of the 548 men on board the fleet of the eight ships in the winter of 1598 relied on such careful observations and not only 'survived' the passage to the Cape of Good Hope, they continued their 'race' to the other side of the world for another five months to arrive in the Indies in January 1599.

As a 21st century sailor, historian and guest on this planet, I found a new admiration for the skills of our forefathers. Depictions in 16th century publications of journals, which first appeared to me as whimsical fantasies by ignorant

[23] Linschoten Itinerario, Lin II (2e deel), p. 148.

engravers enthralled by distant adventures, became accurate illustrations that one could easily recognize, then and now.

Our technological environment of today is driving expectations that all answers can and should be obtained in nanoseconds with millimeter precision. The old ship journals never showed such hubris, but rather a wondrous desire to be part of a data collection process, and to be taught by nature. It is most impressive to see that the best scientific manifests today show similar spirit by including such honest, humble statements as … "not yet studied in detail", "poorly known", "assumed to be", and where some of the best descriptions in scientific publications rely on data obtained by amateurs sometimes decades, or even centuries ago.

Perhaps the way Jolinck, Ceulens, Reijers and their skippers knew to be an integral part of their total natural environment can inspire all of us today. A call to arms for sailors, amateur bird watchers and experts alike, their contributions vital, perhaps only measured in the future. We have much to learn of what nature can tell us, some of which we are starting to forget. Preserving, observing and recording of our natural environment is important as it will lead to new lessons learned and old ones revived, so that we again can feel rich, mid ocean, with just speckled beans, elephant trunks and velvet sleeves.

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This journal entry, a footnote to the ship logs made by 16th century environmental experts, could not have been written without the counsel of the following imminent 21st century experts who patiently fielded my numerous ignorant questions. Their contribution is most appreciated; of course all errors are mine. Eduard van Breen ©

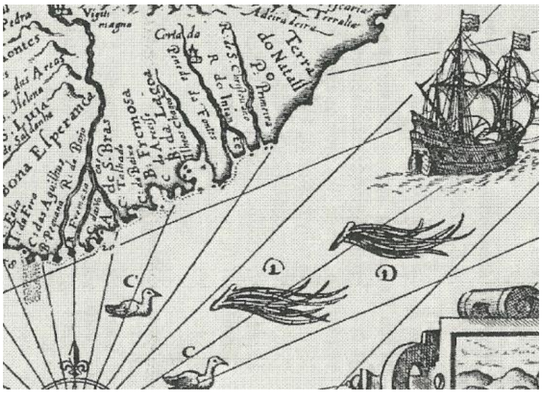
Prof **John J. Bolton**, Past President: International Physiological Society; Botany Department, University of Cape Town, South Africa.

Prof **Peter Ryan**, Department of Zoology, Percy Fitzpatrick Ornithological Institute (COE) University of Cape Town, South Africa.

Prof **Gavin W. Maneveldt,** Department of Biodiversity and Conservation Biology, University of the Western Cape South Africa.

Prof **Herre Stegenga**, National Herbarium of the Netherlands, Universiteit Leiden, the Netherlands.

A business career on four continents allowed **Eduard van Breen** to sail and navigate the same oceans and seas that carried the 16th and 17th century Dutch fleets from the Netherlands to the far corners of the world. Independent scholar, avid sailor and Fellow of the New Netherlands Museum, he currently 'sails' in the wake of a famous 17th century ship, the *Halve Maen*, which connects the early history of the Netherlands and the USA with the history of many other nations, forming a bond of mutual heritage, the subject of his lectures and upcoming book. He is a regular member of the volunteer crew that sails the replica of the 17th century square rigged ship, the *Half Moon*.



Kelp and gulls depicted in the early journals (1595 fleet: Eerste Shipvaart Cornelis Houtman'. Lins. VII, vol I p.7).

The fully operational replica of the 17th century square rigged ship, the *Half Moon* (image: www.halfmoon.mus.ny.us).

Conference Countdown

The next PSSA conference will be hosted by the University of the Western Cape under the chairmanship of Gavin W. Maneveldt. The conference is planned for January 2014. The venue is yet to be determined. Please keep an eye on the PSSA website.

Calendar of Events

Upcoming Conferences

1. 7th Southern Connection Conference. Dunedin, New Zealand, 21-25 January 2013. www.otago.ac.nz/V11-southern-connection/
2. XXIst International Seaweed Symposium. Nusa Dua, Bali, Indonesia, 21-26 April 2013. xxiseaweedsymposium.org
3. 10th International Phycological Congress. Orlando, Florida, USA 2013. www.intphycsoc.org/congresses.php
4. 5th International Society for Applied Phycology. Sydney, Australia, 2014. www.appliedphycologysoc.org/congresses.lasso
5. 15th International Conference on Harmful Algae. Gyeongnam, Republic of Korea, 29 Oct – 2 Nov 2012. omansea.org/news-and-events/conferences/23-conferences/104-15th-international-conference-on-harmful-algae.html
6. 16th International Conference on Harmful Algae. Wellington, New Zealand, September 2014. www.cawthron.org.nz/news/downloads/16th-icha-conference-bid-document.pdf