WEALTH FROM OCEANS FLAGSHIP
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Understanding the effects of marine debris on wildlife:

Year 2 progress report to Earthwatch Australia

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1 Overview

Marine debris poses a global threat to biodiversity of immense proportion. For instance, more than six million tons of fishing gear alone is lost in the ocean each year (Derraik, 2002). Despite this staggering amount of marine waste, fishing gear forms only a small percentage of the total volume of debris in the ocean, not even making the list of the top 10 most common items found during coastal clean-up operations (Ocean Conservancy, 2012). The impacts of this threat on biodiversity are both broad and deep. Marine debris has been reported to have direct impacts on invertebrates, fish, amphibians, birds, reptiles, and mammals (Good et al., 2010). These impacts are known to be a significant threat to the persistence of several threatened or endangered marine species, and likely to be affecting many others. For example, up to 40,000 fur seals are killed each year by entanglement in debris (Derraik, 2002) and entanglement and ingestion are major causes of population decline for some marine mammals. Finally, the impacts from debris in the marine environment are rapidly intensifying, as the volume of refuse humans release into marine systems is growing at an exponential rate.

The goal of our research in this project is to develop a national risk assessment for wildlife species that are affected by marine debris, addressing a topic (marine debris) that has been identified as a 'key threatening process' to wildlife in Australia. The project integrates field, modelling, genetic and biochemical marker approaches to understand the impact of marine debris on fauna at the national scale. One of the critical aspects of this work is that we collaborate and engage heavily with school groups to promote science education and learning through a timely and relevant topic that is part of the national science curriculum, fitting in with maths, chemistry, physics, biology, oceanography and other parts of the national curriculum.

This project seeks to answer four fundamental questions:

1) What are the sources, distribution, and ultimate fate of marine debris?
2) What is the exposure of marine wildlife to debris?
3) When wildlife are exposed to debris, what factors determine whether animals ingest or are entangled by debris?
4) What is the effect of ingestion or entanglement on marine wildlife populations?

In 2011, a three year partnership was entered into by Shell, Earthwatch Australia and CSIRO with a goal of addressing the four fundamental questions listed above.

Our overall aims are to:

- Carry out a nation-wide risk analysis completed for focal species across multiple taxa
- See increased science learning and uptake for individuals, schools, communities and industry across the country
- Inform policy decisions based upon sound science
- Develop a priority list of 'at risk' species based upon distribution, encounter and impact of debris

- Engage with industries contributing to the marine debris issue (with potential solution-based approaches to resolving the issue) and
- Contribute to a change in behaviour resulting in decreased marine debris deposition across the country due to science learning at local scales.

At two years into the project we have made remarkable strides toward achieving our goals and addressing our four focal questions. We have achieved and exceeded the key milestones identified for year two (detailed in Section 2) and we are beginning to realise new opportunities and the impact of our work, as evidenced through engagement with a variety of stakeholders across the country and overseas. We look forward to the final year of the project bringing even greater achievements with it, and we hope to continue to grow this important work in collaboration with our partners, Earthwatch Australia and Shell.

2 Year One in Review (a brief synopsis)

Several key milestones were identified for the first year of the project in 2011-2012. These milestones included: 1) develop project curriculum that fit into the national science curriculum; 2) develop a web based resource for public profile and community engagement; 3) identify potential schools with which to engage in the TeachWild program, particularly focusing on schools in important Shell-identified focal areas; 4) initiate data collection and input; 5) carry out 'Scientist for a Day' excursions with schools; 6) carry out seven-day research expeditions with teachers and, if possible, 7) carry out sea-based research expeditions with teachers.

We met each of these milestone objectives (detailed in progress report for year one – Hardesty and Wilcox, 2012). Not only did we contribute significantly to curriculum content that was developed for TeachWild, but we worked with teachers to develop specific lesson plans for targeted student groups, beyond the TeachWild curriculum, that met the requirements of the national science curriculum.

We successfully developed an online data entry portal that utilised the Atlas of Living Australia's (ALA) Global Biodiversity Information Facility (GBIF). Through our CSIRO partnership with ALA, we were able to develop an open access and easily accessible national marine database that was available to volunteers, students, teachers, and citizen scientists. Here, data on beach surveys, incidental sightings and other site location information was initially collated. The host address for the site was http://www.teachwild.ala.org.au. The data portal was established so that individuals and groups could input data and see summaries of information from across the country. Due to challenges with ease of data entry utilising the ALA system, however, in the last 12 months we have subsequently revised the web portal data entry site (see Appendices A and B).

In year one of the project we carried out coastal and at-sea debris surveys for a significant portion of the Australian coastline and we completed high-seas surveys to quantify marine debris offshore at more than 35 sites from a variety of research vessels.

In addition to identifying schools with whom to engage, we delivered the TeachWild program to more than 1,300 primary and secondary school aged students from around the country. We also took teachers on intensive weeklong research expeditions in which they significantly contributed to our fundamental research aims for the national marine debris project.

Overall, the first year of the project was tremendously successful in meeting our targets, and this was matched by the achievements in year two (see below).

3 Accomplishments and achievements in Year 2

In the second year of the national marine debris project we completed the rest of the coastal debris surveys (see Section 3.1). Our year two teacher and student engagement started with carrying out the Scientist for a Day program at several schools in Victoria. This intensive week visiting five schools in August 2012 was quickly followed by visiting schools and carrying out the 'Scientist for a Day' program in Broome and Darwin in September. Also in September, CSIRO scientist Chris Wilcox took three teachers on a 10-day excursion on CSIRO's research vessel *Southern Surveyor*, during which time Chris and the teachers from Western Australia, South Australia and the Northern Territory collected surface trawl data from Perth to Darwin. This was an important trip in terms of marine debris data collection from surface trawls (see Section 3.2 for details). We have also had intensive engagement with various interested parties from local, state and federal government and non-governmental organisations, and we have had excellent interest in our work in the international forum as well. Further description of our year 2 activities and media engagement is described in the following sections.

3.1 Coastal debris surveys

We have now completed the national survey for coastal debris around the mainland and the island state of Tasmania (Figure 1). We surveyed more than 170 coastal sites, many of which were remote. Access was by car and foot, via float plane (Broome to Darwin and west/southwest Tasmania) and via boat.

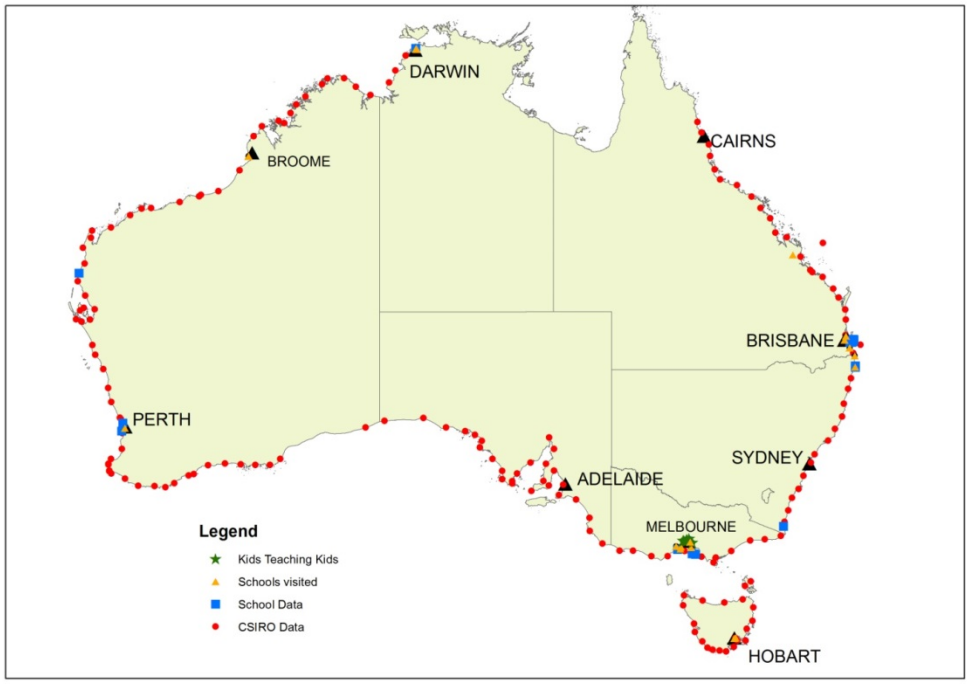

Figure 1. Map showing locations of coastal debris surveys around mainland Australia and the southern island state, Tasmania. This map includes locations of school debris surveys (blue squares), engagement with the 'Kids Teaching Kids' program (green stars) and CSIRO surveys (red circles).

The two last major areas that required surveying in the last year were across the Kimberley region (which required the use of a float plane to survey sites from Broome to Darwin) and Tasmania. Tasmania surveys were conducted by vehicle, on foot and via float plane (in the west and south west of the state where there is no road access). The national coastal debris surveys were completed in June 2013. We are particularly pleased to have completed this mammoth fieldwork component of the project without a single major health and safety incident!

From our CSIRO national coastal debris survey we estimate that there are more than 115 million bits of rubbish on Australia's coastline (including Tasmania but excluding the >350 outlying islands). This is based upon the coast being 35,877km in length and takes into account that we found an average of 6.439 items of anthropogenic debris on each 2m wide transect we carried out. Given that the population of Australia is estimated at 22.32 million people (population clock: http://www.abs.gov.au/ausstats/abs@.nsf/0/1647509ef7e25faaca2568a900154b63?OpenDocument) , this averages about 5.2 pieces of debris for every person in the country.

Overall, we find that about 75% of all waste is plastic, 24% is glass and metal, and 1% is cloth. Of the plastics, it looks like 2% of debris is discarded monofilament (and hence is associated with recreational fishing). Because most plastics float whereas glass and metal sink, we can separate out to some extent the terrestrial versus marine components of debris we find on beaches.

In further analysing the data we consider a number of important components or inputs to marine debris along our coastline. We include two figures to describe the anthropogenic debris at the surveyed sites, and extend that, using model predictions for rubbish along the coast. The first figure (Figure 2) shows the density of debris along the coastline corrected for factors that would cause local sampling bias (such as shape of the coastline, substrate, steepness of the beach [gradient], and backshore substrate type). The second figure (Figure 3) incorporates corrections for sampling bias and incorporates factors that drive terrestrial inputs to debris such as local and regional population density, distances to roads, etc. The spatial pattern shown therefore represents the leftover or residual variation which is inferred to be the marine input of debris (with terrestrial sources and sampling variation removed).

Tasmania data are not included in either figure because we have not had time to input those data and analyse them given how recently surveys were completed. In the coming months we will complete analysis of the entire Australian coastline.

The map (below,) shows the relative density of anthropogenic debris along the Australian coast. This takes into account where surveys were carried out but extends to create a ribbon plot of coastal debris density based upon observed debris and factors that affect debris accumulation at sampling sites (e.g. variables such as shape of the coastline, substrate, gradient and backshore substrate type). Lighter colours represent more debris (note that in the top end of Australia the model predicts high levels of debris, though that region was not surveyed using our methodology). This high level is likely an artefact of the fact that the surrounding areas that were surveyed had increasing quantities of debris so the model predicts even more debris in the top end. This prediction should be ignored until further data can be collected. It is worth noting that the 'dirtiest' areas are not necessarily associated with the highest population densities. The southeast region of Australia and the northwest of the country look to have higher levels of debris than do other areas with lower population density.

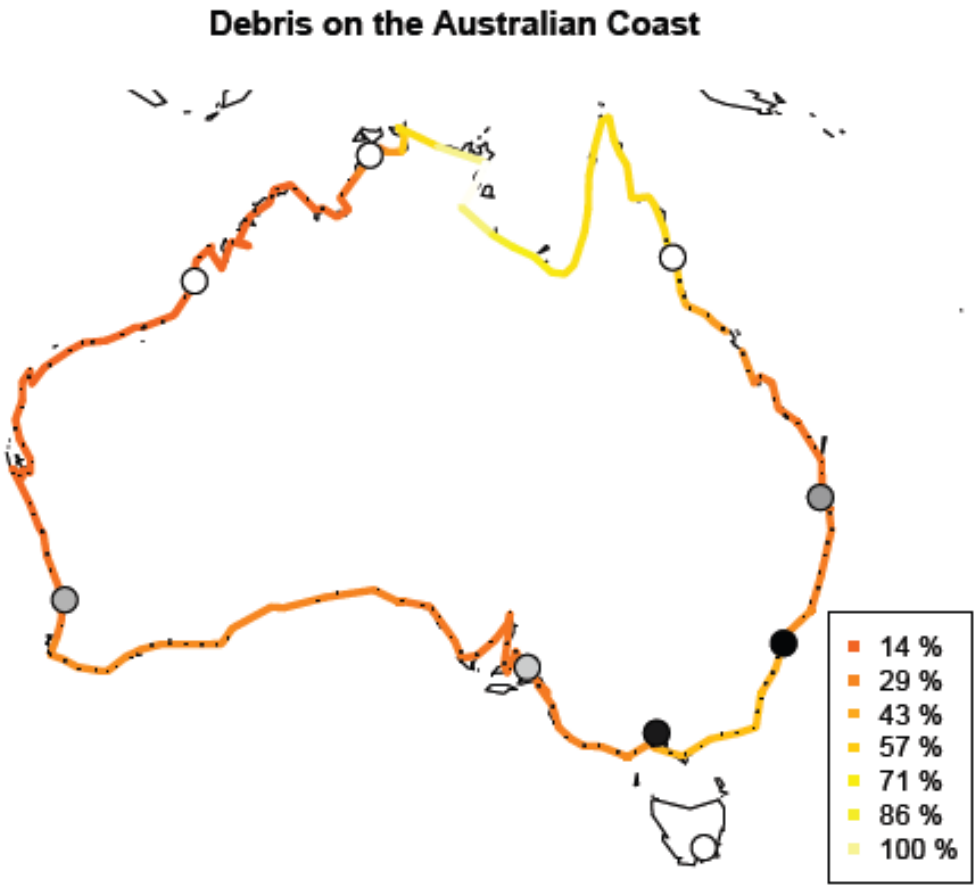

Figure 2. Relative density of anthropogenic debris along the Australian coast.

We next considered the component of debris that is likely coming from the marine environment. In the second model we included not only the shape of the coastline, substrate, gradient and backshore substrate type, but we also took into account the population within 5 km and within 50 km of the surveyed site as well as the distance from the survey site to the nearest road. In this second model, the population parameter at each of the two distances was significant. At 5 km radius from the survey site there is a negative relationship between population density and anthropogenic debris. At the 50 km distance category considering the population density there is a positive relationship. This suggests that at the local scale, where you have more people, you find

beaches having less debris. At the regional scale in contrast, higher population density is associated with an increase in the amount of rubbish on beaches.

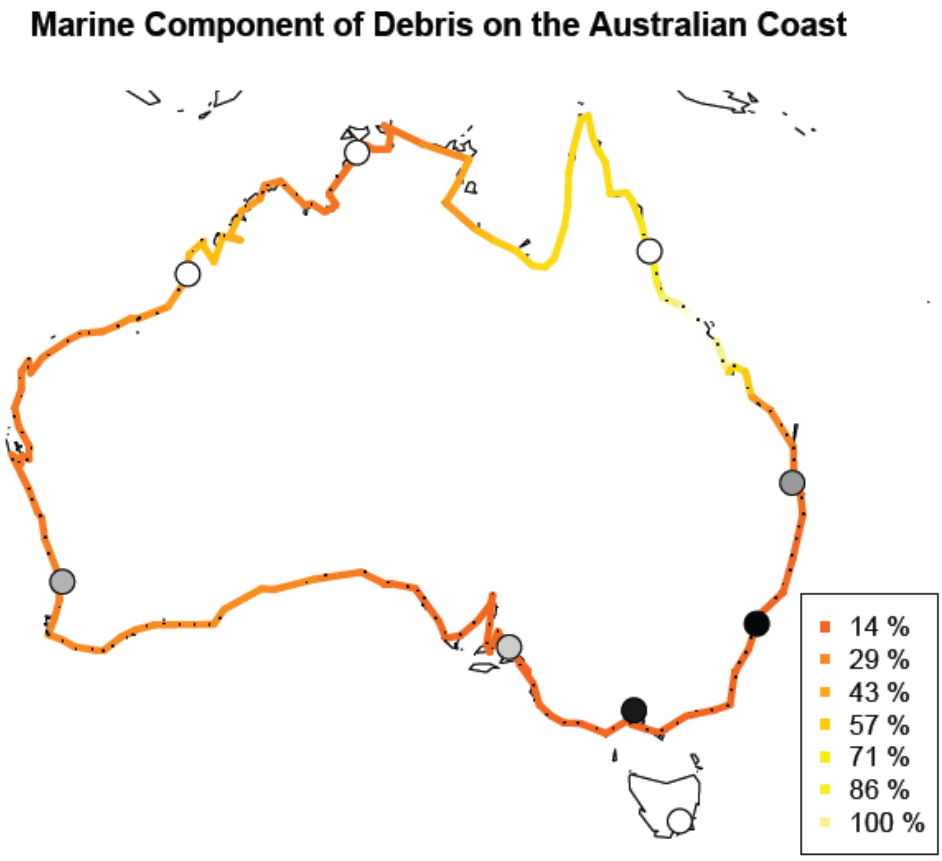

Figure 3. Component of debris that is likely coming from the marine environment.

We will soon be adding analyses from the Tasmania survey sites to the analysis, to complete the continental scale picture.

3.2 At sea surveys

In addition to the 10-day Southern Surveyor research expedition with teachers, we were able to take advantage of another vessel of opportunity to add to the data gaps for where marine debris is in our coastal and offshore waters. Early in 2013 the CSIRO team was able to hitch a ride on one of the AIMS research vessels that was working in Queensland. On board this vessel we were able to conduct more than ten sets of surface trawls in coastal Queensland waters (inside the Great Barrier Reef from north of Cairns to north of Brisbane).

The TeachWild intensive research expedition from Broome to Darwin was a tremendous success, in spite of initial rough conditions at sea which made for a challenging first few days at sea. Everyone adapted quickly to life on board the ship, and we were able to complete trawls at approximately 23 sampling stations – a tremendous feat!

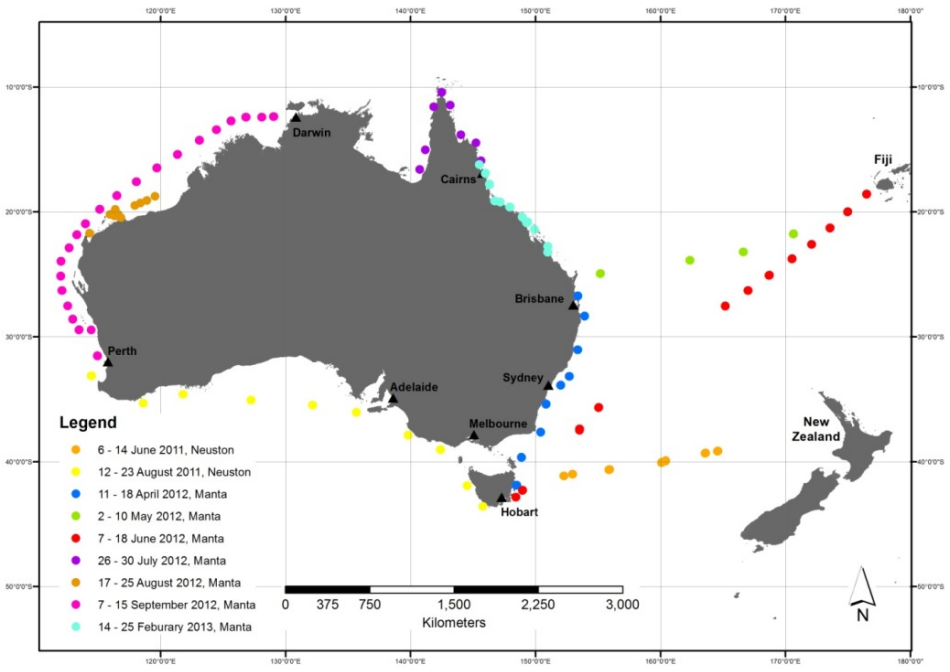

Figure 4. Map showing locations of surface trawl surveys around the continent. Different colours represent different research cruises. In total, marine debris trawls have taken place during nine different voyages and we have sampled at more than 60 sites around the country. Analyses of these data are underway and we hope to have publication of these results before the end of 2013.

Figure 5. Deploying the surface trawl net aboard the *Southern Surveyor*

Teachers have played an important role in collecting data for at-sea marine debris trawl samples. Sorting samples takes a lot of time and patience, but can be rewarded with seeing some exciting marine life as well!

Figure 6. Photos of teachers and researchers collecting data and sorting samples above the *Southern Surveyor*.

3.3 National data portal (improvements)

The data portal was established in the first year of the project so that individuals and groups could input data and see summaries of information from across the country. However, in the course of using the database, a number of issues arose with the Atlas of Living Australia data portal site. While it was not within our area of the project to do so, CSIRO staff have now revised the web portal data entry site (see Appendices B and C) to make the site more user friendly and intuitive. The feedback regarding the changes has been positive.

3.4 Scientist for a Day

In the past twelve months we have carried out Scientist for a Day activities in Northern Territory, Victoria, Western Australia, Tasmania and Queensland. We spent a week each in the Melbourne surrounds in August 2012, a week in Exmouth, Carnarvon and surrounding areas in November 2012, a week in the greater Perth region in February 2013 and a week near Gladstone at the end of May 2013. TeachWild scientist visits to three schools in Tasmania have also taken place independently by CSIRO staff (April/May 2013).

In addition to these live face-to-face interactions with school groups, we have increased our Skype/videoconferencing interactions with school groups. CSIRO staff have had some fantastic Skype/web chats with numerous other primary and secondary school kids throughout the year, including talking with primary school students in Victoria and a year 11 Chemistry class from Western Australia. Having live chats with students while in the field allows us to not only teach kids about marine debris, but also shows them some of the opportunities available for careers in science.

In total, we have engaged with more than 3,000 students since the inception of the TeachWild program, exceeding our goal for numbers of students with whom to interact. Feedback from schools has been very positive and it is heartening to see and learn about some of the creative solutions to reducing rubbish that are being established and gaining traction in schools.

In addition to school engagement, we have delivered TeachWild to a number of Shell Graduates. Graduate days in Melbourne, on Rottnest Island near Perth and in Queensland have all received positive feedback. Importantly, they have provided us with an excellent opportunity to promote learnings from TeachWild to Shell staff, increasing their understanding of the marine debris issue and Shell's role in supporting leading research efforts and their commitment to social investment on extremely relevant and timely topics.

The clear message from Shell employees is that they appreciate the company they work for and they are excited about the opportunities provided by Shell. Learning about marine debris impacts on wildlife has been quite an eye opening experience for many of the participants (or so we understand from feedback from participants). It has been rewarding for us to see some of the personal and professional changes that some of the participants have been interested in developing and implementing at work, home and in their communities.

3.5 TeachWild Intensive Research Teams

In the second year of the TeachWild program we have delivered science and learning for five intensive experience trips for teachers. These have included:

- A *Southern Surveyor* voyage (3-12 September 2013) from Broome to Darwin with 3 teachers
- North Stradbroke Island (24-30 September 2013) with 8 teachers/educators
- Phillip Island (11-14 October 2012) with 9 teachers/educators
- Phillip Island (9-13 April 2013) with 10 teachers/educators
- Rottnest Island (18-20 April 2013) with 8 Shell staff

Activities for the intensive expeditions have been varied but have included coastal debris surveys, at-sea surface trawl surveys (and associated sorting of debris), necropsies of turtles and seabirds, spectrophotometry measurements to look at spectral characteristics of plastics, recording net and other material characteristics for items that have ensnared southern fur seals, and seabird colony surveys to look at debris levels in and near breeding colonies.

We have exceeded the goals and obligations for intensive field expeditions in the last year, and with agreement of all partners, we were able to move some of the deliverables for next year forward to this year. The intensive expeditions have been very successful and have contributed to important data collection needs by CSIRO staff and research partners.

It is worth mentioning that one of the fantastic educators we have worked with, teacher Karen Johns from Victoria, has not only been very inspired by her involvement in the program but she has also been exceptionally inspiring. After her participation in one of the Phillip Island trips she submitted a grant application to work in the Antarctic as part of the artists and educators in Antarctica program. CSIRO scientists wrote a support letter for her application and she continues to be an excellent educator as well as an enthusiastic ambassador for the TeachWild marine debris program. Karen has continued to work with CSIRO staff and will be co-author on a publication we aim to submit (based upon some of the net characteristics work she has been doing with us). She has also participated as a CSIRO volunteer in a second Phillip Island expedition, sharing her knowledge, enthusiasm and experience in TeachWild to further inspire others – students and teachers alike.

3.6 Other CSIRO research activities

Seabird risk analysis: We now have made global scale predictions of exposure to marine debris for 193 seabirds. The expected risk ranges over 7 orders of magnitude. We are now comparing predictions with observations from the literature (last 25 years of published works) addressing stomach contents. We aim to complete this and submit for publication in the coming few months.

Cetacean risk analysis (see IWC in section 3.8): After publication of the turtle risk assessment, the International Whaling Commission has contacted us asking about extending that approach to cetaceans. We have just gained access to species distribution information available and are looking to carry out a

similar analysis to that described above for seabirds - though this will focus on entanglement rather than ingestion and it incorporates fishing effort and gear loss at a global scale.

Chemical marker assay: We have successfully developed a chemical marker assay to identify plastics exposure in seabirds. With a simple field-based method we can quickly and with minimal intrusion, swab the uropygial gland of a bird to test for some of the main plasticizers used in plastics manufacturing. Furthermore, we have initiated a collaboration with Bird Life International on chemical marker approaches to quantify plastics ingestion in seabirds. (Figure 7)

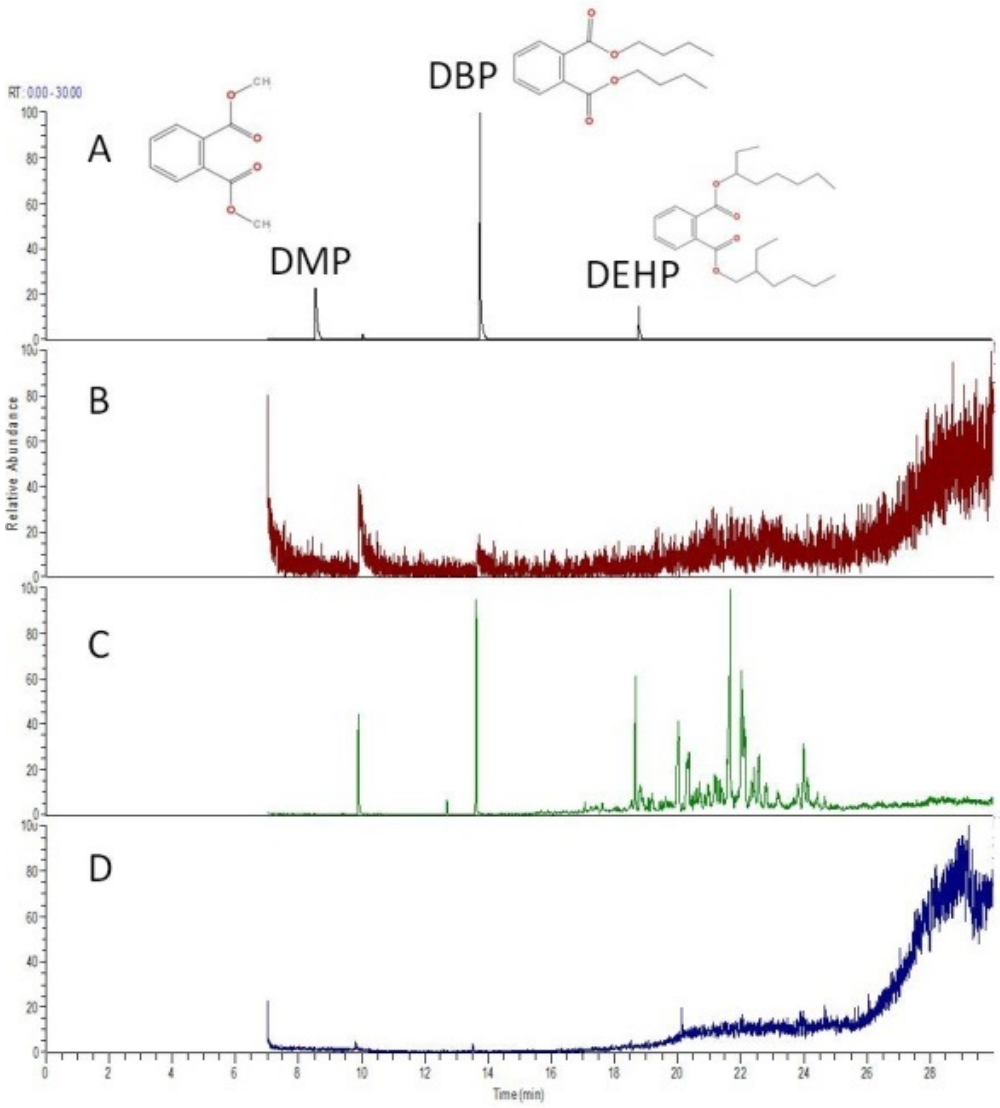

Figure 7. Chromatograms showing examples of phthalates (plasticiser residues) and their occurrence in different samples. (A) Three standards: dimethyl phthalate (DMP), dibutyl phthalate (DBP) and bis (2-ethylhexyl) phthalate (DEHP); (B) Procedural blank showing no phthalate residues; (C) Extract of preen oil collected from a dead Shearwater with abundant plastic content in stomach (contains DBP and DEHP); (D) Extract of preen oil collected from a live Bridled Tern, Houtman Abrolhos Is. (little or no plastic content in stomach).

Juvenile turtle movement and vision experiments: Denise spent a week at Heron Island working with University of Queensland (UQ) collaborators (Townsend, Schuyler and Marshall) focusing on some of the marine turtle components of the project. Satellite transmitters were attached to five juvenile green turtles to look at turtle movements and foraging patterns. This will contribute to our understanding of where and what age classes of turtles are more likely to encounter and be impacted by marine debris. We're already getting good tracking data and we can see where turtles at Heron Island are spending their time. (Figures 8 and 9)

How to catch a turtle ...

Satellite tag and flipper tag on turtle - prior to release …

We ensure that all is well with newly tagged turtles prior to release (swimming in tank at Heron Island Research Station).

Figure 8. Turtle tagging on Heron Island.

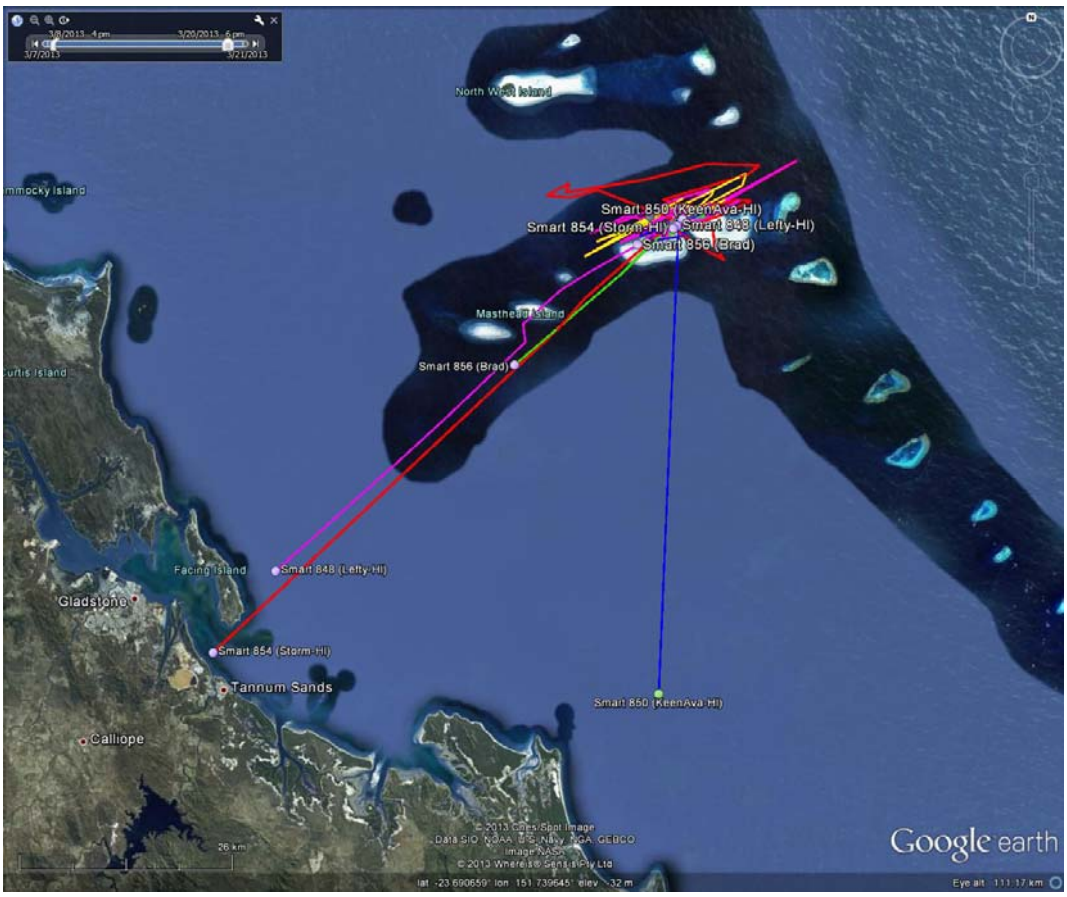

Figure 9. Tracks of turtle movement near Heron Island, Qld.

We also carried out experiments to look at how turtles see (turtle vision experiments) in an effort to better understand how and why turtles may mistake plastics for food. (Figure 10)

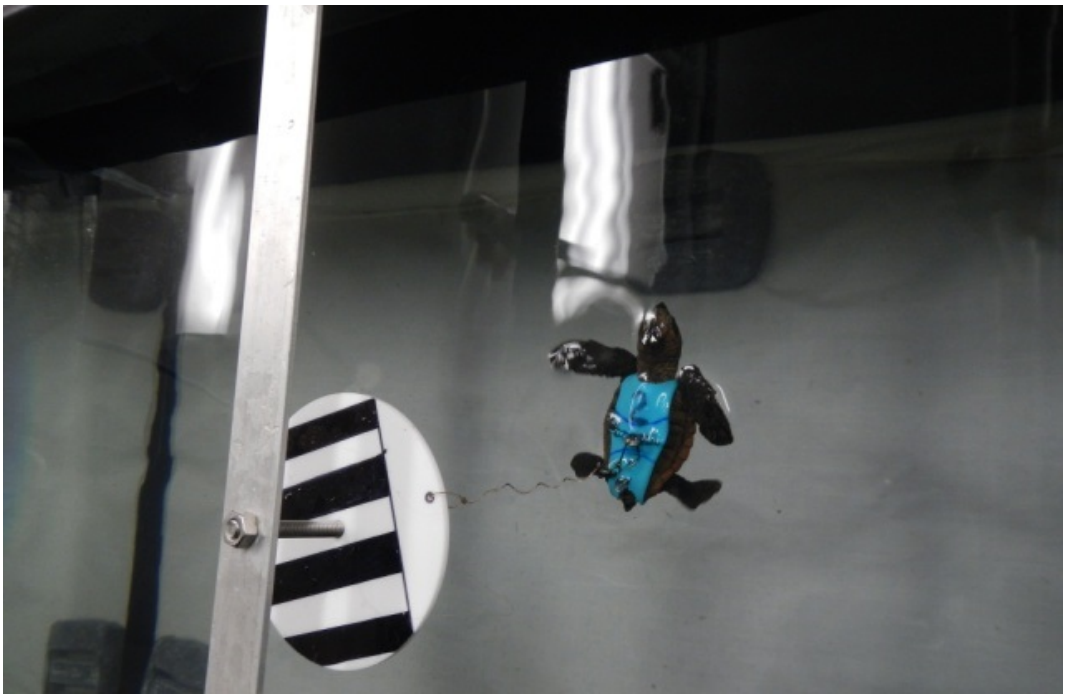

Figure 10. Experiment to investigate turtle vision. This is a focus of PhD student Qamar Schuyler's work. Results are not yet completed but will be by the end of 2013.

Waste management efficacy: With a visiting international student (Clementine Maureaud), we have also begun the process of carrying out surveys at the regional and state level to look at efficacy of council waste management strategies. Our aim is to link council practices, policies and efforts to our coastal debris survey data and identify policy effectiveness. Interviews have been completed for those regions with high and low quantities of rubbish at surveyed beaches from all states and territories. Data analysis is underway and will be completed before the end of 2013.

3.7 Stakeholder and policy impacts

CSIRO marine debris staff have been increasingly called on to act as experts and to share information about their marine debris research findings. In the last twelve months CSIRO staff have:

- Given an informal talk at the Coast to Coast Conference in Brisbane to participants/stakeholders as part of their field excursion to N. Stradbroke Island (September 2012)
- Presented our work as an invited speaker at a multi-agency task force/stakeholder meeting in Cairns which aimed to address issues around retrieval, disposal and data collection of ghost nets in Qld and Federal Waters (e.g. derelict fishing gear issues at sea). Talk title 'Identifying ghost net hotspots, looking for sources, and ameliorating the issue'. Participants included staff from SEWPAC, Cairns Turtle Rehab Centre, GhostNets Australia, QPWS, DAFF, AFMA, QDAFF, Customs and border Protection, SeaNet/Ocean Watch) (February 2013)
- Acted as a marine debris expert and panel advisor at the South Australia state marine debris workshop which involved NGO, state, UNEP, and SEWPaC staff. We shared our methodology, findings to date and encouraged engagement with numerous stakeholder groups who would like to share data and contribute to the national marine debris database (May 2013)
- Participated in a Marine Debris stakeholder meeting in Canberra (with attendees from CSIRO, GBRMPA, DAFF Fisheries, Dept. of Innovation, AMSA, GhostNets Australia, DIT, SEWPaC, JCU, and Tangaroa Blue. (March 2013). See handout (Appendix C) provided to participants
- Participated as keynote speaker at Tasmania Public Marine Debris Community Forum (Hobart, May 2013)
- Gave a World Ocean's Day presentation for Shell staff in Perth (May 2013)
- Participated as scientist in TeachWild's World Ocean's Day Event in Melbourne (May 2013)
- Gave invited public seminar on marine debris research for the Royal Society Southern Highlands group of New South Wales
- Participated as marine debris expert and panel advisor at the Airlie Beach Marine Debris stakeholder meeting in Queensland (June 2013). See handout (Appendix D) provided to participants

As a demonstration of project impact at State and Federal Levels, CSIRO scientists have also

- Had regular engagement/discussion with SEWPaC marine section staff
- Been invited as marine debris expert for meetings in SA, Qld, Tas, NSW
- Provided support for more than 5 organizations who asked for support as part of the recent Caring for Country Biodiversity fund applications for marine debris work

- Had their ghost nets marine debris work selected for a Prime Minister Science note “Hot Science Topic” (May 2013)

  Been invited to present research findings and provide comment on the proposed national container deposit scheme

- Been approached by and had multiple exchanges with the Australia Packaging Covenant/Australian Food and Grocery Council/Packaging Stewardship Forum about our marine debris findings

3.8 International engagement

CSIRO’s international profile in marine debris work is being increasingly recognised. Not only do we receive emails and queries from people wanting to participate in the TeachWild program from overseas (US, Africa, Europe, Asia), but we have participated in a number of scientific and public outreach activities in the past twelve months:

- Invited speaker and workshop participant at the First International Marine Debris Entanglement Workshop hosted by the World Society for the Protection of Animals in Miami, Florida. We presented our work on ghost net impacts on globally threatened turtles. (USA, Dec 2012)
- Invited workshop participant at the marine debris working group supported by the National Center for Ecological Analysis and Synthesis working group in Santa Barbara, California. This is essentially a global think tank that brings together researchers to address hot topics in the ecological/ environmental fields. The weeklong workshop was fruitful and will undoubtedly result in additional publications with other globally recognised leaders in the field. It was clearly acknowledged and recognised that there is no comparable dataset by any researchers at any similar scale around the world – and certainly nothing of this scale has ever been done in the southern hemisphere – this was highlighted in regards to coastal surveys, at-sea surveys and citizen science engagement with school groups. There is a follow up meeting to this one scheduled for November 2013 which we hope to attend. (March 2013)
- Invited workshop participant and guest speaker at the International Whaling Commission Marine Debris workshop in Woods Hole, Maryland. The IWC is particularly interested in our risk analysis approach to cetacean entanglement and ingestion (USA, 13-17 May)
- Invited guest speaker at the African Marine Debris Summit in Cape Town, South Africa. Talk title Marine debris global garbage: (citizen) science tackling a global issue. CSIRO also led the field expedition to carry out a beach clean-up and marine debris survey. International adoption of the CSIRO developed coastal debris survey methodology by delegates from Kenya, South Africa and possibly other countries (5-9 June 2013). (see Appendix E)

3.9 Communications and media

In 2012-13 the national marine debris project was the subject of much media interest (see list below). This does not include media associated with the World Ocean’s Day event in Melbourne, 7 June 2013, as that information has been summarised by the Red Agency and provided to Earthwatch Australia already.

In addition to the list of media below, National Geographic magazine is potentially interested in a story on our marine debris work.

It is worth noting the broad reach of ABC's Catalyst program and our marine debris project exposure on the show. This exposure has increased project profile at the national level and is a continued source of conversation. We often incorporate the Plastic Oceans episode into Scientist-for-a-Day and Intensive Field Excursions.

CSIRO organized, coordinated and gave a Ustream interview which was live-streamed to interested school groups and members of the public (November 2012). A follow up interview presenting results from research findings to date would be worth considering during the final year of the project.

The marine debris project has also been featured in CSIRO's internal newsletter *Monday Mail*, as well as on Twitter and Facebook. The CSIRO project team manages the Facebook page 'Marine Debris Australia'.

Recent media:

- http://www.csir.co.za/enews/2013_jun/19.html
- http://www.heraldsun.com.au/news/breaking-news/more-sea-debris-than-people-in-aust-csiro/story-fni0xqi4-1226658481849
- http://www.smh.com.au/environment/five-pieces-of-rubbish-per-person-on-our-beaches-20130606-2nrss.html
- http://www.heraldsun.com.au/news/victoria/schools-aid-litter-survey-and-expose-a-sea-full-of-rubbish/story-fni0fit3-1226658039656
- 9 May 2013. ABC radio Tasmania. The morning show
- 9 May 2013. ABC radio Hobart
- The Mercury Newspaper 9 May 2013. http://www.themercury.com.au/article/2013/05/09/378757_tasmania-news.html
- The Tasmanian Times 9 May 2013. http://tasmaniantimes.com/index.php?/pr-article/lets-start-talking-rubbish-/
- 10 April 2013. WIN television 6pm and late night news. National marine debris project
- http://www.smh.com.au/environment/litter-data-recycles-case-for-bottle-and-can-refund-20130410-2hlty.html
- ABC pm Radio Regional Queensland. 9 April 2013. CSIRO, GhostNets Australia and Ghostnets in the Gulf of Carpentaria
- ABC pm Radio Mackay. 9 April 2013. CSIRO and Ghostnets removal in the Gulf of Carpentaria
- ABC pm Radio Darwin. 8 April 2013. CSIRO and Ghostnets in the Gulf of Carpentaria
- ECOS magazine 11 Feb 2013. Sea turtles caught up in ghost nets' random harvest http://www.ecosmagazine.com/paper/EC13023.htm
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3.10 Publications completed or in advances stages of preparation

It has been a productive year in terms of scientific output, with several papers already published and others in advanced stages of preparation and/or under review.

The research team has had a paper newly accepted for publication in the high-ranking international journal Conservation Biology:

> Schuyler, Q, BD Hardesty, C. Wilcox and K Townsend 2013. *A global analysis of anthropogenic debris ingestion by sea turtles.* The paper is in the final proof stages with the publisher and we will provide a copy of the paper when it is published.

We have also had a paper published that looks at transboundary issues, intervention points and livelihood issues in ghost net marine debris across the top end of Australia:

> JRA Butler, R Gunn, HL Berry, GA Wagey, BD Hardesty, C Wilcox. 2013. Value chain analysis of ghost nets in the Arafura Sea: identifying trans-boundary stakeholders, intervention points and livelihood trade-offs. Journal of Environmental Management 123: 14-25.

Our first risk analysis work has been completed and published in the top ranking international journal Conservation Letters:

> Wilcox, C, BD Hardesty, R Sharples, DA Griffin, TJ Lawson and R Gunn. 2013. Ghost net impacts on globally threatened turtles, a spatial risk analysis for northern Australia. Conservation Letters, DOI: 10.1111/conl.12001.

With our co-advised PhD student Qamar Schuyler and in association with UQ collaborator Kathy Townsend, a paper looking at debris selectivity by marine turtles in Australia has been published in the international journal PLOS One:

> Schuyler, Q, K Townsend, BD Hardesty and C Wilcox. 2012. To eat or not to eat: debris selectivity by marine turtles. PLOS One 7(7): e40884. DOI:10.1371/journal.pone.0040884.

In association with our Conservation Letters paper, we were asked to provide a popular article for The Conversation on our ghost nets work:

> Hardesty BD and CV Wilcox 31 Jan 2013. *Ghostnets fish on: marine rubbish threatens northern Australian turtles*. The Conversation http://theconversation.edu.au/ghostnets-fish-on-marine-rubbish-threatens-northern-australian-turtles-11585.

International masters student Heidi Acampora has completed her master's thesis entitled 'Assessing the impacts of plastic ingestion on short-tailed shearwaters (*Puffinus tenuirostrus*) in northern Australia'. This thesis formed the basis for a paper which is in the final stages of preparation for submitting to Marine Pollution Bulletin:

> Acampora, H, Q Schuyler, K Townsend and BD Hardesty. 2013. Quantification and an inter-annual comparison of marine debris ingestion by Short-tailed shearwaters (*Puffinus tenuirostrus*). To submit to Marine Pollution Bulletin.

Due to our work in the marine debris field, Hardesty and Wilcox were asked to contribute to a review paper identifying the key threats and impacts of marine debris on wildlife:

> Hamann, M, A Vegter, M Eriksen, C Eriksson, BD Hardesty, EZ Ramirez Llodra, P Ryan, Q Schuyler, K Townsend, C Wilcox, 2013. Global plastic pollution impacts on marine fauna. In preparation for Endangered Species Research.

In addition to the risk analysis work on marine turtles, we have recently carried out a global review of marine debris literature on seabirds and, coupled with oceanographic modelling, have completed a global risk analysis for marine debris ingestion in seabirds which we aim to submit to the journal 'Proceedings of the National Academy of Sciences of the United States of America':

> Wilcox, C, BD Hardesty, TJ Lawson, E van Sebille. 2013. A global risk analysis for marine debris ingestion in seabirds. In preparation for PNAS.

With one of our fantastic TeachWild teachers (Karen Johns of Victoria) and with one of our collaborators from Phillip Island Nature Parks (Roger Kirkwood), we have been working to analyse data to assess entanglement and net characteristics in Australian Fur Seals:

> Lawson, TJ, K Johns, R Kirkwood, BD Hardesty and C Wilcox. 2013. Net characteristics and entanglement in Australian Fur Seals. In preparation for Marine Pollution Bulletin.

With PhD student Julia Reisser, analyses of at-sea coastal debris surveys have been completed. This work compares where debris occurs at sea with where debris is predicted to occur, based upon oceanographic models and empirical data. The paper will be submitted to PLOS One before the end of 2013:

> Reisser, J, J Shaw, C Wilcox, BD Hardesty, M Proietti, M Thums and C Pattiatchi. Quantification and characterization of plastic debris in Australian waters. Submitted to PLOS One (July 2013).

4 Anticipated achievements in Year 3 (Looking forward)

We have high hopes for this final (third) year of the national marine debris project. In addition to visiting with schools in north Queensland (Townsville region), South Australia and NSW, we are excited for the upcoming intensive field programs we have scheduled at Phillip Island and North Stradbroke Island. We would like to ensure that all participants in TeachWild receive a Certificate of Participation, as we think this has value for students and teachers alike.

We would also like to see a web-based conference take place, as that was one of the aspirational goals of the project. We believe that a web conference would raise the profile of TeachWild, the important research being carried out, and would go a long way towards increasing our depth (not just breadth) of engagement with the many schools and students with whom we have engaged.

While it was identified as a challenge to overcome in the first year of the project, we still have not implemented a strategy for addressing the increasing numbers of ad-hoc inquiries. We had not envisaged such a broad and deep level of interest in the work, but it is a happy problem to have such interest in the project. We continue to strive to respond to every query and have done so 100% of the time. Ensuring we have the best communication possible between organisations will help to ensure enquiries do not 'fall through the gaps' and that interested parties see us all as being responsive and interested in engaging with as many group as we can.

With the increasingly high profile of the project and the strong scientific output has also come an increase in media attention. This certainly favours the project and points very strongly to the high impact of the marine debris work we are doing, but it also requires resources beyond those budgeted for and envisaged when we set out on this path. We are ensuring a mindful, professional and appropriate response to the many media enquiries, and paying particular attention to deliver the TeachWild message. This consistency is important in highlighting all TeachWild partners.

References

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Hardesty, BD and C Wilcox (2012). Understanding the effects of marine debris on wildlife: A progress report prepared for Earthwatch Australia by CSIRO.

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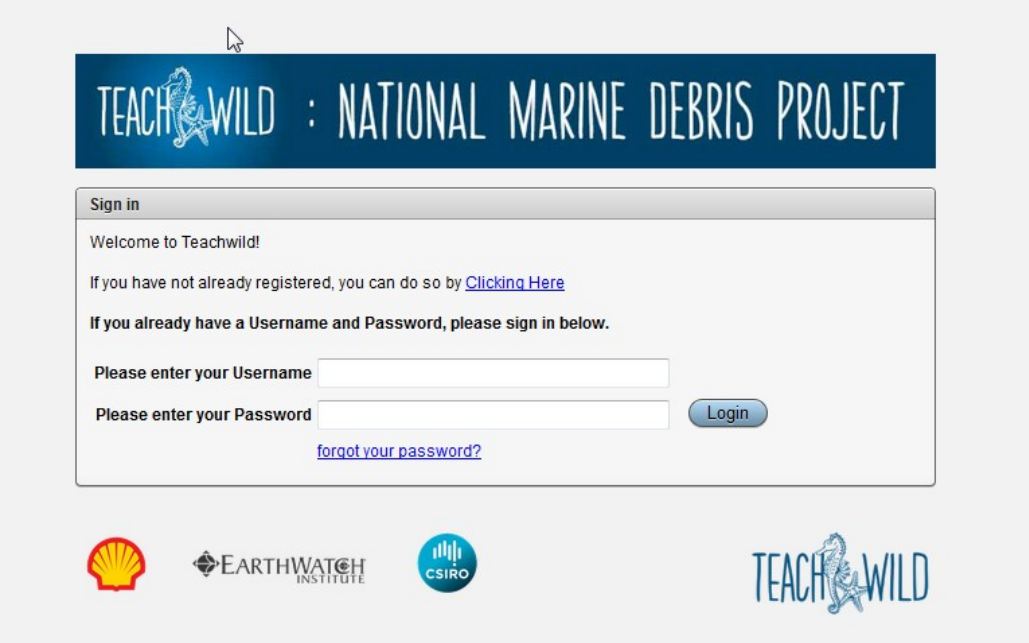
Appendix A: Instructions for data entry with updated data portal (Transects).

TeachWild: National Marine Debris Project

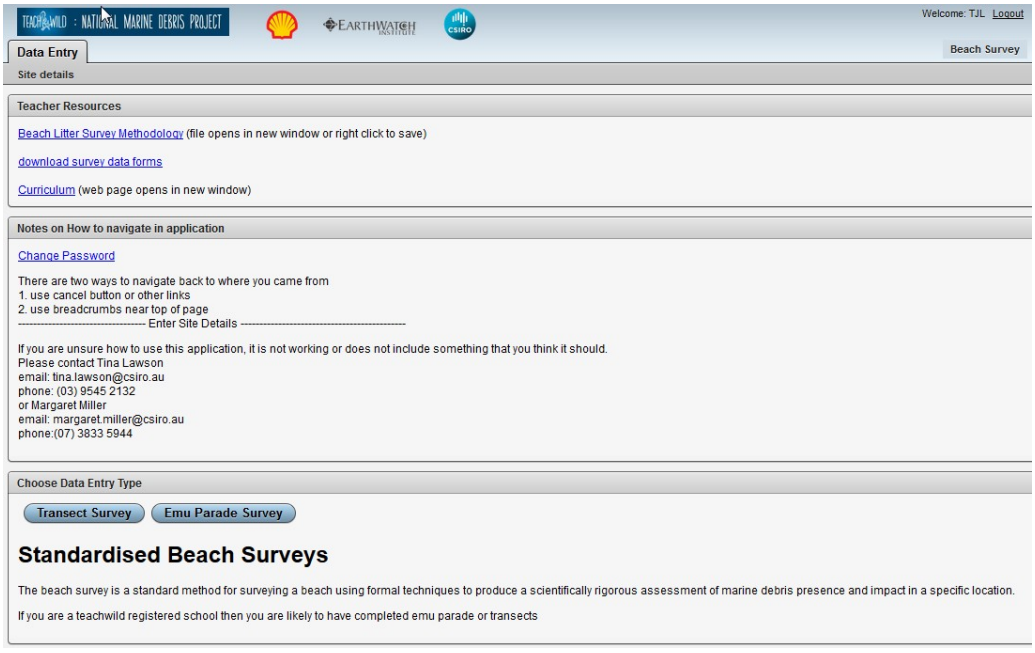
Database instructions: Transects

To enter data, you first need to be registered.

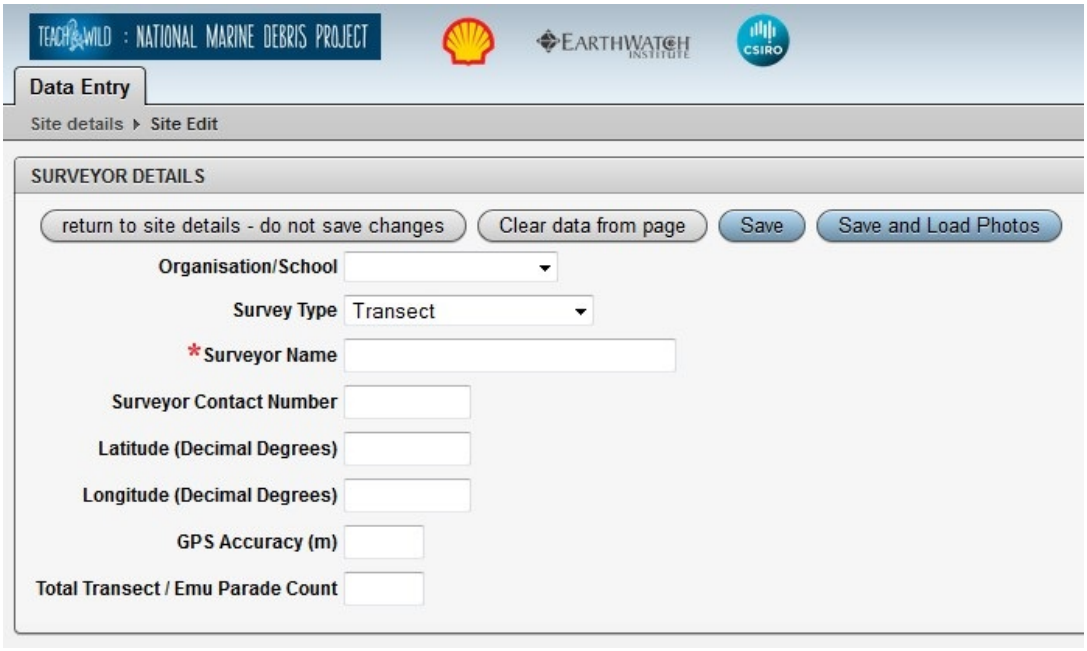
1) Enter your username and password, press the “Login” button.



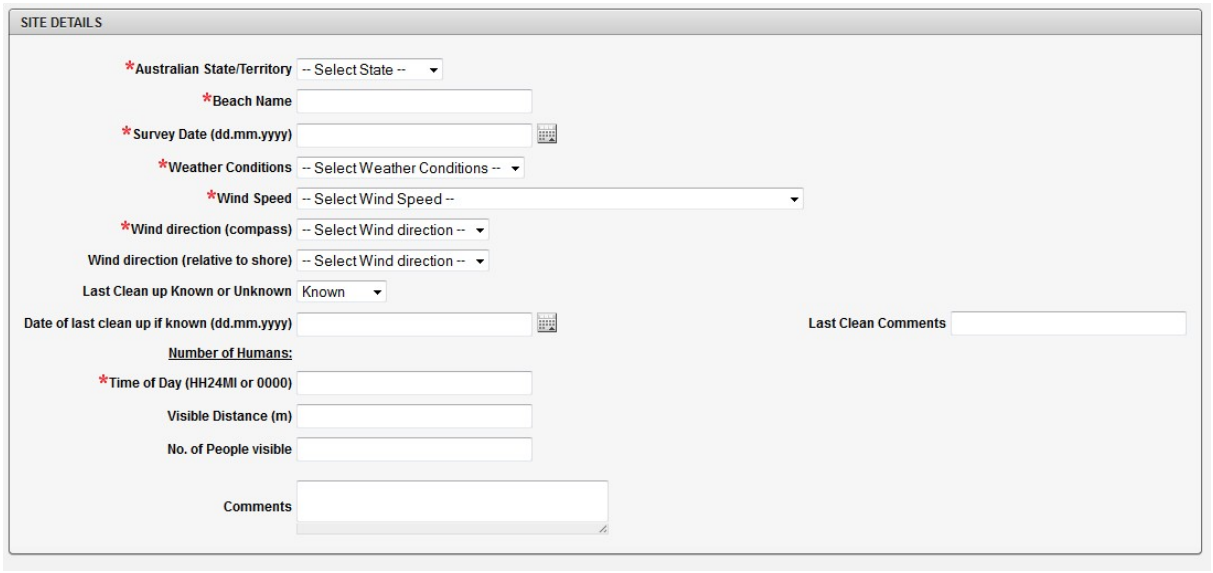
2) Click on the “Transect Survey” button.



3) Enter in the ‘surveyor details’, these are the same details as can be found on your ‘Marine Debris Beach Survey’ data sheets. NOTE: The “latitude (Decimal Degrees)” field must be negative (e.g. -35.12546).



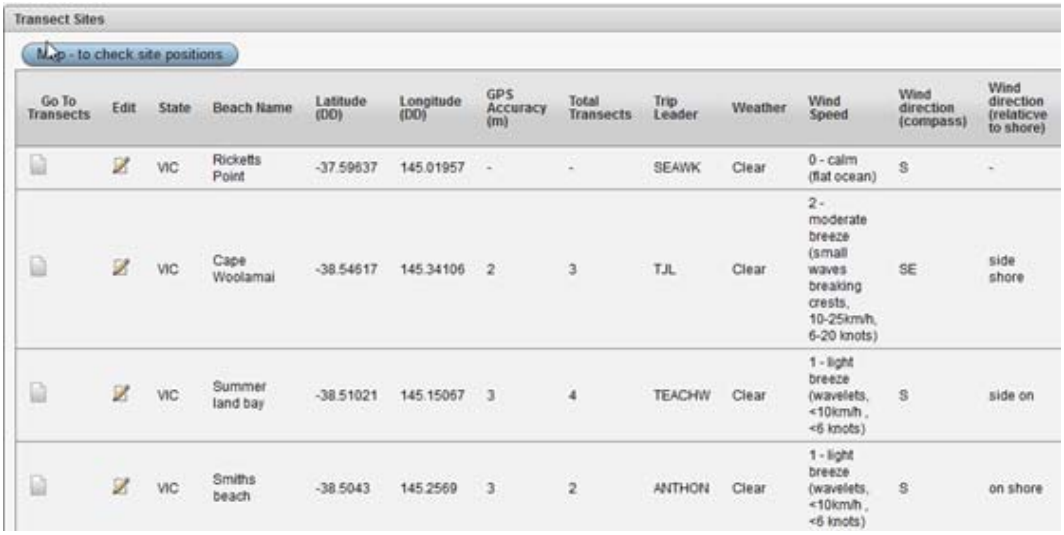
4) Enter in the ‘site details’ as required, these are the same details found on your ‘Marine Debris Beach Survey’ data sheets.



5) Click either the “save” or “save and load photos” button –

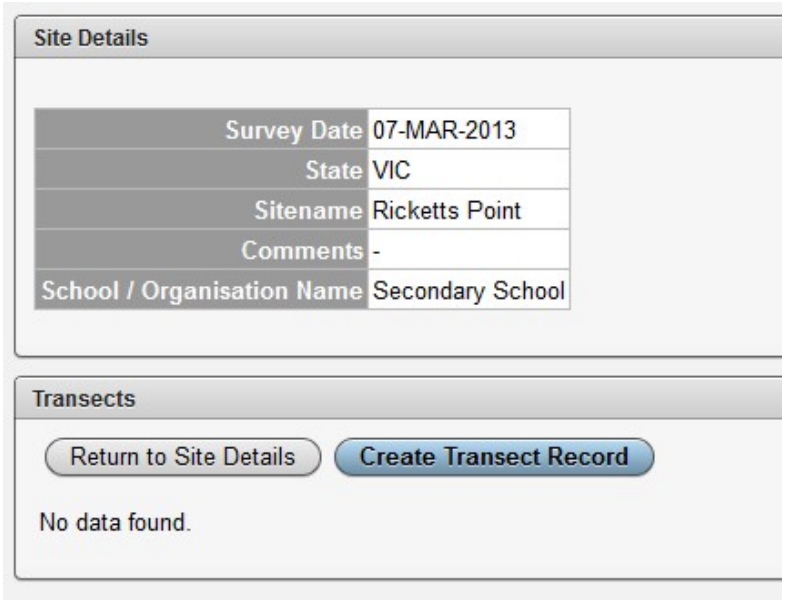
   a. If you clicked the “save and load photos” button, enter in a description such as ‘beach looking north’ then navigate to where your photo is stored, click on it then press the “upload” button. The screen will come up with an ‘action processed’ box (this means your data has been uploaded and you can load subsequent photos) then you will need to press the “cancel” button to get back to your site to enter transect details.

   b. Clicking “save” will take you back to the front screen where you can now enter your transect data.

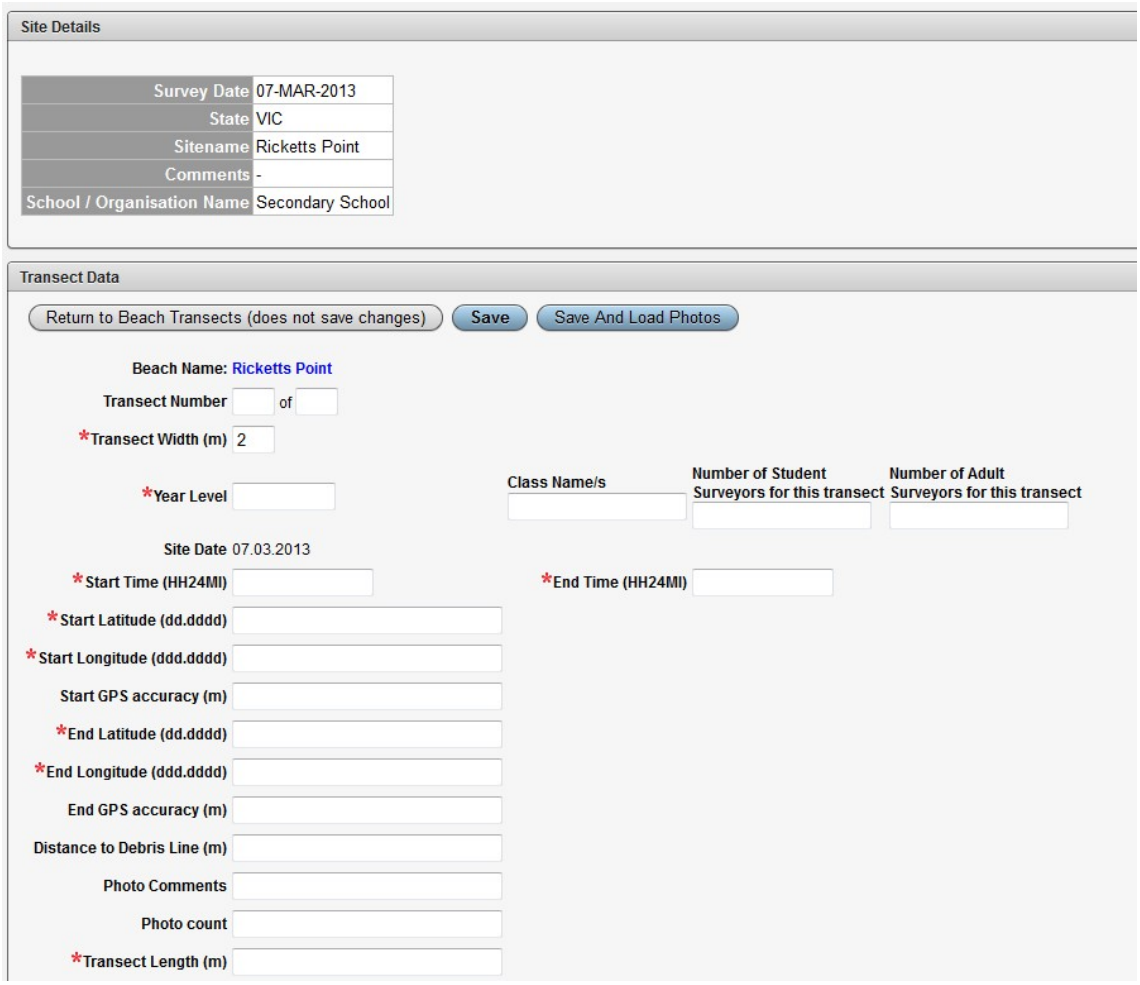


Go To Transects	Edit	State	Beach Name	Latitude (DD)	Longitude (DD)	GPS Accuracy (m)	Total Transects	Trip Leader	Weather	Wind Speed	Wind direction (compass)	Wind direction (relaticve to shore)
		VIC	Ricketts Point	-37.59637	145.01957	-	-	SEAWK	Clear	0 - calm (flat ocean)	S	-
		VIC	Cape Woolamai	-38.54617	145.34106	2	3	TJL	Clear	2 - moderate breeze (small waves breaking crests, 10-25km/h, 6-20 knots)	SE	side shore
		VIC	Summer land bay	-38.51021	145.15067	3	4	TEACHW	Clear	1 - light breeze (wavelets, <10km/h , <6 knots)	S	side on
		VIC	Smiths beach	-38.5043	145.2569	3	2	ANTHON	Clear	1 - light breeze (wavelets, <10km/h , <6 knots)	S	on shore

6) To enter transect details, click on the  icon under ‘go to transects’, and then click on the “Create Transect Record” button.



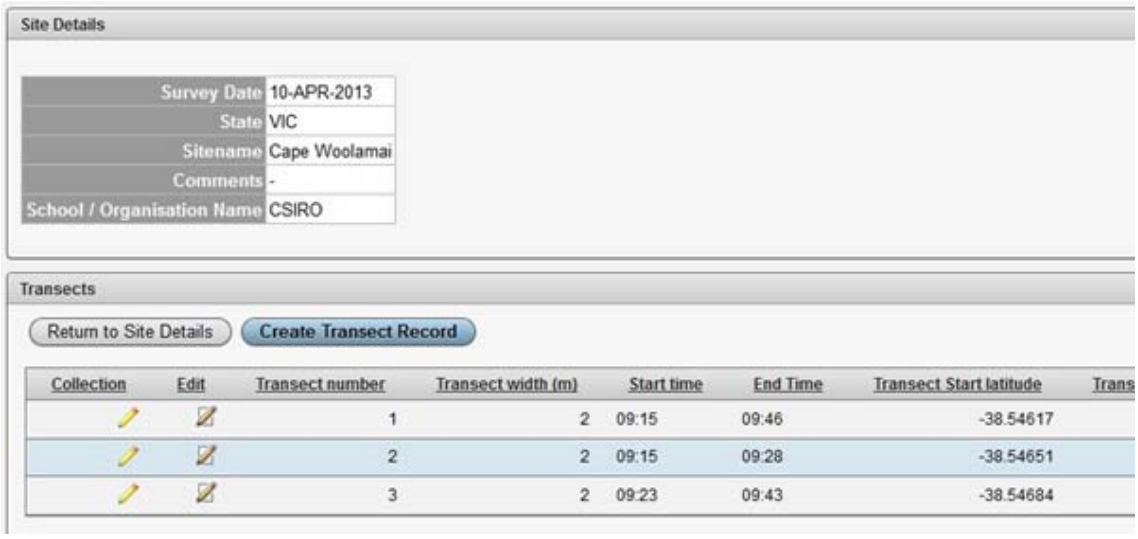
7) Enter in all the 'transect data' noting that these are the same details on your "Transect Data" data sheet. NOTE: Again the "latitude (Decimal Degrees)" must be negative (e.g. -35.12546).



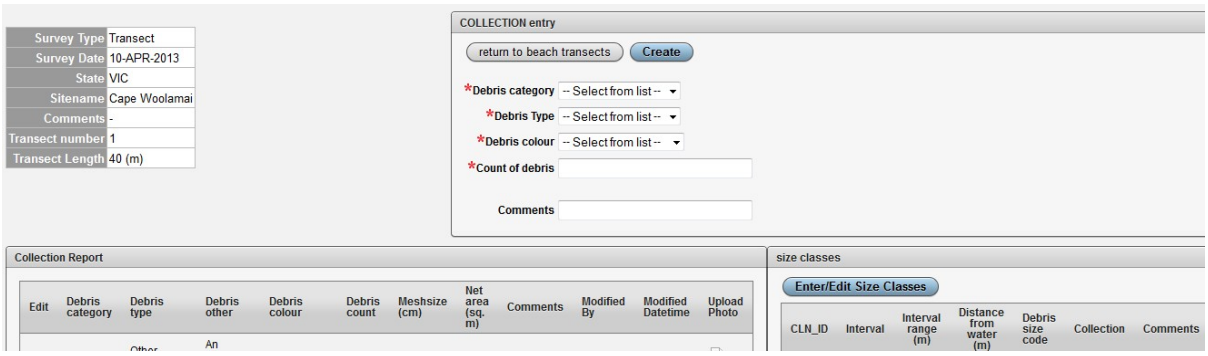
8) Click either the "save" or "save and load photos" button –

   a. If you clicked the "save and load photos" button, do the same steps as you did previously.

   b. Clicking "save" will take you back to the transect data screen where you can enter your collection data.



9) To enter your collection data, click on the  icon under ‘collection’, then enter all your data using the “create” button once you have entered in the debris category, type, colour and number.



10) Click on the “enter/edit size classes” button, click on the “add ten rows” button and enter your size class data.

11) Repeat steps 6 to 10 for each transect.

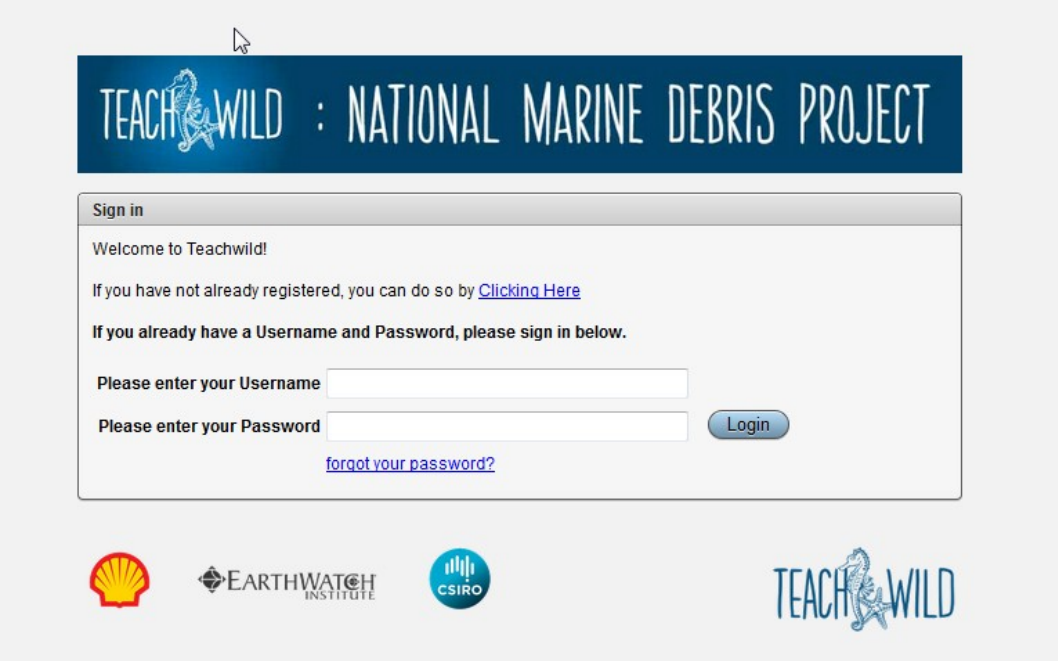
Appendix B: Instructions for data entry with updated data portal (Emu parade).

TeachWild: National Marine Debris Project

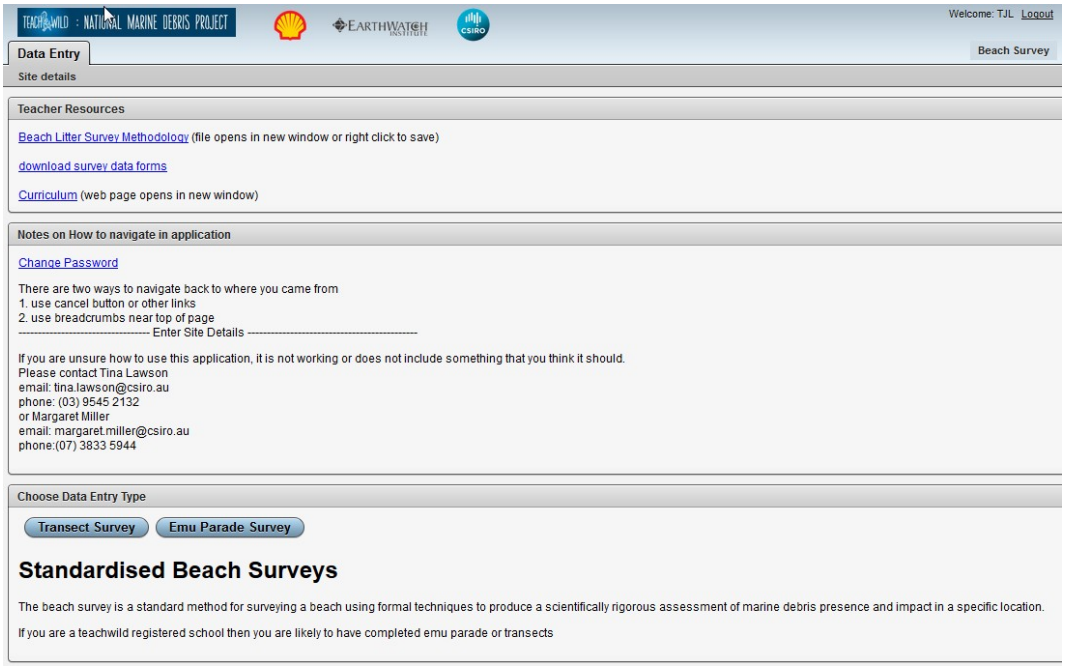
Database instructions: Emu Parade

To enter data, you first need to be registered.

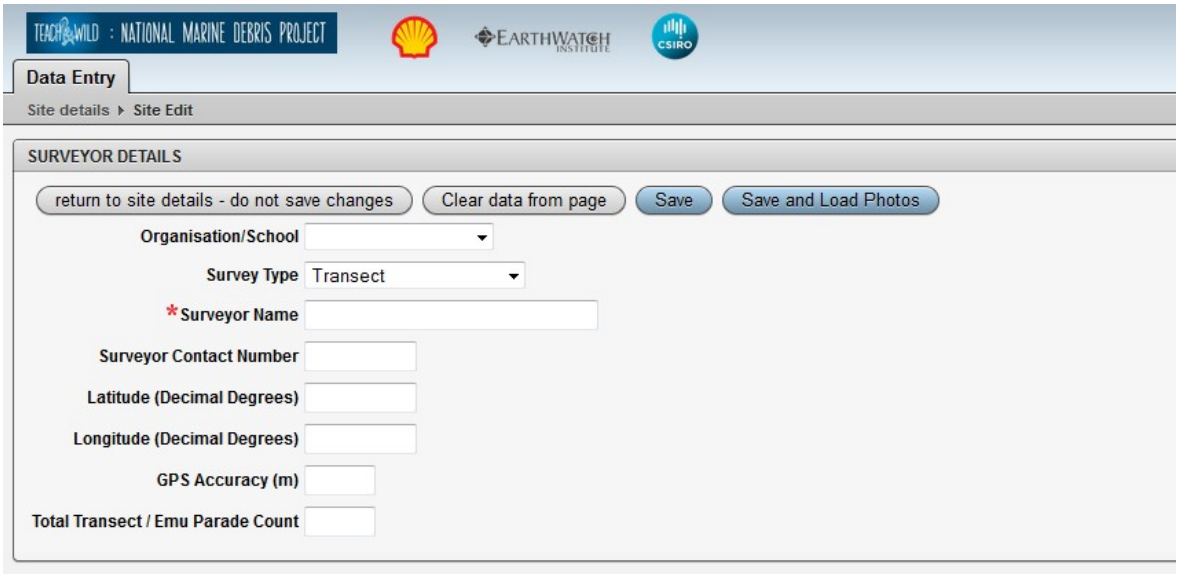
1) Enter your username and password, press the “Login” button.



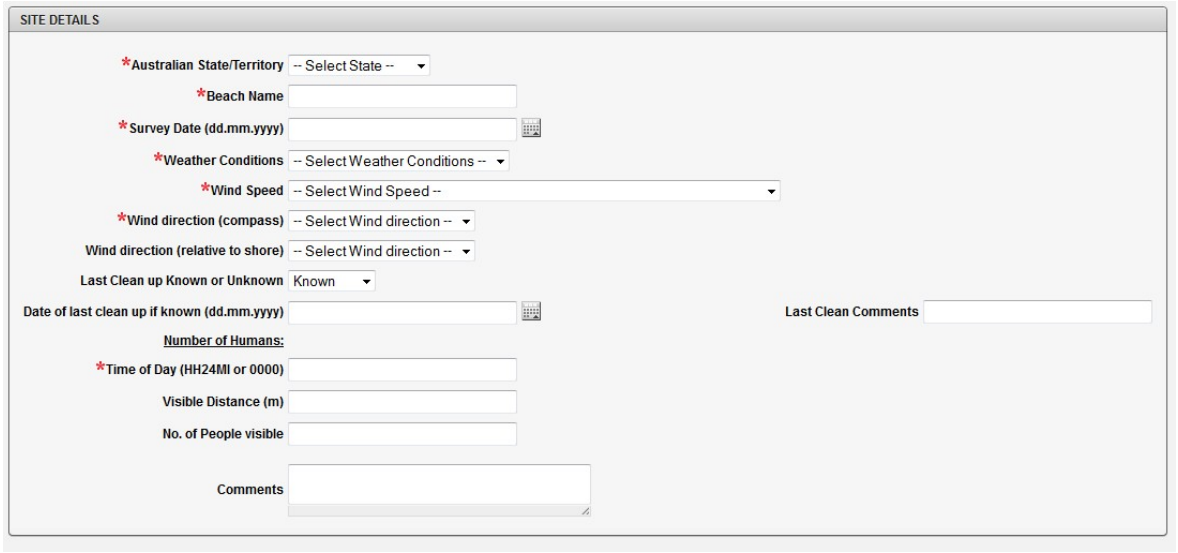
2) Click on the “Emu Parade Survey” button.



3) Enter in the ‘surveyor details’, these are the same details as can be found on your “Marine Debris Beach Survey” data sheets. NOTE: The “latitude (Decimal Degrees) must be negative (e.g. -35.12546).



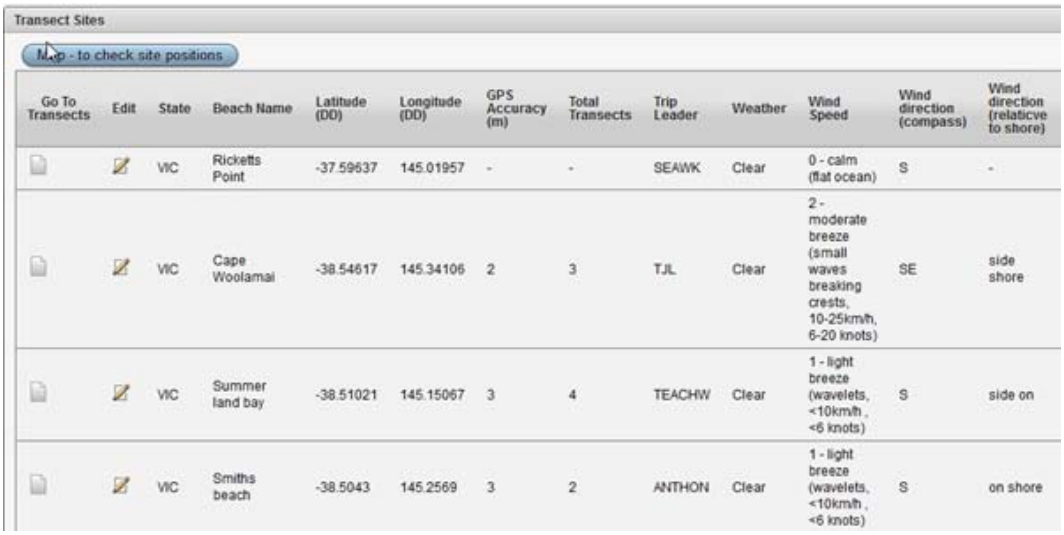
4) Enter in the ‘site details’ as required, these are the same details as can be found on your “Marine Debris Beach Survey” data sheets.



5) Click either the “save” or “save and load photos” button –

   a. If you clicked the “save and load photos” button, enter in a description such as ‘beach looking north’ then navigate to where your photo is stored, click on it then press the “upload” button. The screen will come up with an “action processed” box and you will then need to press the “cancel” button to get back to your site to enter transect details.

b. Clicking “save” will take you back to the front screen where you can now enter your transect data.

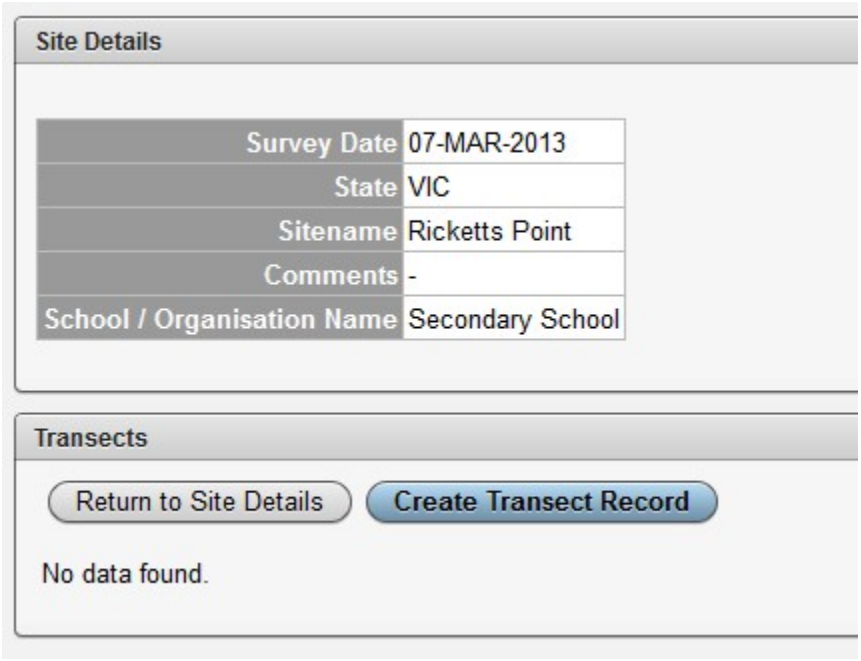


Transect Sites

Map - to check site positions

Go To Transects	Edit	State	Beach Name	Latitude (DD)	Longitude (DD)	GPS Accuracy (m)	Total Transects	Trip Leader	Weather	Wind Speed	Wind direction (compass)	Wind direction (relaticve to shore)
		VIC	Ricketts Point	-37.59637	145.01957	-	-	SEAWK	Clear	0 - calm (flat ocean)	S	-
		VIC	Cape Woolamai	-38.54617	145.34106	2	3	TJL	Clear	2 - moderate breeze (small waves breaking crests, 10-25km/h, 6-20 knots)	SE	side shore
		VIC	Summer land bay	-38.51021	145.15067	3	4	TEACHW	Clear	1 - light breeze (wavelets, <10km/h , <6 knots)	S	side on
		VIC	Smiths beach	-38.5043	145.2569	3	2	ANTHON	Clear	1 - light breeze (wavelets, <10km/h , <6 knots)	S	on shore

6) To enter transect data, click on the  icon under ‘go to transects’, and then click on the “create Transect Record” button.



Site Details

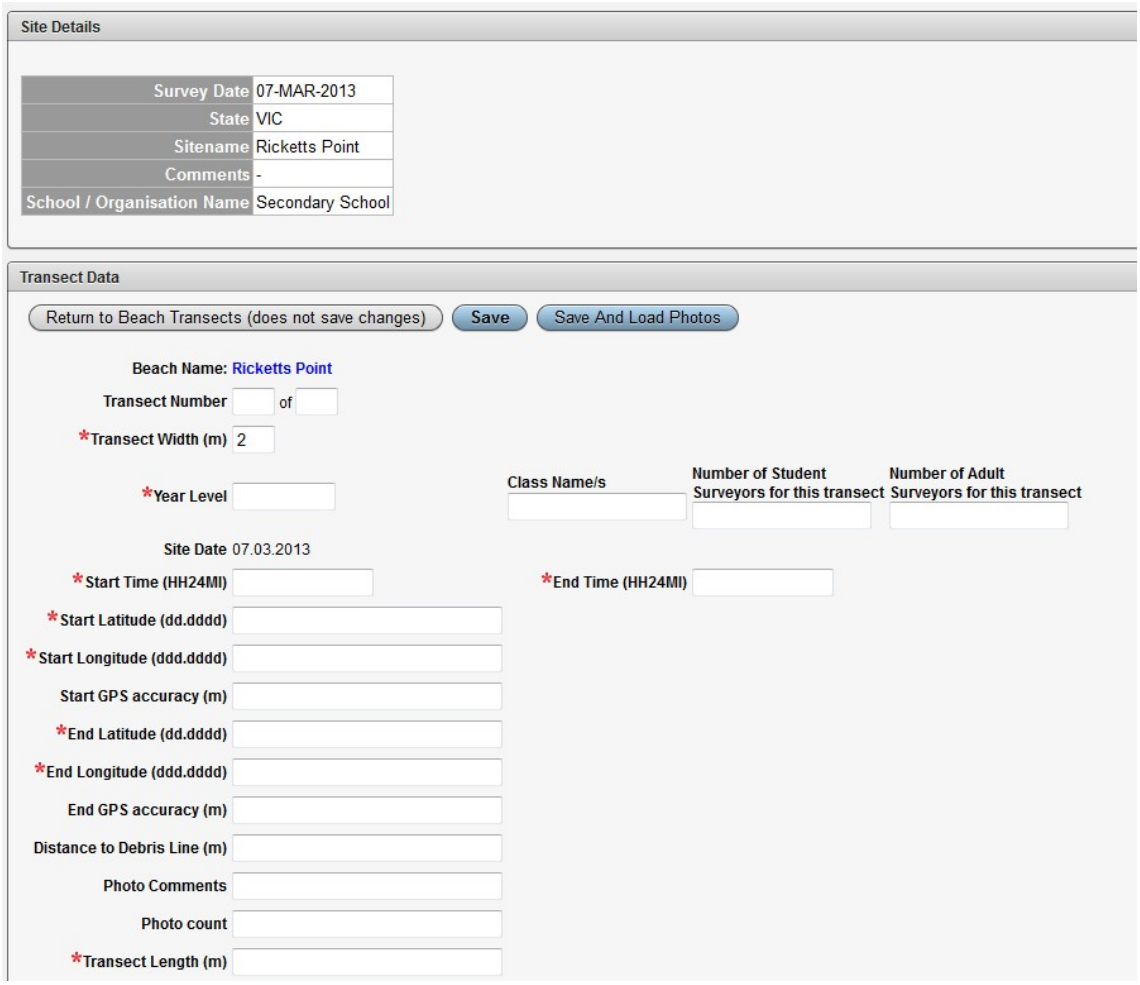
Survey Date	07-MAR-2013
State	VIC
Sitename	Ricketts Point
Comments	-
School / Organisation Name	Secondary School

Transects

Return to Site Details | Create Transect Record

No data found.

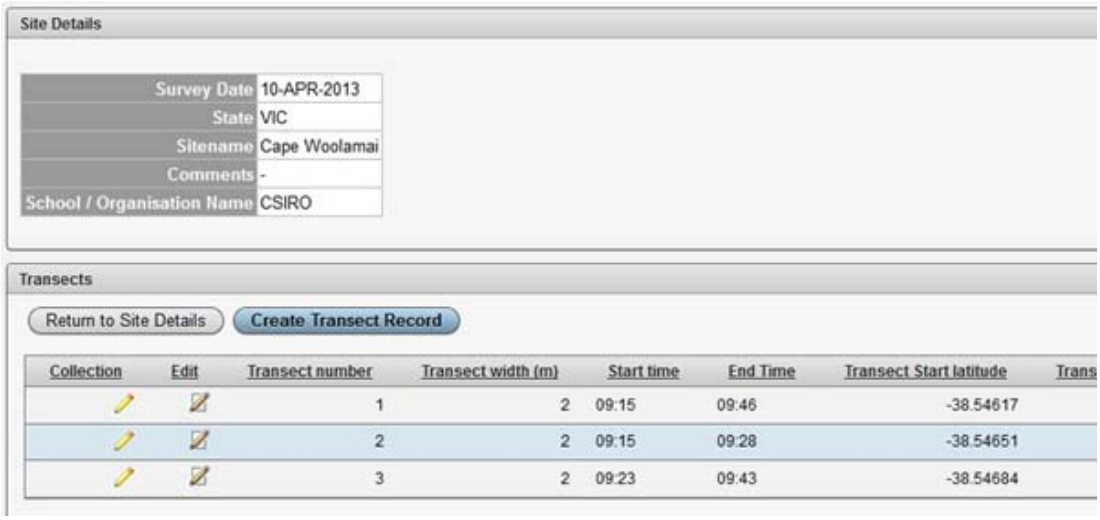
7) Enter in all the 'transect details' noting that these are the same details on your "Transect Data" data sheet. NOTE: Again the "latitude (Decimal Degrees) must be negative (e.g. -35.12546).



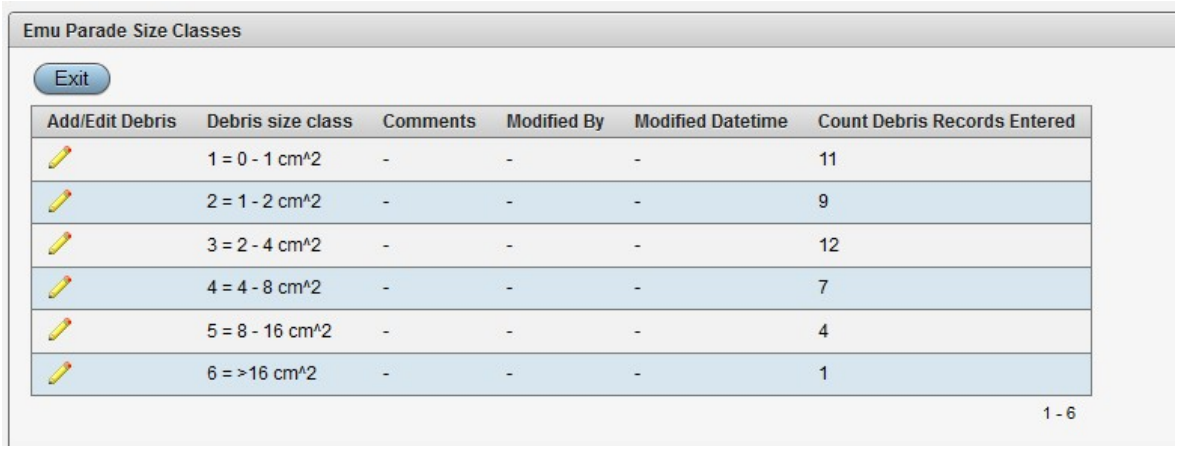
8) Click either the "save" or "save and load photos" button –

   a. If you clicked the "save and load photos" button, do the same steps as you did previously.

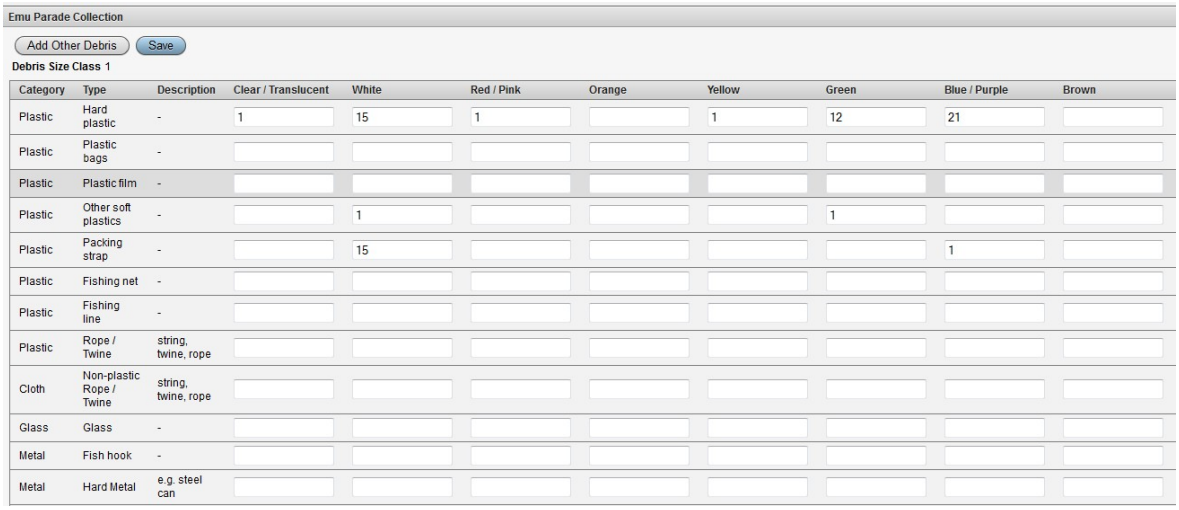
   b. Clicking "save" will take you back to the transect data screen where you can enter your collection data.



9) To enter your collection data, click on the  icon under ‘emu parade’, then click on the same icon next to the size category you want to enter.

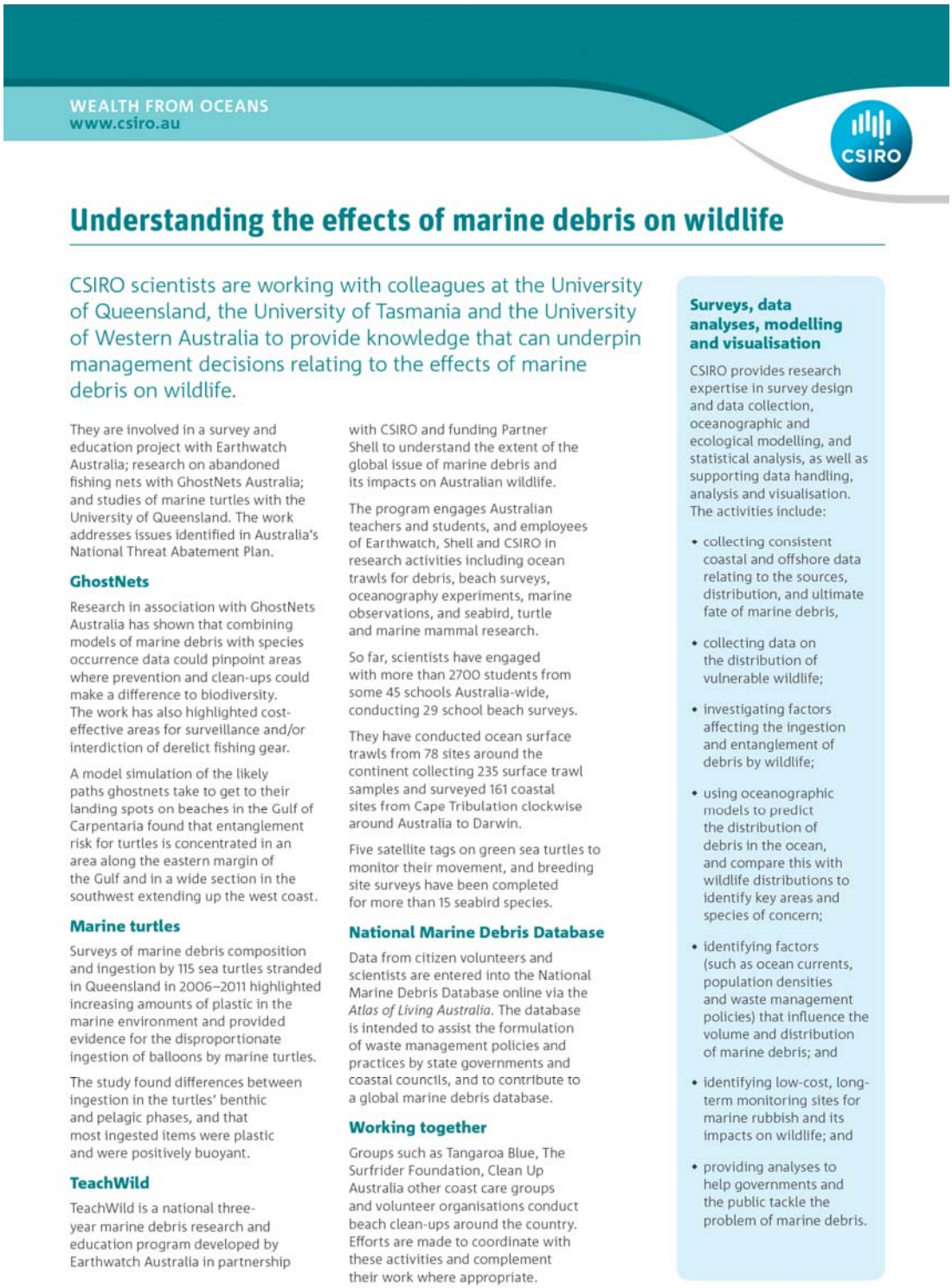


10) Simply enter the number of items you collected in that size category for that type/colour of debris.



11) Repeat steps 6 to 10 for each emu parade.

Appendix C: Wealth from Oceans Flagship flyer – Understanding effects of marine debris on wildlife.



WEALTH FROM OCEANS
www.csiro.au

CSIRO

Understanding the effects of marine debris on wildlife

CSIRO scientists are working with colleagues at the University of Queensland, the University of Tasmania and the University of Western Australia to provide knowledge that can underpin management decisions relating to the effects of marine debris on wildlife.

They are involved in a survey and education project with Earthwatch Australia; research on abandoned fishing nets with GhostNets Australia; and studies of marine turtles with the University of Queensland. The work addresses issues identified in Australia's National Threat Abatement Plan.

GhostNets

Research in association with GhostNets Australia has shown that combining models of marine debris with species occurrence data could pinpoint areas where prevention and clean-ups could make a difference to biodiversity. The work has also highlighted cost-effective areas for surveillance and/or interdiction of derelict fishing gear.

A model simulation of the likely paths ghostnets take to get to their landing spots on beaches in the Gulf of Carpentaria found that entanglement risk for turtles is concentrated in an area along the eastern margin of the Gulf and in a wide section in the southwest extending up the west coast.

Marine turtles

Surveys of marine debris composition and ingestion by 115 sea turtles stranded in Queensland in 2006–2011 highlighted increasing amounts of plastic in the marine environment and provided evidence for the disproportionate ingestion of balloons by marine turtles.

The study found differences between ingestion in the turtles' benthic and pelagic phases, and that most ingested items were plastic and were positively buoyant.

TeachWild

TeachWild is a national three-year marine debris research and education program developed by Earthwatch Australia in partnership with CSIRO and funding Partner Shell to understand the extent of the global issue of marine debris and its impacts on Australian wildlife.

The program engages Australian teachers and students, and employees of Earthwatch, Shell and CSIRO in research activities including ocean trawls for debris, beach surveys, oceanography experiments, marine observations, and seabird, turtle and marine mammal research.

So far, scientists have engaged with more than 2700 students from some 45 schools Australia-wide, conducting 29 school beach surveys.

They have conducted ocean surface trawls from 78 sites around the continent collecting 235 surface trawl samples and surveyed 161 coastal sites from Cape Tribulation clockwise around Australia to Darwin.

Five satellite tags on green sea turtles to monitor their movement, and breeding site surveys have been completed for more than 15 seabird species.

National Marine Debris Database

Data from citizen volunteers and scientists are entered into the National Marine Debris Database online via the *Atlas of Living Australia*. The database is intended to assist the formulation of waste management policies and practices by state governments and coastal councils, and to contribute to a global marine debris database.

Working together

Groups such as Tangaroa Blue, The Surfrider Foundation, Clean Up Australia other coast care groups and volunteer organisations conduct beach clean-ups around the country. Efforts are made to coordinate with these activities and complement their work where appropriate.

Surveys, data analyses, modelling and visualisation

CSIRO provides research expertise in survey design and data collection, oceanographic and ecological modelling, and statistical analysis, as well as supporting data handling, analysis and visualisation. The activities include:

- collecting consistent coastal and offshore data relating to the sources, distribution, and ultimate fate of marine debris,
- collecting data on the distribution of vulnerable wildlife;
- investigating factors affecting the ingestion and entanglement of debris by wildlife;
- using oceanographic models to predict the distribution of debris in the ocean, and compare this with wildlife distributions to identify key areas and species of concern;
- identifying factors (such as ocean currents, population densities and waste management policies) that influence the volume and distribution of marine debris; and
- identifying low-cost, long-term monitoring sites for marine rubbish and its impacts on wildlife; and
- providing analyses to help governments and the public tackle the problem of marine debris.

Publications

Butler JRA, Gunn R, Berry HL, Wagey GA, Hardesty BD and Wilcox, CV (2013) Value chain analysis of ghost nets in the Arafura Sea: identifying trans-boundary Stakeholders, intervention points and livelihood trade-offs. Accepted, *Journal of Environmental Management*.

Schuyler Q, Hardesty BD, Wilcox CV and Townsend K (2013) Are turtles eating more debris? A global analysis since 1900. Accepted, *Conservation Biology*.

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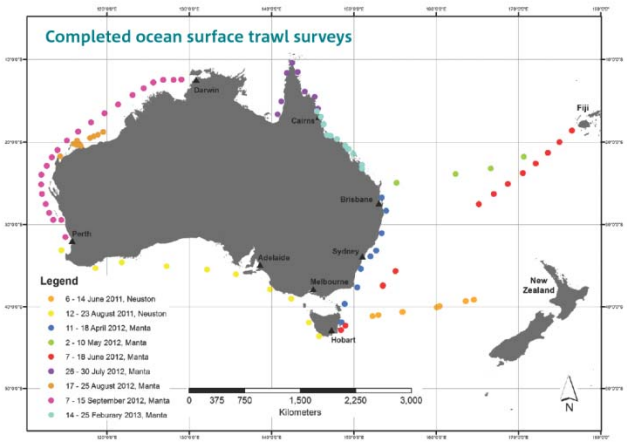

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Citizen science training: www.ala.org.au/blogs-news/fielddata-software-citizen-science-training-course/

facebook: www.facebook.com/pages/Marine-Debris-Australia/233284236732809

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Appendix D: Wealth from Oceans Flagship flyer – Tackling marine debris.

WEALTH FROM OCEANS
www.csiro.au

Tackling marine debris

CSIRO scientists are working to provide knowledge that can underpin management decisions relating to marine debris and its effects on wildlife.

They are involved in a survey and education project with Earthwatch Australia; research on abandoned fishing nets with GhostNets Australia; and studies of marine turtles with the University of Queensland. The work addresses issues identified in Australia's National Threat Abatement Plan.

GhostNets

Research in association with GhostNets Australia has shown that combining models of marine debris with species occurrence data could pinpoint areas where prevention and clean-ups could make a difference to biodiversity. The work has also highlighted cost-effective areas for surveillance and/or interdiction of derelict fishing gear.

A model simulation of the likely paths ghostnets take to get to their landing spots on beaches in the Gulf of Carpentaria found that entanglement risk for turtles is concentrated in an area along the eastern margin of the Gulf and in a wide section in the southwest extending up the west coast.

Marine turtles

Surveys of marine debris composition and ingestion by 115 sea turtles stranded in Queensland in 2006–2011 highlighted increasing amounts of plastic in the marine environment and provided evidence for the disproportionate ingestion of balloons by marine turtles.

The study found differences between ingestion in the turtles' benthic and pelagic phases, and that most ingested items were plastic and were positively buoyant.

TeachWild

So far, scientists have engaged with more than 3000 students from 50 schools Australia-wide, completing 35 school beach surveys. They have conducted ocean surface trawls from 78 sites around the continent collecting 235 surface trawl samples and surveyed some 200 coastal sites from Cape Tribulation clockwise around Australia to Darwin.

Distant waste

Cox Bight and New River Lagoon on Tasmania's south-western coast are hundreds of kilometres from human settlements.

From the air they appear as pristine sands amid wilderness greens and Southern Ocean blues.

Up close it's a different story. Despite their isolation, the beaches here are littered with buoys, bottles, nets, boxes, gumboots, packing straps and ropes.

CSIRO scientists took a float plane from Hobart to five of Tasmania's most remote beaches in May 2013 during the final stage of the national marine debris survey. They landed on flat water near the coast, and hiked to the survey sites.

Other far-flung locations, such as Cape Queen Elizabeth on Bruny Island, were reached after hours of driving and walking.

This was a milestone in a marathon journey: a continent away from the first survey at Cape Tribulation, Queensland, 18 months earlier.

Some 200 beaches were surveyed; not one was rubbish-free.

Giblin River, Tasmania

Publications

Butler JRA, Gunn R, Berry HL, Wagey GA, Hardesty BD and Wilcox, CV (2013) Value chain analysis of ghost nets in the Arafura Sea: identifying trans-boundary Stakeholders, intervention points and livelihood trade-offs. Accepted, *Journal of Environmental Management*.

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National Marine Debris Database

Data from citizen volunteers and scientists are entered online into the National Marine Debris Database. The database is intended to assist the formulation of waste management policies and practices by state governments and coastal councils, and to contribute to a global database of marine debris.

Working together

Groups such as Tangaroa Blue, The Surfrider Foundation, Clean Up Australia other coast care groups and volunteer organisations conduct beach clean-ups around the country. Efforts are made to coordinate with these activities and complement their work where appropriate.

Completed coastal beach surveys

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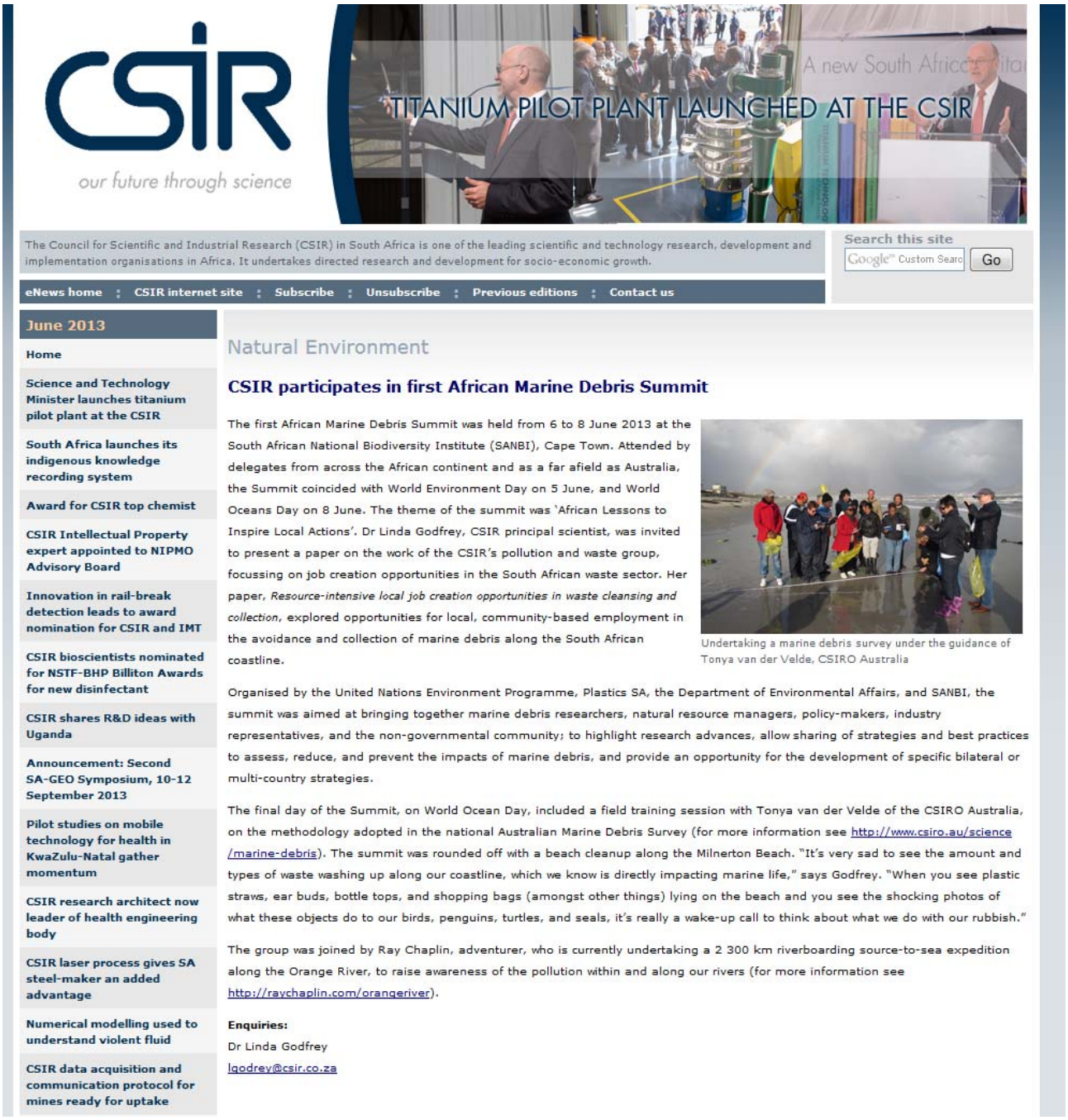
facebook: www.facebook.com/pages/Marine-Debris-Australia/233284236732809

Appendix E: CSIRO participation in international marine debris meeting in South Africa.



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