

REDMAP: ECOLOGICAL MONITORING AND COMMUNITY ENGAGEMENT THROUGH CITIZEN SCIENCE

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INTRODUCTION

Waters around Australia are warming at between 2-4 times the global average, facilitating polewards shifts in the distribution of many marine species. Monitoring for such changes in the distribution of species along the 60,000 km of Australia's coastline presents several ongoing challenges. These include a lack of historical data to determine accurate historical distributions and significant funding constraints that limit the extent of contemporary monitoring programs. However, there are a large number of people collectively spending significant time in, on or around our seas, often with meaningful knowledge of their local species and environments, yet their observations are not routinely recorded, verified, collated, stored and therefore made accessible. Additionally, many people now have the capacity to record their observations with high precision and accuracy via digital technology even if their personal knowledge is not complete. Redmap (Range Extension Database and Mapping Project) is a website-based citizen science initiative where community members submit photographic observations of 'out-of-range' species that are then verified post-hoc by an Australia-wide network of scientists. Redmap began as a pilot project in Tasmania at the end of 2009 before expanding across Australia three years later. Here, we give an overview of Redmap to date, concentrating on the Tasmanian aspects of the project.

Shifts in the geographical distribution of species, or 'range-shifts', are globally some of the most frequently reported impacts of climate change as species alter their distributional limits to keep pace with changing environmental conditions (Burrows et al. 2014). Detailed examination of whole assemblages or ecosystems suggest that between 20-85% of species are shifting where they live in response to changes in temperature (Dulvy et al. 2008; Chen et al. 2011; Wernberg et al. 2011). Redmap is a citizen science initiative designed to provide an early indication of what species may be changing their distributions in our coastal marine environments, and may therefore require additional concerted research effort or management focus. The project invites members of the public to submit photographs and data about unusual

observations of marine species made while undertaking marine activities like fishing, diving, boating, and beachcombing. Redmap has two main discrete but linked objectives: 1. ecological monitoring for the early detection of species that may be extending their geographic distribution as our climate changes; and 2. engaging with the public on the ecological impacts of climate change, using their own data. Community members can either use region-specific lists of 'target' species available on the website or smartphone app to help identify which species are unusual to their particular area before logging a sighting; or they can submit photographs of any species they consider unusual for a given area. Photographs of observations are sent to one of a panel of over 80 expert scientists from many different institutions from across the country to verify the species' identification.

After verification, sightings are displayed on the website and the observer is sent detailed feedback on their observation via email.

To date, divers, fishers and beachgoers around Australia have reported 1060+ sightings on Redmap, via the smartphone app or directly to the website (www.redmap.org.au), with over half of these sightings made around the Tasmanian coastline (Figure 1). Most of the sightings

submitted are observations of only one individual; however, many are of schools or groups of animals and so the actual number of individuals observed is much higher. Nearly a third of the verified observations were considered uncommon where they were spotted i.e. they were south of their known home ranges. Many of the sightings that were not designated as technically 'out-of-range' have been valuable for improving our knowledge of the distribution of poorly known or rare species.

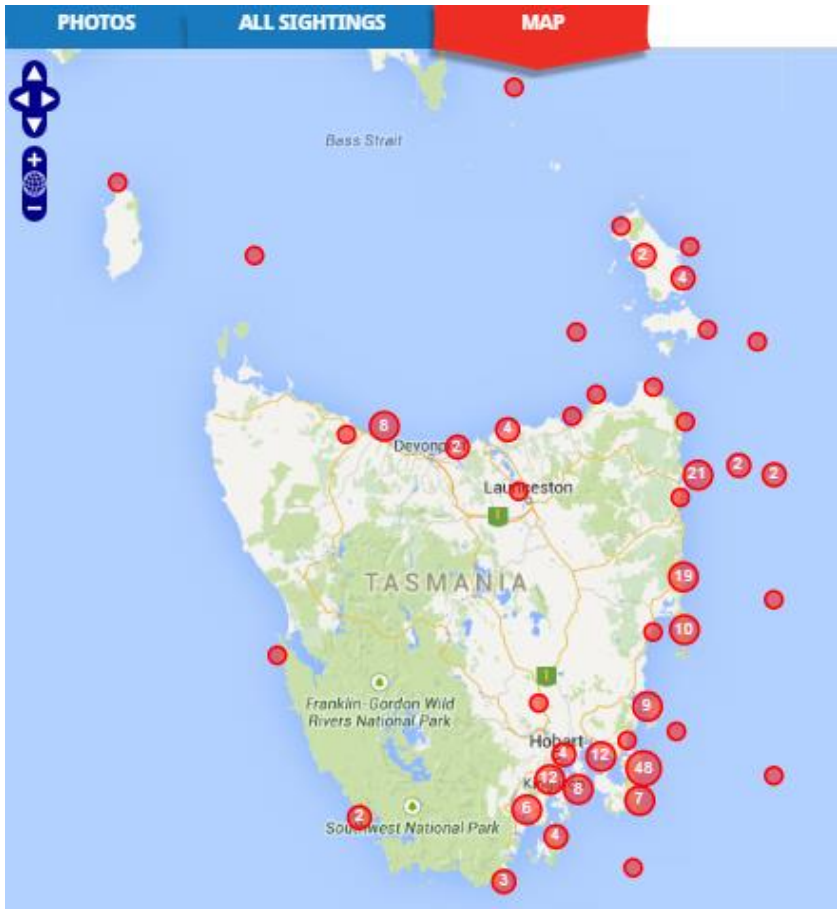


Figure 7. Map highlighting the locations of community observations submitted to Redmap within Tasmania

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Plate 1. The eastern rock lobster (*Sagmariasus verreauxi*) is the most reported species on the Redmap website, observed in areas along the Tasmanian east coast that are not considered part of its historical range

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Plate 2. A juvenile mosaic leatherjacket (*Eubalichthys mosaicus*) was spotted off Maria Island by Redmap member Antonia Cooper in June this year

The eastern rock lobster *Sagmariasus verreauxi* (Plate 1) – venturing down Tasmania’s east coast – is to date the most logged species on Redmap and is thus far showing “high” confidence as potential range extending species (Robinson et al. in press). This species has been recorded intermittently in Tasmanian waters over several decades; however, we are now seeing groups of 35+ adults and sub-adults on the east coast, as well as frequent observations of individuals. Other commonly reported ‘out-of-range’ species in Tasmania include zebrafish (*Girella zebra*), yellowtail kingfish (*Seriola lalandi*), white-ear (*Parma microlepis*), herring cale (*Olisthops cyanomelas*), luderick (*Girella tricuspidata*), old wife (*Enoplosus armatus*), and snapper (*Pagrus auratus*). To confidently quantify how far a species has shifted its marine postcode south we need to collate more data over a longer time frame. However, a qualitative

level of confidence in potential range extensions in Tasmanian species was estimated (Robinson et al. in press) and information on the raw data that is submitted to Redmap shows some individual sightings logged in Tasmania (Figure 1) and how far south they were spotted from their usual poleward range boundary (Table 1). Some observations are clearly significant: for example, the juvenile mosaic leatherjacket (*Eubalichthys mosaicus*) spotted off Maria Island by Redmap member Antonia Cooper in June this year (Plate 2). This species is not normally found in southern Tasmania in mid-winter. Juveniles of potential range-extending species recorded in colder months are particularly important as they indicate the prospect of species being able to survive (and therefore reproduce) throughout the year, increasing their likelihood of establishing a population (Bates et al. 2014).

Species	Month spotted	Where	Distance (km) south of southerly range
 Onespot puller (<i>Chromis hypsilepis</i>)	August	St Helens	68km
 Mosaic leatherjacket (<i>Eubalichthys mosaicus</i>)	June	Maria Island	127km
 Snapper (<i>Pagrus auratus</i>)	March	Blackmans Bay	173km
 Eastern rock lobster (<i>Sagmariasus verreauxi</i>)	Feb	Tasman Peninsula	190km
 Green moray (<i>Gymnothorax prasinus</i>)	May	St Helens	195km
 White-ear (<i>Parma microlepis</i>)	March	Freycinet	203km
 Eastern King Prawn (<i>Melicertus plebejus</i>)	April	Hobart	273km

Table 4. Examples of sightings submitted to Redmap Tasmania that were ‘out-of-range’ i.e. south of their expected distributions

To synthesise what the out-of-range observations submitted to Redmap may mean in terms of potential range shifts of species, the Redmap team developed a qualitative rapid assessment tool to classify levels of confidence (i.e. high, medium and low) in potential range extensions for a variety of Redmap-listed species in Tasmania. This method was adapted from those used in the early detection of invasive species, and included data submitted by Redmap contributors over a three year time period (2009-2012). The assessment considered the confidence with which we could determine the historical range limits, factors that would influence detectability of species, and the temporal consistency of out-of-range observations. In consultation with many of the fishers and divers that submitted their observations to Redmap, this assessment was drafted and published as a 'report card' for public dissemination of the project results (www.redmap.org.au/article/the-redmap-tasmania-report-card/). The process behind the report card was quite novel and so the report card has been extended and drafted as a journal article for scientific dissemination (Robinson et al. in press). Additionally, Redmap has contributed small but influential contributions to a number of significant studies (Johnson et al. 2011; Last et al. 2011; Madin et al. 2012; Ramos et al. in press; Ramos et al. 2014).

CONCLUSION

Ocean temperatures around most parts of the Australian coast have warmed at over twice the global average, and even faster off the eastern coast of Tasmania (Hobday & Pecl 2014). This increase in temperature is facilitating a significant change in the distribution of Tasmania's marine species (Last et al. 2011; Johnson et al. 2011). Through Redmap we are hoping to develop a longer-term record of verified observations of out-of-range species in

Tasmanian waters to add to the data available from traditional scientific surveys, and also the growing database of Reef Life Survey (reeflifesurvey.com).

Citizen science is becoming an important tool for monitoring and evaluating local and global environmental change (Parmesan & Yohe 2003; Silvertown 2009). Through the interest and dedication of Tasmanian fishers, divers and beachcombers, Redmap data can make significant contributions to our growing understanding of how Tasmanian marine ecosystems are changing over time. Importantly, Redmap is also playing a major role in communicating with the general public about the importance of Tasmania's marine ecosystem, and how this may be changing over time.

HOW YOU CAN HELP!

If you catch or see a fish that you find "unusual" in your local seas, share your sighting and photo on the Redmap app or redmap.org.au. The continued support of fishers and divers will, over time, allow Redmap to better understand and predict changes in the distributions of Australia's marine life. There are however many other ways you can assist Redmap, and you don't even have to get wet. For more information visit this page:

<http://www.redmap.org.au/about/how-you-can-help-redmap/>

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