# UNCOMMON, CRYPTIC and SITE-ASSOCIATED REEF FISHES: RESULTS OF SURVEYS ALONG FLEURIEU PENINSULA & IN ENCOUNTER BAY 2009

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**UNCOMMON, CRYPTIC and SITE-ASSOCIATED REEF FISHES:**
**RESULTS OF SURVEYS ALONG FLEURIEU PENINSULA & IN ENCOUNTER BAY 2009**


## SUMMARY

Reef locations along the Fleurieu Peninsula and Encounter Bay were surveyed by diving and snorkelling, from December 2008 to June 2009. The surveys are part of a series we began in 2007, through which we have aimed to (i) develop a suitable non-destructive technique to search for various uncommon reef fishes (mostly benthic, and many cryptic) throughout South Australia; and (ii) record and photograph such fishes, in order to learn more about their distribution, habitats, and habits. Our target list comprises more than 50 species from 14 families, for which little information is available on full distribution within South Australia, and habitat. Examples of our records during the 2009 survey period included (i) one uncommonly recorded endemic species in Syngnathidae, and one edge-of-range species, also in Syngnathidae; (ii) a large individual of an uncommonly recorded weedfish, at the edge of the geographic range, with colour and head features not previously recorded for that species (and which may result in taxonomic reassignment of the species in south-eastern Australia); (iii) several cardinalfishes, in a group (Apogonidae) which has very limited dispersal ability, including an example of a mouth-brooding individual, in a habitat which was significantly impacted by dredge spoil two months after the sighting; and (iv) individuals of two species of large, sedentary, reef-associated fished species of conservation concern, which represent the first published records for those localities. We also took approximately 450 photographs of reef fishes, marine invertebrates (including several rare species and endemic species), and benthic habitats along the Fleurieu Peninsula and in Encounter Bay, which will contribute to a named marine image database for the Adelaide and Mt Lofty Ranges NRM board.

The small number of uncommon fishes observed over 25 searches in the 6 month period to June 2009 (mainly on SCUBA and several using snorkel) indicates that further survey efforts are required over time and space to better understand the distribution, relative abundance and habitat of many uncommon reef fishes in South Australia, particularly in areas away from the more easily accessible dive sites off bays and headlands. The techniques learned and the data gathered during this project are providing an ongoing, cumulative body of useful knowledge - for example, in terms of habitat requirements and usage; presence at various locations within the range; and distribution limits. Such information is useful for formal assessments of conservation status of uncommon reef fishes at international (e.g. IUCN Red List), national (*Environment Protection and Biodiversity Conservation Act 1999*) and State (rare and threatened species schedules) scales, and can also assist in the development of management plans to address coastal impacts which may affect populations of such fishes. The project outcomes to date will also assist future surveys, such as searches in more remote coastal areas, and on offshore reefs, to help improve knowledge of the distribution, habitat, and conservation requirements of uncommon reef fishes in South Australia. The data will also assist conservation planning for nearshore reef fish habitats in South Australia, through South Australia's developing system of marine protected areas.

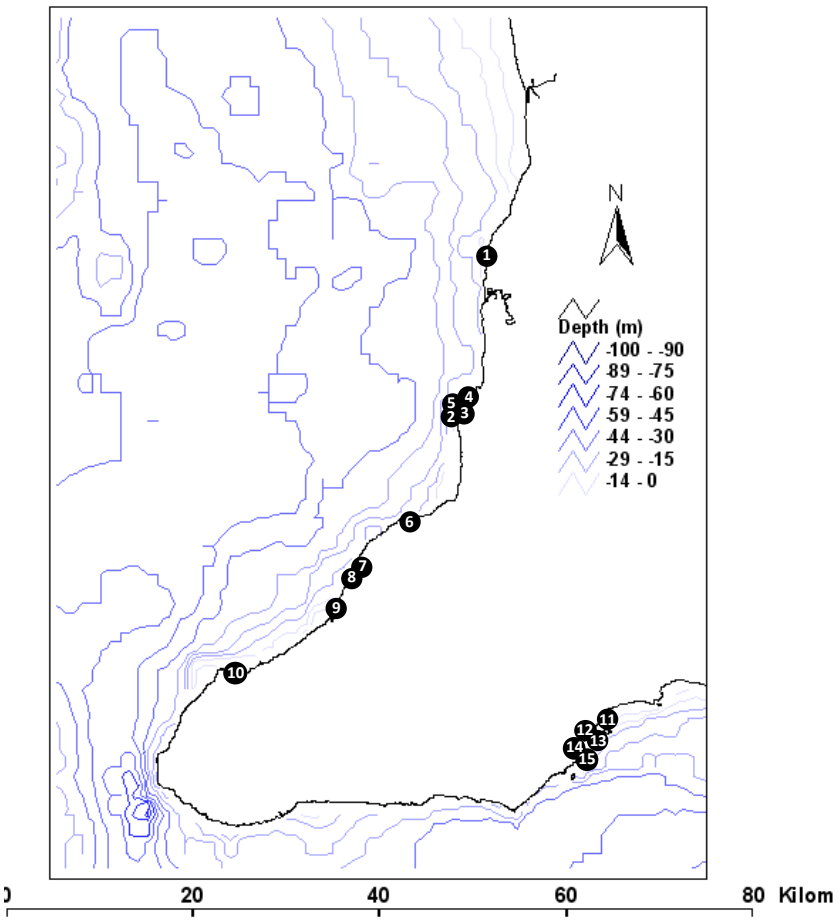

## INTRODUCTION

There are more than a dozen families of uncommon, often cryptic reef fishes of potential conservation concern in South Australia (Baker, 2008, 2009; Baker et al., 2008a,b). For a number of currently known species in such groups, a detailed, comprehensive search for information, using several thousand sources over a seven year period, has shown that there are there are few existing records in South Australia, and very little is known of the distribution within S.A., the habitat requirements, biology, behaviour and ecology (Baker, 2008, 2009). Many of these species could potentially be at risk of localised population decline, due to a combination of factors such as limited geographic range (or edge of range presence in South Australia); existence over a narrow depth range; benthic or bentho-pelagic existence and strong habitat association (which makes them susceptible to various threatening processes); localised, benthic reproduction and limited dispersal, and naturally low abundance.

The surveys presented here are part of a long-term project which aims to help improve knowledge of the distribution and habitat of uncommonly recorded (including possibly rare) and often cryptic reef fishes, thereby assisting in the determining the conservation needs of these species. A number of the uncommon reef fishes, particularly those of limited known geographic range, very narrow depth range, or existence in areas of ongoing threatening processes, might require more formal means of protection or impact

management. One group, the entire family of Syngnathidae, is already listed under State legislation (and contains both rare and very abundant species), but for many other small site-associated fishes, targeted surveys and analysis of data are required, prior to adequate conservation assessments being made.

Previously, with the support of a Wildlife Conservation Fund (DEH) grant and the Adelaide and Mount Lofty Ranges (AMLR) Natural Resources Management (NRM) Board, pilot surveys were conducted along the Fleurieu and other parts of South Australia in 2007-2008, to establish and refine techniques (Baker et al., 2008a,b). Given the paucity of information about these fishes, in this project we attempted to devise a suitable, non-destructive technique for finding and recording uncommon reef fishes, particularly the small, well camouflaged / cryptic species. We also aim to learn more about the distribution and habitat of these species, through dive and snorkel searches at various sites along southern Fleurieu Peninsula and Encounter Bay. The pilot surveys undertaken in 2007-08 yielded new information for a number of uncommon species, including range extensions, new information on habitats, maximum size, and breeding season. Surveys were again undertaken in 2009, with the assistance of the AMLRNRM Board, and our surveys this year included some sites not previously searched. The sites we have visited in the 2009 season (6 months) are shown below, in addition to several sites we surveyed on previous occasions (i.e. some of the Aldinga sites, and the sheltered side of Granite Island) (**Map 1)**. The surveys described here, undertaken at various sites along the Fleurieu Peninsula and in Encounter Bay, also support previous desk-top investigations on the *Marine and Estuarine Fishes of Conservation Concern in the AMLR NRM Region* (Baker, 2007a), and further field investigation of these fishes was recommended in the AMLR NRM Board's *State of the Region Technical Report*.




**Map 1: Map showing sites surveyed along southern Fleurieu Peninsula, December 2008 – June 2009.**

Numbers correspond with sites listed in Table 1

## METHODS

The location of sites surveyed is shown in **Map 1**. From December 2008 to June 2009, dives were undertaken by team members and associates at the following locations: (i) O'Sullivans Beach (10th December 2008; 30th January, 6th February, 15th February, and 11th May 2009); Aldinga Reef (10th May, 2009); (iii) Myponga (30th May, 2009); (iv) Carrickalinga Head and surrounds (5th January and 14th February 2009); (iv) Carrickalinga Bay (8th March 2009); (iii) Carrickalinga North Bay (17th February, 22nd February and 13th April 2009); (iii): Normanville (10th January, 17th January and 2nd February 2009); (v) Rapid Bay Jetty (9th January and 20th March, 2009), and several sites in Encounter Bay, including Rosetta Head / "The Bluff" (13th January and 20th June, 2009), "Bluff Beach" (21st June, 2009); a site offshore from "Whalebones" in western Encounter Bay (13th January 2009), and "Whalebones" (12th January, 19th and 21st June, 2009).

At the majority of sites listed above, a minimum of 2 and maximum of 4 divers per site searched for uncommon fishes amongst macroalgae, and also on reef surfaces, under ledges and in crevices, following approximate north-south or east-west lines across reefs at chosen sites, where possible. Based on previous pilot surveys in 2008 (Baker et al., 2008a,b), we have found that the most effective method of finding uncommon benthic fishes is quiet, patient searching on SCUBA near the bottom. This includes searches under ledges, in crevices, and under and in macroalgae (using hands to part the plants).

For several of the areas within the AMLRNRM region at which we searched during 2009 (Aldinga, Carrickalinga, Rapid Bay and Encounter Bay), supplementary data are also provided from previous dives, during which the commonly observed mobile fishes were recorded using visual census. The technique entails diving or snorkelling in a given direction, recording the number and size of fishes within a 5m swathe over a distance of 100m. Four of the authors are well experienced in the method, and have been trained in estimating fish sizes correctly. Experience with a 100m line has shown that this takes approximately 10 minutes swimming time, at the speed at which we normally record number and size of common reef fishes. Therefore, at the four locations cited above, we used 10 minute swims as an estimate of a 100m transect. At each site we used a minimum of 4 replicates, and **Appendix 1** of this report provides example data for groups of 4 replicate 100m swims, with an estimated total coverage of 2000 $m^2$.

At each site, habitat substratum characteristics have been noted, major algal canopy species recorded, and an index of exposure estimated subjectively according to the dominant macroalgae canopy species present (see Shepherd and Brook, 2007). We estimated rocky bottom relief, according to the average elevation of the reef above the surrounding bottom under the transects.

## RESULTS AND DISCUSSION

### ***Habitats***

For the sites visited during the survey period, the depth, relief and type of rocky bottom substrate, and the dominant algal canopy and understorey species, are given in **Table 1** below. Several of these sites were also visited by two of the authors on previous occasions, and supplementary data were recorded, including fish density data, other details of sites (visibility, exposure index, percentage canopy cover) and numbers and species of fish encountered (numbers 2000 $m^2$). These data are provided in **Appendix 1.**

**Table 1.** Bottom topography and algal dominants at 15 sites, including most of those surveyed from December 2008 to June 2009.

| Site | Depth, Substratum & Relief | Main cover / algal canopy species |
|---|---|---|
| **1. O'Sullivans Beach** | 3m. Metamorphic basement rock boulders, ~ 1m relief, interspersed with cobble / pebble reef and sand | Canopy cover approx. 80%. Main canopy cover includes mixed *Cystophora* species, *Sargassum* species, and *Ecklonia radiata*. Understorey includes articulated corallines, and mixed turfing brown (e.g. *Zonaria* spp., green (e.g. *Caulerpa* spp.) and red (e.g. *Wrangelia* sp.) macroalgae. |

| Site | Depth, Substratum & Relief | Main cover / algal canopy species |
|---|---|---|
| **2a. Aldinga Reef (off point to south)** | Sandstone with few crevices; 0.1 - 0.25m relief | Canopy cover approx. 30%. Moderate relief, grading to flatter cobble reef and sand southwards. *Ecklonia*, *Cystophora* in canopy. Red turf (e.g. *Gelidium*), *Padina* sp., *Lobophora variegata*, and crustose and articulated corallines on reef, with minor cover of green *Caulerpa* (e.g. *simpliciuscula* or *papillosa*), the red *Osmundaria prolifera* and zooanthid colonies |
| **2b. Aldinga Reef (off point northward)** | Sandstone, with abundant caves and overhangs; 2m relief | Canopy cover approx. 90%. Macroalgae cover as Site 3 above. |
| **3. Aldinga Reef (off point near shore)** | Sandstone with numerous pinnacles, crevices, ledges /overhangs ; 1m relief | Canopy cover approx. 80%. Macroalgae cover as site 3 above. |
| **4. Aldinga Reef (on flats to north)** | 1 – 2m. Flat sandstone; 0.1m relief | Canopy cover approx. 10%. Low relief reef with turfing algae, and patches of *Caulocystis*. Reef patches interspersed with sand, covered with seagrass (mainly *Heterozostera*). |
| **5. Aldinga Reef (offshore)** | Flat sandstone; 0.5m relief | Canopy cover approx. 60%. Macroalgae cover as site 3 above. |
| **6. Myponga** | 3 – 5m. Metamorphic basement rock boulders, 1-2m relief, interspersed with cobble / pebble reef and sand | Canopy cover approx. 80%. Main canopy cover includes mixed *Cystophora* species, *Sargassum* species, and *Scaberia agardhii*. Numerous sponges (many species) on boulders; turfing macroalgae include *Lobophora variegata*, *Padina* sp., and *Dictyosphaeria sericea*. |
| **7. Carrickalinga Head and surrounds** | 5 – 7m. Metamorphic basement rock boulders (0.5-2m relief) | Canopy cover approx. 50%. *Ecklonia radiata*, and mixed *Cystophora* species (e.g. *C. moniliformis, C. subfarcinata*); low plants of *Sargassum*, turfing brown macroalgae and sparse green macroalgae (e.g. *Caulerpa flexilis* and *C. cactoides*), and encrusting macroalgae in understory. Some bare boulders. |
| **8. Carrickalinga Bay** | Shallow site: 4m. Parallel lines of metamorphic basement rock, <1m relief, interspersed with rubble and sand.<br><br>Middle depth site: 6m. High relief (1.5 - 2m) metamorphic basement rock with ledges, undercuts, crevices etc; and rubble bottom.<br><br>Deeper site: 6 – 9m. Metamorphic basement rock reef (0-2m, mostly <1m) | Shallow site: Low cover of brown canopy macroalgae and turfing algae.<br><br>Middle depth site: *Ecklonia radiata;* mixed species of *Sargassum* and *Cystophora*; encrusting coralline algae; abundant sponges and ascidians on ledges and in crevices etc.<br><br>Deeper site: Similar to middle depth site: *Ecklonia radiata;* mixed species *Cystophora*; (*C. monilifera, C. moniliformis, C. subfarcinata, C. expansa*) and *Sargassum* (e.g. *S. linearifolium* or *S. spinuligerum*) |
| **9. Normanville** | 1-3m. Low relief (<0.5m). Patches of cobble reef, sand, seagrass | Shallow cobble reef with sand, seagrass and patches of macroalgae (e.g. *Caulocystis*) |

| Site | Depth, Substratum & Relief | Main cover / algal canopy species |
|---|---|---|
| **10. Rapid Bay jetty** | 3-5m. Bottom under and around jetty piles mainly sand, rubble, small boulders and metal jetty debris. | Mainly *Caulocystis*, *Cystophora*, *Scaberia* and turfing species on bottom adjacent to shallow part of jetty. Patches of *Amphibolis* seagrass off southern side of jetty, less than 3m deep. *Ecklonia* and *Sargassum* on piles, with turfing reds (particularly *Laurencia*), sponges, hydroids, etc. Amongst the brown macroalgae, sponge cover and diversity on piles increases further seaward, and colonial ascidians, including *Clavelina moluccensis* , also occur on piles in deeper water (midway to T section). Also on the mid-section piles are mixed *Caulerpa* species. |
| **11. Granite I., Encounter Bay** | 2m. Sloping granite wall & blocks; 2m relief | *Ecklonia radiata*, *Scaberia agardhii*, and species of *Cystophora* and *Sargassum* on steep reef blocks. |
| **12. "Whalebones", Encounter Bay** | Shallow site (1 – 2m): Calcareous reef platform with many holes, ledges and undercuts<br><br>Deeper site (4-5m): High relief (2m) calcareous reef structures with caves, undercuts, columns and "swim-throughs", surrounded by seagrass | Shallow site: Low, dense cover of mixed *Cystophora* and *Sargassum* species, with abundant articulated corallines (several species) in understory, green (*Dictyosphaeria* and *Caulerpa* spp.) and turfing brown (e.g. *Colpomenia sinuosa*) macroalgae, and patches of zooanthids. N.B. Abundant *Heliocidaris erythrogramma* urchins (approx 5 per square metre). Reef platform surrounded by mixed seagrass (*Heterozostera*, *Posidonia*, *Amphibolis*) and sand patches.<br><br>Deeper site: calcareous reef structures covered with mixed *Cystophora* (including *C. moniliformis* and *C. monilifera*) and *Sargassum* species, with understorey of articulated corallines, mixed *Caulerpa* species, and abundant attached invertebrates (sponges, ascidians, bryozoans etc). Reef patches interspersed with sand (covered mainly with *Amphibolis* seagrass). |
| **13. Offshore from "Whalebones", Encounter Bay** | 4 – 6m. Calcareous reef 0-2m relief . | *Ecklonia radiata* and *Scytothalia dorycarpa*, with understory including articulated corallines, multi-branched red macroalgae, and attached invertebrates (sponges, ascidians, bryozoans etc). |
| **14. Rosetta Head, Encounter Bay** | 5 – 9m. Sloping granite blocks; 2 – 3m relief. | Vertical blocks covered with *Ecklonia*, and mixed species of *Cystophora* and *Sargassum*. Understory of turfing algae (e.g. *Zonaria* sp.) and reds (e.g. *Osmundaria prolifera*, *Plocamium* and *Phacelocarpus* sp.) plus solitary and colonial ascidians, bryozoans and flat encrusting sponges |
| **15. Bluff Beach, Encounter Bay** | 2 – 3m. Granitic and/or metamorphic small rocks and boulders (relief 0.5 m), interspersed with sand | Canopy cover approx. 50%, interspersed with *Amphibolis* seagrass (45%), plus some *Posidonia* (5%). Main macroalgae include mixed *Cystophora* species, and *Scaberia*; minor cover of *Sargassum* species. |
| | | |

Sites varied in terms of exposure to wind waves and swell, from moderately sheltered, such as the reef system at Aldinga and the bay near "The Bluff" (protected from southerly exposure), to moderately exposed, such as the site at Rosetta Head, near the entrance to Encounter Bay. Bottom relief and reef composition varied, from relatively flat sandstone reef in the shallows of Aldinga (and also the pitted calcareous reef platform the shallows of western Encounter Bay), to high relief granite headland reefs (Rosetta Head), and metamorphic basement rock reefs (parts of Carrickalinga Bay). Factors affecting the distribution and abundance of reef fishes are numerous, and include: bottom relief, exposure to swell or waves, algal composition and canopy cover, and preferred food and its availability. Some of the factors affecting distribution and abundance at a given site are explored in a recent report (Shepherd et al., 2008), based on surveys we undertook in late 2007 at north-eastern Kangaroo Island. For many of the slow-moving, site-associated and cryptic benthic fishes, sheltered spaces are important for living and reproduction, and examples include caves, crevices, ledges, spaces in objects (e.g. empty shells, under metal or rock debris, or jetty structures) and proximity to benthos used for camouflage (examples include macroalgae and sponges). We provide below a summary of the less common species recorded during the survey period, with notes on distribution and habitats.

## ***Examples of Species Recorded***

### *Syngnathidae*

The syngnathid fauna of South Australia is rich, and includes both common and abundant species, and rare and low density species (Baker, 2007b, 2008; Browne et al., 2008). Generally, many of the life history characteristics of syngnathids make them susceptible to impacts, and vulnerable to population decline. Such characteristics include low population densities (for most species, other than a few of the shallow-water, seagrass-dwelling pipefishes); strong habitat association; small home range sizes and low mobility; possible low rates of natural adult mortality (due to low levels of predation, hence human-induced mortality may disrupt population dynamics); monogamy and localised reproduction; aggregation (in some species) for feeding and/or breeding; small brood sizes, and strong association between adults and young (see Baker, 2008 for summary, and references). Generally, little is known of the biology, population dynamics and ecology of syngnathid species. A number of syngnathids associated with reefs, or with mixed seagrass / reef / rubble habitats are of interest during the surveys of uncommonly recorded fishes in South Australia, including surveys in Gulf St Vincent (GSV) and Encounter Bay, where few individuals of these species have ever been recorded. Species of interest include Red Pipefish *Notiocampus ruber;* Verco's Pipefish *Vanacampus vercoi;* Southern Little Pipehorse / Southern Pygmy Pipehorse *Idiotropiscis australis / Acentronura australe;* Javelin Pipefish *Lissocampus runa;* Smooth Pipefish *Lissocampus caudalis;* Ring-Back (Ring-backed) Pipefish *Stipecampus cristatus;* Western Upside-down Pipefish *Heraldia* sp. 1 (southern form of *H. nocturna*); Tiger Pipefish *Filicampus tigris*, and Southern Gulfs Pipefish *Stigmatopora narinosa.*

Baker (2008) provided detailed synopses on the distribution (including published and unpublished records of these species in South Australia), habitats, biology, vulnerable population characteristics and threatening processes for these species. Main points are summarised in here, for two species recorded during the 2009 survey period. One is an endemic species in the list above of uncommonly recorded pipefishes; the other has been more frequently recorded during the past few years (due to searching efforts by MLSSA member D. Muirhead, and ex-Reef Watch diver K. Smith) , but Gulf St Vincent appears to be the western edge of the geographic range for the latter species.

It is noted that since January 2006, fishes in the Syngnathidae (seadragons, pipefish, pipehorses) have been formally protected in South Australia, under the *Fisheries (General) Variation Regulations 2006* of the *South Australian Fisheries Act*.

*Verco's Pipefish*

*Vanacampus vercoi* is known to date only from the central part of the South Australian coast. Previous records and habitat details are summarised in Baker et al. (2008b) and Baker (2008, 2009). During an AMLRNRM Board-assisted pilot survey period in April 2008, we recorded one large adult specimen of Verco's Pipefish off Bluff Breach (near Rosetta Head / "The Bluff") in Encounter Bay, and one of us (D. Muirhead) recorded both adult and juvenile Verco's Pipefish at Normanville, on the Fleurieu Peninsula (March, 2008). The live specimen at Rosetta Head was positively identified by R. Kuiter, from photographs we took *in situ* (see Baker et al., 2008b, **Figure 1A**). The Encounter Bay specimen represented a south-eastern extension of the known geographic range, and the first record for Encounter Bay. It also represented

presence in a habitat not previously recorded for this species (i.e. in the vicinity of a boulder, densely covered with mixed *Cystophora* species and *Scaberia agardhii*, surrounded by seagrass). The Encounter Bay specimen we photographed in 2008 was larger (approximately 15cm) than the published maximum size, and had a bright orange-red abdomen, possibly an indication that the individual was in reproductive phase. In January 2009, we recorded another specimen of Verco's Pipefish in the same area of Encounter Bay. The specimen recorded in 2009 was smaller (approximately 10cm) and more evenly coloured, without the orange-red abdomen. Unfortunately, all photographs taken of that pipefish at Encounter Bay in 2009 were unclear (**Figure 1b**). Verco's Pipefish was also recorded again at Normanville by D. Muirhead in February 2009 (**Figure 2**). This Normanville specimen was smaller than those observed in Encounter Bay in 2008 and 2009, and may have been a juvenile. The Normanville site is shallow, close to shore, with a mixed bottom cover of sand, seagrass patches, seagrass detritus and rubble (with low algae, such as *Caulocystis* sp.). The identify of *Vanacampus vercoi* for the Normanville specimen was confirmed by R. Kuiter, and an example of a specimen recorded by D. Muirhead at Normanville has recently been published on the Australian Museum web site.

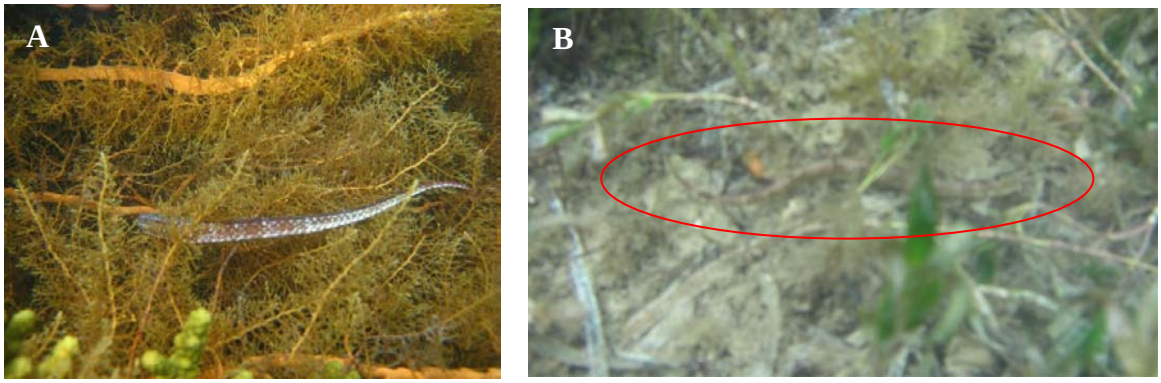



**Figure 1A:** Verco's Pipefish *Vanacampus vercoi*, observed at a site in south-western Encounter Bay in April 2008. **1B**: a smaller individual of *V. vercoi* observed in the same bay in January 2009. Photos: (c) H. Crawford.

**Figure 2:** Verco's Pipefish *Vanacampus vercoi*, observed at Normanville in February 2009. Photo: (c) D. Muirhead, MLSSA

*Crested Pipefish*

Crested Pipefish *Histiogamphelus briggsii*, also known as Brigg's Crested Pipefish, or Brigg's Pipefish, is a relatively large pipefish (23-25cm) found in south-eastern Australia, from New South Wales to South Australia, including Bass Strait (where it is relatively common) and northern Tasmania (Scott, 1980; Dawson, in Gomon et al., 1994; Kuiter, 1996b, 2003, cited in Baker, 2008).

In South Australia, this species is known mainly from the south-eastern and central coast, with records to date from Robe (upper south-east SA); Kangaroo Island (Glover, 1979); Fleurieu Peninsula / south-eastern Gulf St Vincent (e.g. Normanville / Yankalilla Bay, Myponga Beach); Port Noarlunga in the southern metropolitan area, and the metropolitan coast of GSV (e.g. Brighton, Seacliff, Marino) (South Australian Museum record, 1946; Dawson, 1985; Eschmeyer, 1999; S.A. Museum data, 2003, cited by T. Bertozzi, SAM, pers. comm., 2005; D. Muirhead and K. Smith, unpubl. data, 2004 and 2005; Smith, 2005; K. Smith, unpubl. data, 2005, 2006; K. Smith, pers. comm., 2007, cited by Baker, 2008). The species appears not to be commonly recorded; however, at some shallow-water beach locations in New South Wales, Crested Pipefish congregates in large numbers during summer (Dawson, in Gomon et al., 1994). Although this species also appears to be relatively common at sampled sites on the eastern side of Gulf St Vincent (K. Smith, pers. comm., 2006), this gulf may be the western edge of the geographic range. Crested Pipefish is found in a variety of habitats; particularly nearshore sandy areas near the protection of rocks or seagrass; also rubble near reefs, or near (or amongst ) macroalgae, or piles of macroalgal detritus, and it also occurs in more open habitat (Dawson, in Gomon et al., 1994; Smith, 2007; data by K. Smith and R. Browne, cited by Baker, 2008). This pipefish has also been recorded in *Zostera* seagrass detritus over fine sand bottom, and in shallow dredge samples, in south-eastern Australia (Dawson, 1985). In north-eastern Tasmania (Jordan et al., 1998) and in S.A. (K. Smith, pers. comm., 2006), the species has also been recorded in sand habitat adjacent to seagrass beds. The species is well camouflaged, and can look like decaying *Posidonia* seagrass (Smith, 2007). Crested Pipefish is found over a relatively narrow depth range, and is known to date from less than 2m down to about 20m, but may also occur slightly deeper (Dawson, in Gomon et al., 1994; K. Smith and D. Muirhead, unpubl. data, 2005, 2006; Kuiter, 2003; CSIRO Ichthyology records, in Australian National Fish Collection, cited by Baker, 2008). This pipefish occurs singly or in small aggregations, and individuals are quite mobile most of the time; Crested Pipefish may be migratory at a small scale, and seasonal in abundance, in certain areas (Kuiter, 1996b, 2003). Recent examples of Crested Pipefish recorded at Normanville are shown in **Figure 3** below. Given the shallow distribution and the habitat of this species, populations it may be vulnerable to decline from nearshore habitat impacts, and this is discussed further in the section below on **Threatening Processes**.


**Figure 3A-C**: Two individuals of Crested Pipefish *Histiogamphelus briggsii*, observed at Normanville in January 2009 (**A**) and February 2009 (**B, C**)
Photos (c) D. Muirhead, MLSSA

***Clinidae (Weedfishes)***

The Clinidae family contains the weedfishes, of which there are more than 25 species in southern Australia. Most are found over a narrow depth range in nearshore waters. Members of the Clinidae are strongly site-associated in shallow seagrass beds and macroalgae-covered reef habitats. Some species are common in such habitats; others are known from very few records. Weedfishes are very well camouflaged benthic fishes, and a single species can be highly variable in colour and patterning according to the habitat. This characteristic makes identification in the field difficult, as does the "skittish" behaviour of weedfishes, which move quickly to nearby cover when disturbed, and thus provide few photographic opportunities *in situ*. Clinids are viviparous (bear live young) (Gunn and Thresher, 1991, cited by Baker, 2009), and therefore reproduce at a local, site-associated level, and have low dispersive ability, characteristics that can increase vulnerability to processes causing population decline. Kelleher et al. (1995) mentioned that the live-bearing characteristic of the Clinidae accounts for much of the speciation and endemism in this group of fishes in southern Australia. These species may be susceptible to population declines from physical disturbance to habitat and siltation from dredging, channel development, boating in shallow waters; also sediment- and effluent-induced dieback of macroalgae and seagrasses etc), but species-specific data are lacking, in relation to locations where these impacts have been recorded (Baker, 2008, 2009).

Reef-dwelling weedfishes for which few records and little information are available in the survey area, and in South Australia generally, include:

- Kuiter's Weedfish *Heteroclinus kuiteri* Hoese and Rennis, 2006
- Wilson's Weedfish *Heteroclinus wilsoni* (Lucas, 1891)
- Long-Snouted / Sharp-Nose / Longnose / Forster's Weedfish *Heteroclinus tristis* (= *H. forsteri*) (Klunzinger, 1872)
- Rosy Weedfish *Heteroclinus roseus*
- Milward's Weedfish *Heteroclinus* sp. 6 (Hoese et al., in Gomon et al., 1994)
- Whitley's Weedfish *Heteroclinus* sp. 2 (Hoese et al., in Gomon et al., 1994)
- Coleman's Weedfish *Heteroclinus* sp. 4 (Hoese et al., in Gomon et al., 1994)
- Kelp Weedfish *Heteroclinus eckloniae* (McKay, 1970)
- Little Weedfish / The Girls' Weedfish *Heteroclinus puellarum* (Scott, 1955)

Compared with the 2008 surveys, very few weedfishes were observed at the sites we surveyed in 2009. The only species of note is detailed below.

*Long-snouted / Sharp-nose Weedfish*

*Heteroclinus tristis* (previously known as *H. forsteri*) is found across southern Australia, and is most abundant on reefs in Tasmania and Victoria (Hutchins and Swainston, 1986; Edmunds and Hart, 2003; B. Hutchins, pers. comm., 2006, cited by Baker, 2009). South Australia is at the western edge of the geographic range, and although the species may not be uncommon here, there are few published records in this State, possibly due to the cryptic habitats and effective camouflage of this species in macroalgae-rich reef habitats. The relatively few records in S.A. to date have come from the gulfs region (e.g. south-western Spencer Gulf; Edithburgh and other locations along the "heel" of Yorke Peninsula; the metropolitan coast, and Fleurieu Peninsula); northern and north-eastern Kangaroo Island, and the Encounter Bay to Murray Mouth area. The type locality is "Murray River" (collected during the late 19$^{th}$ century and described by Klunzinger, 1872), which likely refers to the Encounter Bay or Murray Mouth area. During our 2009 surveys, we recorded a large specimen (25cm) against a granite wall in Encounter Bay, in the vicinity of brown *Cystophora* canopy macroalgae, and green *Caulerpa* macroalgae. The specimen was vivid, bright lime green (**Figure 4A,B**), a colour not previously recorded for this species. The identity of the specimen in photographs was confirmed by R. Kuiter as likely to be *H. tristis*. However, according to Kuiter (pers. comm., June 2009) there are differences in this and other South Australian specimens of *H. tristis* compared with those in Victoria (originally named *H. forsteri*, but now considered to be a synonym of *H. tristis*). The snout may be shorter, and the eye-tentacles more rounded and short, compared with the Victorian specimens. Bright green individuals of this species have apparently not been recorded in south-eastern Australia, where they are usually red or brown. Considering that South Australia contains the type locality of *H. tristis*, the specimens from Encounter Bay may represent the "true" *H. tristis*, and specimens from Victoria may therefore be another, unnamed species (R. Kuiter, pers. comm., June 2009). During a previous survey period (April 2008), at Rosetta Head in Encounter Bay we observed under red macroalgae (8m) a large (> 10cm), dark red/maroon-coloured weedfish with many transparent patches in the dorsal fin, which may also have been *H.*

*tristis*. The shape, body markings and fin details matched those of the bright green specimen we observed in 2009. Also, a diver from the Flinders University dive club (A. King) observed and photographed a golden-coloured specimen of *H. tristis* at a site just out of Encounter Bay, in late 2007. The examples above may indicate the great variability in colour (dark red/maroon, golden brown; bright green) within a single species of weedfish, according to habitat. However, the specimens recorded from Encounter Bay, and the apparent differences between those and *H. tristis* individuals in south-eastern Australia, indicate that more taxonomic work is required on members of *Heteroclinus* in southern Australia. In recent years, a project on the genetics of species in Clinidae has been planned in south-eastern Australia, but details are not available for this report.

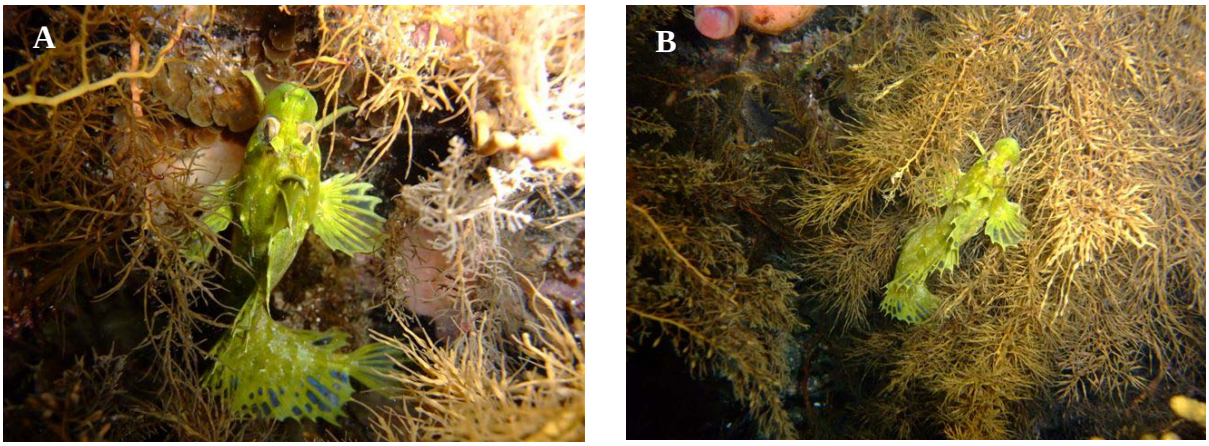



**Figure 4A** and **4B**: *Heteroclinus* (probably *H. tristis*) in Encounter Bay, June 2009 Photos: (c) J. Baker

***Serranidae (Sea Perches)***

Globally, the Serranidae is a large family, containing fishes such as groupers, sea perches, and rock cods. The life history characteristics and habits of fishes in this family increase their vulnerability to decline. Serranid fishes are generally large, slow moving, relatively long-lived, reef-associated benthic species that reproduce as protogynous hermaphrodites, and maintain specific population structures. Serranid fishes are vulnerable to capture by a number of fishing methods, and susceptible to other site-specific impacts. In South Australia, some of the species in Serranidae include Harlequin Fish *Othos dentex*, found on shallow reefs in South Australia and Western Australia; the Butterfly Perch *Caesioperca lepidoptera* and the Barber Perch *Caesioperca rasor*; and the Black-banded Sea Perch *Hypoplectrodes nigroruber*. Less commonly known members in South Australia occur mainly in the western part of the State, and also in W.A., with examples including Western Orange Perch *Lepidoperca filamenta*, Slender Orange Perch *Lepidoperca occidentalis*, and Western Wirrah *Acanthistius serratus*. Of the serranids cited above, Black-banded Sea Perch, which was recorded during the survey period, is discussed here. The species ranges from NSW through to the central coast of Western Australia. Within South Australia, *H. nigroruber* is known mainly from the west coast and gulfs region. Examples of locations from where this species has been recorded include eastern Great Australian Bight (e.g. Thevenard / Ceduna area, and islands in the Investigator Group); Spencer Gulf (e.g. Port Lincoln area, Cowell / Franklin Harbour area, Port Hughes, Moonta); Gambier islands south of Spencer Gulf; northern Kangaroo Island (e.g. Cape Torrens, Cape Forbin, Emu Bay, Seal Beach, Cape Cassini, Hogg Point; Point Marsden), and north-eastern Kangaroo I. (e.g. Snapper Point, Cable Bay, Penneshaw); south-western Gulf St Vincent (Troubridge Point, Troubridge Island, Edithburgh Jetty); Fleurieu Peninsula (Cape Jervis, Rapid Bay Jetty), and eastern Gulf St Vincent (Aldinga, Port Noarlunga Reef, *Lumb* Wreck; Seacliff Reef; Glenelg Barge and Dredge, Grange Tyre Reef) (Kuiter, 1983; Branden et al., 1986 and 1994; MLSSA, 1999; Anonymous, 2001; K. Smith, unpubl. data, 2001 - 2006; Reynolds, 2002; Edgar et al., 2006; South Australian Museum records, Museum of Victoria record, cited by Baker, 2008). During the survey period, we recorded this species at Rapid Bay Jetty, Carrickalinga and Myponga. The latter two locations are the first published records of this species at those locations, and add to the knowledge of distribution of this species in Gulf St Vincent.

Although the Black-banded Sea Perch is found across southern Australia, and is not uncommon in parts of the range, it is of conservation concern for a number of reasons, including the following (from Baker, 2008):

- it is a relatively large, slow-moving, benthic, reef-associated fish (which is often observed resting on the substrate, perched on its pectoral and ventral fins), and the life history and habits of such species make them vulnerable to exploitation, and localised population impacts;
- it is site-associated with shallow subtidal reefs over a relatively narrow depth range (less than 40m) in upper continental shelf waters. In some areas, particularly metropolitan reefs, processes that reduce the quality of such habitat (such as reduction or change in benthic cover due to land-based discharges, and reduction in water quality) may adversely affect Black-banded Sea Perch populations, but no specific data are available;
- it is probably a protogynous hermaphrodite, as are most members of the sub-family Anthiinae (to which *Hypoplectrodes* belongs) (P. Heemstra, South African Institute for Aquatic Biodiversity, pers. comm., 2006). Individuals first mature as females and, after spawning one or more times, change sex and spawn thereafter as males: Heemstra and Randall, 1999). This mode of reproduction is a vulnerable population characteristic. Protogynous hermaphrodites maintain specific population structures (e.g. ratio of males to females, and numbers per group), and the reproductive capacity of the population can easily be disrupted due to over-exploitation by fishing, or by other sources of mortality;
- it is vulnerable to capture by a number of fishing methods, including recreational angling and spear-fishing; minor bycatch in some commercial fisheries (e.g. rock lobster), and collection for the aquarium trade. Fishing may potentially be a threatening process, given the life history characteristics of species in Serranidae such as *H. nigroruber*, but there are no catch restrictions in any State; no species-specific catch statistics; and no assessments have been undertaken (in any part of the range) on the effects of fishing on Black-banded Sea Perch population abundance or structure.
- there is a lack of data on the relative abundance and population dynamics of this species across the range.

**Figure 5A** and **5B** show examples of *Hypoplectrodes nigroruber*, recorded during the survey period.

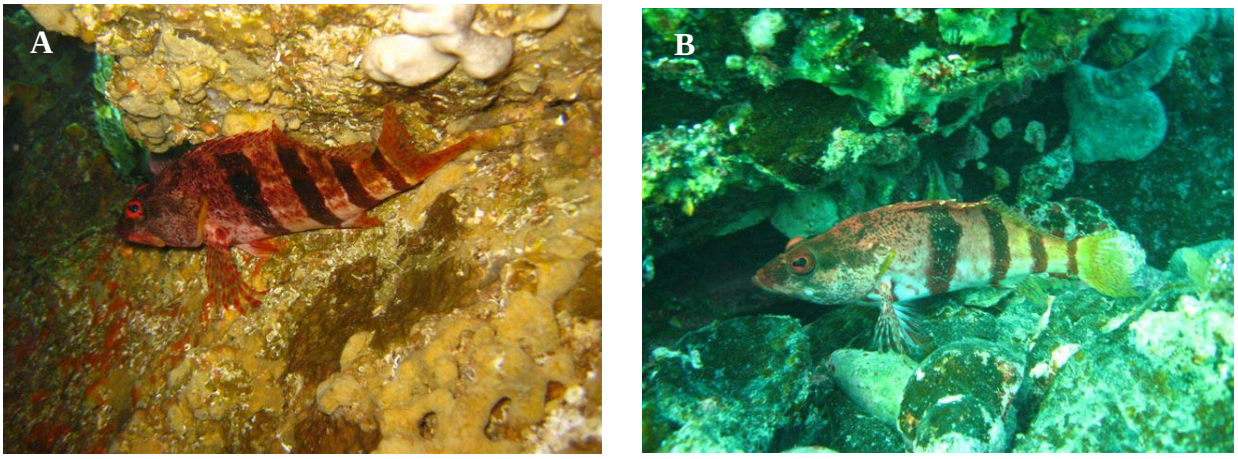



**Figure 5**: **A:** Juvenile *Hypoplectrodes nigroruber* at Myponga, May 2009. Photo: (c) H. Crawford.
**B:** *H. nigroruber* at Carrickalinga, April 2009. Photo: (c) J. Brook

***Apogonidae (Cardinalfishes)***

Another site-associated family of reef fishes with limited dispersal ability is the Apogonidae (cardinalfishes). The *Vincentia* cardinalfishes are benthic, mouth-brooding species (Allen, 1999) with localised reproduction, found mainly in shallow subtidal seagrass beds and/or nearshore reefs, and all these characteristics may increase the vulnerability of such species to localised impacts. One of the more common species is the Southern Cardinalfish *Vincentia conspersa*, found in south-eastern Australia States, with the Great Australian Bight being the western limit. It has been recorded throughout South Australia, from the far west to the south-east, on reefs and also in nearshore seagrass beds, and in estuaries (see Baker, 2008 for summary of records). Less commonly recorded is the slightly smaller Scarlet Cardinalfish *V. badia*, found in W.A. and S.A., with most of the S.A. records to date being from Gulf St Vincent and Spencer Gulf. There is enough variation in colour pattern between the two species to make identification in the field difficult (M.

Gomon, Museum of Victoria, pers. comm., 2009). This is particularly so when the whole body of the individual is not seen, because the features that distinguish the two species include number of lateral line scales; number of scale rows between lateral line and ventral fin base, and number of gill rakers (Gomon et al., 2008). During our 2009 surveys, we observed a cardinalfish in reproductive phase, in a crevice at O'Sullivan's Beach (3m deep) in February 2009 (**Figure 6A**). The fish was mouth-brooding eggs, the outlines of which were clearly discernible *in situ*. Unfortunately, photographs taken at the site are not of sufficient clarity to show detail of the mouth brood. We also recorded cardinal fishes at Aldinga Reef (2m) in May 2009, and at two sites in Encounter Bay: The Bluff (January and June 2009) (**Figure 6B,C**) and "Whalebones" on the western side of Encounter Bay (June 2009) (**Figure 6D**). Most sightings were of the Southern Cardinalfish, but it could not be determined whether the individuals at O'Sullivan Beach, and in western Encounter bay, were the Southern (*V. conspersa*), or less common Scarlet (*V. badia*) Cardinalfish.

Taxonomic work is required to determine the number of *Vincentia* taxa in South Australia. to date, there are three species confirmed (*V. conspersa*, *V. badia*, and *V. macrocauda*), and it is possible that the Western Australian species *V. punctata* also extends into western South Australia. It is noted that there are South Australian specimens that are not easily identified as either *V. conspersa* or *V. badia*, using the currently available descriptions and keys. It is not known whether this is due to the inadequacy of the keys, or perhaps indicative of hybridisation or the presence of cryptic taxa (R. Foster, S.A. Museum, pers. comm., 2006, cited by Baker, 2008). For these fishes, more information on the distribution, habitats, biology, vulnerable population characteristics and threatening processes (including trawling), is provided in the chapter on Apogonidae in Baker (2008), and in the section below, on **Threatening Processes**.

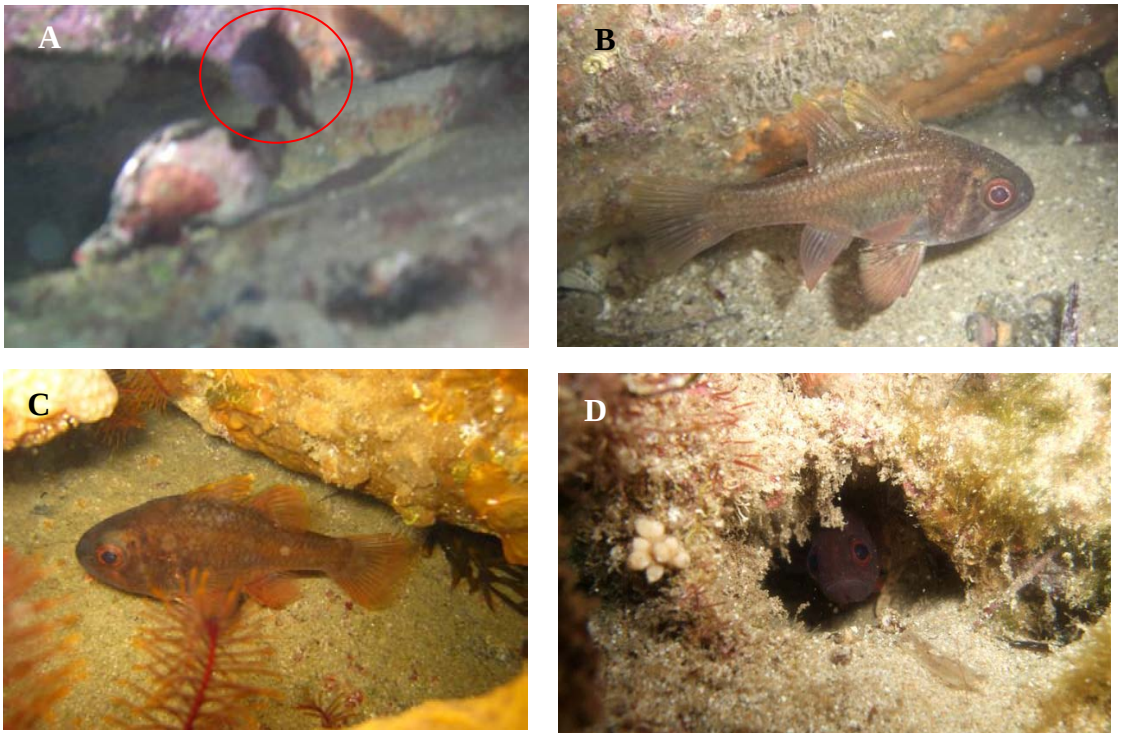



**Figure 6A-D**: Individuals of *Vincentia* cardinalfishes. **A**: *Vincentia* (*conspersa* or *badia*) in reproductive phase, i.e. mouth-brooding, recorded at O'Sullivans Beach, February, 2009. Photo: (c) J. Baker. **B** and **C**: *V. conspersa* at Rosetta Head, Encounter Bay, January and June, 2009. Photos: (c) H. Crawford. **D**: *V. conspersa* or *V. badia*, western Encounter Bay, June 2009. Photo: (c) A. Brown.

***Ophidiidae (Rock Ling)***

The Ophidiidae family is distantly related to the cods in body form, and includes the cusk-eels, brotulas, assfishes and lings (Gomon, in Gomon et al., 1994; Nielsen et al., 1999, cited by Baker, 2008). Rock Ling *Genypterus tigerinus* is one of the few species in the family that occurs in shallow water. The closely related Pink Ling *G. blacodes* occurs in deeper waters, and is an important commercial species in Commonwealth fisheries of south-eastern Australia, despite little being known of the species' biology or population dynamics. Adult Rock Ling are very large (to 1.2m, and ~ 7kg), possibly long-lived, site-associated reef fish. (N.B. the related Pink Ling *G. blacodes* has been aged to about 30 years: Robins, in Nielsen et al., 1999).

Rock Ling are highly esteemed as food, and vulnerable to over-exploitation by both commercial and recreational fishers. Although Rock Ling has a broad distribution in the temperate marine waters of Australia and New Zealand, it is considered to be uncommon species in South Australia, with most records known from Gulf St Vincent and Spencer Gulf (see summary in Baker, 2008), and from south-eastern South Australia. Rock Ling are associated with a variety of mainly nearshore habitats, but the distribution also extends to around 60m (Hutchins and Swainston, 1986; Kuiter, 1993; Robins, in Nielsen et al., 1999).

Juvenile Rock Ling usually inhabit seagrass-lined estuaries, and are often found under objects or small reef patches within the seagrass beds (Kuiter, 1993, 1996a; Gomon, in Gomon et al., 1994; Edgar, 2000). In Tasmania, juveniles have been recorded in low numbers in estuaries lined with *Heterozostera* seagrass, and occasionally, *Posidonia* seagrass (e.g. Jordan et al., 1998). Adults inhabit shallow, rocky reef areas, and are usually found under ledges, and in caves, crevices and other rocky recesses, where they often remain during the day. They are also found around jetties, shipwrecks, artificial reefs (including tyre reefs, concrete cubes, pipes and other structures) (Beinssen, 1976; Kuiter, 1993, 1996a; Branden et al., 1994; Gomon, in Gomon et al., 1994; Furlani, 1998; MLSSA, 1999; Edgar, 2000; Coutin, 2001; Australian Museum, 2002, cited in Baker, 2008). Although Rock Ling often inhabit shallow reefs close to the shoreline in bays, inlets and along open beaches, adults sometimes move away from inshore areas, and can occur in coastal reef areas in burrows under rocks, in waters 15m deep or more (Kuiter, 1993). In Victoria, near Ricketts Point Marine Sanctuary, the species has been recorded on unvegetated soft sediments (Plummer et al., 2003). Another example of a habitat in which *G. tigerinus* has been less commonly recorded, is coarse sand bottom nearly 50m deep, in a clump of sessile invertebrates composed of sponges, with some hydroids, ascidians and bryozoans (Roob and Currie, 1996, cited by Plummer, 2003). Rock Ling eat rock lobsters (Winstanley, 1977, cited in Kailola et al., 1993); seagrass-dwelling fishes (Hindell, 2006), and crabs such as *Nectocarcinus* species (S. Shepherd, SARDI, pers. comm., 2006).

Adult Rock Ling are large, slow-moving and site-associated on shallow reefs and other underwater features, and are thus vulnerable to capture by fishers. This species is taken by spear, hook and line, nets and other recreational fishing gear, and only in Tasmania and Victoria have catch limits been established. Rock Ling in some areas of southern Australia have been over-exploited by recreational fishing, including netting and spear-fishing. There are spear-fishing records in all southern States, and S.A. records include Rapid Bay and other locations along Fleurieu Peninsula, Kangaroo Island, and Yorke Peninsula (details are provided in the synopsis on *G. tigerinus*, in Baker, 2008). In Victoria, recreational fishing groups report that the species is speared at various locations, including natural and artificial reef habitats in Port Phillip Bay, where Rock Ling is occasionally found in caves, under ledges, and in tyres, pipes and other structures. The species is also considered to be highly susceptible to gill netting (Edgar, 2000). In south-eastern Tasmania, *G. tigerinus* is caught over reefs and soft-bottom habitats by recreational gill-netters (Lyle et al., 2000), and by other nets, and lines. The National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) reported that 4,500 Ling (species unspecified) were caught and kept by recreational fishers in southern Australian states during the survey time period (May 2000 to April 2001), comprising 1,258 specimens in New South Wales; 2,019 in Victoria; 156 in South Australia; and 1,067 in Tasmania. Given the inshore nature of Rock Ling, and the offshore distribution of Pink Ling, it is likely that a significant proportion of the unspecified "Ling" caught by recreational fishers during this survey, was the Rock Ling *G. tigerinus*. Rock Ling is a minor commercial species in Commonwealth-managed fisheries (taken mostly in small quantities by trawls, long-lines, drop-lines, gill-nets and other gear in south-eastern Australia), and also in some State fisheries in NSW, Victoria, Tasmania (e.g. taken by gill-nets, and possible over-exploited), S.A. and W.A., where it is also part of the bycatch in prawn trawls, gillnets, lobster pots and crab pots, and other gear (see summary of fisheries in Baker, 2008). Species-specific catch and effort data from commercial fisheries in State waters are inadequate, and there are few controls over the commercial fishing of this species. Activities and processes that may impact upon Rock Ling populations are discussed below, in the section on **Threatening Processes**.

An example of Rock Ling recorded during the survey period is provided below (**Figure 6E**).

**Figure 6E:** Rock Ling *Genypterus tigerinus*, recorded at Carrickalinga, February, 2009. Photo: J. Brook.

***Tripterygiidae***

Species in another benthic, egg-brooding group - the triplefins (Tripterygiidae), are commonly known within South Australia, and some are apparently abundant and widely distributed, such as the Yellow-back (or Black-throated) Threefin (triplefin) *Helcogramma decurrens*; the Western Jumping Blenny *Lepidoblennius marmoratus*; and the Common (or Clarke's) threefin *Trinorfolkia clarkei* (see summary in Baker, 2008). However, the potentially vulnerable population characteristics of the whole group is noted here, such as strong site association; the guarding of benthic eggs in a "nest"; and use of shallow coastal habitats that may be subjected to localised impacts (Baker, 2008). Of the threefins, the Crested Threefin *Trinorfolkia cristata* is of particular conservation interest because it may be endemic within this State . However, this reef-associated species has been commonly recorded, and appears not to be rare within the known range, with records from numerous locations in South Australia (Baker, 2008, and references therein). During the survey period, we recorded this species at Rapid Bay jetty, and O'Sullivans Beach. Processes that impact upon the extent, quality and cover of nearshore reefs may adversely affect populations of site-associated nearshore reef fishes such as Crested Threefin, but there are no specific data.

***Other Data (e.g. Species Richness)***

During some of the surveys we have undertaken at sites listed in **Table 1**, we also utilised time underwater to record other (i.e. more common and more mobile) reef fish species observed during the searches for less common and cryptic benthic species (e.g. **Appendix 1**). Some of these data will contribute to a report on visual surveys of common fishes at over 200 shallow reefs in S.A. (Shepherd, Baker and Brook, in prep.). We have collated species lists for a number of reef and jetty sites visited during the uncommon fish surveys, and these will be detailed in future publications.

During the 2009 season, we also took approximately 450 publication quality photographs of reef fishes, marine invertebrates (including several rare species and endemic species), and benthic habitats along Fleurieu Peninsula and Encounter Bay, which will contribute to a marine image database for the Adelaide and Mt Lofty Ranges NRM board.

***Threatening Processes***

For many of the strongly site-associated benthic reef fishes of limited dispersal ability, coastal developments and discharges that affect the quality of benthic habitat might be a threat to nearshore populations. This includes all of the species and family groups listed above, but in particular the less mobile species which live their entire life in one location, and produce live young. For such species, examples of threatening processes can include dredging of channels (for maintenance etc), decline of macroalgae and seagrass cover from residential, industrial, and rural discharges into coastal waters (from point sources and diffuse sources), coastal developments, trawling / netting in seagrass beds, power boating (and consequent disturbance of benthic habitat, and siltation) in shallow waters where these fishes are present.

A recent and pertinent example, is the irregular dredging of the boat harbour at O'Sullivans beach. The previous dredging occurred in 2001, but the impacts of that event were not documented. The site was not dredged during other years of the early 2000s, nor in the mid-2000s, and our searches in the shallow subtidal

reef area off O'Sullivans Beach indicate that in early 2009, there existed a diverse and productive reef system, with relatively abundant and diverse reef fish fauna (in comparison with some of the other reefs we have surveyed in other parts of the metropolitan coast), numerous invertebrates (including Giant Cuttlefish *Sepia apama* egg-laying sites) and a healthy cover of large canopy macroalgae, and understory species (**Figure 7A,B,C**). However, in April 2009, the adjacent boat harbour was dredged as part of a regular maintenance program, and 15,000 cubic metres of fine sediments were removed from the harbour, and dumped on the rocky beach adjacent to the O'Sullivans Beach reef. Apart from almost complete smothering of the rock and coarse sand beach with fine sediment (**Figure 8A,B**), the sediment was very rapidly transported by tides and waves onto the adjacent reef, which became completely covered. When photographs were taken after the dredge event, the original benthic relief of O'Sullivan's Beach reef was barely visible (**Figure 9,A,B,C**), and indicated the significant depth of the dredge spoil covering the reef. Canopy macroalgae, sponges and bryozoans and other attached biota were smothered, and in the short term, many dead and dying mobile invertebrates (and also cuttlefish eggs) were observed washed up on the beach. Although many of the mobile fishes may swim away from the site of disturbance, others cannot do so, such as the mouth-brooding cardinal fishes, and these would likely have died when their "home" crevice(s) (which also serve as nurseries for the mouth-brood) were smothered with sediment. The site at which this species was observed prior to the dredging impact will be monitored over time (see below). Longer term effects are likely to include reduction in cover of canopy macroalgae (firstly because blades of smothered macroalgae cannot photosynthesis efficiently, and secondly because the propagules of the next generation cannot settle on sediment-covered rocks, recruitment strength may be adversely affected: see Turner and Cheshire, 2002, and Turner, 2004); reduction in invertebrate species richness and abundance; reduction in food supply (mysids, polychaete worms etc); loss of reef structure and species diversity, and creation of disturbed environment favourable to opportunistic, invasive species.

With the assistance of Marine Life Society of South Australia, from spring 2009 onwards, some of the authors are undertaking a volunteer project to monitor reef recovery at the O'Sullivan's Beach reef that has been adversely affected by dredge spoil. The project will be utilising the University of Tasmania's Reef Life Survey monitoring protocol.

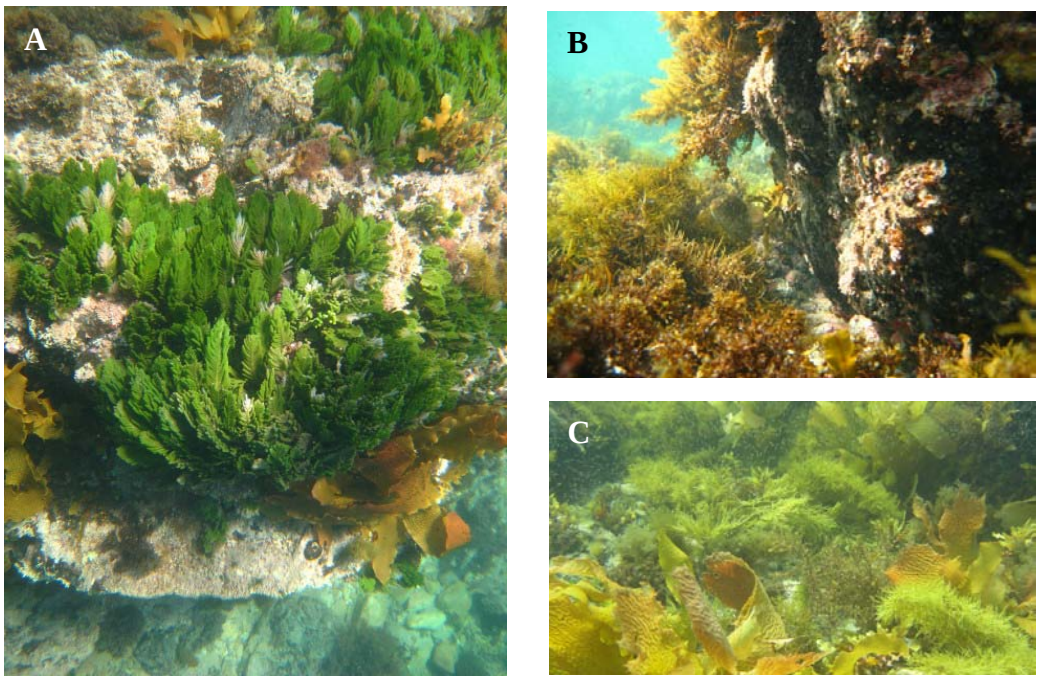



**Figure 7A,B,C:** O'Sullivans Beach shallow subtidal reef (~ 3m deep) prior to 2009 dredging of adjacent boat harbour; photographs taken January – February 2009. Photos: (**A** and **B**) H. Crawford; (**C**) J. Baker.

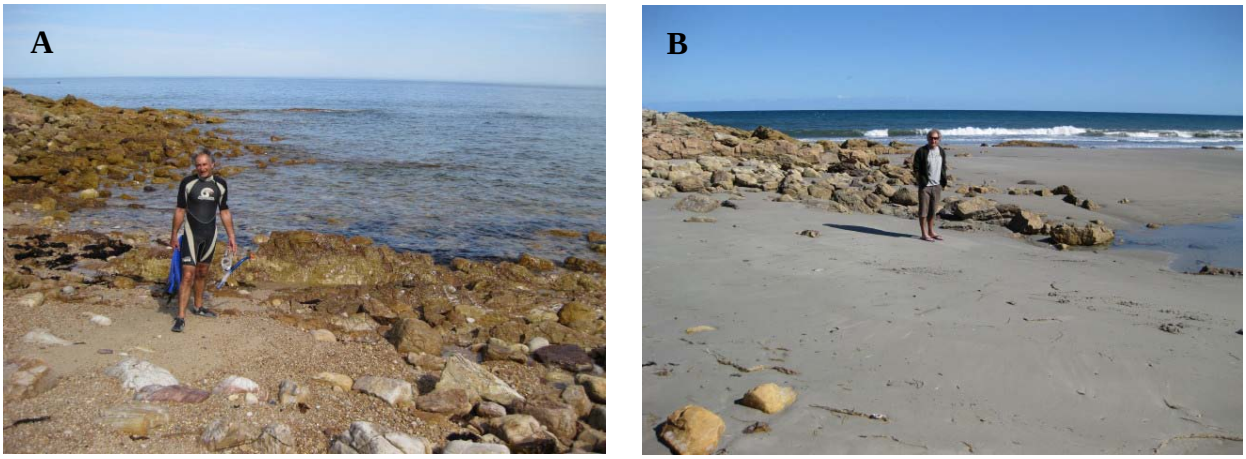



**Figure 8A,B:** O'Sullivans Beach intertidal and shallow subtidal reef system. (**A**) Before 2009 dredging of adjacent boat harbour; photograph taken 30th January 2009. (**B**) After 15,000 cubic metres of boat harbour dredge spoil was dumped on the beach, photograph taken 3rd April, 2009. Photos: (c) H. Crawford.

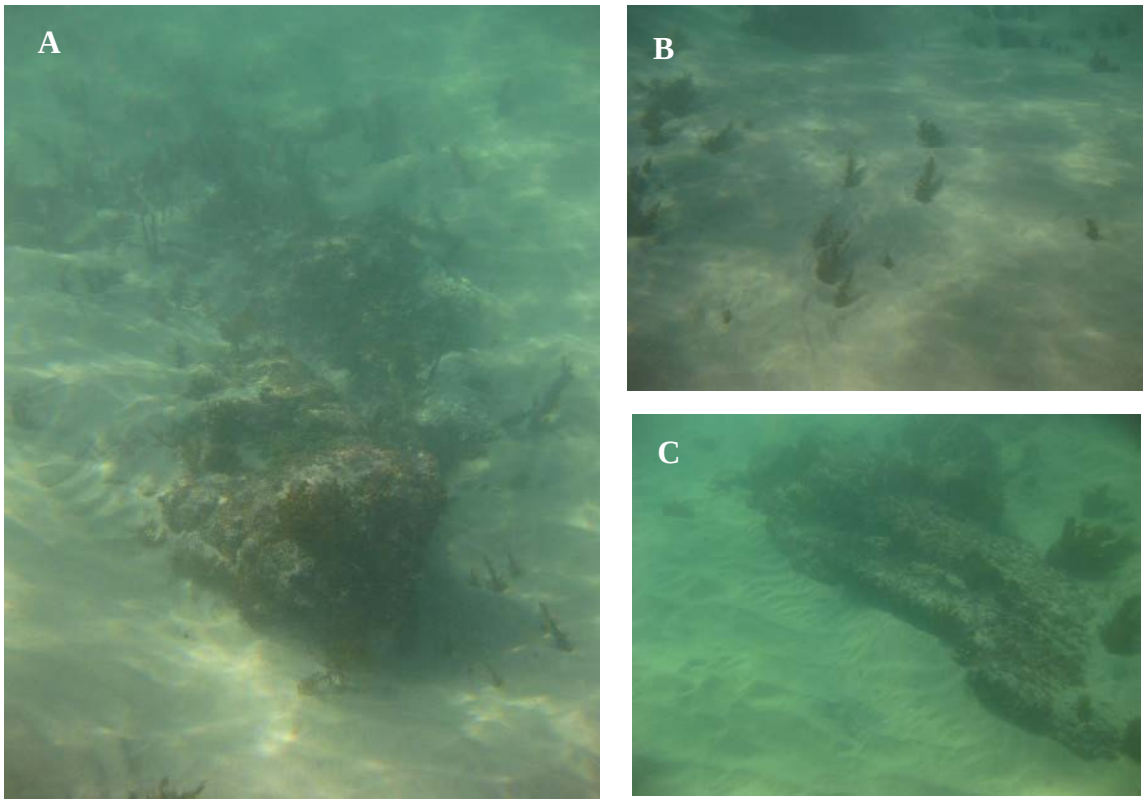



**Figure 9A,B,C:** O'Sullivans Beach shallow subtidal reef (~ 2 - 3m deep) after 2009 dredging of adjacent boat harbour, showing smothering of reef with fine sediments of dredge spoil. Photographs taken April 2009. Photos: (c) H. Crawford.

In addition to the cardinalfish example sites above, many of the small, site-associated fishes of interest in our survey program are vulnerable to population depletion from coastal impacts, but there is a distinct lack of species-specific data. Few data are ever collected on such fishes, and also, few data are collected on threatening processes. As the example of metropolitan dredging cited above shows, there has been no government monitoring, before, during or after the event.

In addition to coastal impacts such as sedimentation and discharges, fishing can be another threatening process for site-associated reef fishes. Although most of the cryptic, reef-associated species are not subject to excessive fishing pressure (and some are not caught at all, either intentionally or as bycatch), there are exceptions, including some of the large species that are valued as food fishes. For Rock Ling, fishing mortality is considered to be one of the main threatening processes for populations. Rock Ling, being a large, sedentary, site-associated fish in nearshore reef systems, is highly vulnerable to capture. The species has a low resilience to exploitation, in terms of minimum population doubling time (based on growth and/or fecundity estimates) (Froese and Pauly, 2006, cited by Baker, 2008). In some areas, lings have reportedly "been mostly eliminated by netting and spearing" (Gomon, in Gomon et al., 1994). Edgar (2000) reported that Rock Ling "seem to have virtually disappeared from much of the southern coast", partly due to their high susceptibility to spear-fishing and gill-netting. Nevill (2006) reported on a community survey that showed apparent reduction over time (from the 1950s, to 1982), in Rock Ling numbers at one spear-fishing site in Port Phillip Bay, and numbers had not recovered by 2006. There are recreational fishing limits on the capture of this species in Tasmania and Victoria, and such restrictions on angling, and spear-fishing catches are also required in other parts of southern Australia, including South Australia. In fisheries for invertebrates such as rock lobster and crab, pot and trap designs that reduce the bycatch of benthic fish species (such as Rock Ling) should be encouraged.

No-take marine reserves across the range may assist recovery of depleted populations of site-associated fishes such as Rock Ling, and also Serranids such as Harlequin Fish, and Black-banded Sea Perch, amongst many other reef fishes. It is noted that in Tasmania, several years after the Maria Island Marine Reserve was set up, numbers of Rock Ling increased in the reserve, relative to surrounding fished areas. The scientists monitoring that reserve (G. Edgar and N. Barrett) considered that the Rock Ling was one of the over-fished species that may locally benefit from the existence of the reserve (see Edgar and Barrett, 1997, 1999; Barrett and Edgar, 1998). However, only one individual been recorded within the Maria Island Marine Reserve during more recent annual surveys (1998-2004), and very few during 10 years of monitoring this and other reserves in Tasmania (Stuart-Smith et al., 2008), indicating that populations may also be influenced by long-term climatic cycles. In addition to fishing-related impacts, it is considered that populations of Rock Ling might be at risk from long-term climatic changes (G. Edgar, University of Tasmania, pers. comm., 2006).

Although not targeted, even small, cryptic reef-dwelling species may be subject to bycatch mortality. For example, in South Australia, cardinalfishes have been recorded in both the Gulf St Vincent and Spencer Gulf prawn trawl fisheries (Richardson, 1999, and Carrick, 1997, cited by Baker, 2008), and Southern Cardinalfish is a minor part of the bycatch in the Blue Crab Fishery (Svane and Hooper, 2004; Currie and Hooper, 2006, cited by Baker, 2008). In South Australia, a system should be developed for the ongoing collection and monitoring of bycatch data from the Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery (as currently occurs in the Spencer Gulf Prawn Trawl Fishery), sufficient to enable identification of long-term trends in bycatch (Australian Government DEH, 2004; Dixon et al., 2005). It is noted that prawn fisheries in southern Australia have made significant efforts during the past decades to reduce the bycatch of bony fishes. Examples for Spencer Gulf and Gulf St Vincent include the spatial and temporal organisation and "real time" management of the fishing fleet in some areas (e.g. Spencer Gulf) to minimise capture of undersized prawns and bycatch species, and developments in gear design to reduce bycatch, such as square-mesh cod-ends, bycatch chutes, hopper/conveyor systems, and the fitting of exclusion devices (e.g. MacDonald, 1998; Carrick, 1997; Broadhurst et al., 1999; South Australian Prawn Industry Association web site, 2000; PIRSA, 2003). Measures (such as improvements in net design) to reduce the bycatch of benthic fish species in all trawl fisheries are recommended.

Other issues regarding uncommon, site-associated reef fishes include the lack of knowledge of relative abundance, biology and population dynamics over space and time.

***Conclusions, and Further Work***

During the 2009 survey period, we continued to use visual and manual searches through the benthos on SCUBA, as a successful non-destructive method for finding the some of the small uncommonly-recorded reef fishes that were the targets for this project. Some of the target species dwell in crevices (e.g. several of the reef pipefishes, the cardinalfishes, and rock ling, amongst others); some utilise the cover provided by dense macroalgae (e.g. weedfishes), and some (e.g. anglerfishes, threefins and some of the pipefishes) are well camouflaged against various bottom surface covers, such as rocks and rubble, dead seagrass and macroalgae, low sponge and ascidian cover, shell rubble, and jetty debris (decaying wood, rusty metal etc). In that regard, slightly different search techniques are required for each group, and over the course of the surveys, knowledge of suitable search strategies developed and improved.

Information from our reef fish searches can assist fish conservation efforts in a number of ways. The techniques learned and the data gathered during this project are providing an ongoing, cumulative body of useful knowledge - for example, in terms of habitat requirements and usage, and distribution limits. Such information is useful for formal assessments of conservation status of reef fishes at international (e.g. IUCN Red List), national (*Environment Protection and Biodiversity Conservation Act 1999*) and State (rare and threatened species schedules) scales, and in developing management plans to address coastal impacts that may affect populations of such fishes. As an example of assistance to conservation listings, the information we have gathered on Verco's Pipefish during 2008 and 2009 surveys has been used to update and correct an international nomination for that species to be listed under the IUCN Red List. The original listing assumed a more narrow distribution and habitat usage than our surveys have indicated. Documenting the locations at which uncommon reef fishes occur, can also assist with periodic impact assessments in coastal marine areas, and ensures that particularly vulnerable species are not excluded from such assessments.

The small number of uncommon fishes observed in approximately 25 searches in 2009 (collectively on SCUBA and snorkel) was expected, given the apparent rareness / uncommonness of the species in the target list. Further searching is required over time and space to better understand the distribution, relative abundance and habitat of many uncommon (and some particularly rare) reef fishes in S.A., particularly in areas away from the more easily accessible dive sites in the southern gulfs. The lack of boat facilities during the survey period restricted our dives to depths of less than 10m, hence it was not possible to search for some of the deeper-dwelling reef fish species (see Baker et al 2008a,b for examples of target species). In South Australia, more surveys are required in reef habitats, and also in mixed seagrass / sand / macroalgae and rubble habitats, particularly in the South East, Gulfs and Eyre Peninsula region, to better determine the distribution and relative abundance of small uncommon cryptic nearshore fishes, and to document site-specific threatening processes.

In late 2009-2010, we hope to survey a number of less accessible reef sites (by boat, as well as shore diving), and to expand the survey program to include the nearshore reefs of upper and lower south-eastern South Australia, which, to date, have been very inadequately and infrequently surveyed, even for common reef fishes. To date, no surveys for uncommon and cryptic fishes in have been undertaken in such areas.

We are gradually developing a network of contacts within the South Australian diving community to assist searches for and recording of uncommon benthic fishes, and staff from museums and independent consultancies across Australia have been helpful in verifying species identifications during the survey periods to date. Marine divers and photographers with an interest in the less common and cryptic benthic fishes should continue to be encouraged to search for such fishes, and to provide their photographs (with date, and location) to museums or independent fish experts in southern Australia, for positive identification. Recreational divers can make a significant contribution to knowledge of the distribution, depth range, habitat and even the biology of less commonly recorded fishes. It is hoped that this process can become more formalised in future, and we would like to engage dive clubs (both university-based and independent) in future surveys to help us contribute to knowledge of distribution and habitats of uncommon fishes in South Australia, and to assist in community education about the existence of such fishes, and the potential threats they face. The techniques learned and the data gathered during this project will provide useful background for further searches (e.g. in more remote coastal areas, and in offshore reef areas), to help improve knowledge of the distribution, habitat, and conservation requirements of uncommon reef fishes in South Australia. The data will also assist conservation planning for nearshore reef fish habitats in South Australia, through South Australia's developing system of marine protected areas.

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**Appendix 1.** Examples of sites surveyed along southern Fleurieu Peninsula and Encounter Bay, including numbers of species and averaged densities (per 2000 $m^2$) of more common reef-associated fishes recorded during the surveys, with data on relief, visibility, and exposure. Group 1 = pelagic species found throughout water column; Group 2 = species associated with sand or seagrass that wander into reef areas; Group 3 = benthic omnivores or carnivores; Group 4 = species which live and move about under the algal canopy or rest in shelter; Group 5 = cave-dwelling or cryptic species. AR1 = Aldinga Reef (off point to south); AR2 = Aldinga Reef (off point northward); AR3 = Aldinga Reef (off point near shore); AR4 = Aldinga Reef (on flats to north); AR5 = Aldinga Reef (offshore); CB = Carrickalinga Bay; RB = Rapid Bay Jetty; GI = Granite Island, Encounter Bay; RH = Rosetta Head, Encounter Bay; BB = "Bluff Beach", Encounter Bay. Data for these and other sites along Fleurieu Peninsula & Encounter Bay will be listed and analysed, in a forthcoming publication on shallow reef surveys using timed swims to visually record relative densities (Shepherd, Baker, and Brook, in prep.).

| ***Sites*** | **AR1** | **AR2** | **AR3** | **AR4** | **AR5** | **RB** | **GI** | **RH** | **BB** |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Replicates x 100 m | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Depth | 4 | 4 | 4 | 3 | 5 | 8 | 3 | 4 | 2 |
| Rocky bottom relief (m) | 0.1 | 2 | 1 | 0.1 | 0.5 | 1 | 0.5 | 2 | 0.5 |
| Visibility (m) | 7 | 8 | 8 | 8 | 10 | 8 | 10 | 8 | 8 |
| Exposure index (0-4) | 2 | 2 | 2 | 2 | 2 | 1.5 | 3 | **3** | 1 |
| % algal canopy cover | 30 | 90 | 80 | 10 | 60 | 5 | 80 | 95 | 60 |
| **Fishes Density/2000m2** | | | | | | | | | |
| **Group 1** | | | | | | | | | |
| *Sphyraena novaehollandiae* Snook | | | | | | 4 | | | 3 |
| *Dinolestes lewini* Long-finned pike | | | | 1 | | 16 | | 17 | 23 |
| *Trachurus novaezelandiae* Yellowtail scad | | | | | | 50 | | | |
| *Scorpis aequipinnis* sea sweep | | 4 | | | | | 23 | 45 | 29 |
| *Scorpis georgiana* banded sweep | | 21 | 14 | | 4 | | | | |
| *Pseudocaranx georgianus* silver trevally | | | | | | | | 3 | |
| *Caesioperca rasor* barber perch | | | | | | | | | |
| *Enoplosus armatus* old wife | | 7 | 7 | | 2 | 25 | 1 | 5 | 2 |
| *Arripis georgianus* Australian herring / tommy ruff | | | | | | | | | |
| *Aldrichettia forsteri* yellow-eye mullet | | | 25 | | | | | | |
| **Group 2** | | | | | | | | | |
| *Myliobatis australis* eagle ray | 3 | | | | | | | | |
| *Dasyatis brevicaudata* smooth stingray | | 5 | | | 2 | | 2 | | |
| *Platycephalus speculator* southern flathead | | | | 1 | | | | | |
| *Sillaginodes punctata* King George whiting | | | | 2 | | 23 | | | |
| *Sillago schomburgkii* yellow-fin whiting | | | | | | | | | |
| *Hyporhamphus melanochir* sea garfish | | | | | | | | | |
| *Neoodax balteatus* little weed whiting / little rock whiting | | | | | | | | | |
| *Haletta semifasciata* blue weed whiting / blue rock whiting | | | | | | | | | 8 |
| *Phycodurus eques* leafy sea dragon | | | | | | 2 | | | |
| *Upeneichthys vlamingii* blue-spotted goatfish / red mullet | | | | | 2 | 45 | | 3 | 3 |
| *Parequula melbournensis* silverbelly | | | | | | 29 | | | |

| **Group 3** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Achoerodus gouldii*<br>western blue groper | | | | | | | 16 | 19 | 16 |
| **Group 3 (cont.) / *Sites*** | **AR1** | **AR2** | **AR3** | **AR4** | **AR5** | **RB** | **GI** | **RH** | **BB** |
| *Dactylophora nigricans*<br>dusky morwong | 2 | 5 | 2 | | 5 | 3 | | 6 | 2 |
| *Kyphosus sydneyanus*<br>silver drummer | | 118 | 47 | | 55 | | 1 | | |
| *Pentaceropsis recurvirostris*<br>long-snouted boarfish | | | | | | 18 | | | |
| *Cheilodactylus nigripes*<br>magpie perch | 3 | 22 | 29 | | 10 | 31 | 1 | 33 | 7 |
| *Girella zebra*<br>zebra fish | | 4 | | | 12 | 63 | 25 | 64 | |
| *Notolabrus tetricus*<br>blue-throated wrasse | | 11 | 12 | | 8 | 54 | 5 | 31 | 7 |
| *Notolabrus parilus*<br>brown-spotted wrasse | | 6 | 6 | | 2 | 21 | | | |
| *Dotalabrus aurantiacus*<br>Castelnau's wrasse | | | | | | | | | |
| *Austrolabrus maculatus*<br>black-spotted wrasse | | | | | | 26 | | | |
| *Meuschenia flavolineata*<br>yellow-striped leatherjacket | | | | | | 2 | | | |
| *Meuschenia freycineti*<br>6-spined leatherjacket | | 11 | 7 | 1 | 3 | | | | |
| *Meuschenia galii*<br>Blue-lined leatherjacket | | | | | | 4 | | | |
| *Meuschenia hippocrepis*<br>horseshoe leatherjacket | | 3 | 4 | 2 | 2 | 21 | 2 | 16 | 3 |
| *Acanthaluteres brownii*<br>spiny-tailed leatherjacket | 1 | | 1 | 1 | | | | | |
| *Eubalichthys cyanoura*<br>blue-tailed leatherjacket | | | | | | 2 | | | |
| *Eubalichthys gunnii*<br>Gunn's leatherjacket | | | | | | | | | |
| *Scobinichthys granulatus*<br>rough leatherjacket | | | | | | 35 | | | |
| *Meuschenia scaber*<br>velvet leatherjacket | | | | | | 24 | | | |
| *Brachaluteres jacksonianus*<br>pygmy leatherjacket | | | | | | 3 | | | |
| *Chelmonops curiosus*<br>western talma | | 2 | 8 | | 3 | 10 | | | |
| **Group 4** | | | | | | | | | |
| *Aplodactylus arctidens*<br>southern sea carp | | | | | | | 2 | 6 | 1 |
| *Aplodactylus westralis*<br>western sea carp | | | | | | | | | |
| *Odax acroptilus*<br>rainbow cale | | | 2 | | | 1 | | | 3 |
| *Odax cyanomelas*<br>herring cale | | | | | | 15 | 16 | 14 | 3 |
| *Pictilabrus laticlavius*<br>senator wrasse | | | | | | | | 2 | 4 |
| *Eupetrichthys angustipes*<br>snakeskin wrasse | | | | | | | | | |
| *Siphonognathus beddomei*<br>pencil weed whiting | | | | | | | 25 | 2 | |
| *Siphonognathus caninus*<br>sharp-nosed weed whiting | | | | | | 4 | | | |
| *Parma victoriae*<br>Victorian Scaly fin | | 3 | | | 1 | 16 | 1 | 2 | |
| *Tilodon sexfasciatus*<br>6-banded coral fish | | 12 | 23 | | 1 | 18 | | 13 | 5 |
| *Diodon nichthemerus*<br>globefish | | | | | | | | | |
| *Tetractenos glaber*<br>smooth toadfish | | 1 | 1 | | | | 2 | 3 | |
| *Contusus richei*<br>barred toadfish | | | | | | | | | |
| *Aracana ornata*<br>ornate cowfish | | | | | | | | | |
| *Parapercis haackei*<br>wavy grubfish | | | | | | | | | |

| **Group 5 / *Sites*** | **AR1** | **AR2** | **AR3** | **AR4** | **AR5** | **RB** | **GI** | **RH** | **BB** |
|---|---|---|---|---|---|---|---|---|---|
| *Paraplesiops meleagris*<br>western (or southern) blue devil | | | | | | | | | |
| *Pempheris multiradiata*<br>common bullseye | | 15 | | | | 81 | | | |
| *Pempheris klunzingeri*<br>rough bullseye | | | | | | 6 | | | |
| *Parapriacanthus elongatus*<br>slender bullseye | | | | | | 9 | | | |
| *Pempheris ornata*<br>orange-lined bullseye | | | | | | 4 | | | |
| *Trachinops noarlungae*<br>yellow-headed hulafish | | 60 | | | 20 | 75 | | | |
| *Cochleoceps bicolor*<br>western cleaner clingfish | | | | | | 6 | | | |
| *Helcogramma decurrens*<br>black-throated threefin | | | | | | 1 | | | |
| *Trinorfolkia cristata*<br>crested threefin / triplefin | | | | | | | | | |
| *Trinorfolkia clarkei*<br>Common threefin / triplefin | | | | | | | | | |
| **Number of species** | 4 | 18 | 15 | 6 | 16 | 35 | 14 | 18 | 16 |
| **Number of individuals** | 9 | 309 | 188 | 8 | 132 | 747 | 122 | 284 | 119 |