A TAGGING STUDY ON YELLOWTAIL KINGFISH (SERIOLA LALANDI) AND SAMSON FISH (S. HIPPOS) IN SOUTH AUSTRALIAN WATERS

K.S. HUTSON1, #, B.P. SMITH1, R.T. GODFREY1, I.D. WHITTINGTON1,2, C.B. CHAMBERS1, I. ERNST1 & B.M. GILLANDERS1

1. School of Earth and Environmental Sciences, Darling Building DP418, The University of Adelaide, North Terrace, SA 5005
2. Monogenean Research Laboratory, Parasitology Section, South Australian Museum, North Terrace, Adelaide, SA 5000

# Corresponding author: kate.hutson@adelaide.edu.au

Summary
Wild yellowtail kingfish (Seriola lalandi Valenciennes, 1833) and Samson fish (S. hippos Günther, 1876) were tagged with nylon-headed, single-barbed dart tags between December 1, 2004 and December 31, 2006 in Spencer Gulf and offshore from the west coast of Eyre Peninsula, South Australia. Two-hundred and forty-one S. lalandi and 73 S. hippos were tagged. Twenty-four S. lalandi were recaptured and the maximum distance between capture points was 130 km and the maximum time at liberty was 442 days. Two S. hippos were recaptured, of which one was at liberty for a maximum of 378 days. Both S. hippos were recaptured at the original capture site. Recapture results indicate that large S. lalandi remain in, or return to, northern Spencer Gulf. This region may be important for aggregations of large, reproductively mature S. lalandi. One large S. lalandi tagged at Port Augusta was recaptured near Fitzgerald Bay, indicating that wild fish may move past S. lalandi sea-cage farms in this region. This course of movement may provide opportunities for disease and parasite interactions between wild and farmed fish. An additional outcome of this research was the residual impact that it has had on sustainable fishing practices in South Australia with increased recreational fisher participation in the tag and release of S. lalandi and S. hippos.

KEY WORDS: conventional tagging programme, fish movement, parasite interaction, sea-cage aquaculture, recreational fishing, South Australia.

Introduction
Yellowtail kingfish (Seriola lalandi) and Samson fish (S. hippos) are pelagic, schooling fish, which generally inhabit rocky reefs and adjacent sandy areas in coastal waters. Both species are capable of migrating considerable distances (Gillanders et al., 2001; Rowland et al., 2006). In Australia, S. lalandi inhabits southern coastal waters from Queensland to Western Australia and northern Tasmania, while S. hippos has a disjointed distribution from southern Queensland to Montague Island in New South Wales and from Yorke Peninsula, South Australia to Shark Bay in Western Australia (Hutchins & Swainston, 1986). Despite intensive tagging programmes in Australia for S. lalandi on the east coast (Gillanders et al., 2001) and for S. hippos on the west coast (Rowland et al., 2006), there are limited data available concerning the movements of wild Seriola spp. in South Australian waters. A likely reason for this is the negligible economic significance of the commercial fishery. Indeed, the total catch for S. lalandi has only exceeded 2 tonnes once in the last 32 years (McGlennon, 1997). Furthermore, Seriola spp. are mobile and migratory species which makes them difficult to study. Nevertheless, S. lalandi and S. hippos are popular recreational target species in South Australia and are highly regarded by fishers for their sporting attributes and large size. Consequently, there may be opportunities for recreational fishers to contribute to research programmes on Seriola spp. Seriola lalandi also supports an expanding aquaculture industry in Spencer Gulf, South Australia, where it is farmed in sea-cages in Fitzgerald Bay near Whyalla, Arno Bay and Boston Bay near Port Lincoln (Fig. 1). The nature of wild Seriola movements is
critical for informed management of the recreational fishery and to understand potential interactions between wild and farmed carangids in Spencer Gulf (e.g. Windsor & Hutchinson, 1990).

We conducted a small-scale tagging programme in Spencer Gulf and offshore from Eyre Peninsula in South Australia to investigate the timing and nature of Seriola movements. The purpose of this paper is to report on preliminary recapture data and movements for Seriola spp. in South Australian waters. This research provides new information on Seriola movements and will be a useful foundation for future management of the recreational fishery and assessment of interactions between wild Seriola spp. and the S. lalandi aquaculture industry.

Materials and Methods

Conventional tagging programmes and participation

A tagging programme for Seriola spp. in South Australia was conducted in conjunction with the South Australian branch of the Australian National Sportfishing Association’s tagging programme, called ‘Saftag’. Tag data from fish we captured between December 1, 2004 and December 31, 2006 were provided to Saftag for inclusion in their locally administered database. We sought additional tag records from New South Wales Fisheries (NSWF) because game fishing clubs in South Australia commonly use NSWF tags. Data were gathered from Saftag (Marcel Vandergoot, 288 Hayman Road Lewiston South Australia 5501 Australia) and NSWF databases (Karen Woodrick, Game Fish Tagging Program, NSW Department of Primary Industries, PO Box 21 Cronulla NSW 2230 Australia) for all existing tag and recapture records for Seriola spp. captured or recaptured in South Australian waters up to and including December 31, 2006.

Fish capture

Seriola lalandi were captured by line in Arno Bay in March 2005 and at Port Augusta in Spencer Gulf between December 2004 and December 2006 (Fig. 1). Four charter operators fishing offshore from Port Lincoln participated in the tag programme and captured, tagged and released fish at Rocky Island in 2005 (Fig. 1). Recreational fishers assisting the programme tagged fish at Coffin Bay, Fitzgerald Bay, Port Augusta and Yatala Reef in 2005 and 2006 (Fig. 1). In addition, we netted small schools of S. lalandi in northern Spencer Gulf in October 2005 and in October 2006 (Primary Industries and Resources South Australia exemption no. 9901854). When a fish was landed, a nylon-headed, single-barbed dart tag (Hallprint Pty Ltd) with a unique identification number was inserted into the muscle adjacent to the dorsal fin at a 45º angle, so that the barb on the tag would lock into the pterygiophores. Total length (TL) was measured to the nearest mm, where possible.

We considered and carried out capture-recapture analysis to estimate population numbers in northern Spencer Gulf but these data did not meet the assumptions required and are not presented here.

Results

A total of 340 S. lalandi and 88 S. hippos specimens has been tagged between February 1991 and December 31, 2006, in South Australia (Table 1) at 25 locations (Fig. 1). Of this total, we tagged and released 241 S. lalandi and 73 S. hippos specimens for this study with the assistance of charter operators and recreational fishers. Before this tag programme, only 53 S. lalandi and 1 S. hippos had ever been tagged and released in South Australian waters since the first record in 1991. In period of the current study, 86 large S. lalandi (>1000 mm TL) were tagged near Port Augusta in northern Spencer Gulf (Table 2). Approximately 8.2% of S. lalandi tagged between February 1991 and December 31, 2006 were recaptured across South Australia after being at liberty for between 3
to 442 days, while 2.3% of *S. hippos* tagged were recaptured following 302 and 378 days at liberty (Table 1).

**Table 1.** Total tag records for *Seriola lalandi* and *S. hippos* captured in South Australia between February 1991 and December 31, 2006. Location abbreviations: Ardrossan (A), Arno Bay (AB), Althorpe Islands (AI), Balgowan (B), Coffin Bay (CB), Cape Willoughby, Kangaroo Island (CW), west coast Eyre Peninsula at Convention Beach, Sceales Bay, Streaky Bay and Yalata Reef (EP), Fitzgerald Bay (F), Greenly Island (GI), northern shore of Kangaroo Island at Cape Dutton, Emu Bay, Smiths Bay and Western River (KJ), offshore Port Lincoln at Cabbage Patch Reef and Four Hummocks Island (OPL), Port Augusta (PA), Port Broughton (PB), Port Hughes (PH), Port Lincoln (PL), Rocky Island (RI), Wallaroo (Wa), Wardang Island (WI) and Whyalla (Wh). Total length omitted for clarity and is included in the text. All recaptures were by line unless otherwise indicated.

| Species    | Year | No. tagged | Location | # recaptured (line and net) | % recapture rate (line and net) | Days at liberty | Movements > 5km | # released after recapture |
|------------|------|------------|----------|-------------------------------|---------------------------------|-----------------|-------------------|--------------------------|
| *S. lalandi* | 1991 | 2          | CW       | 0                             | 0                               | -               | -                 | -                        |
|            | 1993 | 1          | EP       | 0                             | 0                               | -               | -                 | -                        |
|            | 1995 | 2          | CW       | 0                             | 0                               | -               | -                 | -                        |
|            | 1999 | 2          | EP, KI   | 0                             | 0                               | -               | -                 | -                        |
|            | 2000 | 2          | A, CW    | 0                             | 0                               | -               | -                 | -                        |
|            | 2002 | 21         | B, CW, PA, PB, PL, KI, Wh     | 2                             | 9.5                             | 25 and 51       | Wh to PA         | 1 (KI)                   |
|            | 2003 | 18         | B, PA, PH, KI, Wa             | 2                             | 11.1                            | 3 and 24        | -                 | 0                        |
|            | 2004 | 14         | B, GI, PA, PH                 | 3                             | 21.4                            | 32 a, 40 a, 95 a| -                 | 0                        |
|            | 2005 | 205        | AB, AI, EP, KI, OPL, PA, RI, Wh| 18 (16 & 2)                  | 8.7 (7.8 & 1.0)                | 8 – 442 a b     | AB to PH & WI    | 6 (PA)                   |
|            |      | 73         | CB, PA, F, OPL                | 3                             | 4.1                             | 46, 85, 98      | PA to F          | 1 (F)                    |
| **Total**  |      | 340        |          | 28 (26 & 2)                   | 8.2 (7.6 & 0.6)                |                 |                   | 8                        |
| *S. hippos* | 2003 | 1          | EP       | 0                             | 0                               | -               | -                 | NA                       |
|            | 2005 | 77         | RI, OPL                          | 2                             | 2.6                             | 302 a & 378 a   | -                 | 1 (RI)                  |
|            | 2006 | 10         | GI, RI, OPL                      | 0                             | 0                               | NA              | NA                | NA                       |
| **Total**  |      | 88         |          | 2                             | 2.3                             |                 |                   | 1                        |

* Includes fish tagged in the year indicated, but recaptured in the following year

| Year       | 2005 | 2006 | Total |
|------------|------|------|-------|
| Total no. tagged | 39   | 47   | 86    |
| Mean total length in mm (range) | 1212 (1110–1480) | 1215 (1100–1250) | 1180 (1110–1480) |
| Total no. recaptured (line and net) | 7 (5 and 2) | 2 | 9 (7 and 2) |
| Min and max days at liberty | 8 – 442 a | 46 and 98 | 8 – 442 |
| Number released after recapture | 3 | 2 | 5 |
| % recapture (line and net) | 17.9% (12.8% and 5.1%) | 4.3% (8.1% and 2.3%) | 10.5% |

* Includes fish tagged in the year indicated, but recaptured in the following year
Movements

Four recaptured fish showed movements >5 km (Fig. 1). One small *S. lalandi* (480 mm TL) tagged at Whyalla in 2002 was recaptured 51 days later, 40 km north towards Port Augusta (Fig. 1). Two small *S. lalandi* (380 and 430 mm TL) tagged at Arno Bay in 2005 (33°55’21”S, 136°36’14”E) were recaptured approximately 100 km southeast after 39 days at Wardang Island (34°27’35”S, 137°23’15”E) and approximately 130 km northeast after 49 days at Port Broughton (33°21’35”S, 137°33’21”E), respectively (Fig. 1). A larger individual (1110 mm TL) tagged at Port Augusta in 2006 (32° 42’04”S, 137°46’17”E) was recaptured 50 km south at Point Lowly, near Fitzgerald Bay (32° 24’14”S, 137°19’16”E) and was at liberty for 46 days (Fig. 1). Two *S. lalandi* (950 and 870 mm TL) tagged at Rocky Island were recaptured 18 and 41 days later, respectively, at the same location. Twenty-one *S. lalandi* tagged at Port Augusta were recaptured at Port Augusta, including four individuals (>1000 mm TL) tagged in May 2005 or May 2006 and recaptured in the same area eight, 88, 98 and 149 days after release. A further four large fish were recaptured at Port Augusta following 326, 328, 383 and 442 days at liberty. Two recaptures of *S. hippos* (910 and 1070 mm TL) tagged at Rocky Island were made at the same location 302 and 378 days later.

Observations in northern Spencer Gulf

We observed *S. lalandi* schools during October 2005 and October 2006 while netting in shallow water (1 to 4 m depth) in northern Spencer Gulf. Large *S. lalandi* (>1000 mm) were observed alone, in pairs and in small to large schools containing from 10 to >200 individuals. Schools of large fish contained individuals of various sizes (1110 to 1480 mm TL). One fish originally captured on rod and reel (1220 mm TL) was recaptured 149 days later (1290 mm TL) in the net with another 19 individuals.

**Figure 1.** Tag and release localities and inferred movement of *Seriola* spp. in South Australia between February 1991 and December 31, 2006. (Yatala Reef, west of Streaky Bay not shown).
Discussion

Seriola movements

Although *S. lalandi* can swim considerable distances (Gillanders *et al*., 2001), the observed distance between mark and recapture locations for the majority of fish was <5km. We found that large *S. lalandi* remained near, or returned to, Port Augusta for up to five months, as shown by four individuals (>1000 mm TL) tagged in May (2005 or 2006) and recaptured in the same area eight, 88, 98 and 149 days after release. *Seriola lalandi* may return to Port Augusta seasonally, as indicated by four large fish recaptured in the same area after 326, 328, 383 and 442 days at liberty. The absence of recaptures and landings between November 2005 and April 2006 may indicate lowered recreational fishing pressure during this time. Alternatively, large fish may leave the area during summer, returning in late autumn/early winter. Indeed, one large *S. lalandi* captured at Port Augusta in October 2006 and recaptured near Fitzgerald Bay in December 2006, suggests a seasonal southerly movement.

Our annual observations in northern Spencer Gulf in October 2005 and October 2006 indicate that Port Augusta is visited by aggregations of large, mature *S. lalandi*. This area comprises a sheltered, shallow region with mangrove habitat. McGlennon (1997) suggests some *S. lalandi* spawning may occur at Port Augusta and that spawning was imminent for some fish caught in a fishing competition in August 1996. In contrast, it is speculated that *S. lalandi* in New South Wales are pelagic spawners, moving offshore to spawn (Smith *et al*., 1991). Knowledge about whether *S. lalandi* aggregate at in northern Spencer Gulf as part of a spawning event is important for the management of the recreational fishery. Port Augusta is the most accessible location from the state capital (Adelaide) where large *S. lalandi* between 15 and 45 kg (~1000 to 1530 mm total length, TL) can be captured. Indeed, *S. lalandi* may be susceptible to localised depletion in this region if large numbers of fish are being removed before they spawn.

Two *S. hippos* tagged in autumn (March 2005 and May 2005) were recaptured at their original capture location, around one year later (302 and 378 days). In a similar conventional tagging programme of *S. hippos* in Western Australia, approximately 8,850 fish have been tagged off Rottnest Island where they form spawning aggregations in summer (December to February). Recapture data indicate these fish migrate east along the south coast of Western Australia as far as the south coast of Kangaroo Island, South Australia and return to Rottnest Island in summer to spawn (Rowland *et al*., 2006). It is likely that *S. hippos* in South Australia form part of this migratory stock and the time of recapture fits with the spawning notion.

Recapture rates

The recapture rate of *S. lalandi* by recreational anglers (8.2%) throughout South Australia was similar to that recorded for *S. lalandi* tagged on the east coast of Australia (8%) (Gillanders *et al*., 2001). Recaptures are considerably lower for *S. hippos* tagged in South Australia (2.3%) and Western Australia (1.8%) (A. Rowland, pers. comm.). The recapture rate of large *S. lalandi* tagged in 2005 at Port Augusta by fishers was greater (12.8%) than in 2006 (4.3%). This may be because fish tagged in 2006 have been at liberty for a relatively shorter period of time (a maximum of 232 days in 2006 compared with 603 days for 2005, up to and including December 31, 2006). Recreational fishing pressure in this region combined with fish remaining in the area for an extended period (i.e. five months) may subject this species to local depletion. However, promotion of appropriate tag and release approaches may reduce any possible danger of depletion in northern Spencer Gulf.

Recaptures of tagged fish in this study indicate that individuals survive the capture, tag and release procedure. Certainly, an individual fish captured by line, tagged, and subsequently netted in a school, demonstrates that individuals are capable of locating and reforming with a school. However, Gillanders *et al*., (2001) found that fish marked by more experienced taggers have better recovery rates. In this study, the majority of fish were tagged by experienced taggers. Therefore, it
may be necessary to educate inexperienced taggers about appropriate tagging and handling methods for large *S. lalandi* to reduce tag-associated mortality. This would also ensure that tags are inserted correctly, thereby minimising tag loss.

**Interaction between wild and farmed *S. lalandi***

The nature of wild *Seriola* movements is critical to understand the potential impact of parasite interaction between wild and farmed fish. In the northern hemisphere, there is intense debate about the potential for parasitic crustaceans (= sea lice e.g. *Lepeophtheirus salmonis*) to impact upon wild salmonids that migrate past salmon farms. Some scientists have linked increased parasite loads in the northern hemisphere with declines in wild fish stocks (e.g. Tully *et al.* 1993; Butler 2002; Krkošek *et al.*, 2005) while others argue that over-fishing, habitat loss and climate change are responsible for the declines (Noakes *et al.*, 2000). In South Australia, a large *S. lalandi* tagged at Port Augusta in October 2006 and recaptured near Fitzgerald Bay in December 2006 indicates that large wild fish may migrate past *S. lalandi* sea-cage farms during summer. Consequently, interaction between wild and farmed fish may be more likely to occur at this time of year. Currently, summer in South Australia is the period where farmed fish have to be treated frequently for monogenean parasites. This is because parasite eggs hatch more quickly in warmer sea temperatures. However, increased interaction between farmed and wild fish in warmer months may also contribute to seasonally elevated infection levels.

**Research development and interest in the community***

The South Australian fishing community expressed an overwhelming interest in the tagging programme documented here. In northern Spencer Gulf, retired commercial netters and recreational fishers volunteered their time to locate fish schools and informed us when *S. lalandi* were sighted. Anglers’ dogged pursuit to participate in this programme in order understand more about the nature of *S. lalandi* movements is a testament to an emerging tag and release ethos for this species in the recreational fishing community. Integration of this tag programme with the activities of fishers enabled us to tag an unprecedented number of wild *S. lalandi* and *S. hippos*. We believe this work has helped to promote sustainable recreational fishing practices for *Seriola* spp. in South Australia and expect this will be reflected in further tag and recapture records at more localities off the coast of South Australia. Pop-up satellite archival tags may provide information on specific movements, but they may have problems such as increased expense, limited battery length, marine fouling, increased drag and increased predation (e.g. Kerstetter *et al.*, 2004; Grusha & Patterson, 2005). As an alternative, cooperative tagging programmes provide a cost-effective method to obtain useful biological data such as movements between areas (Gillanders *et al.*, 2001). Multiple recapture data would be especially informative to determine seasonal movements of *Seriola* spp. and collaborating with willing fishers and capitalising on their good will and mutually beneficial outcomes is a practical way to ensure that this information source is used.

**Acknowledgements***

We thank Pelagic, Calypso Star, Why Not and Black Hawk fishing charters and recreational fishers who helped with this work, especially John Bills, Anthony Everett, Matthew Halls, Simon Jones, Jack Laidlaw and Rod Leith. We are extremely grateful to Darren Godfrey and Jimmy Whitaker for their help netting fish at Port Augusta. We are grateful to Marcel Vandergoot (Saftag coordinator), Karen Woodrick (NSW Fisheries) and Andrew Rowland (Murdoch University) who provided tag data. This research was supported by an Australian Postgraduate Award to KSH and was funded by Primary Industries and Resources, South Australia and the Fisheries Research and Development Corporation (grant no. 2003/220) to Dr Colin Johnston, IE, IDW, BMG, KSH and CBC.
References

Butler, J.R.A. (2002) Wild salmonids and sea louse infestations on the west coast of Scotland: sources of infection and implications for the management of marine salmon farms. Pest Management Science 58, 595-608.

Gillanders, B.M., Ferrell, D.J. & Andrew, N.L. (2001) Estimates of movement and life-history parameters of yellowtail kingfish (Seriola lalandi): how useful are data from a cooperative tagging programme? Marine and Freshwater Research 52, 179-192.

Grusha, D.S. & Patterson, M.R. (2005) Quantification of drag and lift imposed by pop-up satellite archival tags and estimation of the metabolic cost to cow nose rays (Rhinoptera bonasus). Fishery Bulletin 103, 63-70.

Hutchins, B. & Swainston, R. (1986) "Sea fishes of Southern Australia" (Swainston publishing, New South Wales).

Kerstetter, D.W., Polovina, J.J. & Graves, J.E. (2004) Evidence of shark predation and scavenging on fishes equipped with pop-up satellite archival tags. Fishery Bulletin 102, 750-756.

Krošek, M., Lerwis, M.A. & Volpe, J.P. (2005) Transmission dynamics of parasitic sea lice from farm to wild salmon. Proceedings of the Royal Society B. 272, 689-696.

McGlennon, D. (1997) Report to the scalefish management committee on yellowtail kingfish (Seriola lalandi). South Australian Research and Development Institute, Adelaide, 5pp.

Noakes, D.J., Beamish, R.J. & Kent, M.L. (2000) On the decline of Pacific salmon and speculative links to salmon farming in British Columbia. Aquaculture 183, 363-386.

Rowland, A., Mackie, M., Gill, H. & Bevan, A. (2006). A tagging study on Samson fish (Seriola hippos) in Western Australian waters: movement and post-release survival. Conference abstract. (Australian Society for Fish Biology Conference, September, Hobart, Tasmania).

Smith, A., Pepperell, J., Diplock, J. & Dixon, P. (1991) Study suggests NSW kingfish one stock. Australian Fisheries, March, 34-36.

Tully, O., Poole, W.R., Whelan, K.F. & Merigoux, S. (1993) Parameters and possible causes of epizootics of Lepeophtheirus salmonis Krøyer infesting sea trout (Salmo trutta L.) off the west coast of Ireland. In 'Pathogens of wild and farmed fish: Sea Lice' (Eds. G. Boxshall and D. Defaye, editors) pp. 202-213. (Ellis Horwood, Chichester).

Windsor, M.L. & Hutchinson, P. (1990) The potential interactions between salmon aquaculture and the wild stocks - a review. Fisheries Research 10, 163-176.