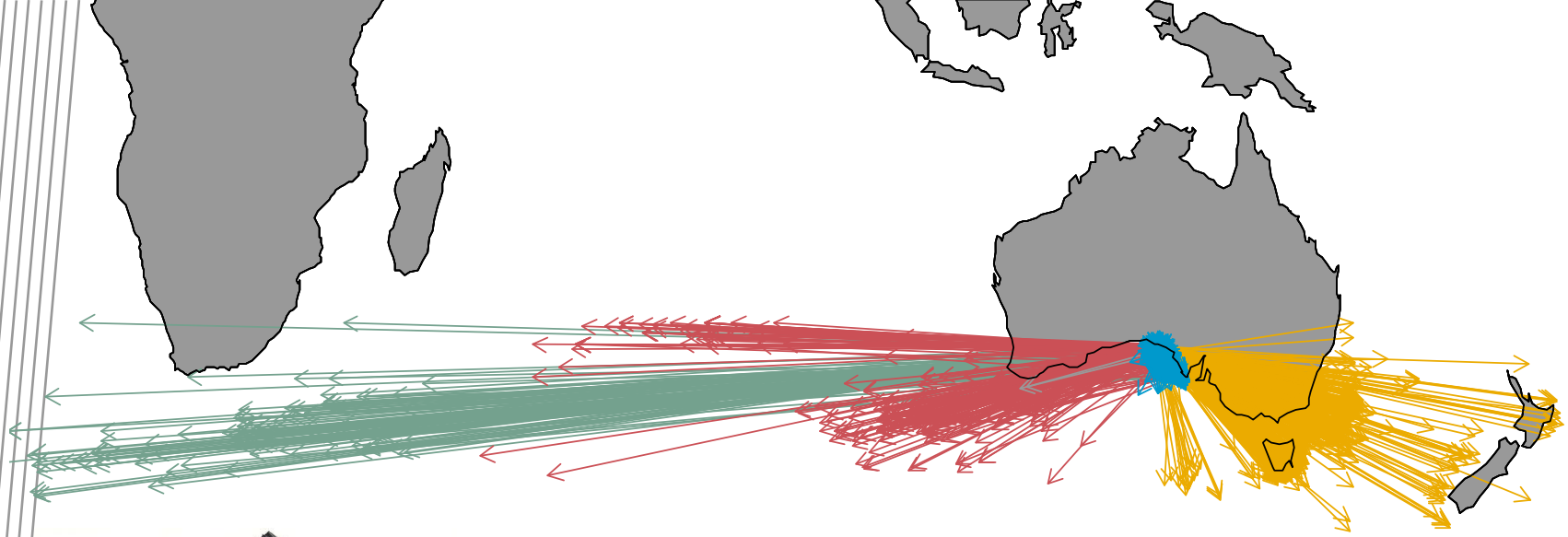
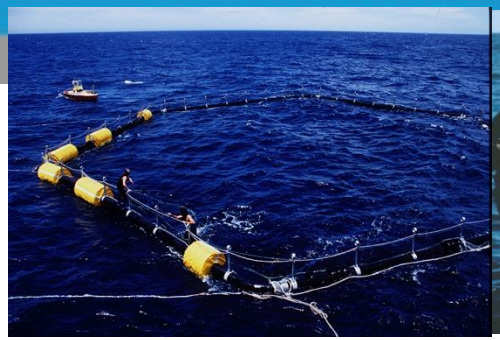
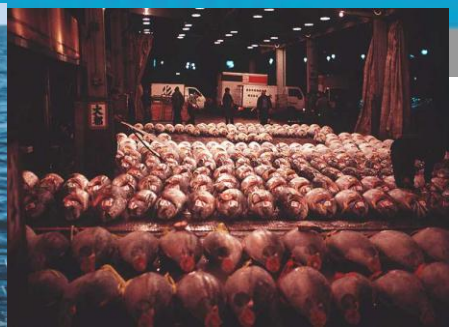


www.csiro.au

Overview of Southern Bluefin Tuna Tagging Programs

Tom Polacheck



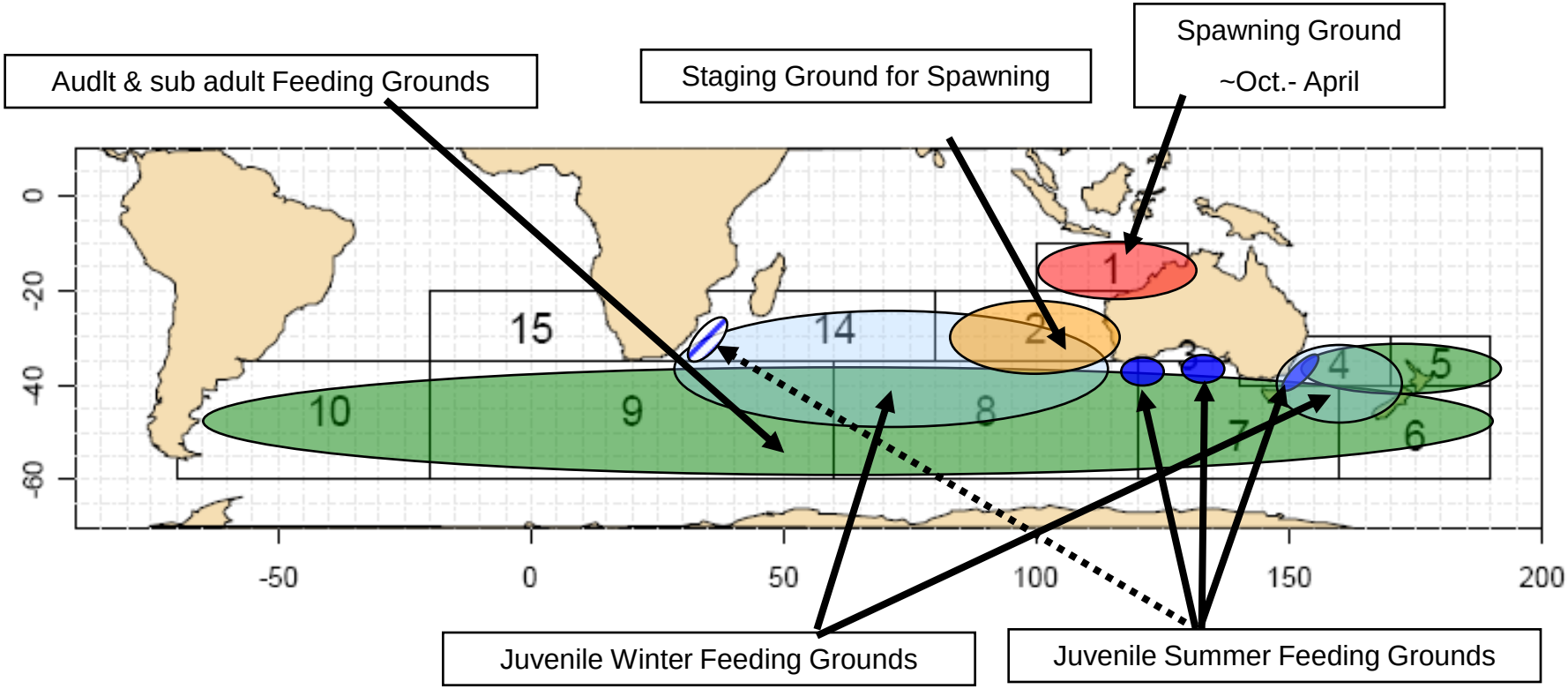


CSIRO

SBT Background – Species

- Long-lived (up to age 40), with age at maturity 8+ years
- Highly migratory, with distribution spanning southern ocean from South Africa to New Zealand
- Single spawning ground in northeast Indian Ocean south of Indonesia
- During austral summer, juveniles found in coastal waters south of Australia
  - age 0-2 commonly found south of Western Australia (WA)
  - age 1-4 commonly found off South Australia in Great Australian Bight (GAB)
- During austral winter, juveniles found in deep oceanic waters
  - age 2+ found from South Africa to NZ
  - age 1 less certain, some caught off WA Juveniles harvested by

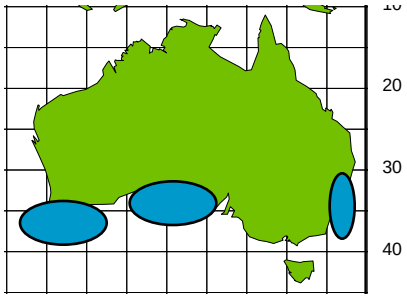
SBT FISHERIES



- Fisheries
  - Australian surface fishery (primarily purse seine and pole-and-line) operating in coastal waters south of Australia in austral summer
  - Japanese, Taiwanese and Korean longline fleets operating on high seas and NZ EEZ (joint venture) and in Australia EEZ in 1990s mainly during austral winter

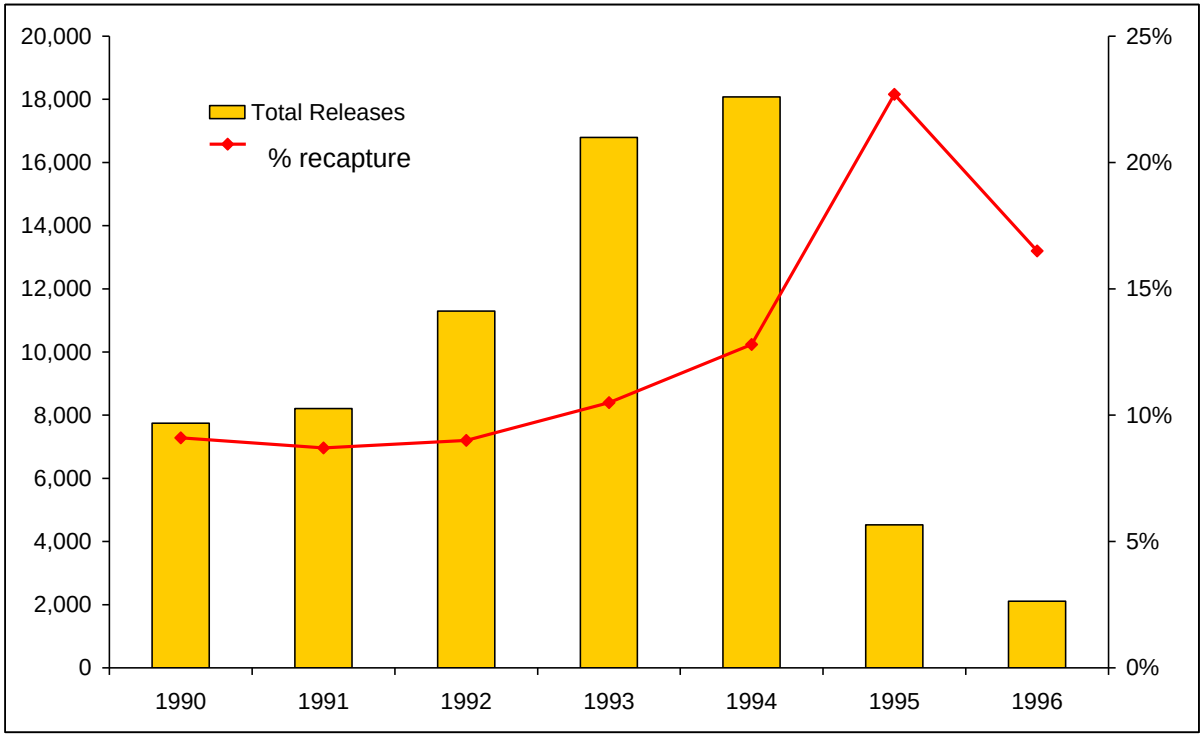
SBT Background – Tagging experiment

- Major conventional tagging experiments conducted in 1960s (1959-1969), 1980 (1983-84), 1990s (1991-1997) and 2000s (2001-2007)
- A total of ~206,000 tags released and ~24,000 recovery
- 1990s and 2000s were similar in design (multi-year/multi-cohort) and tagging methods
- Most deployments from pole and line in WA, SA and NSW (only in 1960s) with some longline releases in 1990s and 2000s



- Longline releases' recovery rates similar to pole and line
- Three periods of archival tag deployments (1993-1995, 1998-2000 and 2002-2007)

1990s Tag releases and Recaptures



2002-2007 Tag releases and Recaptures

Cohort	Number releases	Number recaptures	Percent
1998	50	7	14.0
1999	1190	138	11.6
2000	5789	885	15.3
2001	9899	2048	20.7
2002	10307	1390	13.5
2003	14481	1727	11.9
2004	15154	104	0.7
2005	17877	15	0.1
2006	3952	7	0.2

SBT Growth – changes over time

Fig. 1. (*a*) Optimal integrated seasonal von Bertalanffy log *k* growth curve for each decade for southern bluefin tuna (*Thunnus maccoyii*). (*b*) The same curves plotted relative to the 1960s curve for better comparison. Lower solid line, 1960s; long-dashed line, 1970s; short-dashed line, 1980s; upper solid line, 1990s.

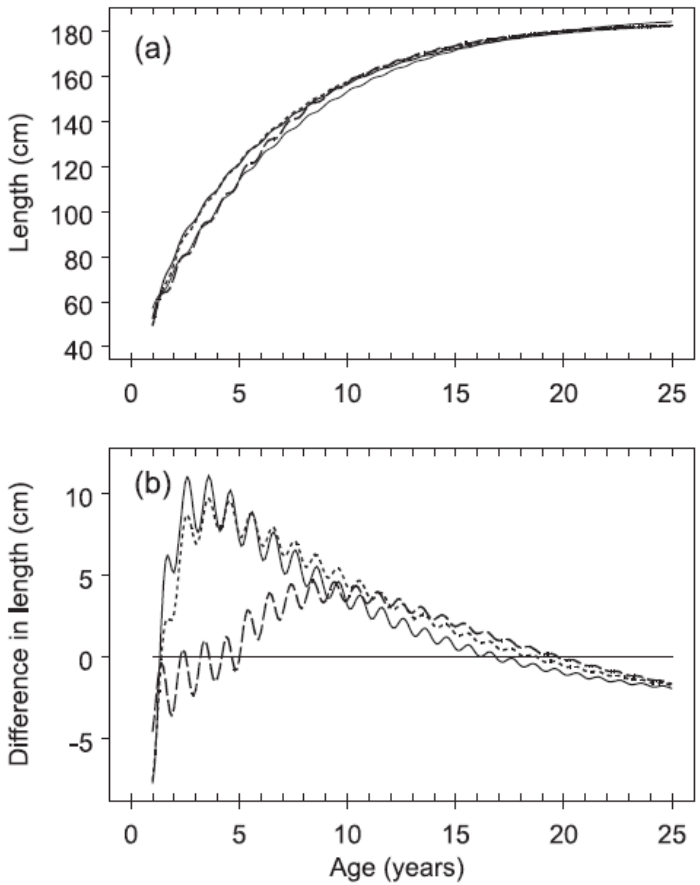
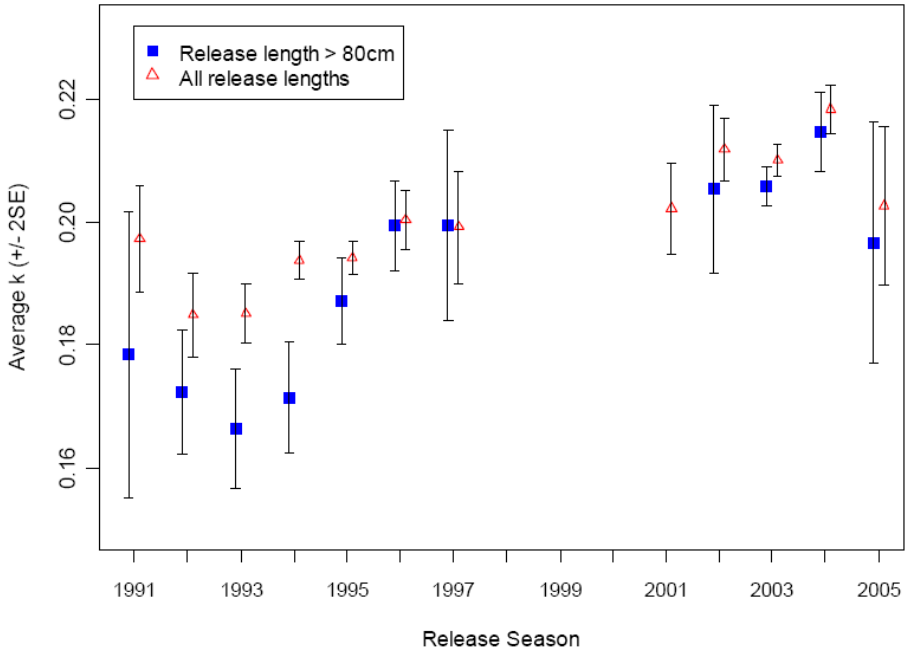
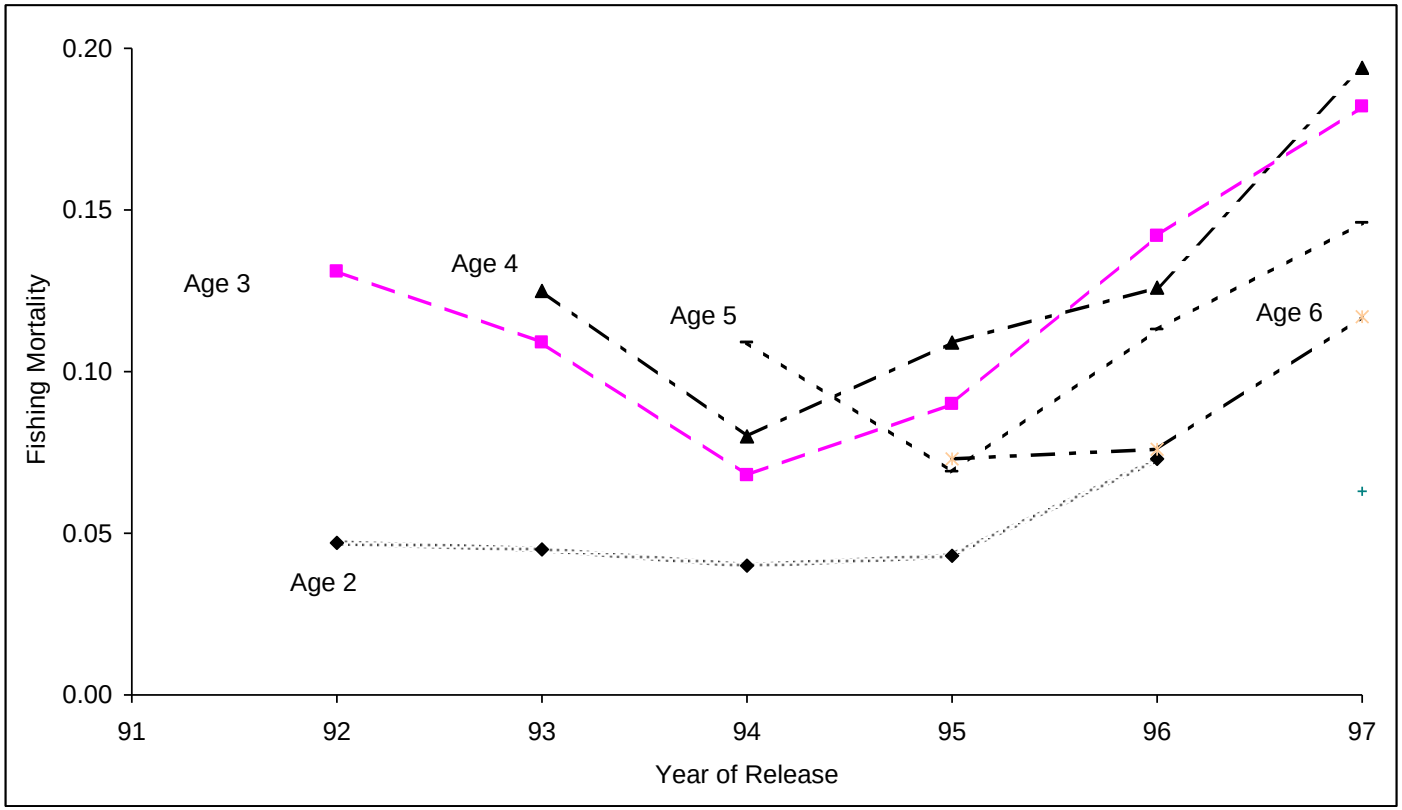


Figure 4. Mean von Bertalanffy growth rate parameter (*k*) for recaptured fish (calculated assuming $L_\infty = 185$ cm) versus release season. Only fish at liberty for over 30 days are included in the averages, and only averages calculated using more than 5 observations are shown.



Fishing Mortality Rates - 1990s experiment



Reporting Rate Estimates

- Tag seeding:
  - 10 fish per tow cage from 40 fish sampled for length at time of transfer to farm cages (~300 plus seeded tags per year)
  - double tagged and tag shedding corrected estimation of reporting rate
  - Concerns about lack of independence in shedding and experience/ability of some taggers
  - high variability among cages and different operators
  - size effects likely
- Re-release of wild tagged fish caught during the 40 fish sampling
  - ideal approach but sample size small

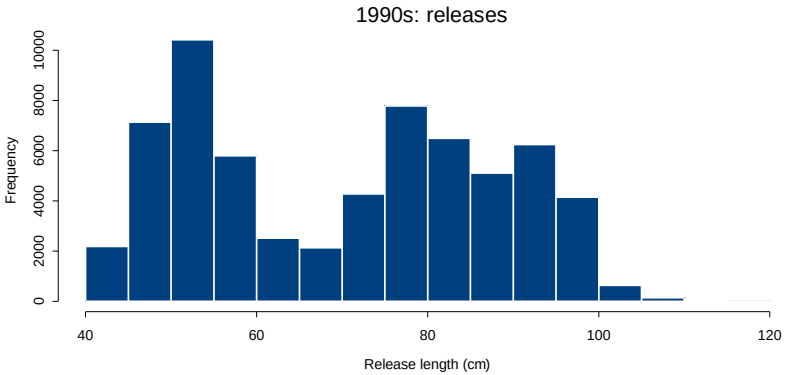
Reporting Rate Estimates
Australian Farm Returns

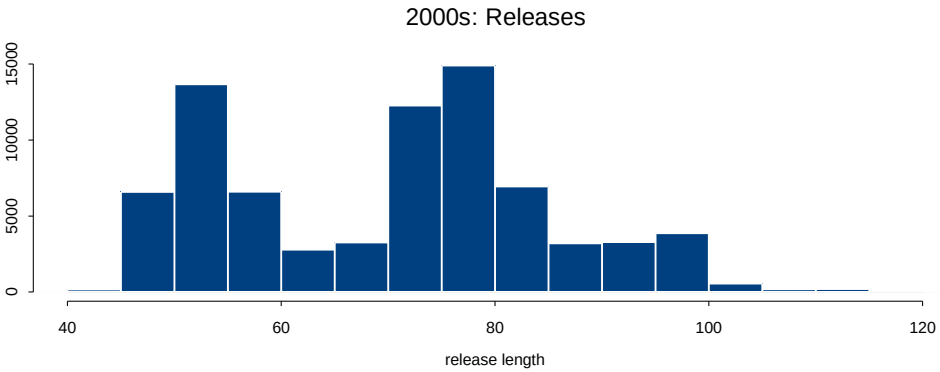
	Reporting Rate Vector	2002/2003	2003/2004	2004/2005	2005/2006
	A0	0.65	0.55	0.42	0.22
	A1	1.00	1.00	1.00	1.00
	A2	1.00	0.79	0.62	0.34
Tag Seeding	A3	0.65	0.55	0.42	0.30
	A4	1.00	0.79	0.62	0.47
Re-releases	A5	0.47	0.47	0.47	0.47
	A6	0.67	0.67	0.33	0.33

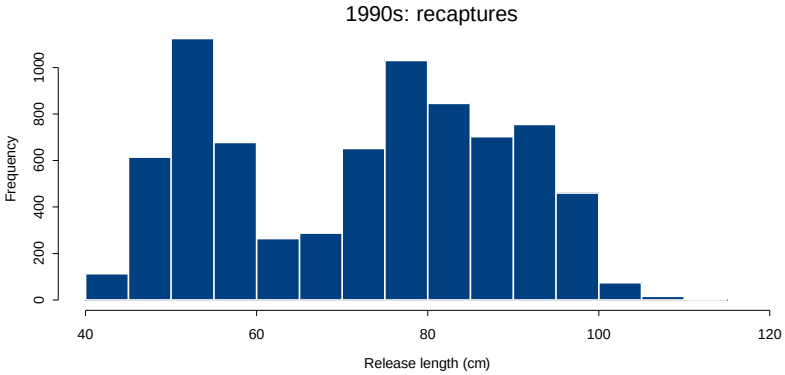
Shedding Rates – 2000 tagging experiment

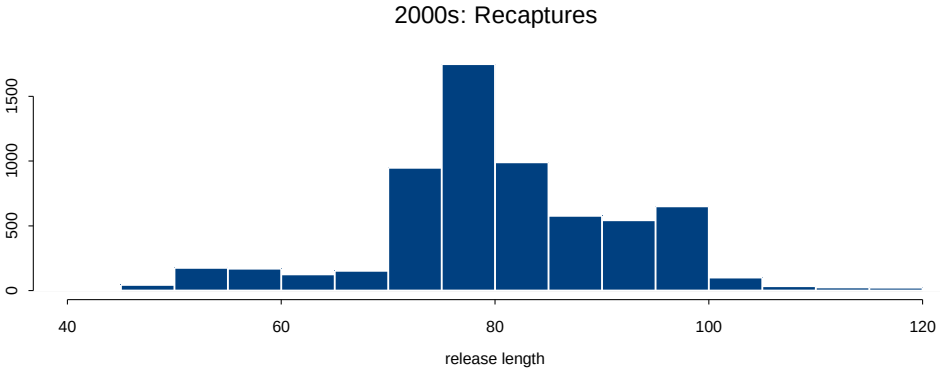
	Tagger ID	Initial retention fraction (ξ)	Continuous shedding rate (Ω)	Recaptures with 2 tags	Recaptures with 1 tag	Total number recaptures
	2	0.976	0.105	1842	768	2610
	4	0.909	0.204	817	803	1620
	418	1.000	0.173	47	47	94
	419	1.000	0.284	75	103	178
	444	1.000	0.198	52	45	97
	570	0.850	0.143	87	76	163
	1439	0.778	0.070	258	222	480
	1525	0.887	0.000	169	43	212
	1646	0.884	0.144	228	178	406
	ZZ	0.438	0.000	7	18	25
Tagger Group						
1	2	0.976	0.105	1842	768	2610
2	418+444+570+ 1439+1646	0.821	0.099	672	568	1240
3	4+419	0.914	0.211	892	906	1798
4	ZZ	0.438	0.000	7	18	25
5	1525	0.887	0.000	169	43	212

Release Length of Fish Tagged and Release Length for those Fish that were Recaptured

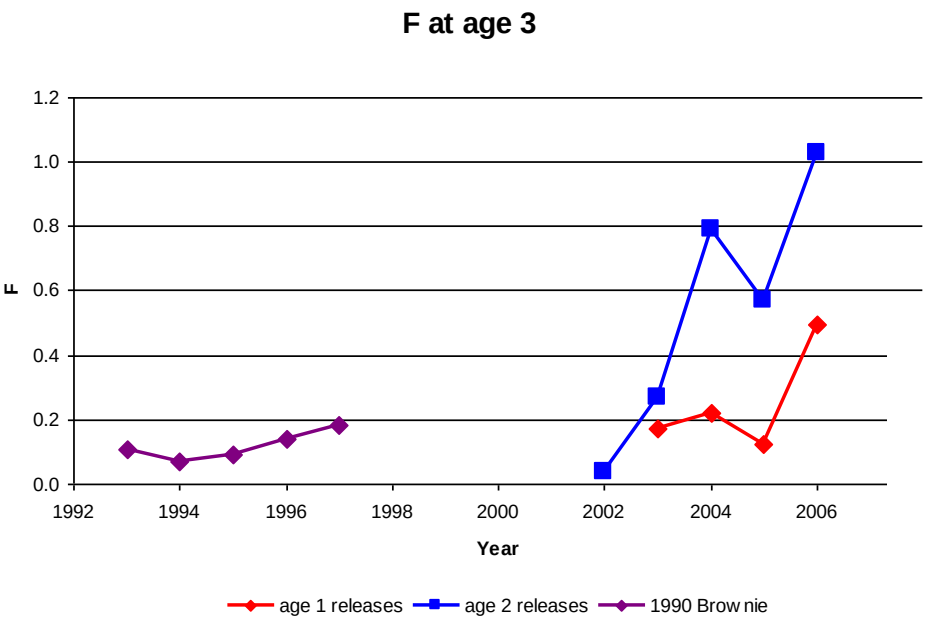


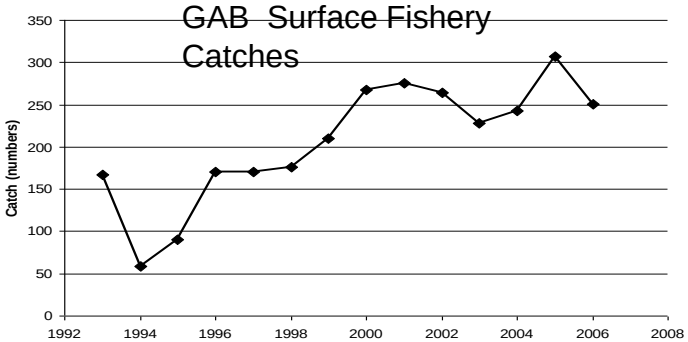


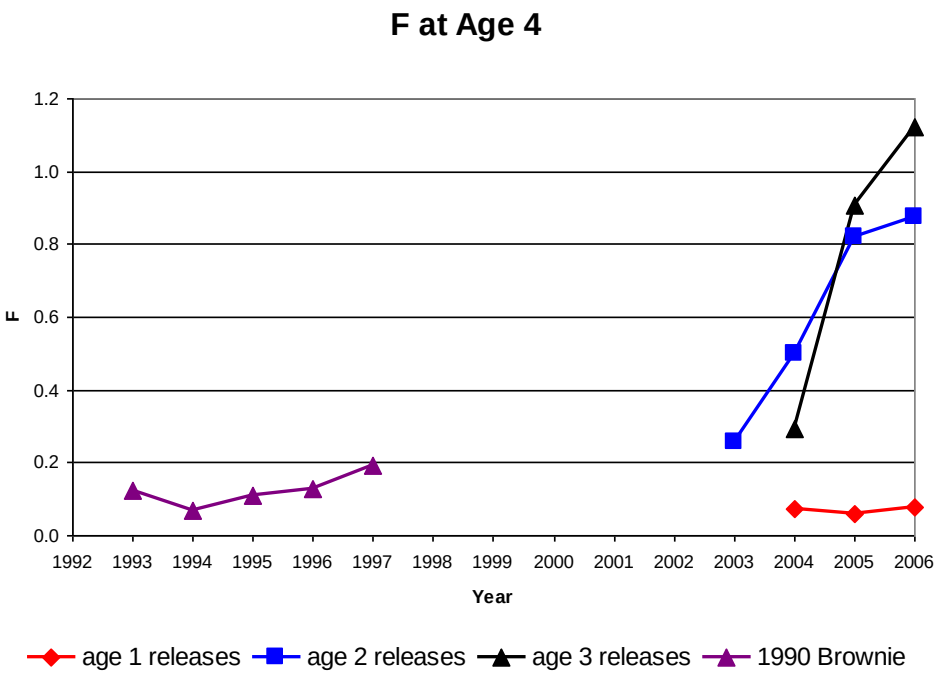


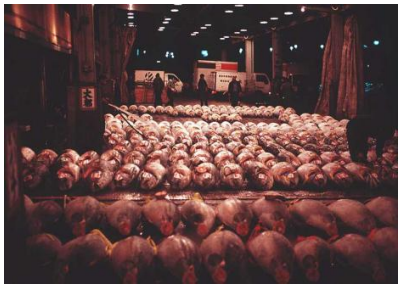


Fishing Mortality Rates: 1990s vs 2000s experiments



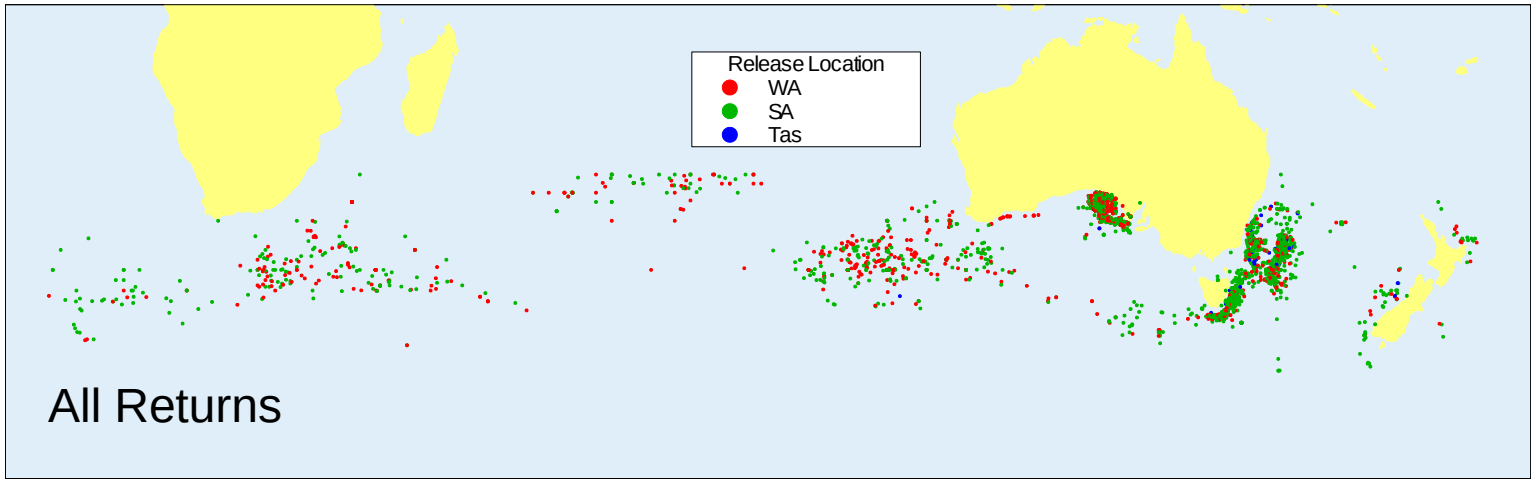


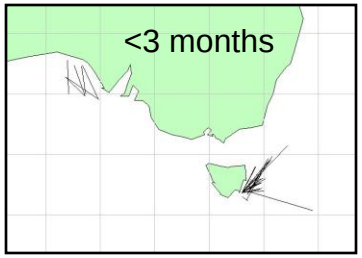




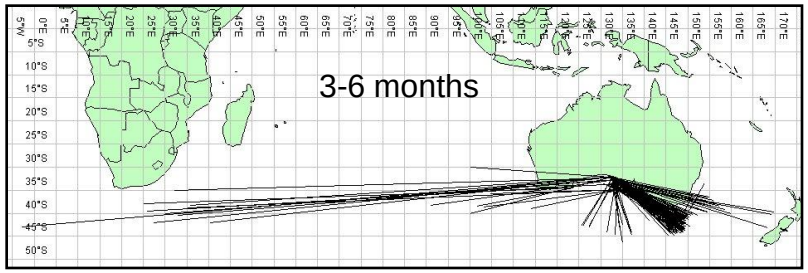
Movements and Migration: Decadal Changes 1990s-2000's

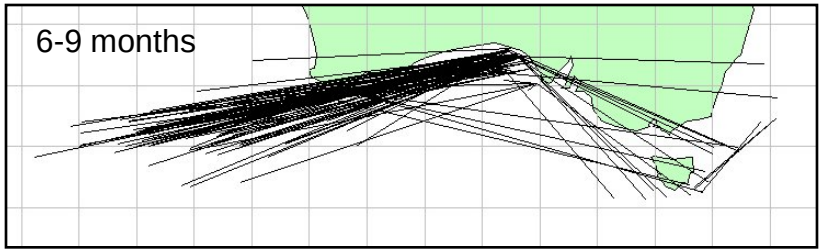
Conventional Tag Returns from Releases in the 1990s

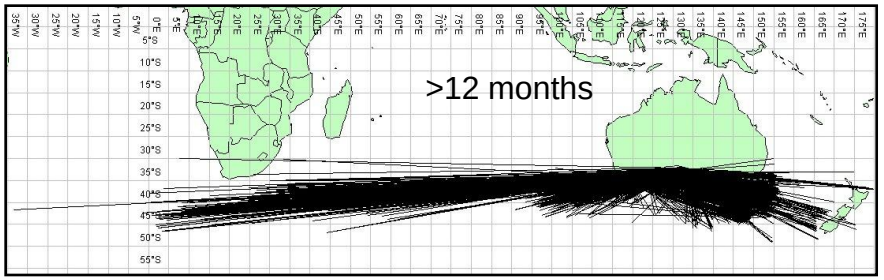




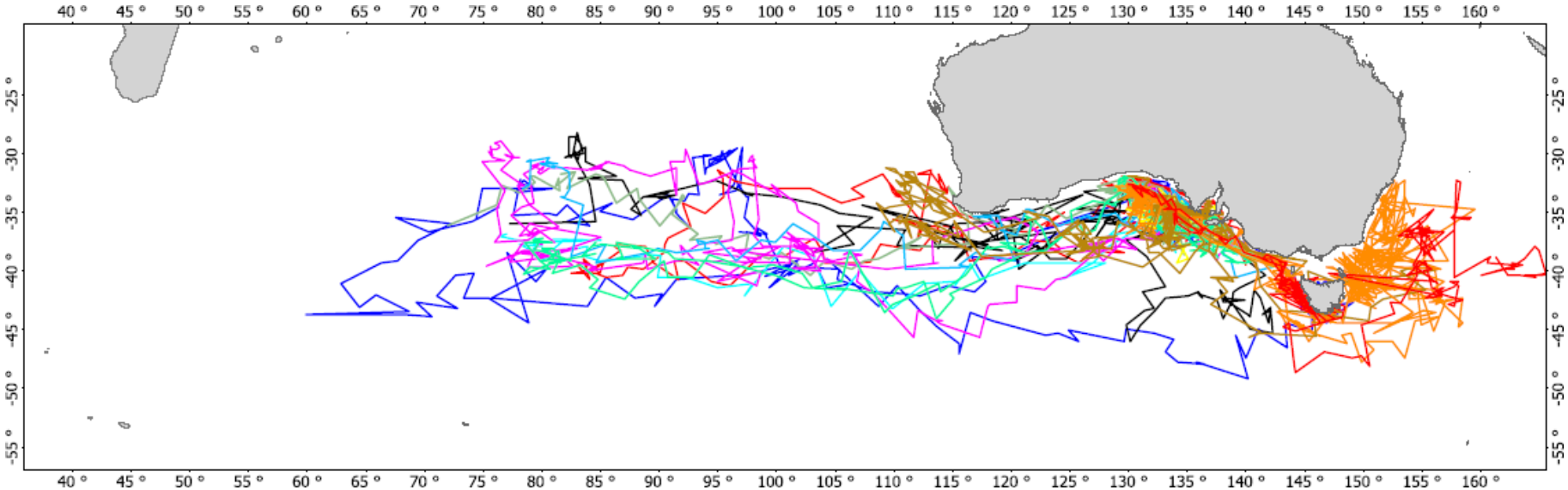
Japanese Longline Return

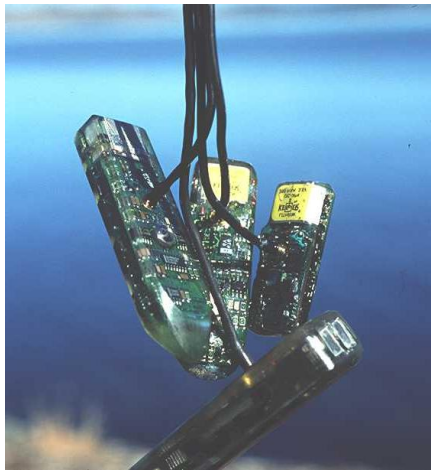


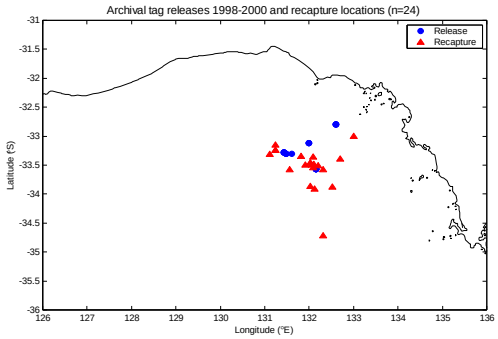




Typical Long Term Movement Pattern – most released and recovered in Australian Waters

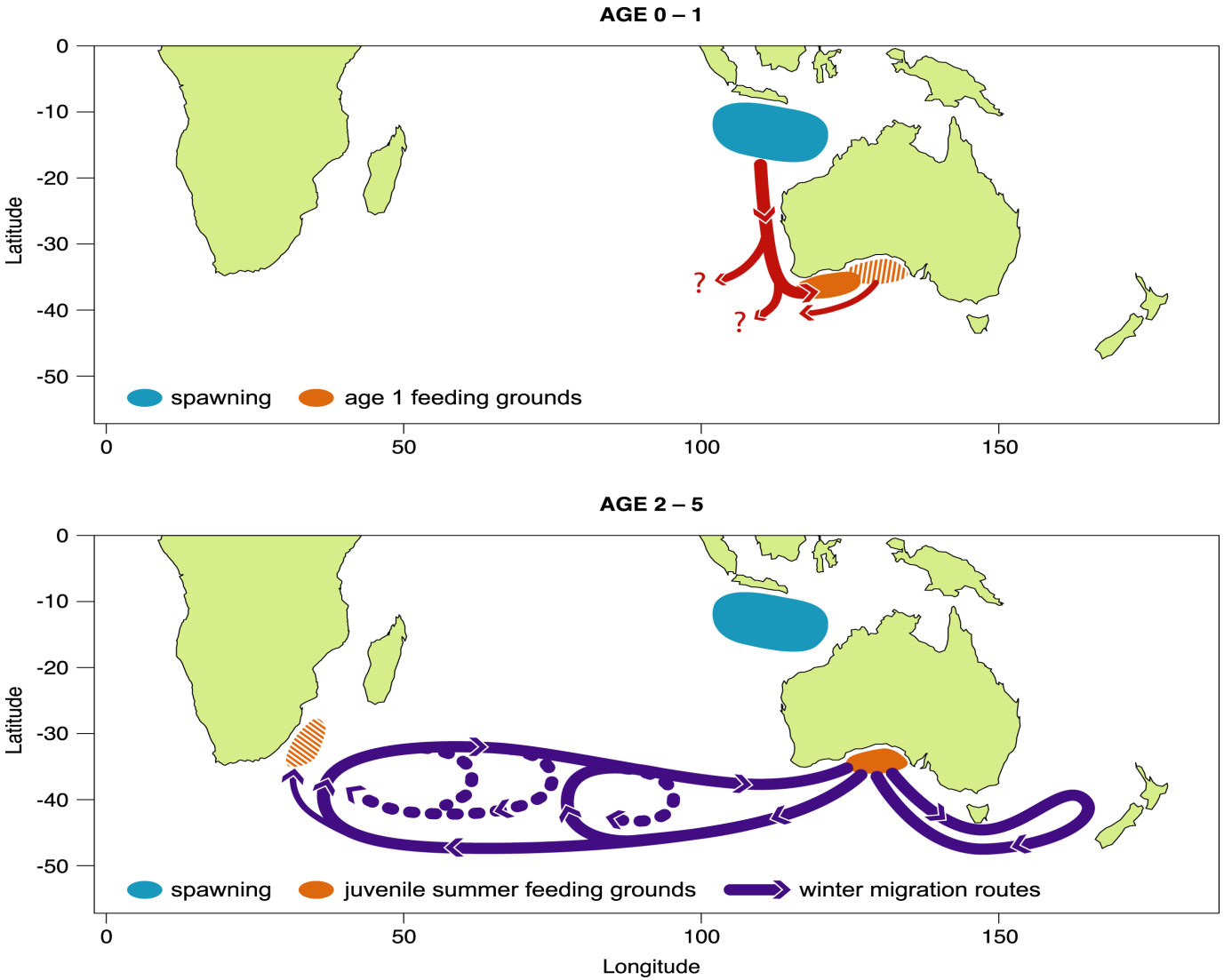






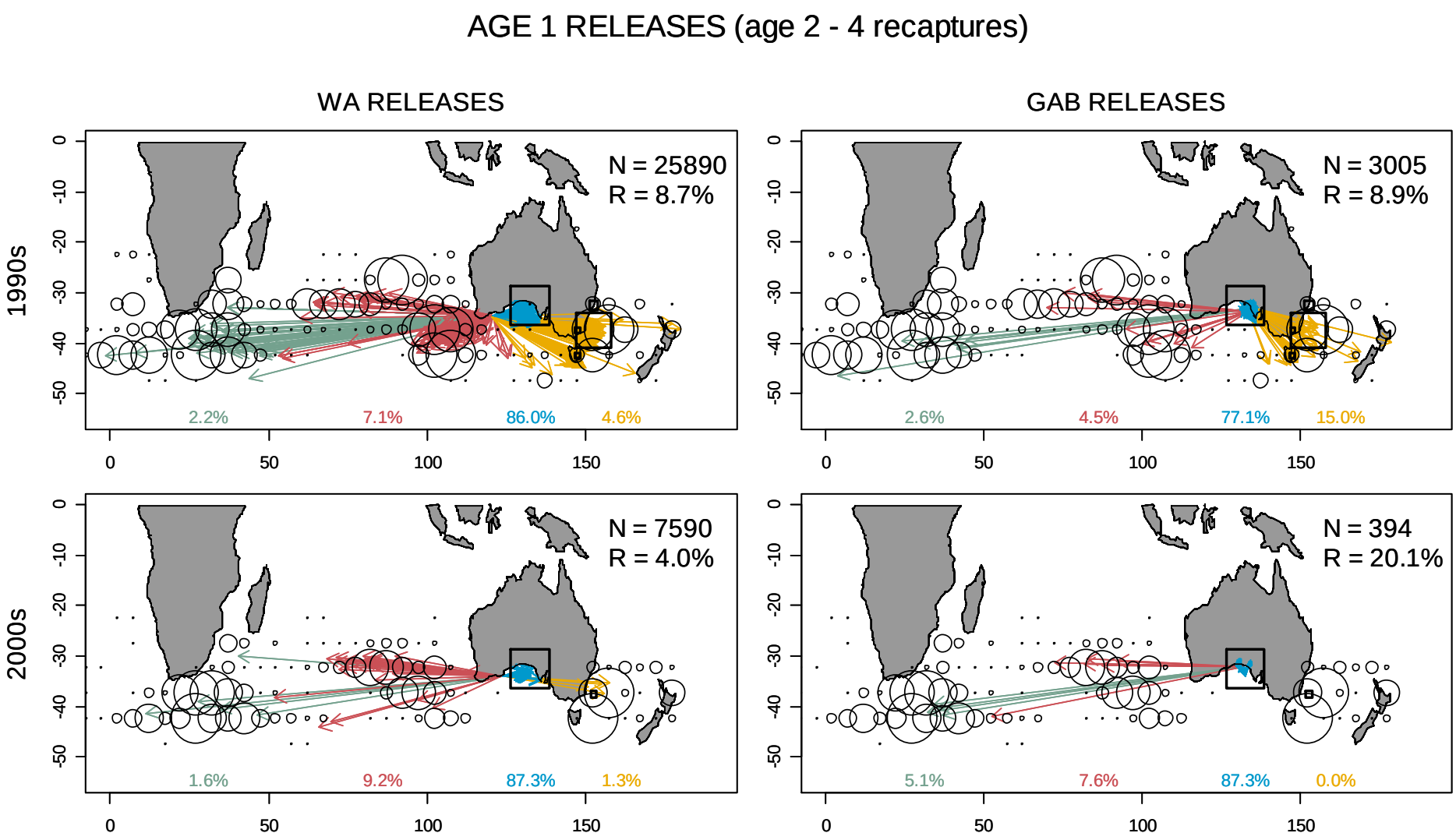
Release and recovery location

Current Understanding of Juvenile SBT Migration Pathways in the 1990s

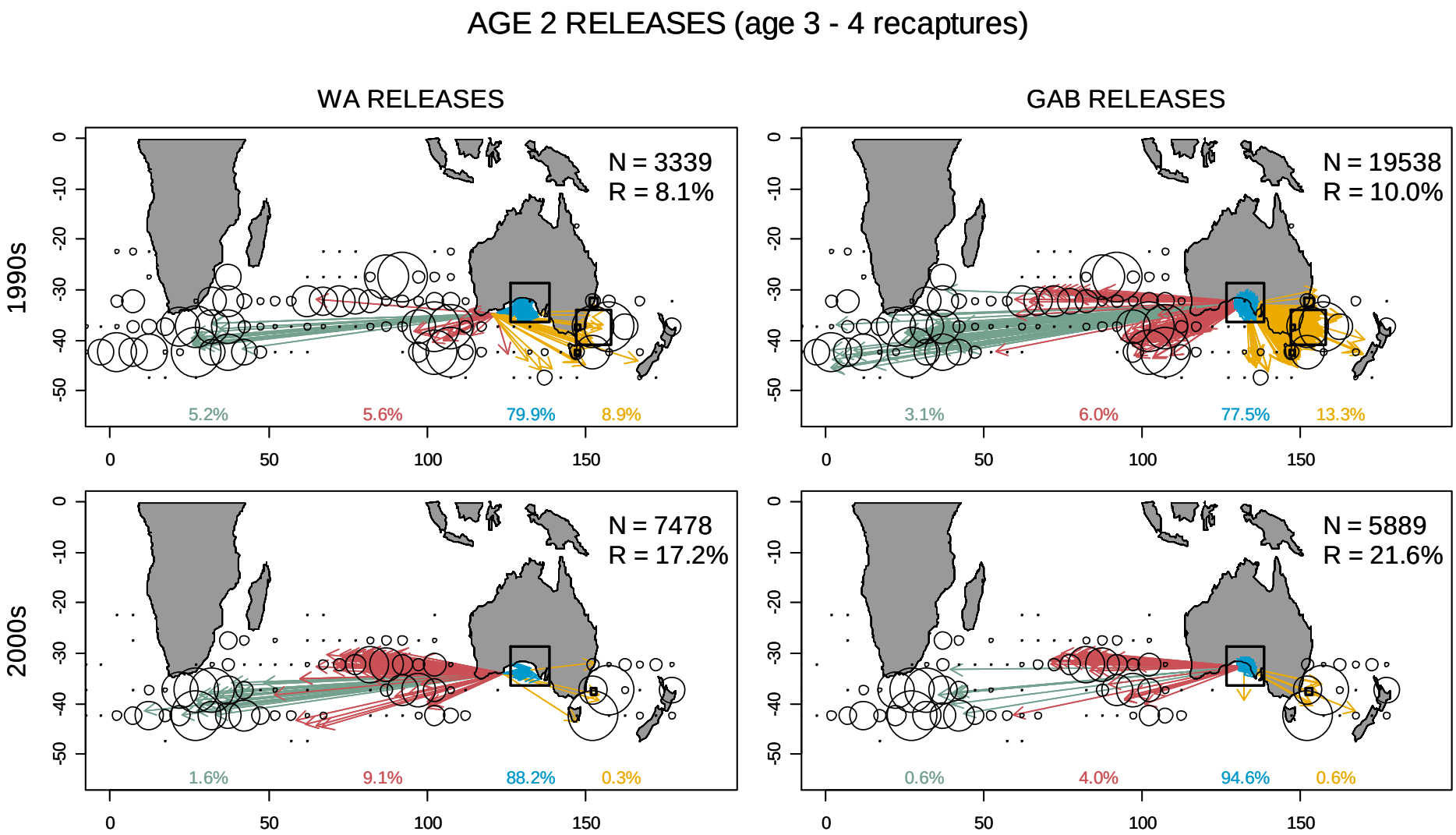


Synthesis of:

- archival tag data
- conventional tagging data
- catch data (length frequency and cpue)

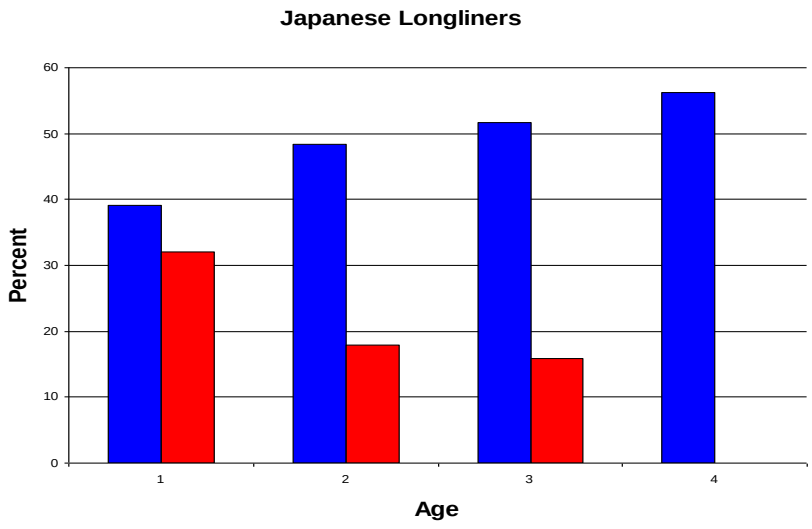


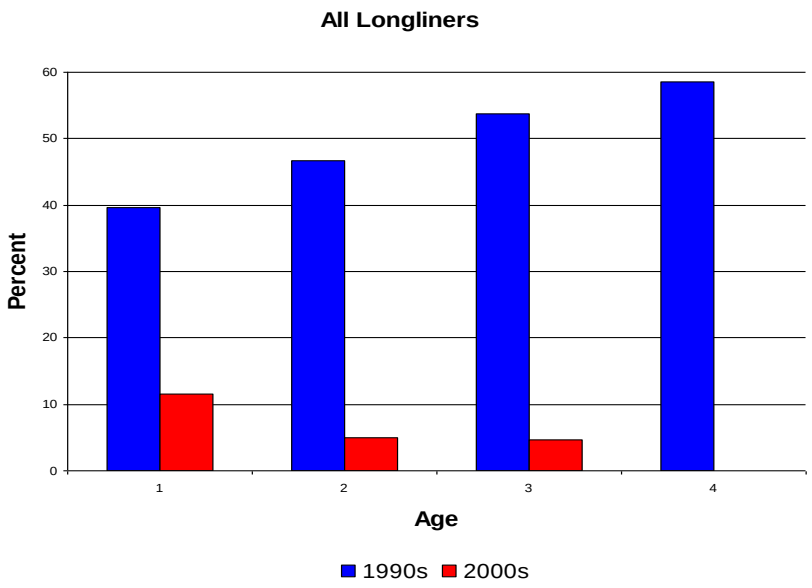
Conventional Longline Returns 1990s versus 2000's

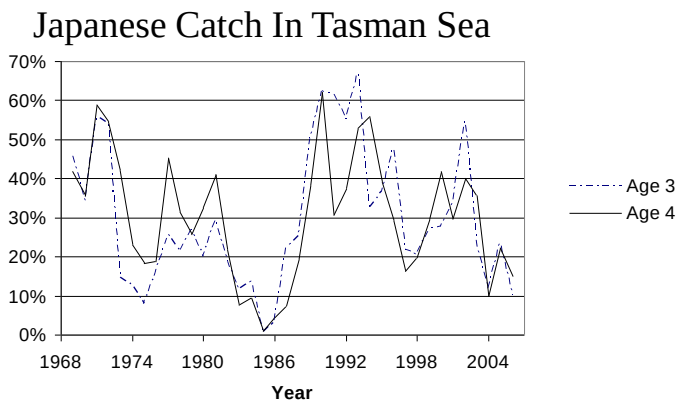


Conventional Longline Returns 1990s versus 2000's

Percent of longline returns that were from the Tasman Sea

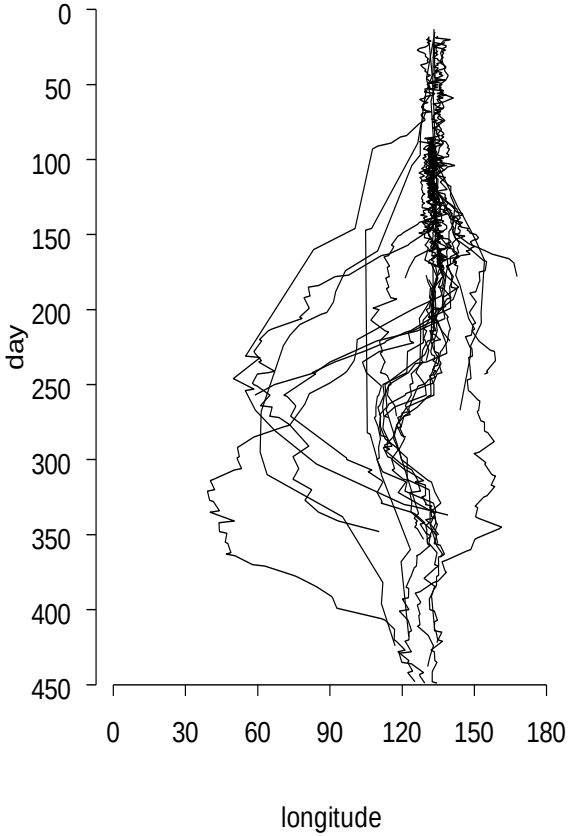




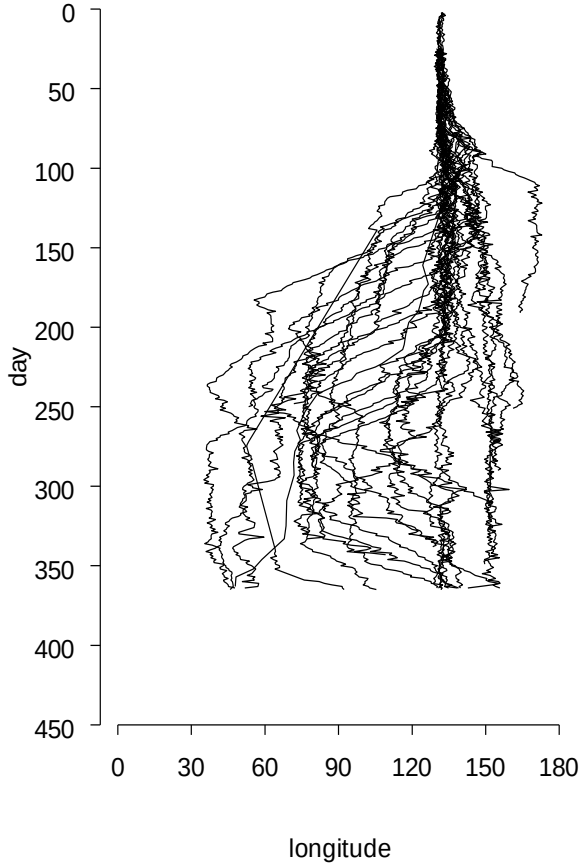


Archival Tag East-West Movements

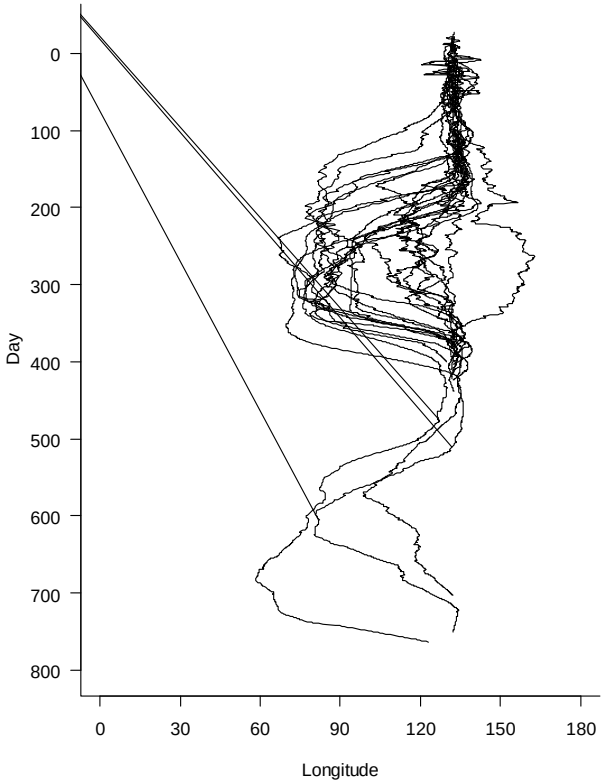
1993-1995 Releases



1998-2000 Releases



2002-2005 Releases



Archival Tag East-West Movements

East

	Maximum Longitude	
Year	≤145	>145
1993	2	0
1994	6	2
1995	11	5
1998	9	7
1999	6	2
2000	5	3
2002	2	0
2004	8	0
2005	13	1
2006	1	0
2007	1	0
Total	64	20

33%

4%

P<0.001

West

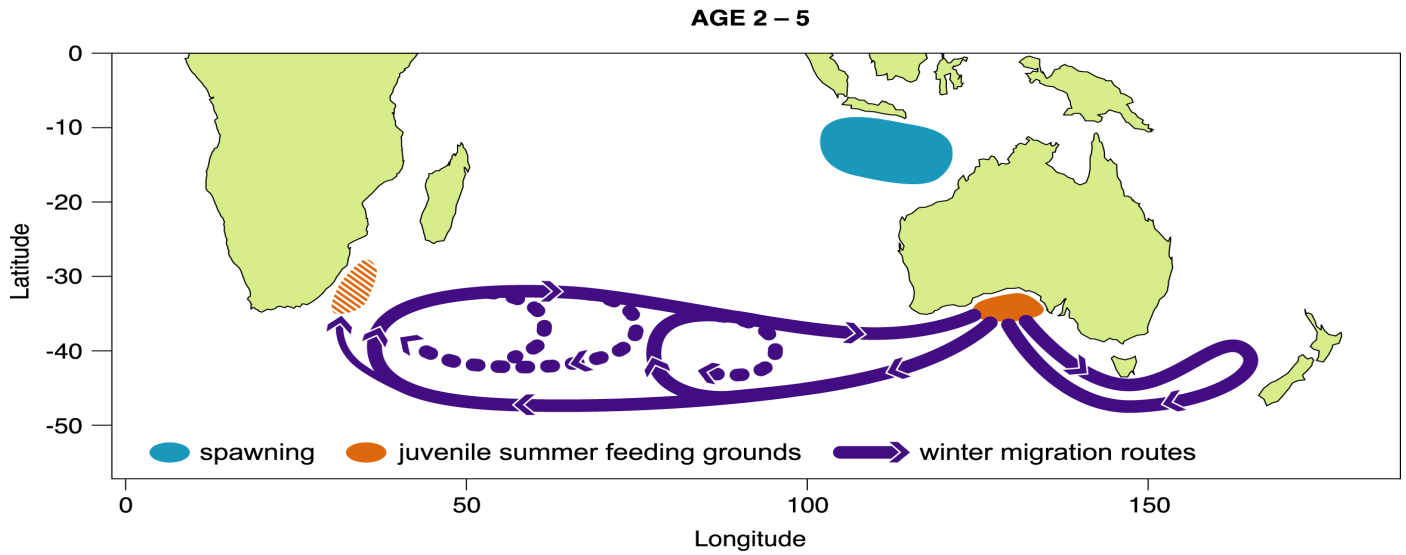
	Maximum Longitude	
Year	<65	>65
1993	0	2
1994	3	5
1995	1	15
1998	1	15
1999	3	5
2000	2	6
2002	0	2
2004	1	7
2005	0	14
2006	0	1
2007	0	1
Total	11	73

17%

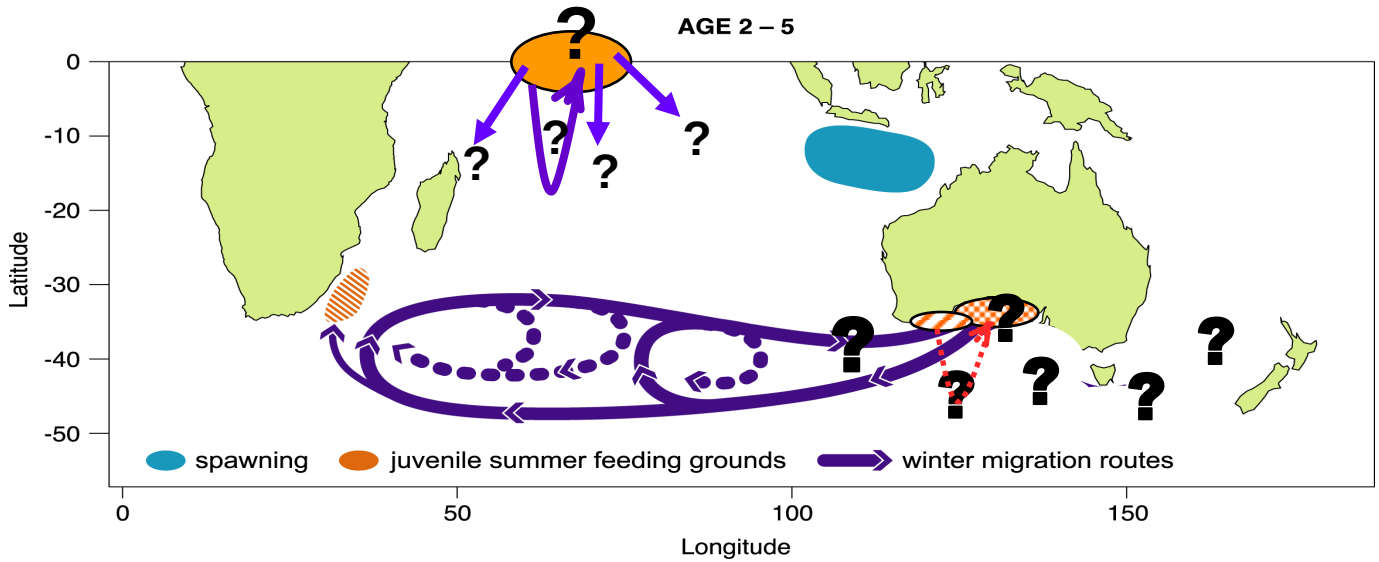
4%

P<0.01

Juvenile SBT Migration Pathways
1990's vs 2000's



1990s

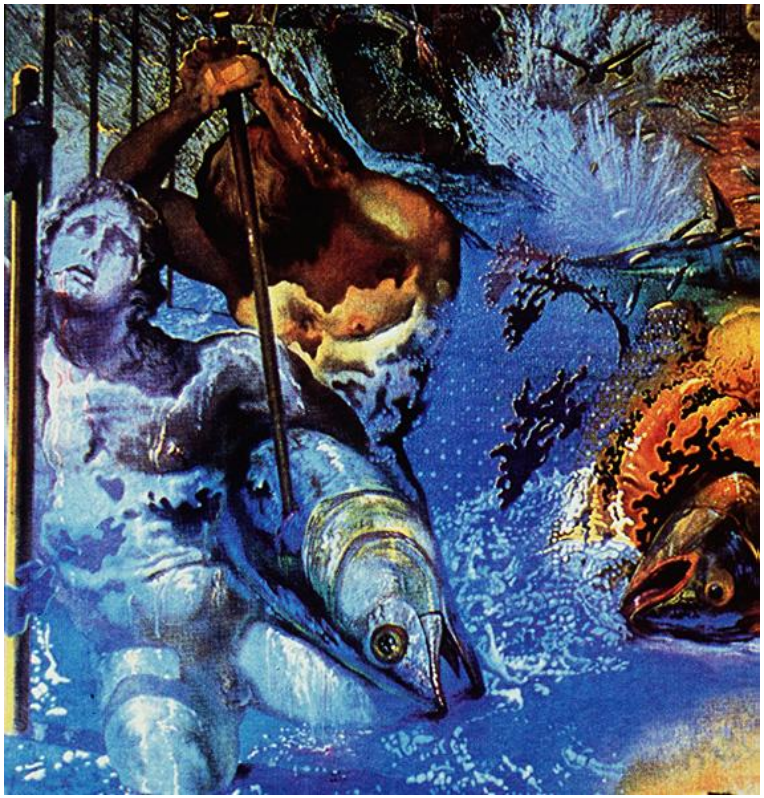


2000s

Summary - juvenile

- Changes (increase) in growth rates over 4 decades
- Reporting rates – essential but need to ensure seeded and wild releases are same
- Shedding rates – tagger effects which need to be taken into the analyses
- Current fishing mortality rates for age 3 and 4 fish found in the GAB appear extremely high and are substantially greater then in the1990s
- There is an unexplained difference in the return rates for age 1 fish tagged in WA and GAB in the 2000s that was not apparent in the 1990s – where are all the 1 year old fish?
- Movement and migration patterns of juvenile SBT ave changed between the 1960 and 1980/90 and between the 1990's and 2000s (non-stationarity)

Acknowledgements



- Bill Hearn
- taggers,
- crews of the tagging vessels
- Liaison officers
- Data managers
- John Gunn
- Sophie Bestley
- Alistair Hobday
- Grant West
- Australian, Japanese and Taiwanese Fishing industry
- And a multitude of others (including a large number of funding sources)

Salvador Dali

Summary of Fundamental Distinction In Tagging Experiments

Data on Only Number Recaptured

- **Single Release** → **Tag Attrition** → **Rate of Returns Over Time** → **F&M** (if constant) or **F_i** (if M known)
- **Multiple Releases** → **Brownie** → **Difference in # of Returns from Separate Releases** → **Z_i, F_i & M_i** (except M_i for last release period)

Data on Number Recaptured & Number Examined For Tags → **Petersen** → **Proportion of Animals with Tags** → **P_0**