



Northern
Territory
Government



Queensland Government
Department of Primary Industries and Fisheries



Australian Government
Fisheries Research and
Development Corporation

DEPARTMENT OF REGIONAL DEVELOPMENT,
PRIMARY INDUSTRY, FISHERIES AND RESOURCES

The Feasibility of Genetag: Genetic Tagging for Monitoring Mortality Rates and Catchability

*Rik Buckworth¹, Jenny Ovenden²,
Damien Broderick², Michael Macbeth²*

1 NT Fisheries

2 Qld Fisheries

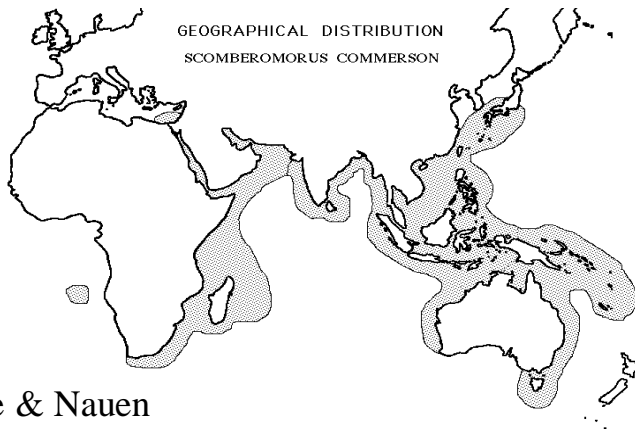
IPFC/ASFB Fremantle 31 May- 5 June 2009



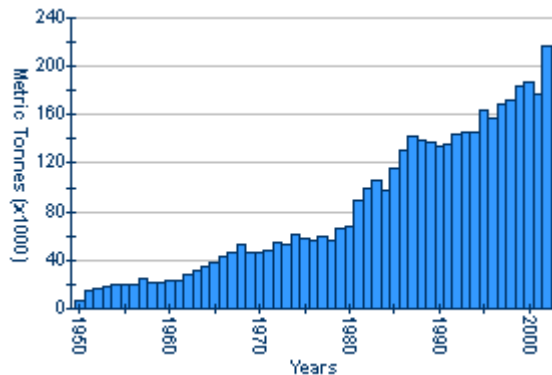
Overview

- The Motivation: Most fisheries are difficult to monitor
- Many species are difficult to tag- Why use *genetic* tagging? Concepts
- Feasibility requirements
- Proof of concept, and Challenges
- Future directions

Scomberomorus commerson are important fish



(Collette & Nauen
1983)



(Source: FAO)

- Small Australian line fishery, 2-3000 tonnes, \$15-20 million: **Grow? Restrict?**
- Overfishing signals in some fisheries - N Australia, Middle East
- Biology ~ moderately well known
- Spatially: metapopulation?
- Large, pelagic, aggregative, reefs
- **HOW should we monitor??**



Mark-recapture would be good. . .

- Monitors F with relatively few tags annually
- Robust to spatial complexity - if tag distribution follows effort, then local high F s are detected



BUT . . .

- Fish don't always survive capture and release –fragility, barotrauma, cryptic
- Tags are shed
- Tags are under-reported
- For some species/ fisheries these problems may be insurmountable
- \$\$\$\$\$



Northern
Territory
Government

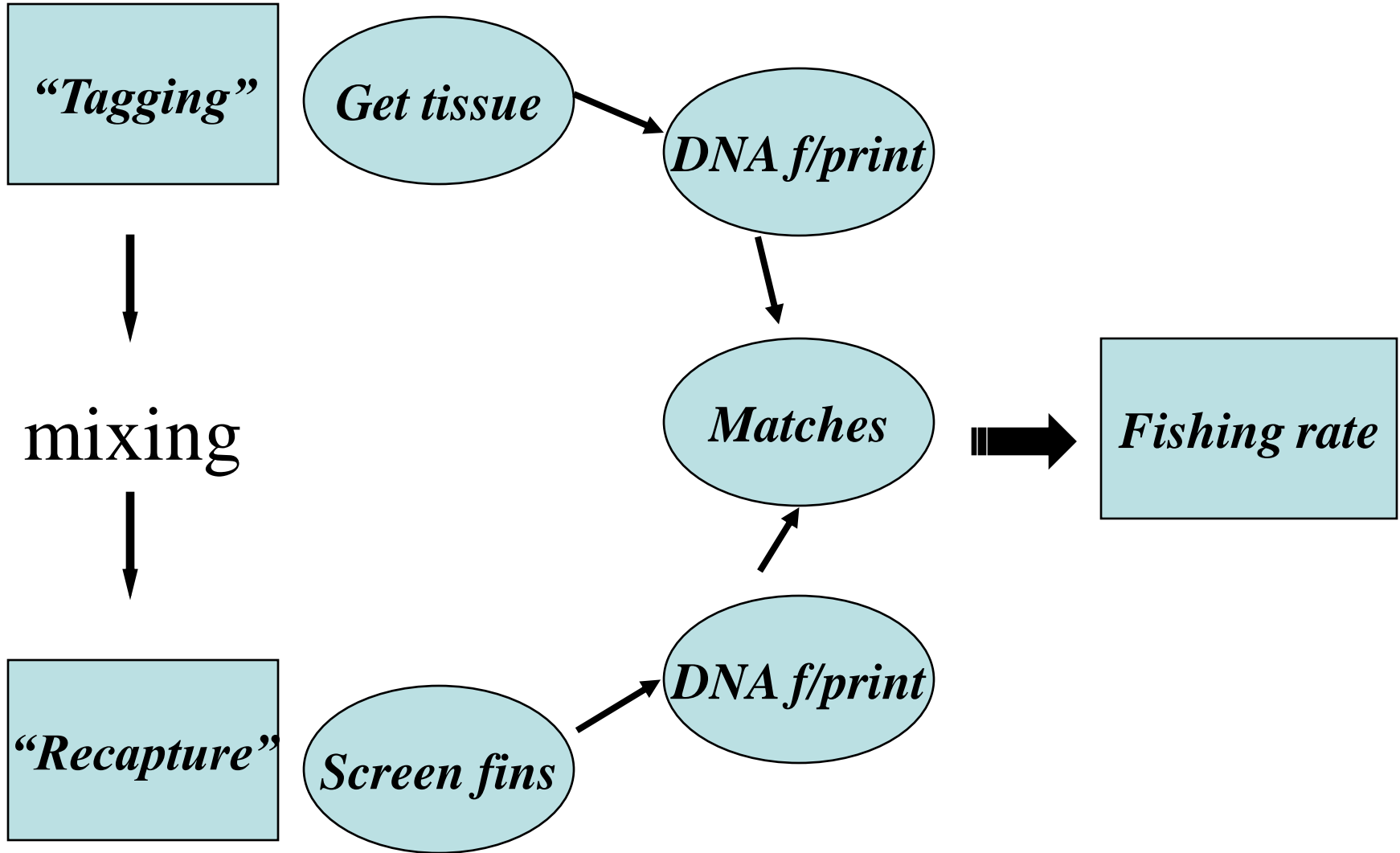
Spanish mackerel . . .



Photo: Peter Zeroni



Genetag process





Genetag overcomes several problems

- **'tag'** - collect tissue *in situ*, identify individual fish from msDNA (no tag loss or mortality)
- **'recaptures'** - screen the commercial catch for **matches to** those fish (overcomes non-reporting)
- **fishing rate** - proportion 'recaptured' / screening fraction



Genetag project objectives

- Demonstrate genetic mark-recapture in a commercial fishery
- Evaluate the feasibility of this approach as the basis of a monitoring system for the NT Spanish mackerel fishery



Gene tag monitoring feasibility needs

- Tissue collection - *In situ* method (+ distribution, collection, storage, databasing)
- Polymorphic loci suitable for multiplexing
 - Efficient approach to screening (must do 1000s)
- Database matching and other analytic tools – dealing with large amounts of data means huge number of comparisons
- Experimental control – conventional tagging



Remote tissue sampling is feasible



- Design predicted to produce 44-85% successful strikes, depending upon deployment (3 experiments; Buckworth 2004)
- ~ 1000 Spanish mackerel genetagged near Darwin

Genetics components - and screening efficiently- feasible

- A suitable set of polymorphic loci (high resolution; Broderick et al. in prep.)
- Optimization to choose “best” sets among those loci, basic simulation software (multiplexing) (Hoyle et al., 2005)
- Procedures: Heavily automated screening (& multiplexing) to reduce costs (lab costs ~ Aus\$5/sample)



Genetic Analysis Challenges – Met!

- **Shadows:** there is a finite probability that distinct individuals may have the same genotype
- **Errors** in genotyping **Partial** genotypes (genotype not successful at all loci - NB tiny tissue bits)
- **Trade-offs:** More loci and more samples increase precision BUT increase complexity and costs
- How to deal with all that? See Damien Broderick!!



Feasible!: Results in a nutshell?

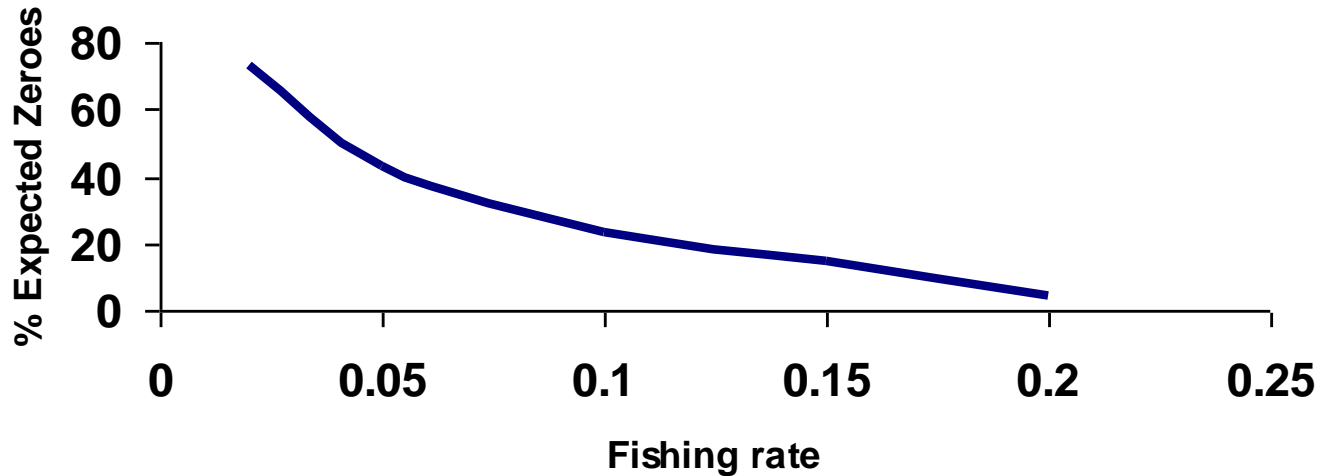
- Mass screening completed: > 9000 genotypes of 4+ loci (533 hooks, 7833 fins, 634 samples from conventional tagging)
- Several confirmed genetag recaptures:
 - Many at liberty 15 mins -2 days- struck at lures within trips
 - 22 that were genetagged and then detected in the screened catch – but **within** trip
 - NO long-term recaptures (?)
- 35 conventional tag recaptures each from years 1 -4 (~3%); minimal movement
- **PROOF OF CONCEPT**



- Fine scale impact of fishing can be very high: gross mean removal rate 53% of actively feeding fish in a 'school' (preliminary analysis, 14 fishing episodes)
- We removed most of our own tagged fish!!



Interpretations . . . Why No long-term recaps?



- Frequency of zero recaps expected with reduced number of tags is high ASSUMING full mixing
- With minimal mixing, very low expectation of returns – cf conventional tags



Next

- Monitoring system design that targets high probability of recaptures
- Utilise the power of mark-recapture theory to maximise information value
- Improving system performance with development of hook designs, new manufacturing materials to reduce costs
- Maximizing tissue quality throughout capture and collection chain – reduce sources of error and maximise feedback

Acknowledgements

- Fishing Industry
- Fisheries Research & Development Corporation
FRDC 2002/011, 2006/017.
- Northern Territory Fisheries, Department of Primary Industry, Fisheries & Mines (Bryce, Donati, Phelan, de Lestang, Sellers and plenty of others)
- Queensland Fisheries (McPherson, Street, Hoyle, Peel, Peel)
- Western Australian Department of Fisheries (Newman)
- UBC Fisheries Centre (Walters, Martell)
- Simon Fraser Univ. (Cox)



Northern
Territory
Government

Geneticists lurking among the Shadows?





Challenge: using information among the Shadows

- We are dealing with very tiny samples of tissue leading to many incomplete genotypes (preservation, biochemistry, interpretation)
- Including information from those genotypes could substantially improve precision of recapture rate estimates, perhaps substantially
- Analogy – truncated streamer tags
- An empirical approach to enable this



Conclusions

- Genetic tagging addresses the problems of mark-recapture for estimating fishing rates, especially for difficult to tag species
- The Genetag approach has now been proven as a concept; from this point there are challenges, mostly those of more standard mark-recapture programs
- It has the potential to team with conventional tagging - **harness** the enthusiasm of anglers!
- Potentially, are many variations of the approach that may be applicable to other species and fisheries



Northern
Territory
Government

Scomberomorus commerson

(with a major predator)



Narrow-barred Spanish mackerel, king mackerel,
kingfish, ikan tengirri, ikan rajah, seerfish, tenguige . . .

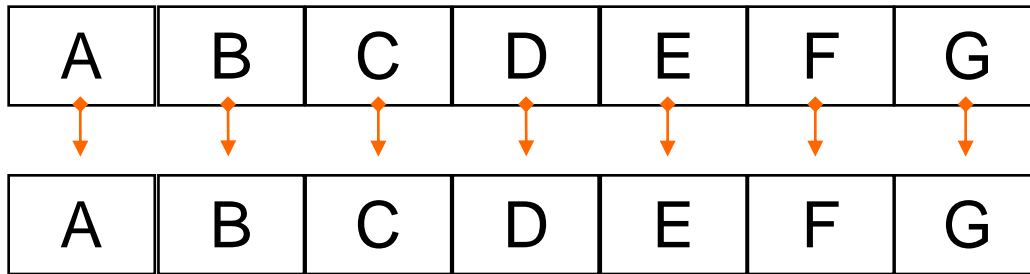


Northern
Territory
Government

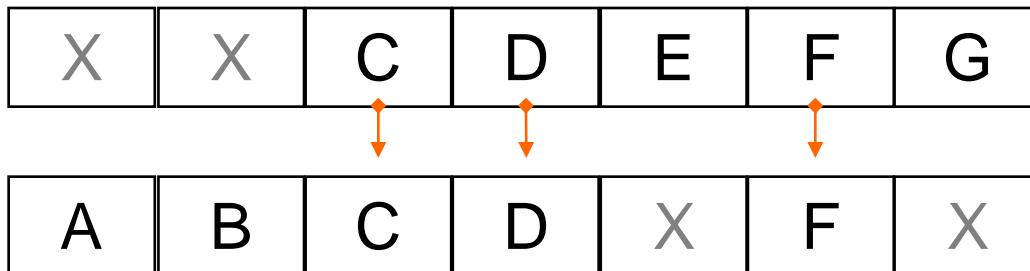


Another gratuitous big fish photo

Tricky challenge – Incomplete genotype effect on recapture detection



Tag 7 loci dataset
7/7 match.
Recap **High certainty**



Tag 5 loci dataset
3/3 match.
Recap **Low certainty**



How should we monitor?

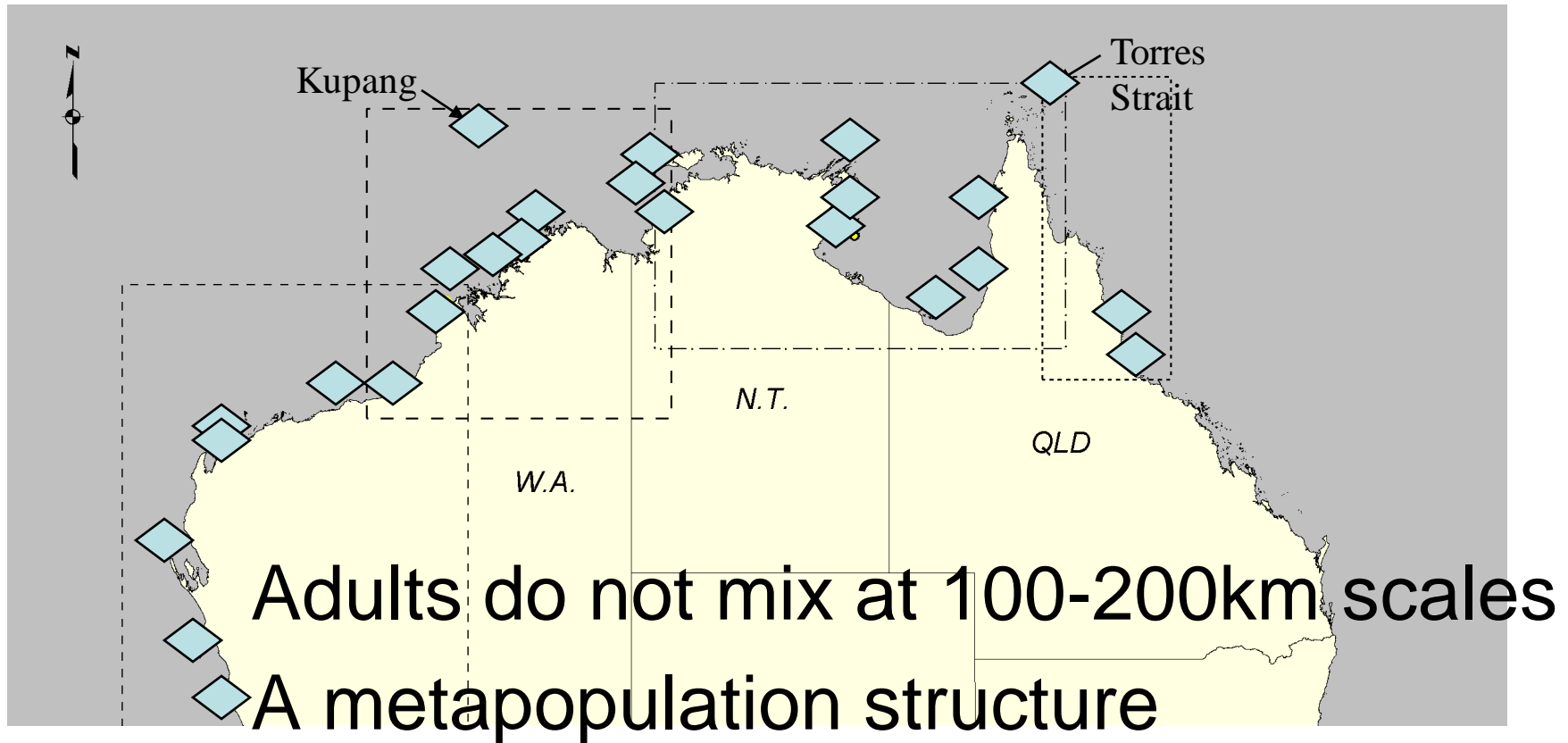
- Should Australian fisheries be allowed to grow , or be curtailed?
- Monitoring information– all types are problematic:
 - Surveys (trawl, gillnet, aerial) – large, fast swimming fish, shoaling around reefs, many similar species - \$\$
 - Age structure - spatial effects -\$\$
 - Catch rates (logs, observer) - not very informative, but CHEAP
 - Mark-recapture – individual capture (logistics), fragile, cannibalistic, sharks, \$\$

A Control, An Opportunity: Combined genetic - conventional tagging

- Experimental Control – to guard against the conclusion of a very low F if there were no Genetag recaptures
- Gene/conventional-tagged fish could give information on post-release survival and tag shedding – as well as add information on fishing and movement rates
- Recreational tagging could contribute real value in this way



Complex spatial dynamics of Spanish mackerel



(Newman *et al.* 2007.)

- Fish are individually handled, a relatively small number of large fish are landed
- A small but supportive industry
- An almost mono-specific fishery - other species usually < 5%
- Informative monitoring system needed!
- Enthusiastic recreational fishery that is mostly spatially separate



Example trips

Trip	Days Fished	Landed	Tips/Lures	Fins/Sampled	Recaps: Lure-Lure	Lure- Fin
404	10	551	78/91	110/189	1	2
407	11	1028	28/56	416/520	0	3

- Poor performance of lures vs baited lines (We had 2/6 lines in trip 404 but just 17% of the strikes)
- Variable success (amplification) with struck lures (87% and 50%), and retrieval of fin information (58% and 80%)
- More recaptures among incomplete genotypes?

What is the impact of fishing?

$$\text{Catch} = \text{Optimum fishing rate } (F_{opt}) \\ \times \\ \text{Biomass } (B_t)$$

- Theoretically near-optimum - tracks environmental change
- 2 obvious approaches to monitoring and management:
 - measure and control B - *catch controls*
 - measure and control F - *effort controls, direct controls*