Drivers of on-the-water recreational fishing site choice in New South Wales, Australia

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Abstract: To effectively manage recreational fisheries, managers require an understanding of the drivers of recreational fisher behaviour. In this preliminary study, we explore drivers of recreational fishing site choice in New South Wales (NSW), Australia. In contrast to previous site choice studies, we investigate whether cues of fishing quality (e.g., depth and rugosity), as opposed to catch expectations can be used to explain site choices. We find that recreational fishers in NSW were more likely to visit sites with lower travel cost, greater water depths, and with fish aggregation devices (FADs). Unsurprisingly, the effect of FADs was particularly pronounced on trips targeting pelagic species. This working paper provides some preliminary evidence that cues of fishing quality could be used to explain site choices, but further research is needed particularly involving higher resolution data on habitats that are likely to be important site quality cues.

Key words: recreational fisheries, random utility model, travel cost, non-market valuation, site-choice model

JEL classifications: N/A

Research categories: Environmental Economics and Policy

Introduction:

Recreational fishers are key users of many coastal marine environments, as a groupoftenoutnumbering and even out-catching adjacent commercial fishers (Coleman *et al.*, 2004; Cooke and Cowx, 2004; Arlinghaus, Tillner and Bork, 2015; Hyder *et al.*, 2018). Recreational fisheries also provide substantial social and economicbenefits, that include sizeable economic injections, as well as enjoyment and wellbeing benefits for fishers (Cisneros-Montemayor and Sumaila, 2010; Beardmore *et al.*, 2014; Griffiths *et al.*, 2017; Hyder *et al.*, 2018). Ensuring management is sustainable and optimises the social and economic benefits of recreation is key to ensuring the on-going delivery of these benefits.

It is increasingly being recognised that achieving sustainable and optimal management requires an understanding of behavioural dynamics of recreational fishers(Fenichel, Abbott and Huang, 2013; Hunt, Sutton and Arlinghaus, 2013). Recreational fisheries often involve large numbers of heterogenous and spatially dispersed fishers with high levels of flexibility in terms of fishing locations and target species (Hunt, Sutton and Arlinghaus, 2013). Designing simple, enforceable, and effective regulations in this context requires a thorough understanding of fisher behaviour.

Random utility models (RUMs) represent one of the most frequently used modelling techniques to understand recreational fisher behaviour (Fenichel, Abbott and Huang, 2013). These models involve evaluating how attributes of fishing sites explain observed site choices, providing insights into drivers of site choices, and a modeling framework to simulate fisher behaviour (Hunt *et al.*, 2019).

Recreational fishing is an extremely important past-time in NSW with a 2013/14 survey estimatingparticipation by almost 900 thousand people, taking nearly 3.2 million fishing trips annually(West *et al.*, 2015). In this working paper we present preliminary RUM results exploring site choices for marine recreational fishers across coastal New South Wales (NSW), Australia. We are not aware of any studies that have used RUMs to explore fishing site choices in NSW, though some studies have employed travel cost and contingent behaviour approaches (Gillespie, Collins and Bennett, 2017).

In this preliminary study we diverge from previous recreational fishing site choice studies by exploring models without expected catch as an explicit site variable. Instead, we explore whether non-catch factors, and proxies for catch (e.g. depth or the presence of Fish Aggregation Devices) can explain site choice decisions. This is motivated by the results of Farr and Stoeckl(2018) who show that fishers' cannot accurately predict their catch on a given trip. We hypothesise instead that fishers may be relying on cues of fishing quality (rather than catch expectations) to inform site choice decisions.

Methods:

Model formulation

In this study we use the RUMframework to understand drivers of marine boat-based recreational fishers in NSW. In the RUM framework, each fisher i, faced with the set of all possible fishing sites j, selects the site where they expect the highest utility U_{ij}. The utility function for a site is expressed as:

$$U_{ij} = \beta' x_{ij} + e_{ij} \qquad (1)$$

where $x_{ij}$is a vector of site attributes, β is the vector of coefficients, and $e_{ij}$is the error term. Assuming the errors are independent and identically distributed extreme values, the probability of the fisher choosing a specific site can be expressed using the conditional logit formula:

$$prob_{ij} = \frac{\exp(\beta' x_{ij})}{\sum_{j=1}^{J} \exp(\beta' x_{ij})} \qquad (2)$$

Using data on actual site choices, and attributes of all j available sites, equation 2 is used to estimate values for β, representing the importance of various site attributes to site choices.

Application

Site choice data was obtained through a 12-month phone diary survey conducted between June 2013 and July 2014 by the NSW Department of Primary Industries (West *et al.*, 2015). Survey participants were initially recruited through a regionally stratified White Pages random telephone screening survey across NSW and the Australian Capital Territory. This screening survey had a 75.5% response rate andwas completed by9,412 households.

Households with individuals of at least 5 years of age who indicated an intention to fish in the next 12 months were asked to take part in the 12-month phone diary survey (n=2,008). In total 1,681 households completed the full 12-month phone diary, with a response rate amongst eligible households of 83.7%. The 12-month phone diary survey involved respondents receiving regular phone calls (between weekly and monthly depending on fishing intentions) from trained survey staff, who recorded details of fishing trips taken. Trip details included target species, numbers of retained and released fish by speciesand the fishing site visited. Fishing sites were provided as point locations.

From this data set, trips were extracted that were conducted on a private boat, in marine (oceanic or estuarine) waters in which line fishing gears was used. This data subset included 583 households taking 2,285 fishing trips.

One issue with applying the RUM framework to this data is that information on whether the trip was multi or single day was not available. Given this, we focus on modelling on-the-water site choices from the boat ramp to the on-the-water fishing location. Details of the boat ramp used to launch the vessel were also not available from the data. As such, we have assumed that fishers' launch at the public boat ramp closest to their final on-the-water destination. This assumption is likely wrong in many cases and will likely upwardly bias the effect of travel cost on site choice. Nonetheless, the model is fit-for-purpose as a preliminary investigation into the drivers of site choices for NSW recreational fishers.

Discrete fishing sites for the RUM were defined using a 5 x 5 nautical mile grid, excluding land;coastal grids that intersected with land are smaller than offshore grids. Point locations of sites visited in the phone-diary survey were assigned to their containing grid. Alternative sites for each trip were defined as all grid cells within 100 km one-way distance from the assumed launching boat ramp. This resulted in an average of 276 available sites for each fishing trip.

A range of site attributes were investigated as potential drivers of on-the-water site choices. Travel cost was estimated as the round-trip distance multiplied by $0.54 per km which, represented the estimated fuel-based boat costs (Honda Marine, 2009; DMIRS, 2018). Boat depreciation costs and value of travel time were not incorporated into the travel cost.Excluding boat depreciation costs is justified given that periodic running of boat engines extends their life. Opportunity cost of travel time was not included as data on fisher income was not available. Appropriate treatment of travel time in recreational models is not resolved, and assumption of a zero travel time cost is not uncommon (Rolfe and Prayaga, 2007; Pascoe *et al.*, 2014; Lupi, Phaneuf and von Haefen, 2020).

Depth and rugosity of the site were extracted using standard Australian bathymetry with a 9 arcsecond resolution (~250m at the equator) (Whiteway, 2009). Rugosity was estimated using the Benthic Terrain Modeler in ArcGIS, applying a 900x900 m window for analysis (Walbridge *et al.*, 2018). Averages across each site were used for both depth and rugosity.

Weather data was extracted for the fishing trip from the Centre for Australian Weather and Climate Research (CAWCR) wave hindcast model (Smith *et al.*, 2020). The hindcast model provides wave height and wind speed for coastal Australia in 4-arcminute grid resolution (approximately 7.4 km at the equator). For simplicity, wave height (m) and wind speed (m/s) records were matched to fishing trips using monthly averages.

Sea surface temperature was extracted from satellite records from Advanced Very HighResolution Radiometer (AVHRR) sensors. 6-day averaged data was extracted from the at a resolution of 0.02x02° (approximately 2.2km at the equator)(IMOS, 2020). For simplicity data was matched to trips over one-month averaged periods. The gradient of the SST was estimated using the terrain function in the R statistical software and applying an 8-cell analysis window (Hijmans *et al.*, 2015).

Site area, presence of a fish aggregation device, and the presence of offshore islands in the site were also used as site variables

Three RUMs were used to describe drivers of on-the-water site choices for boat-based marine recreational fishers in NSW. Model 1 is a basic model focussing on commonly available site attributes: travel cost, depth, wave height and site area. Note that offshore distance and wind speed were omitted from this (and all models) due to strong correlations with depth ($r = 0.88$) and wave height ($r = 0.70$) respectively. Rugosity was omitted as it was found to have no effect on site choice. Model 2 includes additional site variables SST gradient, FAD and Island. Model 3 introduces interactions between site attributes and trip/fisher characteristics. Interactions were explored with dummy variables indicating an avid fisher (fished on 20+ occasions in the 12 months prior), a trip targeting a pelagic fish species, and a trip targeting demersal fish species Table 1.

Table 1. Site and trip/fishervariables used to explain on-the-water site choices for recreational fishers.

Variable	Description
Site attributes:	
Travel cost	Boat fuel cost for accessing site ($)
Offshore distance	Distance offshore of site from closest shoreline (km)
SST Gradient	Gradient of the SST surface based on values in the surrounding 8 cells
Depth	Average depth across the grid cell (m)
Rugosity	Average rugosity index across the grid cell
Wave height	Significant wave height (m)
Wind speed	Wind speed (m/s)
Area	Area of the site (km^2)
FAD	Fish Aggregation Device present at site
Island	Offshore island intersects with the site
Trip/fisher characteristics:	
Avid	Fisher reported fishing on more than 20 occasions in the 12 months prior to the main survey
Pelagic	Fisher was targeting a pelagic species on the trip
Demersal	Fisher was targeting a demersal species on the trip

Results:

As expected, all models show that fishers are less likely to visit sites with a higher travel cost, and more likely to visit shallow water sites, and larger sites(Table 2). Wave height had no significant effect on site choice, although this is likely due to moderate correlations with depth ($r = 0.49$) and area ($r = 0.41$).

Model 2revealed that the presence of a FAD at a site strongly increased the probability of visitation. The presence of an offshore island increased probability of a visit but was not significant at the 0.05 level. SST gradient was not a significant driver of site choice.

Model 3 suggested some heterogeneity in preference for FADs, with fishers on trips targeting pelagic species more likely to visit FADs than other fishers. Model 3 also provided some evidence that avid fishers are more likely to visit sites with a higher SST gradient that non-avid fishers, though the effect was not significant.

Table 2. Estimated random utility models of on-the-water site choices for the NSW marine boat-based recreational fishery.

	Model 1			Model 2			Model 3		
Variable	Coeff.	St. error	Signif.	Coeff.	St. error	Signif.	Coeff.	St. error	Signif.
Travel cost	-0.518	0.030	***	-0.541	0.028	***	-0.544	0.028	***
Depth	-0.004	0.000	***	-0.005	0.000	***	-0.005	0.000	***
Wave height	0.297	0.289		0.102	0.303		0.092	0.305	0.763
log(Area)	1.138	0.086	***	1.201	0.089	***	1.206	0.089	***
SST gradient				1137.384	1138.557		-54.452	1615.638	0.973
Fad				2.598	0.490	***	1.890	0.430	***
Island				0.326	0.191		0.307	0.189	0.106
Fad.pelagic							2.658	0.502	***
SST gradient.avid							2580.386	2259.480	0.253
LL	-2107			-2013			-1980		

*** p-value<0.001; ** p-value<0.01; * p-value<0.05

Discussion:

In this study we created a RUM of on-the-water site choices for recreational fishers in the NSW marine boat-basedrecreational fishery. In this preliminary investigation, we explore site choices without expected catch attributes usually used for site choice analysis (Hunt *et al.*, 2019). Instead, we employ cuesfor fishing quality like site depth and the presence of FADs which may drive catch expectations, particularly in the absence of experience with which to form such expectations.

We found some evidence that signals of catch expectations are useful in describing drivers of recreational fishing site choice. Fishers exhibited a preference for deeper water sites (all else equal). It is important to note that this preference is exhibited whilst controlling for travel cost which captures a desire for sites close to boat ramps and that depth and travel cost were moderately correlated in our model (r = 0.46) making it difficult to separate out their effects. Nevertheless, a preference for deeper water sites may be explained by the expectation that larger pelagic and demersal fish are present in deeper waters offNSW.

Models indicated that the presence of a FAD increased the likelihood of a site being visited, and the value of a fishing trip. Part worth estimates from Model 3 suggest that a FAD increases the value of a site by \$3.47 ± 0.76 per trip for non-pelagic fishers, and \$4.89 ± 0.96[1] for fishers who target pelagic species. Given that FADs are primarily associated with catching pelagic species, it is somewhat surprising that fishers' not explicitly targeting

[1] Partworths represent the monetary value of a one-unit change in a site variable, and are estimated by taking the negative of the site variable coefficient divided by the travel cost coefficient.

pelagic fish still exhibited a preference for sites with FADs. However, this may be due to a lack of target species information for 33% of trips.

The SST gradient had no significant effect on site choices. It was hypothesised that fishers, who have access to information on SST, may target SST fronts as these represent areas of mixing and potentially high primary productivity (Leathwick *et al.*, 2006; Druon, 2010). The lack of a significant effect may indicate that the majority of fishers are not using this information, or that our data is inadequate to capture the effect (e.g. too spatially or temporally coarse).

The RUMs presented here are intended to be a preliminary investigation into the drivers of recreational fishing site choices. Any model is a simplification of reality, and the models presented here are potentially especially so. Our models are missing critical information about the structure and habitat present at a site. A rugosity index was used to capture some habitat effect, but this was not significant likely because the rugosity index was estimated from coarse bathymetry data. Similarly, other drivers of expected fishing quality such as levels of water pollution andthe effects of localised depletion were not captured in our models.

Nevertheless, our study shows that at least some observable characteristics of sites, such as depth, distance from boat ramp, and the presence of FADs partly explain recreational fishing site choices in NSW. Further research is warranted to explore the relative performance of RUMs using cues of site quality versus catch expectations. Ideally this comparison should incorporate information on habitat cues (e.g. a more spatially resolved indicator of rugosity). Further research is also needed to explore the heterogeneity in fishing preferences across the fishers of NSW and particularly how preferences for site attributes change with different targeting modes (e.g. pelagic versus demersal).

The results presented here build on previous research on recreational fisher behaviour and perceived site quality. Deepening understanding of these human dimensions of recreational fisheries is necessary to better design management regulations to maintain fished population sustainabilityand optimise the social and economic benefits from recreational fishing.

References:

Arlinghaus, R., Tillner, R. and Bork, M. (2015) “Explaining participation rates in recreational fishing across industrialised countries,” *Fisheries management and ecology*, 22(1), pp. 45–55.

Beardmore, B. *et al.* (2014) “Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and the anglers,” *Canadian journal of fisheries and aquatic sciences. Journal canadien des sciences halieutiques et aquatiques*. NRC Research Press, 72(4), pp. 500–513.

Cisneros-Montemayor, A. M. and Sumaila, U. R. (2010) “A global estimate of benefits from ecosystem-based marine recreation: potential impacts and implications for management,” *Journal of Bioeconomics*, 12(3), pp. 245–268.

Coleman, F. C. *et al.* (2004) “The impact of United States recreational fisheries on marine fish populations,” *Science*, 305(5692), pp. 1958–1960.

Cooke, S. J. and Cowx, I. G. (2004) “The role of recreational fishing in global fish crises,” *Bioscience*, 54(9), pp. 857–859.

DMIRS (2018) *FuelWatch Historical Price Search*, *Fuel Watch*. Department of Mines, Industry Regulation and Safety. Available at: https://www.fuelwatch.wa.gov.au/fuelwatch/pages/public/historicalPriceSearch.jspx (Accessed: August 22, 2018).

Druon, J.-N. (2010) “Habitat mapping of the Atlantic bluefin tuna derived from satellite data: Its potential as a tool for the sustainable management of pelagic fisheries,” *Marine Policy*, 34(2), pp. 293–297.

Farr, M. and Stoeckl, N. (2018) “Overoptimism and the undervaluation of ecosystem services: A case-study of recreational fishing in Townsville, adjacent to the Great Barrier Reef,” *Ecosystem Services*, 31, pp. 433–444.

Fenichel, E. P., Abbott, J. K. and Huang, B. (2013) “Modelling angler behaviour as a part of the management system: synthesizing a multi-disciplinary literature,” *Fish and fisheries*, 14(2), pp. 137–157.

Gillespie, R., Collins, D. and Bennett, J. (2017) “Adapting the travel cost method to estimate changes in recreation benefits in the Hawkesbury–Nepean River,” *Australasian Journal of Environmental Management*, 24(4), pp. 375–391.

Griffiths, S. P. *et al.* (2017) “Quantifying subjective human dimensions of recreational fishing: does good health come to those who bait?,” *Fish and fisheries*, 18(1), pp. 171–184.

Hijmans, R. J. *et al.* (2015) “Package ‘raster,’” *R package*, 734. Available at: ftp://h64-50-233-100.mdsnwi.tisp.static.tds.net/pub/cran/web/packages/raster/raster.pdf.

Honda Marine (2009) *Fuel Consumption Reports*, *Honda Marine*. Available at: https://marine. honda.com. au/Fuel_Consumption_Reports (Accessed: August 22, 2018).

Hunt, L. M. *et al.* (2019) “Catch and Non-catch-related Determinants of Where Anglers Fish: A Review of Three Decades of Site Choice Research in Recreational Fisheries,” *Reviews in Fisheries Science & Aquaculture*, 27(3), pp. 261–286.

Hunt, L. M., Sutton, S. G. and Arlinghaus, R. (2013) “Illustrating the critical role of human dimensions research for understanding and managing recreational fisheries within a social-ecological system framework,” *Fisheries Management and Ecology*, 20, pp. 111–124.

Hyder, K. *et al.* (2018) “Recreational sea fishing in Europe in a global context-Participation rates, fishing effort, expenditure, and implications for monitoring and assessment,” *Fish and fisheries* , 19(2), pp. 225–243.

IMOS (2020) *IMOS - SRS - SST - L3S - Single Sensor - 6 day - day and night time - Australia*. Available at: https://catalogue-imos.aodn.org.au/geonetwork/srv/api/records/023ae12a-8c0c-4abc-997a-7884f9fec9cd (Accessed: 2020).

Leathwick, J. R. *et al.* (2006) “Variation in demersal fish species richness in the oceans surrounding New Zealand: an analysis using boosted regression trees,” *Marine ecology progress series*, 321, pp. 267–281.

Lupi, F., Phaneuf, D. J. and von Haefen, R. H. (2020) “Best practices for implementing recreation demand models,” *Review of Environmental Economics and Policy*, 14(2), pp. 302–323.

Pascoe, S. *et al.* (2014) “Economic value of recreational fishing in Moreton Bay and the potential impact of the marine park rezoning,” *Tourism Management*, 41, pp. 53–63.

Rolfe, J. and Prayaga, P. (2007) “Estimating values for recreational fishing at freshwater dams in Queensland,” *The Australian journal of agricultural and resource economics*, 51(2), pp. 157–174.

Smith, G. A. *et al.* (2020) “Global wave hindcast with Australian and Pacific Island Focus: From past to present,” *Geoscience data journal*. doi: 10.1002/gdj3.104.

Walbridge, S. *et al.* (2018) “Unified geomorphological analysis workflows with benthic terrain modeler,” *Geosciences Journal*, 8(3), p. 94.

West, L. D. *et al.* (2015) *Survey of Recreational Fishing in New South Wales and the ACT, 2013/14*. Fisheries Final Report Series No. 149. NSW Department of Primary Industries.

Whiteway, T. G. (2009) *Australian bathymetry and topography grid, June 2009. Geoscience Australia Record 2009/21*. Geoscience Australia Record 2009/21. Geoscience Australia.