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LETTER

Setting the Record Straight: Assessing the Reliability of Retrospective Accounts of Change

Ruth H. Thurstan, Sarah M. Buckley, Juan C. Ortiz, & John M. Pandolfi

School of Biological Sciences and ARC Centre of Excellence for Coral Reef Studies, The University of Queensland, St Lucia, Queensland 4072, Australia

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Correspondence
Ruth Thurstan, School of Biological Sciences, Gehrmann Building, The University of Queensland, St Lucia, Queensland 4072, Australia.
Tel: +61-450-586-263;
fax: +61-733-654-755.
E-mail: r.thurstan@uq.edu.au

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Abstract

Ecological degradation is accelerating, reducing our ability to detect and reverse declines. Resource user accounts have the potential to provide critical information on past change but their reliability can rarely be tested, hence they are often perceived as less valid than other forms of scientific data. We compared individual fishers' catch records, recorded 1-50 years ago, with their memories of past good, typical and poor catches for the corresponding time period. Good and poor catches were recalled with reasonable accuracy, matching variability in recorded catch with no significant change observed over time. Typical recalled catches were overestimated and became significantly more exaggerated over time, but were more comparable to mean than median recorded values. While accuracy of resource users' memory varied with the type of information recalled, our results suggest that carefully structured interview questions can produce reliable quantitative data to inform resource management, even after several decades have elapsed.

Introduction

Ecological degradation is widespread and escalating at an unprecedented rate (Myers & Patz 2009), yet the process of reversing degradation is often hampered by a lack of data on past ecological states. Monitoring programs are resource-intensive, costly to maintain, and are limited in their spatial and temporal coverage (Risk 1999). In contrast, observations from resource users can provide information on species and environments over longer periods and at different spatial scales to monitoring efforts. Perspectives from resource users thus provide an opportunity to improve our understanding of long-term change (Johannes *et al*. 2000; Chalmers & Fabricius 2007). Information commonly sought includes observations of local environmental change (Nichols *et al*. 2004), species reproductive events (Ames 2004; Aswani & Hamilton 2004), migratory or feeding patterns (Huntington 2000), and relative trends in species abundance over time (Mallory *et al*. 2003; Eddy *et al*. 2010). Quantitative estimates of change have also been elicited from resource users, particularly with regard to changes in catch or size of target species (Sáenz-Arroyo *et al*. 2005a; Lozano-Montes *et al*. 2008).

Interviews with different generations of resource users have highlighted the phenomenon of shifting environmental baselines, whereby each subsequent generation accepts the ecological conditions they observed at the beginning of their lifetime as natural. If ecological degradation occurs across several generations, these intergenerational changes in perspective can result in contemporary generations failing to appreciate the full extent of ecosystem change (Pauly 1995; Sáenz-Arroyo *et al*. 2005a). For example, Papworth *et al*. (2009) demonstrated a generational shift in environmental baselines by comparing respondents' perceptions of UK bird population trends with 20 years of survey data. They found that older respondents were able to name the most common bird species in the past with greater accuracy than younger respondents. However, while a number of studies have observed intergenerational differences in resource user accounts, thus inferring the existence of shifting baselines, comparable biological data are often lacking to empirically test this phenomenon (Papworth *et al.* 2009). Researchers often have to assume that retrospective accounts of abundance, as recounted by individuals across different generations, are equally reliable. Yet, a number of potential biases exist in individuals' memory that may contradict this assumption. For example, memory illusion, where recall is influenced by memories of extreme events, may exaggerate accounts of decline (Papworth *et al.* 2009; Daw 2010). In contrast, generational amnesia results in the shifting baseline syndrome described above, which masks the true extent of decline across generations. Personal amnesia is another potential form of bias, which occurs when individuals reinvent their past experiences within the context of more recent experiences, effectively forgetting how different past environments were (Papworth *et al.* 2009; Daw 2010).

These potential biases make it important to understand the levels of uncertainty surrounding estimates of change from resource users. Comparison with empirical data sets can help to validate retrospective accounts (Gilchrist *et al.* 2005; Jones *et al.* 2008). For example, Anadón *et al.* (2008) compared the distribution and abundance of reported contemporary sightings of tortoises (*Testudo graeca*) by local shepherds with standard ecological field-sampling protocols, and Daw *et al.* (2011) compared fishers' reported catch rates with community landings data and results from underwater visual census for the preceding 10 years. However, much of our understanding of long-term recall comes from medical or cognitive psychology disciplines (Collins *et al.* 1985; Bradburn *et al.* 1987). In the natural sciences, retrospective accounts are traditionally labeled as anecdotal and perceived to be less valid than other forms of data (Johannes *et al.* 2000; Sáenz-Arroyo *et al.* 2005b). Hence, while empirical validation is lacking, hurdles to the incorporation of these data into science and management frameworks will remain. To address this issue, we interviewed fishers who held long-term catch records and compared these to their memories of past catches. Two questions were considered; how accurately do retrospective accounts reflect catch records, and does this accuracy alter with time? By comparing fisher's accounts with their individual catch records, we were able to quantitatively examine for the first time both the magnitude of recall bias, and the rate at which this alters with time.

Methods

Sampling strategy

We conducted interviews with fishers based along the east coast of Queensland, Australia, a total distance of more than 1,500 km. We used snowball sampling, a technique where additional contacts are generated via interviewee referral, alongside other methods to identify active and retired fishers to question them about their memories of change in eastern Australian fisheries. Snowball sampling enabled us to focus our search efforts on long-term fishers, and include "hidden" members of the population such as retired and recreational fishers (Faugier & Sargeant 1997). We attempted to minimize the over- or underrepresentation of particular subgroups by initiating discrete chains of contact through tackle shop owners, fishers' representatives, fishery managers, and fish buyers. Active fishers were also identified via commercial license holder listings, online forums, and charter businesses. Searches of a region ceased when few or no new names were obtained from our contacts (Huntington 2000). At the end of interviews, we identified suitable candidates for this study by asking if they had kept records of past catches and if they would be willing to supply these to the researchers. This ensured that fishers' were unable to consult logbook records prior to questioning. Interviews took place in person between January 2012 and January 2014 and all fishers were interviewed individually. Where further clarification or completion of an interview required, we conducted follow-up interviews either in person or by phone.

Interview structure

Studies from cognitive and experimental psychology have found that participants frequently have trouble recalling either the timing or particular details of an event, but that recall can improve if provided with appropriate prompts or cues (Jobe & Mingay 1989; Berney & Blane 1997). Hence, our initial questions focused upon each fisher's personal fishing history, for example, what age they began fishing, what species they targeted, how their locations fished had altered, and what year they upgraded particular technology or vessels. We also asked fishers' which management measures had affected their fishing activities the most and what year these occurred. This initial information enabled us to construct a timeline for each individual fisher with cues that could be used to help prompt the fisher to recall catches from a particular period (Table S1).

The next part of the interview focused upon catches. We asked fishers to recall good, typical, and poor daily catches (numbers or kilograms of fish caught per day using the same gear) for their primary target species during the past year or, if retired, the period when they last fished (Daw *et al.* 2011). We then asked fishers about catches for the period when they first began fishing and additional periods, using the cues they had provided during the survey (Table S1).

Logbook records

While some fishers keep personal catch records, all Queensland commercial fishers are obliged by law to submit records of catch to the state fisheries department on a daily basis. Records were not pursued if the fisher was not the license holder or if they stated that their records did not reflect actual catches. Out of approximately 250 fisher interviews, 74 fishers were willing and able to provide catch records that corresponded to periods of time for which they were able to recall past catches. We digitized and extracted logbook records (numbers or kilograms of fish caught per day) for each period an individual was able to recall catch rates.

Data analysis

For each fisher, we compared the recalled catch rate with their corresponding logbook records. Where fishers used different units to those in their logbook records, they were asked to provide conversion rates to enable comparisons. For the years prior to 2011, we bounded catch records into 3-year bins to account for inaccuracies in interviewees' recall of the timing of events. Fishers targeted different species with many switching target species throughout their career. Thus, to eliminate scaling issues and to facilitate comparisons between fisheries, we compared fishers' recalled catches to their logbook records in two ways: (1) we calculated the percentage difference between recalled typical catch and mean and median recorded catch values for the corresponding 3-year period (Daw *et al.* 2011) and (2) we ranked all catch records for the corresponding 3-year period and normalized these values using the Box-Cox transformation (Box & Cox 1964). We then assigned each fisher's recalled catches a percentile rank (0-100%) according to the percentage of catch records that were lower than the fisher's recalled catch.

We used two general linear mixed models to test if time affected fishers' perception of good and poor catches. The percentile rank of the fishers' recollected catch in relation to their recorded catch was included as the response variable. Fisher identity was included as an unreplicated random factor (to account for the lack of independence between observations when fishers' provided data for more than one period of time), with year as a continuous predictor (covariate).

To test if fishers' recollections of typical catches were affected by time, and if their recollection better matched median or mean recorded catch, a general linear mixed model was again used. The relative difference between fishers' recalled and recorded data was included as the response variable. Two measures of central tendency (mean and median) were included as a fixed factor. Fisher identity was included as an unreplicated random factor, with year as a continuous predictor (covariate). Significance was tested using a permutational approach (PERMANOVA).

Where zero catch entries were provided, these were included in our analyses. Using logbooks that explicitly provided zero catches, we conducted an additional test to determine how much the accuracy of fishers' recall altered with and without zero catch values included. Paired *t*-tests determined whether the presence/absence of zeros significantly altered the accuracy of individual fishers' recall.

Results

Data collection

Logbooks were gathered from 62 commercial, 10 charter, and 2 recreational fishers. Seventy-four percent of fishers fished with lines, predominately targeting Spanish mackerel (*Scomberomorus commerson*), coral trout (*Plectropomus leopardus*), and snapper (*Pagrus auratus*). Eighteen percent of fishers used net and predominately targeted mullet (*Mugil cephalus*), while 8% of fishers used trawl gear to target benthic invertebrates (mostly banana *Penaeus merguiensis* and tiger prawns *P. esculentus*). Twenty-one fishers provided personal logbooks, while 53 logbooks were accessed from the Queensland Fisheries Department with the permission of the individual fisher. The earliest individual records held by the Queensland Fisheries Department date from 1988, while personal logbooks recorded catches as early as 1964. The number of continuous years that catches were recorded ranged between 3 and 40 years, with a mean value of 16.8 (standard error = 2.9) years. Sixty-seven fishers provided retrospective data for two time periods that corresponded with their logbook records, while 7 fishers provided just one. In total, we collected 423 recalled data points across 141 individual catch distributions.

Quantifying the reliability of retrospective accounts

Fishers' recall of good, typical, and poor catches reflected the distribution of their catch records. Fishers' recollections of good catches fell within the 89th percentile rank of their recorded catch distribution (95% confidence interval = 87.6–92.0, Figure 1a), meaning that the "good" catch they recalled was greater than 89% of their catch records for that same period. Recalled typical catches fell within the 65th percentile rank of their recorded catch (95% confidence interval = 61.9–68.8; Figure 1b),

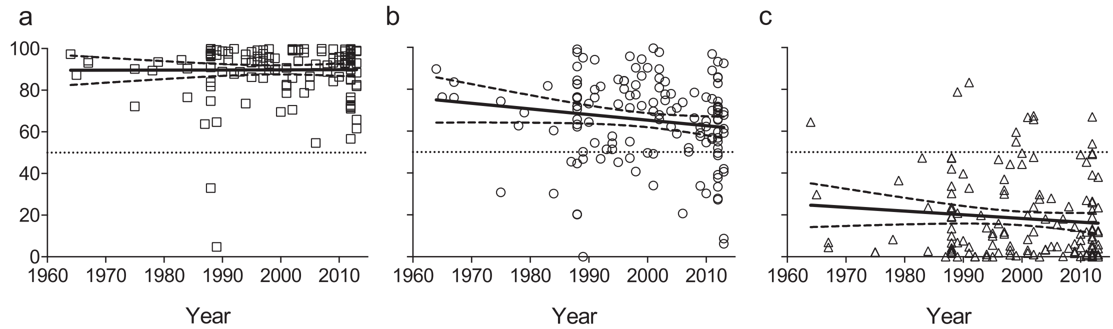

Figure 1 Fishers' recollections of (a) good, (b) typical, and (c) poor catch compared to their individual logbook records. Recorded catch distributions are plotted as percentiles and fishers' recalled catches are assigned a percentile rank according to where their recalled catch fell within their catch distribution. Regression lines (solid line) and 95% confidence intervals (long dashed line) are shown. The short dashed line indicates the 50^{th} percentile of catch records.

while fishers' recollections of poor catches fell within the 18^{th} percentile rank of their recorded catch distribution (95% confidence interval = 15.2–21.7; Figure 1c). Thus, fishers' recollections of good and poor catches fell within the upper and lower quartiles of their catch records, respectively.

Fishers' recall of typical catch more closely reflected mean than median logbook values, with significant differences displayed between the two measures of central tendency (mixed model analysis, pseudo-F = 8.060, $P = 0.002$; Table 1). For catches recalled within the past year, fishers' recall was 10.8% (95% confidence interval = −2.7–24.3%) higher than mean recorded values (Figure 2a), and 35.7% (95% confidence interval = 16.4–55.0%) higher than median recorded values (Figure 2b). Recalled typical catches also showed a significant decline in accuracy with time (mixed model analysis, pseudo-F = 4.535, $P = 0.032$; Table 1). Compared to mean catch values, fishers' recall became more exaggerated as time passed, increasing at a rate of 0.65% per year elapsed between the event and timing of recall. When compared to median catch values, this rate of change increased to 1.31% per year. In contrast to typical catch, no significant trend with time was observed for recalled good (pseudo-F = 0.036, $P = 0.860$) or poor (pseudo-F = 2.360, $P = 0.147$) catches (mixed model analysis, Table 1).

Table 1 Permutation mixed model results of fishers' recalled catch compared to their individual logbook records

	df	SS	MS	Pseudo-F	P(perm)
Typical recalled catch					
Year	1	11.23	11.23	4.535	0.032*
Fisher	66	202.63	13.07	1.380	0.006*
Central tendency	1	17.94	17.94	8.060	0.002*
Year* central tendency	1	3.39	3.39	1.525	0.191
Residual	198	440.61	2.23		
Total	267	675.8			
Good recalled catch					
Year	1	6.10	6.10	0.036	0.860
Fisher	66	14,809	224.37	1.563	0.039*
Residual	65	9,331	143.55		
Total	132	24,146			
Poor recalled catch					
Year	1	771.42	771.42	2.360	0.147
Fisher	66	33,552	508.36	2.075	0.006*
Residual	65	15,926	245.02		
Total	132	50,249			

Central tendency refers to the accuracy of recalled typical catch when tested against median and mean recorded catch values.
*denotes a significant value ($P < 0.05$).

Effect of zero catch records

Sixteen logbooks explicitly recorded zero catch and thus could be used to test what effect including/excluding zero catch records had on the accuracy of fishers' recall. On average, the inclusion of zero catch records reduced fishers' recall accuracy, inflating estimates by a further 12% for both mean and median recorded catches, a significant increase (paired t-test = 2.680 and 3.259, $P = 0.017$ and 0.005, respectively).

Discussion

A lack of data on past species abundance increases the risk that resource managers and scientists will make erroneous assumptions about the status of a resource (Bonebrake *et al*. 2010; McClenachan *et al*. 2012). Many conservation and research programs rely upon resource

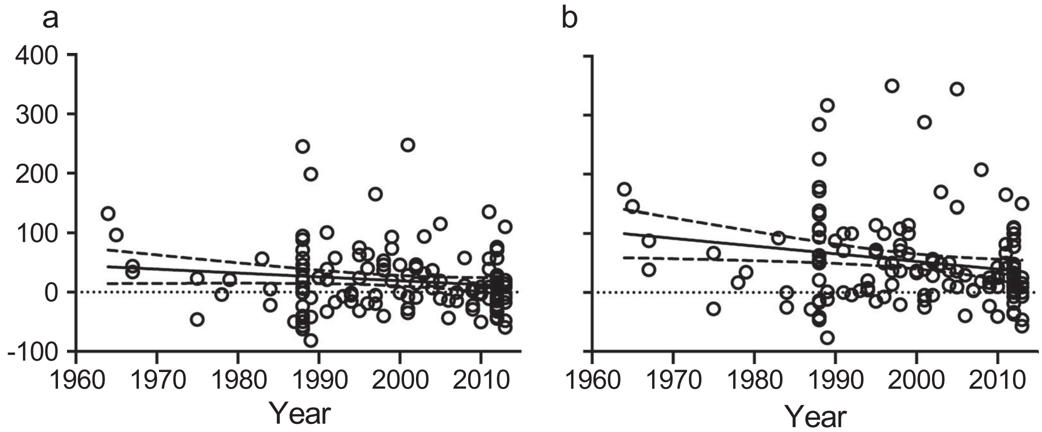

Figure 2 Percentage difference between fishers' recalled typical catch and their corresponding (a) mean and (b) median recorded catch for the same period. Regression lines (solid line) and 95% confidence intervals (long dashed line) are shown. The short dashed line highlights zero percent, where fishers' recall of past catches shows no difference to their logbook records. Values that lie above this line occur when fishers overestimate their typical catch, while values that lie below this line occur when fishers underestimate their catch.

users for information on long-term trends (Johannes *et al*. 2000). However, it is acknowledged that various biases exist in retrospective data (Papworth *et al*. 2009) and the perceived lack of reliability of resource user observations remains a major hurdle in its successful integration into management (Soto 2006).

To our knowledge, our study is the first time that the magnitude and rate of change in recall bias of resource users has been quantified across multiple decades. We found that fishers' recall of good and poor catches reflected their recorded values, consistently falling within the upper and lower quartiles of their logbook records, respectively. Recalled good and poor catches were not significantly affected by time, hence fishers' recall remained reliable even after several decades had elapsed (Figure 1, Table 1). In contrast, typical recalled catches were generally overestimated and fishers' accuracy of recall significantly declined as time passed, although the rate of change was relatively slow and appeared linear over time. Fishers' overestimation of typical catch suggests that their recall of intermediate values is significantly influenced by memories of high catches, an influence that increases as time elapses. These findings suggest that questions about good or poor catches will elicit less biased, more reliable recollections over long periods of time compared to intermediate values.

While recalled typical catches exhibited significant declines in accuracy with time, fishers' recalled values were more closely aligned to mean recorded values than median (Figure 2), a pattern that remained consistent over time. This can be explained by the distribution of fishers' recorded catch data, which tended to be strongly right-skewed (a common characteristic of fisheries landings data), resulting in mean values that were higher than median values. This finding has important implications for anyone wishing to reconcile resource user observations with other data sources. In light of their specific biases, not only must resource user observations be carefully interpreted alongside other temporal data, but consideration must also be given to which measures (i.e., mean, median) are likely to provide the most useful comparisons between resource user observations and other data sources.

Fisheries agencies commonly use standardized catch rates as the primary indicator/basis of stock status. However, in many countries, regular collation of catch rate data is logistically infeasible because of a lack of resources. Hence, if the level of recall bias could be estimated for a fishery, fishers' retrospective catch rates could be gathered at relatively low cost, adjusted, and subsequently integrated into stock assessments. Alternatively, past catch rates could be used to assess trends over time, or as a benchmark to support the development of indicators for the recovery of depleted fish stocks, although the upward bias displayed in typical recalled catches would have to be treated with caution. The difference between good and poor recalled catches also demonstrates the range of catch rates that can be expected, which could potentially be adopted as upper and lower reference points. Accordingly, if catch rates began to fall outside of the reference region or exhibit increasing levels of fluctuation, a management response would be triggered. These applications could be similarly applied to assessing wider resource management trends (species abundance or habitat density/areal coverage, for example).

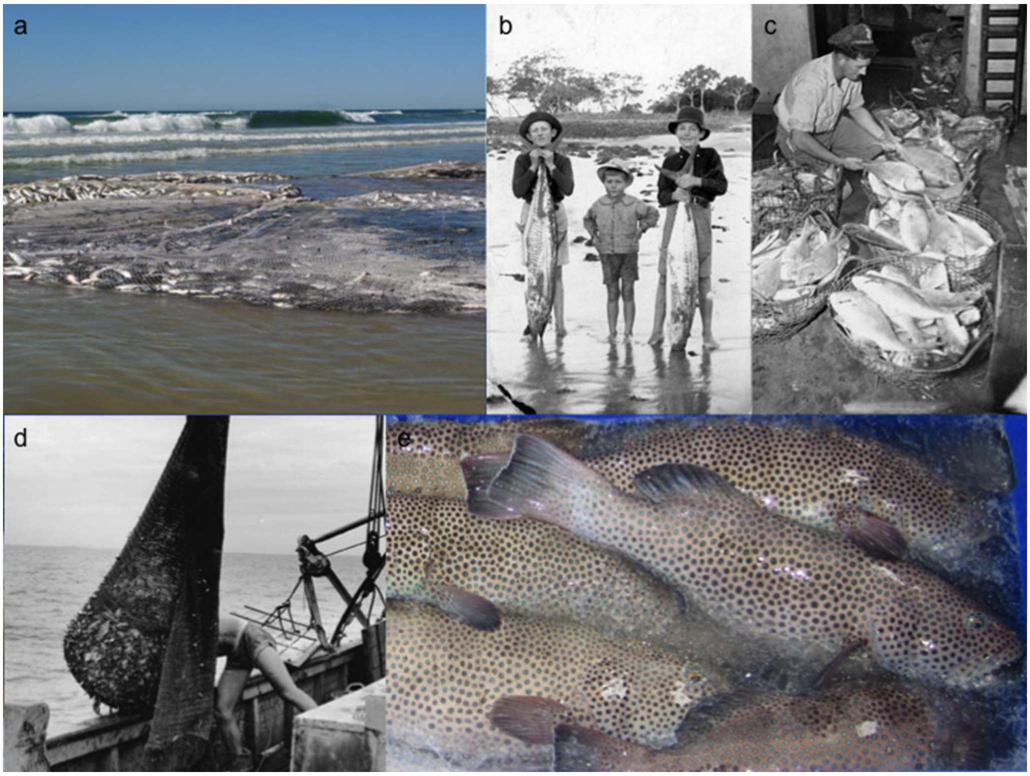

Figure 3 Species targeted by interviewees (a) mullet (*Mugil cephalus*) catch, 2012, (b) mackerel (*Scomberomorus* sp.), ca. 1935, (c) snapper (*Pagrus auratus*), 1957, (d) prawn (*Penaeus* sp.) trawl haul, 1955, and (e) coral trout (*Plectropomus areolatus*), 2012. Image credits for 3b courtesy of Sunshine Coast Libraries, 3c courtesy of National Archives of Australia (item number A1200, L24364), and 3d courtesy of Queensland State Archives (digital image ID 11986).

In our study, we used the terms "good," "typical," and "poor" when interviewing resource users. These were terms that resource users related to and felt able to answer, but they are also inherently subjective (an issue tackled by Bertrand & Mullainathan 2001 and Ainsworth *et al*. 2008). This subjectivity, coupled with recall bias, may contribute to the high levels of variance in our data (for example, some fishers' reported "poor" catches corresponded with their minimum recorded catch, while other reported "poor" catches fell above the 50th percentile of catch records). This suggests that in order to combat high levels of variability and to successfully detect environmental trends from retrospective observations, large sample sizes are required. As large sample sizes are not always possible, an alternative approach would be to provide more detailed instructions to interviewees prior to the interview, for example, a "good" catch equates to the top 10% of catch, a "poor" catch equates to the bottom 10% of catch. Such an approach could help to reduce variability between fishers and thus increase confidence in the data. Increased confidence in the data could also be achieved by reinterviewing a sample of the original respondents to assess the consistency of responses from interview to interview (Flick 2006). However, when interviews rely upon engaging the memory of a respondent, follow-up interviews must also take care to engage the interviewee to the same extent as the initial interview (for example, taking the time to reconstruct the temporal cues that prompt recall of an event) if viable comparisons are to be made. In cases where we conducted follow-up interviews ($n = 20$), we did not detect inconsistencies in responses to questions asked a second time.

Another consideration is the possibility that fishers' will endeavor to provide what they perceive to be socially desirable answers about their past catches, thus biasing their response (Fisher 1993). This may occur because of concerns about how peers will perceive their response, or how scientists will use the resulting data. We attempted to mitigate this bias by being clear about the objectives of the study and emphasizing that each respondent – and their raw data – would remain anonymous. We detected no social stigma by fishers against catching either small or large numbers of fish, indeed, fishers were usually keen to point out the range of variability in their catches. The willingness of interviewees to share their fishing history, including their logbook data, also provided us with reasonable confidence that such biases were minimal.

Zero catches are important in the calculation of catch rate, but are rarely accounted for in fisheries records (O'Donnell *et al*. 2012). Sixteen logbooks explicitly provided zero catches, enabling us to test how much of a difference the inclusion of zero catches made to the accuracy of fishers' recall. On average, the inclusion of zero catches further decreased the accuracy of fishers' recall of typical catch, with fishers overestimating past catch by a further 12% for both mean and median values. Although a small sample, this suggests that fishers' recall of typical catch could be more exaggerated than our estimates suggest, particularly if fishers' experience high quantities of zero catch days (in single-species fisheries, for example).

Historic data on past environments are sparse and retrospective accounts are often the only way to acknowledge the magnitude of ecological change; however, the opportunity to formally test their reliability is rare. By comparing past accounts to individual logbooks, we were able to calculate both the magnitude and rate of change in retrospective bias over time in eastern Australian fisheries (Figure 3). Our study shows that resource users do overestimate when questioned about intermediate values, and that these biases significantly increase as time passes. However, recall of high or low values are reliable and remain so even decades later. This research thus provides empirical evidence to support the existence of the shifting environmental baseline syndrome, a much reported but little tested phenomenon in the ecological literature (Papworth *et al*. 2009). That certain recollections are more prone to bias than others has important implications for researchers and managers who use retrospective accounts to gauge levels of ecological change, as interviews that incorporate less frequent events or high/low values are likely to present a more accurate picture of change. Acknowledging and quantifying these biases is an important step to encouraging their future adoption into management frameworks.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Table S1. Questions asked of fishers during interview.

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