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SHORT COMMUNICATION

Reporting by-catch and mortalities in targeted biological field surveys on fishes

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ABSTRACT

1. There is a paucity of information on the mortality of fishes and the capture and mortality of non-target by-catch organisms during scientific fish research surveys.

2. To investigate the extent of by-catch and reporting by biologists during fish surveys, a questionnaire survey of active field biologists in southern Africa was undertaken together with two case studies of field surveys from nine river systems in southern Africa.

3. The majority of researchers questioned record non-target organisms only occasionally (40%), and very few collect additional biological information (15%) with some not recording any information at all (20%). The vast majority of researchers do not, however, present or publish by-catch or mortality data despite this information having been collected. The case studies using fish field surveys show that while by-catch is often low, non-fish vertebrates (amphibians, reptiles and mammals) and invertebrates such as large crustaceans are often present. Fish surveys also resulted in unwanted mortality of both target and by-catch organisms.

4. It is proposed that reporting by-catch during field surveys of fishes can provide important information on distribution, abundance and population structures of certain non-target fauna and that in addition to by-catch considerations, indirect mortality associated with gear use should also be reported and recorded. Such information will aid in the assessment of risk of deploying certain gear types in certain environments.

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KEY WORDS: by-catch risk; field survey methods; fyke net; invertebrates; non-target species; vertebrates

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INTRODUCTION

The capture of non-target organisms is a major concern in freshwater environments (Raby *et al*., 2011; Larocque *et al*., 2012). By-catch from commercial fisheries has had devastating population-level impacts on non-target organisms such as the extinction of the Yangtze River dolphin *Lipotes vexillifer* (Raby *et al*., 2011). Commercial and recreational trap fisheries in particular result in high mortalities of obligate air breathing organisms such as freshwater turtles, diving birds, water rats (*Hydromys chrysogaster*) and platypuses (*Ornithorhynchus anatinus*) in Australia (*sensu* Grant *et al*., 2004). As such, much effort has been directed at reporting, quantifying and mitigating by-catch associated with commercial harvesting of selected species highlighting the importance of such considerations (Raby *et al*., 2011; Larocque *et al*., 2012).

Another concern, albeit not of the same magnitude, is the capture of non-target organisms or mortality of fishes with high conservation priority during scientific field surveys and experiments on fishes. Both active (e.g. electrofishing) and passive sampling gears (e.g. gillnets and fyke nets) commonly used during field surveys of fishes can result in variable levels of fish and unwanted by-catch mortality (Snyder, 2003; Barko *et al*., 2004; Ellender *et al*., 2012a, b). It has been documented that scientific sampling by electrofishing can lead to mortalities of some species of fish caught such as the Eastern Cape redfin *Pseudobarbus afer* in South Africa (Ellender *et al*., 2012a) and a wide variety of other fishes globally (see the comprehensive review by Snyder, 2003). Scientific sampling can lead to unintended mortalities of threatened fishes. For example, owing to the high mortality rates of delta smelt *Hypomesus transpacificus* from experimental trawl surveys in the San Francisco Estuary, California, alternative methods of undertaking population assessment, such as underwater video, are being investigated (Feyrer *et al*., 2013). Another example is the mortality of the majority of largemouth yellowfish *Labeorbarbus kimberleyensis* caught as by-catch during gillnet fishery surveys of South Africa's largest impoundment, Lake Gariep (Ellender *et al*., 2012b). By-catch organisms such as freshwater turtles have also been recorded when using fyke nets (Larocque *et al*., 2012), but the extent of unwanted mortality or the frequency of by-catch in scientific sampling is not always known or accurately documented. Addressing potential issues associated with the capture and mortality of non-target organisms starts with the reporting of such catches.

In order to assess the extent of by-catch during field surveys on fishes and the extent of reporting on by-catch and unwanted mortalities during these surveys this study comprised two components. First, a key informant questionnaire was sent to field biologists in southern Africa to investigate the extent of reporting by-catch during scientific field surveys targeting freshwater fishes. Second, field data from fyke net fish surveys of nine South African river systems were used as case studies highlighting the proportion of by-catch or unwanted mortality. The importance of reporting all catches and conservation implications of the surveys are discussed.

METHODS

Reporting by-catch during scientific field surveys

A questionnaire was sent to 24 fish biologists, ecologists or conservation practitioners who have published information from field surveys of fishes in southern Africa between 2005 and 2015. This list of researchers was exhaustive and acquired from a literature review between 2005 and 2015 (B. R. Ellender, unpublished data) and was therefore considered representative for the southern African region. Four questions were posed: 1. Do you record unintentional by-catch during fish directed surveys (e.g. crabs, terrapins/turtles, frogs, otters (yes, no, sometimes))? 2. Do you record additional information (e.g. dead/alive, length (yes, no, sometimes))? 3. Do you include any of this information in your reports or manuscripts (if yes, please supply reference)? 4. If no, do you publish data sets on by-catch at all (supplementary material, etc., if yes, please supply example)?

Field surveys

Two case studies were used to highlight the proportion and issues of fyke net by-catch associated with field surveys targeting fishes in South Africa. The first case study concerns data from 931 fyke net sets during directed sampling for eels (*Anguilla* spp.) from nine river systems in South Africa (2008–2012). The second case study reports data collected during fish community surveys of two river systems, the Kariega (January-March 2015) and Keiskamma rivers (November 2010), in the Eastern Cape, South Africa (Table 1). Field sampling was undertaken using double-ended fyke nets (14 m long, 80 cm deep, valve length 3 m with 12 mm mesh size on the cod-end, fitted with otter guards with an aperture size of 60 × 70 mm). Fyke nets were laid in the afternoon (15:00–17:00), left overnight and retrieved the following morning (08:00–10:00). After retrieval the catch was identified, measured and counted.

RESULTS

Reporting by-catch during scientific field surveys

In total, 20 researchers responded to the questionnaire (83.3% response rate), representing the majority of research practitioners conducting fish surveys in the southern African region. Respondents generally indicated that the recording of by-catch during scientific surveys targeting fishes was low (yes = 40%; no = 20%; sometimes = 40%). Additional information on by-catch is recorded on an ad hoc basis (yes = 15%; no = 50%; sometimes = 35%) and not always included in reports or published (yes = 15%; no = 60%; sometimes = 25%) or provided as supplementary information in manuscripts (yes = 15%; no = 85%; sometimes = 0%). Only three respondents indicated that if they had by-catch it was sent to scientists in the relevant field.

Table 1. Location, habitat type and sampling effort of fyke net surveys of the Kariega and Keiskamma River systems, Eastern Cape, South Africa

System/River	Habitat	Fyke net nights
Kariega		
Assegaai	River	9
Craig Doone	Impoundment	2
Rivendell Farm	Impoundment	8
Mosslands	Impoundment	12
Yarrow	Impoundment	7
Keiskamma		
Keiskamma	River	7
Tyume	River	5
Gxulu	River	2
Cata	Impoundment	16

Case study 1: Fyke net eel surveys

From 931 fyke net sets, 589 eels and 4944 specimens of non-target species were caught over a 5-year period (2008–2012, Table 2). The highly variable data indicate that recording of other biota occurs, but the data for some of the abundant but less charismatic biota such as African clawed frog *Xenopus laevis* show that these biota are reported on an ad hoc rather than routine basis.

Case study 2: Fish community field surveys

In the Kariega River system three non-target organisms were caught – African helmeted turtle *Pelomedusa subrufa* (Frequency of Occurrence (FO) = 5.3%; Relative Abundance (RA) = 0.1 ± 0.4 per net night), *X. laevis* (FO = 34.2%; RA = 1.0 ± 1.8 per net night), and Cape river crab *Potamonautes perlatus* (FO = 57.9%; RA = 1.2 ± 1.9 per net night). A broad range of size classes of *X. laevis* (range: 5–190 mm; tip of snout to cloaca) and *P. perlatus* (range: 15–90 mm; carapace width) were captured; however, a narrow size range of *P. subrufa* (range: 110–140 mm; shell length) were captured (Figure 1). Damaged fish were recorded from 10% of fyke nets which resulted in mortality of a largemouth bass *Micropterus salmoides* (mortality rate (number killed/number caught) = 11.1%), two moggel *Labeo umbratus* (mortality rate = 16.6%) and one banded tilapia *Tilapia sparrmanii* (mortality rate = 0.38%) (where otters chewed the fish in the cod-end of the net).

Two non-target species – *X. laevis* (FO = 53.3%; RA = 3.3 ± 4.8 per net night) and *P. perlatus* (FO = 26.6%; RA = 0.7 ± 1.6 per net night) were recorded in the Keiskamma River system. In addition, otter-damaged fyke nets were recorded in 23.3% of gillnet sets which resulted in the mortality of 14 Eastern Cape rocky *Sandelia bainsii* (mortality rate = 51.8%).

Table 2. By-catch recorded during fyke net surveys of eel (*Anguilla* spp.) in nine South African river systems

Year	2008	2009	2010	2011	2012	Total
Fyke net sets	177	206	61	177	310	931
Giant mottled eel *Anguilla marmorata*	29	23	4	40	40	136
Longfin eel *Anguilla mossambica*	172	146	43	76	31	468
Other fish	536	2627	86	842	433	4524
African clawed frog *Xenopus laevis*	27	2	99	198	0	326
River crabs (*Potomonautes* spp.) and freshwater prawns (*Macrobrachium* sp.)	33	6	5	48	3	95
Brown watersnake *Lycodonomorphus rufulus*	1	0	0	0	0	1
Otter *Aonyx capensis*	2	1	0	1	0	4
African helmeted turtle *Pelomedusa subrufa*	0	0	0	3	0	0

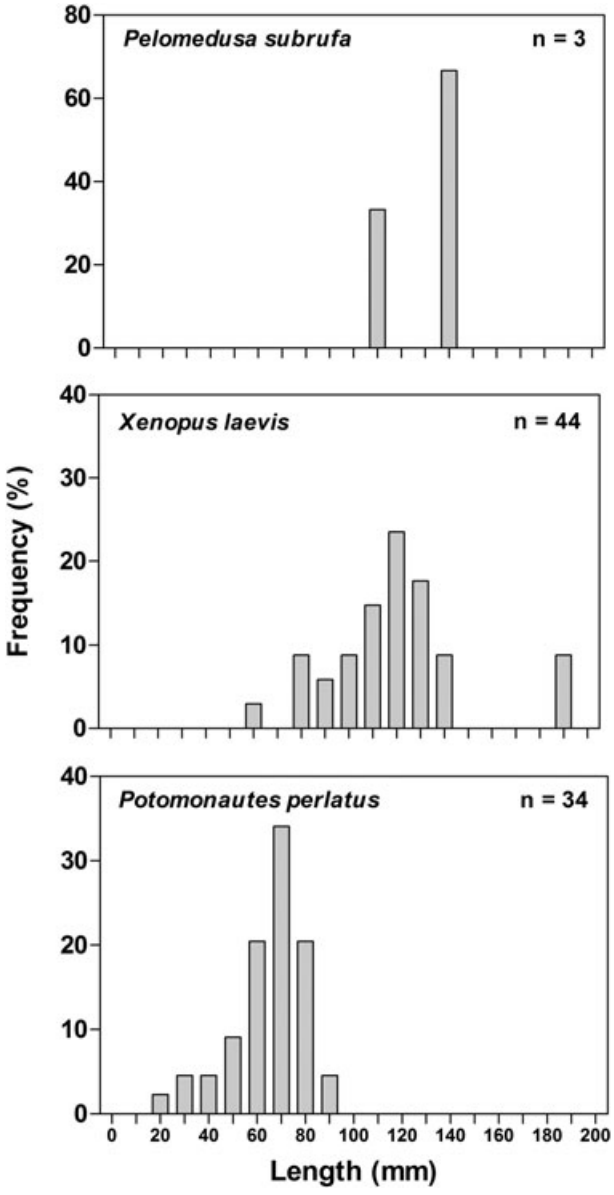

Figure 1. Length–frequency histograms for three by-catch species sampled using fyke nets in the Kariega River system, Eastern Cape, South Africa.

DISCUSSION

From the results of this study it is evident that while scientists are frequently capturing non-target organisms (as was illustrated by the extent of by-catch from the two field case studies and respondents' answers) these data are not being adequately recorded or used. This results in a loss of valuable information on distribution, size structure, abundance or biology that could contribute to a broader understanding of aquatic fauna both in southern Africa and globally. In addition, scientific surveys can cause unexpected mortality of non-target species through mastication by otters through the nets, such as recorded for *S. bainsii*, a range-restricted endemic fish that is IUCN red-listed as Endangered (Cambray, 2007).

The use of fyke nets in field surveys of South African river systems resulted in by-catch and unwanted mortalities, but these were species- and situation-specific. A major contributor to fish mortality during this study was chewing of fish by otters while caught in the fyke net cod-end. Mortality was situation- and species-specific with lower mortality of *M. salmoides*, *L. umbratus* and *T. sparrmanii* (<20% mortality rate) from the Kariega River system than of *S. bainsii* (>50% mortality rate) in the Keiskamma River system. These results are contrary to those of Booth and Potts (2006) who extensively sampled small reservoirs using fyke nets and released all target species (*L. umbratus*) alive. This suggests that otter damage may be the exception rather than the norm. Another source of mortality in fyke nets, which has been observed by the authors but not quantified, is predation in the cod-end of the fyke net. Three of the authors (BRE, OLFW, RJW) have

observed giant mottled eels *Anguilla marmorata* and longfin eels *Anguilla mossambica* gorge themselves on Eastern Cape redfins *P. afer* (IUCN red-listed as Endangered (Swartz and Impson, 2007)) while in the cod-end of the net.

Although the mortality rates of by-catch organisms were not quantified during field surveys, *X. laevis* mortality was observed, most likely as a result of suffocation due to an inability to breathe air while caught in the cod-end of the fyke nets. The mortality of air-breathing organisms is a relatively common occurrence when using passive fishing techniques such as fyke nets (Michaletz and Sullivan, 2002; Barko *et al*., 2004; Grant *et al*., 2004). Not only are obligate air-breathers affected but Michaletz and Sullivan (2002) found that placement of hoop nets in the hypolimnion which was low in oxygen resulted in mortality of channel catfish *Ictalurus punctatus.* Mortality of *I. punctatus* could be mitigated, however, by net placement in the epilimnion (Michaletz and Sullivan, 2002). To avoid unwanted mortality of non-target organisms the use of floats on the end of nets is typically advocated as this provides an opportunity for obligate air-breathing organisms to gain access to air (Bury, 2011; Larocque *et al*., 2012). This is not always possible as the depth of the sampled habitat may preclude the use of such devices.

It is important to note that although sampling may often have lethal endpoints, the information generated by well-designed field surveys is invaluable as the end result is empirical data on the ecology, biology and distribution of a species that may aid in its future conservation (Heupel and Simpfendorfer, 2010). The results of this study highlight three important considerations for field surveys. First, by reporting by-catch, important information on distribution, population structure or relative abundance can be made available to other researchers; second, by-catch is inevitable and every attempt should be made to reduce mortality; and third, other sources of mortality such as endangered fishes being killed by otters while in the net, or predation in the cod-end of fyke nets, can have unintended consequences on sampled populations. If such information is collected and readily reported, risk frameworks can be developed to assess the costs and benefits of using selected gear types within the context of expected by-catch and unintended mortality per region or habitat type. We therefore propose that governing, funding or permitting agencies should consider asking practitioners to record and report relevant peripheral information associated with field sampling.

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