Fisheries Research 107 (2011) 94–99

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Constructing indices to detect temporal trends in discarding

T.L. Catchpole[a,*], R. Enever[b], D.L. Maxwell[a], M.J. Armstrong[a], A. Reese[c], A.S. Revill[a]

[a] Cefas, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
[b] Natural England, Renslade House, Bonhay Road, Exeter, Devon EX4 3AW, UK
[c] Cefas, The Nothe, Barrack Road, Weymouth, Dorset DT4 8UB, UK

ARTICLE INFO

Article history:
Received 8 February 2010
Received in revised form 13 October 2010
Accepted 17 October 2010

Keywords:
Discard rate
Discards
England
Index
Wales
Indicator

ABSTRACT

Discards refer to the part of the catch not retained on board during commercial fishing operations, and returned to the sea. With numerous legislation, policies, and resolutions in place that seek to minimize or eliminate discards, performance indicators are required to measure progress towards this objective. Indices of discards were developed for the purpose of illustrating changes in overall discard patterns over time. A discard quantity index provides annual changes in total discard quantity, a discard rate index and discard proportion indices demonstrate how discarding behaviour during fishing operations changes with time. Knowledge of the consistency in the reporting of fishing effort and landings as well as in the sampling programme is important in identifying genuine trends. The indices examined show their potential as useful tools as indicators of changing discard patterns and were most powerful when used in combination. By utilizing data from the observer programme for England and Wales, a reduction of 61% between 2002 and 2008 in the weight of discards could be demonstrated. In this case study, the reduction in discard weight could be attributed to reducing levels of fishing effort and diminishing catch weights.

1. Introduction

Discards refer to the commercial and non-commercial organisms in the catch that are not retained on board during commercial fishing operations and instead are returned to the sea. Discarding of marine organisms is a widespread feature of commercial fishing operations (Alverson et al., 1994; Kelleher, 2005). Discard patterns are affected initially by catch compositions determined by environmental factors, the fishing gear used, and fisher behaviour. Ultimately fishers themselves decide which parts of the catch to retain and which to discard. Consequently, the extent and patterns of discarding is determined by a combination of regulations, environmental conditions, fisher's preferences and market forces. Moreover, the effect and relative importance of these factors will vary for different species, vessels, métiers and fleets and will fluctuate over time.

Numerous studies have provided valuable insights into the extent and composition of discarding in fisheries around the world (see Kelleher, 2005). The proportion of the total catch discarded is also reported for many fisheries, including for most in Europe (STECF, 2008). There is also information on how the discarding of specific species has changed over time. For example, the discard patterns of two fish species in the Australian Reef Line fishery were attributed to changes in landing restrictions (Welch et al., 2008). Many stock assessments also include discard estimates for individual species, for example plaice (*Pleuronectes platessa*) in the North Sea (Dickey-Collas et al., 2007).

These studies provide either a summary of overall discard patterns or show how discard levels for specific species change over time, however, there are few examples of how overall discard patterns change over time. Two studies that estimated global discard quantities (Alverson et al., 1994; Kelleher, 2005) and conducted 10 years apart suggest that discarding had reduced by 60–84%. However, because the methods differed, the estimates are not directly comparable (Hall and Mainprize, 2005; Davies et al., 2009), and there were no estimates in the intervening period.

There are clearly defined objectives to reduce discards at national and international levels (e.g. EU legislation, the Bergen Declaration, OSPAR biodiversity action plans, and UN General Assembly resolutions (UN, 2008)). These numerous policies and resolutions require performance indicators to measure progress towards the objective of minimizing discards. Here, we develop methods to generate indices of discards for the purpose of illustrating changes in overall discard patterns over time. The indices describe changes in overall discard levels and in the behaviour of fishers during commercial fishing operations. We utilize data from the observer programme for England and Wales, to evaluate these discard indices.

* Corresponding author. Tel.: +44 1502 527793; fax: +44 1502 527739.
E-mail address: thomas.catchpole@cefas.co.uk (T.L. Catchpole).

0165-7836/$ – see front matter.
doi:10.1016/j.fishres.2010.10.012

Table 1
Data used in the calculation of the discard indices.

Year	Gear	Trips sampled	Days sampled	Total fishing days	Mean discards per day (kg) and (s.d.)
2002	Beam trawl	16	69	17 627	942 (1 303)
	Otter trawl	31	77	26 394	338 (226)
	Nephrops trawl	5	7	4 047	1 260 (207)
	Netter	3	11	5 880	301 (113)
2003	Beam trawl	22	139	17 957	768 (532)
	Otter trawl	50	106	23 949	292 (302)
	Nephrops trawl	17	40	4 726	556 (709)
	Netter	7	23	5 669	159 (216)
2004	Beam trawl	36	168	16 549	726 (569)
	Otter trawl	79	170	22 283	409 (453)
	Nephrops trawl	37	49	3 688	372 (295)
	Netter	13	28	5 556	144 (197)
2005	Beam trawl	18	94	15 052	776 (665)
	Otter trawl	55	99	19 445	424 (375)
	Nephrops trawl	22	33	3 971	202 (141)
	Netter	7	30	5 066	329 (660)
2006	Beam trawl	26	143	13 558	536 (406)
	Otter trawl	57	92	18 769	462 (420)
	Nephrops trawl	28	29	3 979	369 (364)
	Netter	7	30	4 079	129 (76)
2007	Beam trawl	33	140	13 337	509 (370)
	Otter trawl	108	171	18 602	399 (418)
	Nephrops trawl	43	57	3 196	276 (243)
	Netter	12	40	3 689	61 (71)
2008	Beam trawl	18	99	11 772	410 (502)
	Otter trawl	104	149	16 335	375 (297)
	Nephrops trawl	35	54	3 096	307 (251)
	Netter	7	22	3 002	64 (44)
	Total	896	2 169	311 273	418 (448)

2. Methods

The Cefas observer programme has monitored catch components of fishing vessels registered in England and Wales, since 2002. Scientific observers sample some 200 trips and 1200 hauls each year on English and Welsh vessels. The number of trips sampled represents 0.5–1% of the total fishing effort. The species, gear types, and areas sampled in the observer programme are determined by EU requirements (1639/2001 and 199/2008). Here the observer data are used in combination with measures of fishing effort and landings data from official EU logbooks completed by fishers.

3. Sampling

The participation by the skippers of commercial vessels in the observer programme is voluntary. Vessels are selected for sampling using a randomly generated list each quarter, and the allocation of sampling effort to métiers is stratified in proportion to the total effort exerted in the same quarter in the previous year. Potential sources of bias in selecting vessels include, restricted access to fishing vessels, either through availability, adverse weather, or refusal of access by skippers, and observers selecting boats by non-random methods. The proportion of sampled vessels that were from the quarterly random list was derived to indicate the randomness of the vessel-selection process.

The observer programme covers fleets within which many different fishing methods and mesh sizes are defined. The sampled trips were merged into four gear groups to reflect the design of the sampling programme for the period investigated (Table 1). These gear groups contribute 95% of discards (and landings) quantities (Enever et al., 2007, 2009).

Once at sea, the sampling scheme is a multistage process in which discards are estimated from a fraction of a haul, and typically >60% of hauls are sampled during a trip (Fig. 1c). All species are sampled; length measurements are taken from all fish species, commercial crustaceans, and cephalopods. Numbers-at-length are raised to haul, based on an estimated proportion of the total catch volume sampled, then to trip, and length–weight parameters (Enever et al., 2007, 2009) are applied to generate estimated weights. Here we present weight data because weights are more common in the language of fisheries managers and the objective of discard reduction. Numbers of fish can equally be used and it is acknowledged that using numbers could be more useful in examining ecosystem effects of discarding and could return different patterns.

The raising factors given to each species in the sampling procedure do offer a source of bias. When it is not possible to measure all fish, observers estimate the volume measured relative to the total. The raising factors for discards are generally larger than for the landings (Fig. 1a and b), because access to the discards tends to be more limited. There are currently no data to establish the precision in the estimations of how much of the total volume is sampled.

4. Raising to fleet level

The method used to raise trip raised discard weight to total discard weight was that recommended by ICES (2004, 2007). Total trip discard weights were raised using two effort metrics as auxiliary variables, the number of trips and number of days fished, (ratio estimator; see Borges et al., 2005, for formulae).

The data were raised across the four gear-groupings and across FAO Fishing Subareas 27.4 and 27.7 in the Northeast Atlantic (ICES Subarea IV and VII) in each year (2002–2008). The raising procedure was stratified by areas that broadly reflected the distribution of the fleet. Raising the data at this spatial scale meant that all exerted fishing effort could be accounted for without extrapolating across un-sampled métiers. This potential source of bias was considered minimized by having sampling effort proportional to fleet effort.

The method of reporting fishing activity differs between the under- and over-10 m vessels. For the period investigated there was no standardised method of reporting the activity and landings of under-10 m vessels. In the UK, only vessels with a registered length of $\geq$10 m are required to keep a logbook of operations. Without con-