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# Ecosystem relevance of variable jellyfish biomass in the Irish Sea between years, regions and water types

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ABSTRACT

Monitoring the abundance and distribution of taxa is essential to assess their contribution to ecosystem processes. For marine taxa that are difficult to study or have long been perceived of little ecological importance, quantitative information is often lacking. This is the case for jellyfish (medusae and other gelatinous plankton). In the present work, 4 years of scyphomedusae by-catch data from the 2007–2010 Irish Sea juvenile gadoid fish survey were analysed with three main objectives: (1) to provide quantitative and spatially-explicit species-specific biomass data, for a region known to have an increasing trend in jellyfish abundance; (2) to investigate whether year-to-year changes in catch-biomass are due to changes in the numbers or in the size of medusa (assessed as the mean mass per individual), and (3) to determine whether inter-annual variation patterns are consistent between species and water masses. Scyphomedusae were present in 97% of samples ($N = 306$). Their overall annual median catch-biomass ranged from 0.19 to 0.92 g $m^{-3}$ (or 8.6 to 42.4 g $m^{-2}$). *Aurelia aurita* and *Cyanea* spp. (*Cyanea lamarckii* and *Cyanea capillata*) made up 77.7% and 21.5% of the total catch-biomass respectively, but species contributions varied greatly between sub-regions and years. No consistent pattern was detected between the distribution and inter-annual variations of the two genera, and contrasting inter-annual patterns emerged when considering abundance either as biomass or as density. Significantly, *A. aurita* medusae were heavier in stratified than in mixed waters, which we hypothesize may be linked to differences in timing and yield of primary and secondary productions between water masses. These results show the vulnerability of time-series from bycatch datasets to phenological changes and highlight the importance of taking species- and population-specific distribution patterns into account when integrating jellyfish into ecosystem models.



## 1. Introduction

Scyphomedusae (Cnidaria, Schypozoa; hereafter referred to as “jellyfish”) are receiving increased recognition as key components of marine ecosystems (Hay, 2006; Doyle et al., 2014). For years now, their role as predators (mostly of crustacean and gelatinous zooplankton, but also ichthyoplankton) has been under scrutiny (Purcell, 1997; Purcell and Arai, 2001), and it is now thought that their competition for food with planktivorous fish, and their predation on fish eggs and larvae, can be driving forces in the emergence of alternative states in altered ecosystems (Richardson et al., 2009; Utne-Palm et al., 2010). Meanwhile, evidence has been accumulating that the nature and the outcome of jellyfish–fish interactions (i.e. whether positive or negative to fish populations)

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depend on which species and which ontogenetic stages are involved (Brodeur, 1998; Lynam and Brierley, 2006; Masuda, 2009). In addition to their potential impacts on fish populations, several studies have highlighted how scyphomedusae blooms can affect the lowest levels of pelagic food webs (Titelman et al., 2006; Tinta et al., 2010) down to nutrient and carbon cycling (Pitt et al., 2005; Condon et al., 2011). They also contribute to bentho-pelagic coupling processes (Billett et al., 2006; West et al., 2008; Yamamoto et al., 2008). However, quantifying the actual contribution of jellyfish to these various processes remains challenging because broad-scale quantitative abundance data are scarce. Such datasets are indeed a prerequisite for (1) establishing the spatial and temporal overlaps of medusae with other components of the ecosystem, and of (2) reliably including jellyfish in numerical models which would allow reasonable extrapolations of findings from laboratory or mesocosms experiments to ecosystem level (Pauly et al., 2009; Purcell, 2009; Ruzicka et al., 2012).

In the Irish Sea, the role of scyphomedusae is of primary interest as there has been an increasing trend in the mean overall jellyfish biomass in the western part of the region since at least 1994 (Lynam et al., 2011). The Irish Sea is a semi-enclosed sea between Ireland and Great Britain (Fig. 1). Based on its bathymetry, it can be subdivided into two regions. The region east of the Isle of Man is relatively shallow with depths less than 50 m, and is influenced by major estuarine inputs with the existence of a salinity front in Liverpool Bay (Dickson and Boelens, 1988). Conversely, the region west of the Isle of Man is characterised by a channel 100–150 m deep (running along a north–south axis), and which becomes

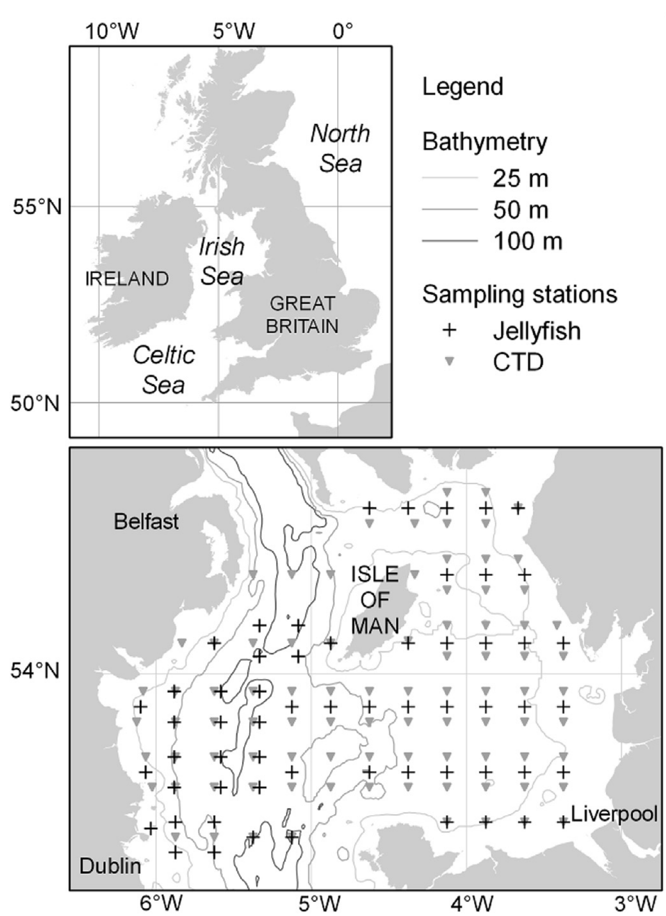


**Fig. 1.** Study site and sampling stations in the Irish Sea.

seasonally stratified during spring and summer (Simpson and Hunter, 1974), leading to the formation of a cyclonic near-surface gyre (western Irish Sea gyre) (Hill et al., 1996). The eastern and western regions therefore present contrasting environments, within which ecological processes (e.g. primary production, fish spawning) present contrasting dynamics. In particular, seasonal production differs between mixed and stratified regions (Gowen et al., 1995), spawning of several fish and crustaceans species (including commercially important ones) concentrates in specific spawning grounds (Fox et al., 2000; Armstrong et al., 2001; Heffernan et al., 2004), and fish larvae are not randomly distributed (Dickey-Collas et al., 1996; Bunn et al., 2004).

As regards to scyphomedusae, six different species can be found in the Irish Sea (*Aurelia aurita*, *Cyanea capillata*, *Cyanea lamarckii*, *Rhizostoma octopus*, *Chrysaora hysoscella*, and at times *Pelagia noctiluca* (Russell, 1970)), and previous analysis of stranding events around Ireland and Wales suggested that different species occur in different ecological regions within the Irish Sea (Houghton et al., 2007; Doyle et al., 2007). Developing knowledge of the spatial distribution of these species in Irish Sea waters is therefore necessary to establish and quantify the potential for competition with, and predation on, other species, and therefore better assess how the increasing trend in the overall jellyfish abundance (Lynam et al., 2011) may affect various ecological processes as shown by much jellyfish research conducted during the past decade. Aerial surveys have been used to describe discrete *Rhizostoma octopus* hotspots in coastal bays (Houghton et al., 2006a), while beach surveys and citizen science schemes have provided useful information on the seasonal occurrence of several species along the coastline (Houghton et al., 2007; Fleming et al., 2013; Pikesley et al., 2014). As regards to more offshore areas, surveys from ships of opportunity (Doyle et al., 2007) have confirmed the presence of *Aurelia aurita* and *Cyanea capillata* beyond immediate coastal waters and suggested that surface distribution patterns could be linked to variations of temperature and salinity (Bastian et al., 2011). However, quantitative information on the abundance and the distribution of these organisms in the main body of the Irish Sea are still missing.

The present work explores four years of quantitative spatially-explicit bycatch data of *Aurelia aurita* and *Cyanea* spp. in the Irish Sea with three specific objectives: (1) to provide the first species-specific quantitative estimates of jellyfish biomasses in the Irish Sea and a description of their distributions; (2) to examine whether inter-annual variations of biomass are consistent across the Irish Sea; and (3) to check whether these are linked to variations in number of individuals or of the size of the individuals. Beyond the specific case of the Irish Sea, these last two points should provide further elements on the importance of considering regional and local scales when studying jellyfish temporal dynamics (Dawson et al., 2014), as well as on the vulnerability of bycatch datasets to phenological changes.

## 2. Methods

### 2.1. Data collection

Between 2007 and 2010, scyphomedusae were caught as bycatch during the Agri-Food and Biosciences Institute (AFBI) of Northern Ireland annual Methot Isaacs Kidd-net Survey (NI-MIK), targeting juvenile gadoid fish, on board the *RV Corystes*. The survey follows a fixed station stratified design, taking place at the end of May and early June (during the period prior to settlement of pelagic juvenile gadoids) across the northern part of the Irish Sea (north of 53.25°N) (Fig. 1). Annually the western Irish Sea (i.e. west of 4.75°W) is sampled twice and the eastern Irish Sea once, but dates