How Deep-sea Jellyfish Impact Different Ecosystem Functions

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Introduction:

1. As Jellyfish evolve, they adapt and reach new environments that significantly impact the food web and nutrient cycling.
    - "Fossil evidence and evolutionary supposition indicate that cnidarians and ctenophores have existed for over 500 million years, during which time they have independently adapted to the major global climate cycles of warming and cooling and changes in oceanic and atmospheric conditions; in line with palaeoecological insights of long-term resilience for terrestrial species (Moritz & Agudo, 2013). A recent study has reported increases in regional and global populations of GZ over decadal time-scales (Brotz *et al*., 2012), although Condon *et al*. (2013) suggest that GZ blooms display predictable periodic or decadal fluctuations rather than a sustained monotonic increase" (Lucas 2014).

2. Little is known/studied in deep-sea environments due to technological limitations. Now as we progress, we can venture further down the water column to see different organisms interact and their impacts to ecosystem functions.
    - "Deep-sea trenches remain one of the least explored ocean ecosystems due to the unique challenges of sampling at great depths. Five submersible dives conducted using the *DEEPSEA CHALLENGER* submersible generated video of undisturbed deep-sea communities at bathyal (994 m), abyssal (3755 m), and hadal (8228 m) depths in the New Britain Trench, bathyal depths near the Ulithi atoll (1192 m), and hadal depths in the Mariana Trench Challenger Deep (10908 m)" (Gallo 2015).

3. How do deep-sea Jellyfish interact with its environment and impact ecosystem functions?
    - "Gelatinous animals are important components of the marine community typically associated with coastal and surface waters (Boero, 2013; Gibbons and Richardson, 2013) and noted for their effects on carbon cycling in the underlying, deeper, waters (Condon *et al.,* 2011; Sweetman and Chapman, 2011; Lebrato *et al.,* 2012). Cnidarian medusae (jellyfish), Ctenophora (comb jellies) and Appendicularia (larvaceans) are important components of the deep sea community below the euphotic zone (Herring, 2002; Haddock, 2004; Robison *et al.,* 2005). These taxonomic groups are often associated with deep pelagic environments with diverse and often cryptic speciation spanning the bathyal (200–3000 m) and abyssal (3000–6000 m) zones (Haddock and Case, 1999; Collins, 2002; Hopcroft, 2005; Matsumoto *et al.,* 2020)" (Jamieson 2021).

Main Body:

1. Evolution of jellyfish/finding new species at deeper depths. (how does this affect the ecosystem functions?)
    - "The Arctic Ocean has been the subject of many gelatinous zooplankton surveys (Bigelow 1920; MacGinitie 1955; Grainger 1965; Uchida 1969; Shirley & Leung

1970; Stepanjants 1989; Kosobokova et al. 1998; Kosobokova & Hirche 2000; Søreide et al. 2003; and others). However in all of these studies, the new species described herein, Bathykorus bouilloni, was never reported. One likely explanation for this disparity is their extreme fragility" (Raskoff 2010).

2. Deep-sea food web structure. (In what way do jellyfish play a role?)
    - "The greatest diversity of prey was consumed by narco medusae, followed by physodes siphonophores, ctenophores and cephalopods. We highlight key interactions within the poorly understood 'jelly web', showing the importance of medusae, ctenophores and siphonophores as key predators, whose ecological significance is comparable to large fish and squid species within the central California deep pelagic food web" (Choy 2017).

3. Population Increase with Jellyfish blooms (how does this affect the ecosystem functions?)
    - "The occurrences of jellyfish superabundances have the potential to change significantly the flux of organic matter to the seabed" (Billett 2006).

4. How Jellyfish carcasses on the seafloor impact the ecosystem functions.
    - "These rapid jellyfish carrion consumption rates suggest that the contribution of gelatinous material to organic fluxes may be seriously underestimated in some regions, because jelly falls may disappear much more rapidly than previously thought" (Sweetman 2014).

5. How Jellyfish impact the nutrient cycle.
    - " The potential influence of elemental cycling by populations of jellyfish on phytoplankton and bacterioplankton production is then assessed. Non-zooxanthellate jellyfish acquire C, N and P predominantly through predation on zooplankton with smaller contributions from the uptake of dissolved organic matter. C, N and P are regenerated via excretion of inorganic (predominantly ammonium (NH_4^+) and phosphate (PO_4^{3-})) and dissolved organic forms (e.g. dissolved free amino acids and dissolved primary amines)" (Pitt 2009).

Discussion/Conclusion:

1. Recap and summary of the paper.
    - " The accumulation of jellyfish material at the seafloor may also led to greater microbial metabolism since the C: N ratio of bacteria (~5–7: 1, Goldman and Dennett 2000) and jellyfish (~4–5, Pitt et al. 2009) are similar leading to easier bacterial degradation of gelatinous detritus. In situations where metazoan decomposition of organic matter is a keystone process in marine sediments (e.g., high latitude systems above 1000 m, Clough et al. 2005, including many Norwegian fjords, Sweetman et al. 2014a), a shift to microbial decomposition could have profound impacts on ecosystem function, including reduced energy

flow to upper trophic levels and lower levels of C-storage in sediments." (Sweetman 2016).

- Talk about the importance of jellyfish in the food web

- "In recent years, a number of publications have described massive accumulations of moribund jellyfish (e.g. covering 10–20% of the seafloor) at the deep seafloor off Oman (Billett et al., 2006), the Ivory Coast (Lebrato and Jones, 2009) and in the Sea of Japan (Yamamoto et al., 2008). These collective observations suggest that gelatinous zooplankton carcasses (hereafter referred to as jelly-falls) may provide an important transport vector for carbon (C) and nitrogen (N) to the deep seafloor, because jellyfish are renowned for their ability to rapidly form massive, yet often short-lived blooms (Purcell et al., 2007, Richardson et al., 2009)" (Sweetman 2011).

-Talk about the importance of jellyfish in the nutrient cycle

2. My closing thoughts on the importance of jellyfish and how they impact different ecosystem functions.

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