Preliminary results: gill health effects of hydrozoan jellyfish on sea-caged salmon

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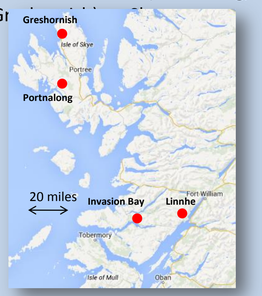
Why hydrozoan jellyfish?

Penned salmon are vulnerable to blooms of jellyfish, which can cause considerable mortality in some cases[1,2]. However, many of the causative species (particularly those belonging to class Hydrozoa) are too small to be easily recognized and tracked by an observer. This study examines the ebb and flow of such cryptic species, and their impact on salmon farms.

How we did it

We monitored four salmon aquaculture sites in the west of Scotland: two sites (Linnhe, Invasion Bay) on the Scottish mainland and two (Portnalong, Gr

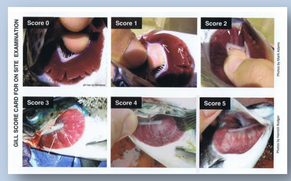


Locations of participating salmon production sites, provided by Marine Harvest Ltd.

Three vertically towed plankton samples filtered at 270 µm were taken weekly at each site and preserved in formalin. Hydrozoan individuals were identified[3,4], tallied, and sorted by taxon.

Deploying the 0.5m diameter x 270 µm ring net plankton tow for a 5m vertical tow

Collecting and preserving a tow sample



Gill health score reference levels

Salmon gill health was measured using a subjective scale of 0-5, 0 describing gills in perfect condition and 5 describing obvious and extensive pathology in both lamellae and arch structures. Gill health was measured between 1-7 days after the time of a plankton tow, to account for lag in development of chronic-type pathology after exposure to hydrozoan jellyfish[2].

References & acknowledgements

1) Doyle, T., De Haas, H., Cotton, D., Dorschel, B., Cummins, V., Houghton, J., Davenport, ., & Hays, G., 2008. Widespread occurrence of the jellyfish *Pelagia noctiluca* in Irish coastal and shelf waters. *Journal of Plankton Research*, 30(8), pp.963-968.

2) (2) Baxter, Emily J et al., 2011. Gill damage to Atlantic salmon (*Salmo salar*) caused by the common jellyfish (*Aurelia aurita*) under experimental challenge. *PloS one*, 6(4), p.e18529.

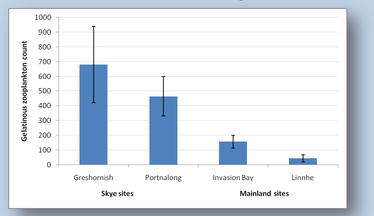
3) (3) Conway, D.V.P. (2012). Marine zooplankton of southern Britain. Part 1: Radiolaria, Heliozoa, Foraminifera, Ciliophora, Cnidaria, Ctenophora, Platyhelminthes, Nemertea, Rotifera and Mollusca. A.W.G. John (ed.). Occasional Publications. Marine Biological Association of the United Kingdom, No. 25, Plymouth, UK

4) (4) Russell, F.R., 1953. *The Medusae of the British Isles Vol. 1: Anthomedusae, Leptomedusae, Limnomedusae, Trachymedusae, and Narcomedusae*. Cambridge, UK: Cambridge University Press.

Thank you to the salmon crews at Linnhe, Invasion Bay, Portnalong and Greshornish for their participation and enthusiasm, to Chris Wallace of Marine Harvest for helping implement the project, to the Statistics Consultation service at the University of St Andrews, to my SPSS crowd-sourcing contributors, to Rachel Shucksmith and Alan Bourhill of the North Atlantic Fisheries College in Shetland, to Fiona Grieve for relieving me of having to count 300 extra *Lizzia* medusae, and to the MASTS committee for its generous funding.

All images by Anna Kintner unless indicated otherwise

Results: spatial-temporal trends

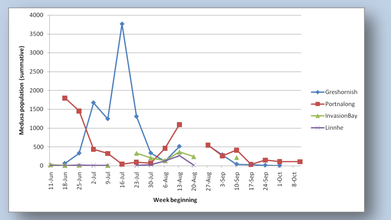


Mean population of hydrozoan jellyish per site +/- 1 SE

Counts ranged from 0 to 3767 hydrozoan jellyfish individuals collected on any given date.

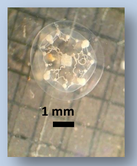
Note the marked difference in hydrooan populations occurring between sites on the mainland and sites on Skye.

All sites were prone to booms and busts during the June-September period, but did not share a temporal pattern. A zero-population point was not universally reached by early October at all sites. Data gaps resulted from skipped tows, samples broken in the post, and failure to properly preserve samples.

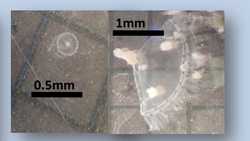


Summed weekly hydrozoan jellyfish counts for each site

Results: species breakdown

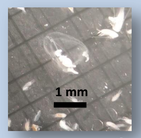


Phialella quadrata, Linnhe 2012

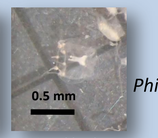


Obelia sp., Portnalong 2012

35 species/taxa were identified across all sites over the summer, most singly or as few individuals rarely occurring. We focused on species which appeared in groups of >30 individuals **and** appeared more than once, leaving 5 species and 2 broader taxonomic groups listed below.



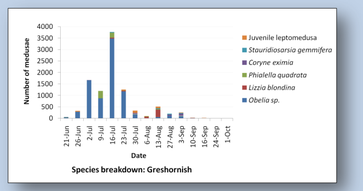
Stauridiosarsia gemmifera, Invasion Bay 2012

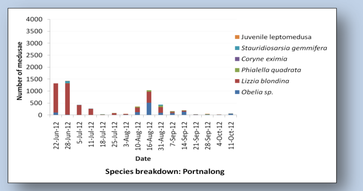


Lizzia blondina, Invasion Bay 2012

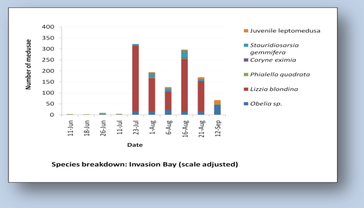
Species	**Taxa (not identifiable to species)**
Obelia sp.	Siphonophore bract (single parts of a colonial hydrozoan)
Lizzia blondina	Juvenile leptomedusa (early developmental stage lacking differentiating features)
Phialella quadrata	
Coryne eximia	
Stauridiosarsia gemmifera	

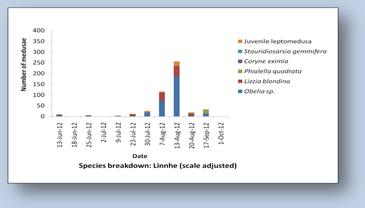
Results: species by site





Note Y axis scale change for Invasion Bay and Linnhe (1:10 from previous figures)

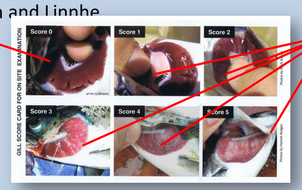




Results: correlations with gill pathology

We used **binary logistic regression (BLR)** to measure effects of the jellyfish population on the health salmon. BLR considers the probability of a binary outcome with a numerical measure. In this case, any gill score greater than 0 was considered "sick" and 0 "healthy;" this outcome was correlated on a fish by fish basis with the jellyfish count. Binary outcomes were a preferable measure for this study due to lack of spread in the gill score data (range = 0:3). Scores were provided from two stocked sites: Greshornish and Linnhe.

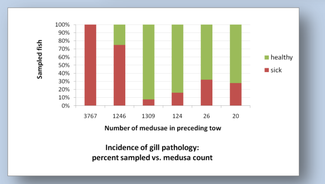
health y



unhealthy

By BLR, there is a significant correlation between the number of jellyfish in a towed sample and the incidence of poor gill health.

(*p < 0.000, df = 1, n = 627 fish*)



NB: this graph only cover displays incidence of gill pathology; days with 100% health are excluded.

Plotting the percentages of fish sampled showing gill pathology vs. the number of jellyfish appearing in a tow shows a trend, but a weak one due to the paucity of available data.

Results: suspect species

Obelia sp. and *Lizzia blondina* constituted the greatest proportions of overall medusa sums. Additional BLR analysis showed that *Obelia* sp. had a significant effect on the incidence of poor gill health ($p < 0.000$). Since the highest numbers of *L. blondina* appeared outwith stocked sites, no gill health correlation could be made as yet. However, as shown at unstocked sites, *L. blondina* can rapidly develop into high-density blooms. Other species cannot yet be analyzed due to "masking" effects: occurrences of high-density blooms occurred in conjunction with higher-density blooms of *Obelia* sp.

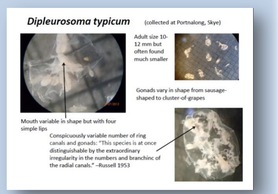
What's next?

Avoiding skipped sampling days. An improved schedule of sampling has been implemented to avoid data gaps.

Additional health sampling. A new data point measuring acute gill bleeding will be added. Mortality rates, amoebic gill disease, and age data will be collected as well.

Extended study period. Weekly sampling at all four sites will continue until November, with monthly sampling over winter. Daily sampling for 14 days at one site will be carried out in order to capture detailed bloom development.

Accessibility of ID literature. Existing ID materials assume taxonomic expertise. We aim to develop a straightforward visual resource to be used by non-biologically trained salmon farm personnel.



Straightforward ID sheet for *Dipleurosoma typicum*

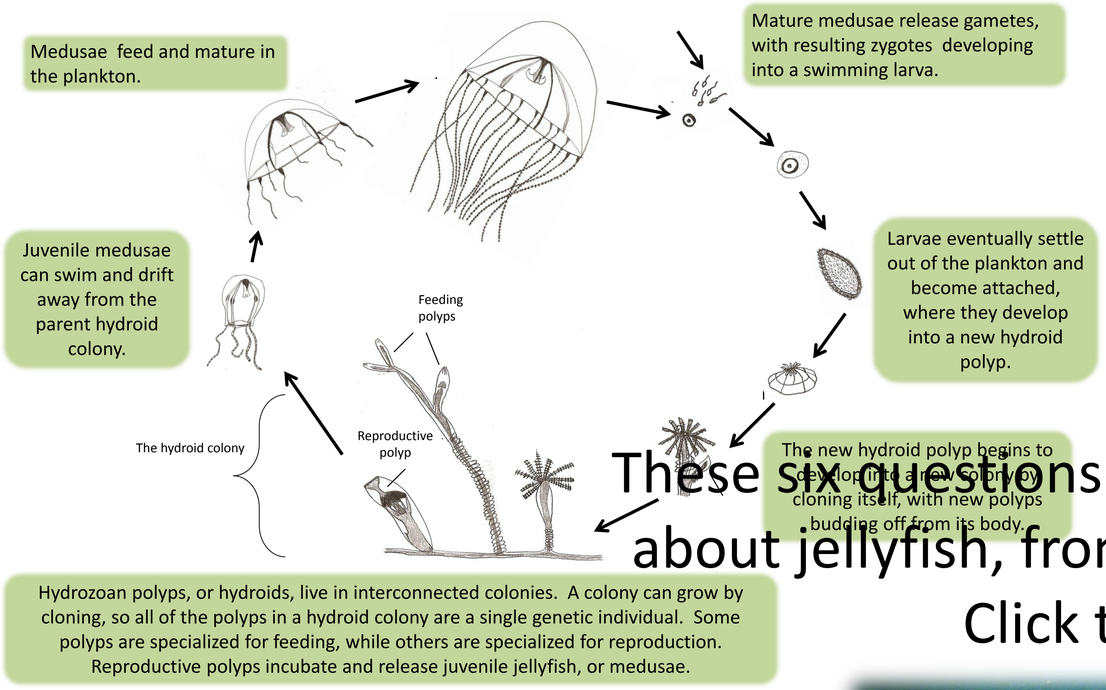
Tap forjellyfish FAQs!

Jellyfish FAQ: Part 1

Kayakers floating in a dense "soup" of hydrozoan jellyfish in Shetland. Photo courtesy of Sea Kayak Shetland.

Q: How do jellyfish reproduce?

A: Jellyfish can live as polyps attached to the seafloor, or as swimming medusae. They reproduce both by cloning or sexually. This diagram follows the life of a hydrozoan jellyfish[1].



Q: How do jellyfish hurt salmon?

A: Jellyfish can hurt salmon in 3 ways:

1) **Jellyfish sting.** When small jellyfish or tentacles from bigger jellyfish are sucked into the mouths of salmon, they can sting the vulnerable gill tissues. This is damaging due to both the stinging action and the venom used by some jellyfish.

2) **Jellyfish carry bacteria** pathogenic to salmon, spreading infectious disease[3,4].

3) **Jellyfish can deplete the dissolved oxygen** during an dense bloom around a salmon pen, causing the fish to suffocate[5].

A commercially produced Atlantic salmon (*Salmo salar*). Photo by Murdo Macleod. Source: http://www.theguardian.com/environment/2012/dec/17/scottish-salmon-fishing

Neoturris pileata hydrozoan medusa, collected near Scalloway, Shetland. Each tentacle can contain millions of stinging nematocysts.

These six questions are the most frequently asked about jellyfish, from MASTS and the public alike. Click to find out more.

Q: I saw an orange blob with tentacles at the beach. Was that a hydrozoan jellyfish?

Cyanea capillata, or the lion's mane jellyfish, is a common scyphozoan jellyfish in Scottish waters.

A: The term "jellyfish" covers many different taxa that produce medusae. In the UK, jellyfish belong to class Hydrozoa (about 87 species) or class Scyphozoa (13 species). Since hydrozoans are much smaller and less easily noticed, the big orange medusa you saw was probably a scyphozoan jellyfish – almost certainly a lion's mane, *Cyanea capillata*[1].

Tap for more jellyfish FAQs!

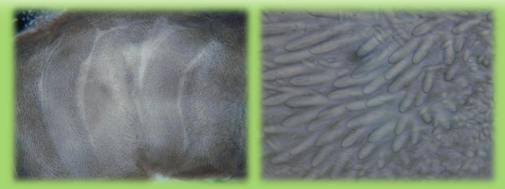
Jellyfish FAQ: Part 2

Q: Ow, that jellyfish just stung me! What's up?!

A: Jellyfish use subcellular structures called nematocysts to capture prey. Nematocysts line the tentacles, and can fire on contact with human skin. Most stings are mild, but can be severe if enough tentacle is involved and the species of jellyfish has potent venom contained in its nematocysts. Jellyfish in Scotland can give only a mild sting or no noticeable sting at all, and are therefore not a danger to most people.

Pandea conica, Shetland

Stinging nematocysts line the tentacles of nearly every species of jellyfish.



Chironex fleckeri tentacle at 40x (left) and 400x (right)

This tentacle shows densely packed and ready-to-fire nematocysts, which will discharge on contact with prey.

Unfired and fired nematocyst.
Photo by Teresa Carrette.

Nematocysts consist of a coiled thread inside a capsule. When it fires, the thread everts to tether prey or inject venom to its tissues.

Firing *Chironex fleckeri* (box jellyfish) nematocysts.
Video courtesy of Tropical Australian Stinger Research Unit, Cairns, Australia.

Q: So, if I've been stung, should I pee on it?

A: NO. Some jellyfish nematocysts are deactivated by vinegar, and others by ammonia. Neither of these are found in urine. In fact, urine is more likely to cause more nematocysts to fire and make the sting worse![6]

Urinating on a jellyfish sting will mean you suffer from two things: having been stung by a jellyfish, and being covered in urine.

Q: Are all jellyfish poisonous?

A: Jellyfish are actually *venomous* rather than poisonous, meaning they can use their nematocysts to deliver toxins into their prey. ("Poisonous "means that toxins must be ingested or absorbed.) Nearly all jellyfish have some venom-containing nematocysts. However, not all jellyfish have stings that we can feel. Some, like the moon jellyfish (*Aurelia aurita*) in Scotland, have very weak venom and only a few nematocysts that can puncture human skin.

Moon jellyfish (*Aurelia aurita*), Bigton, Shetland.

References

(1) Russell, F.R., 1953. *The Medusae of the British Isles Vol. 1: Anthomedusae, Leptomedusae, Limnomedusae, Trachymedusae, and Narcomedusae*. Cambridge: Cambridge University Press

(2) Seaton, D.D., 1989. Fish Kills by Planktonic Organisms. *Aquaculture Information Series*, no. 9.

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(6) http://www.scientificamerican.com/article.cfm?id=fact-or-fiction-urinating