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Is the Presence of Jellyfish Problematic or Beneficial?

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Abstract

Jellyfish are a diverse group of animals. The group consists of Chordata, Ctenophora and, mainly, Cnidaria. Jellyfish are often thought to be harmful, but few can cause fatality in humans. They are important throughout the trophic levels and consume a variety of prey. Jellyfish are used for food and have a high potential for pharmaceutical use. During a jellyfish bloom, energy flows are shunted through the trophic levels. Additionally, unusual increases in populations of jellyfish can cause problems for fisheries, aquaculture, power plants and the tourist industries.

Keywords: Jellyfish, blooming, Cnidaria, jellyfish as food, pharmaceutical uses

Introduction

Brief biology of jellyfish

The group name Jellyfish, or jellies, combine all jelly animals, such as jellyfish (Hydrozoans, Scyphozoans and Cubozoans) comb-jellyfish (Ctenophora) and Tunicates (Urochordata). This review concentrates on a brief biology of Hydrozoans, Scyphozoans and Cubozoans.

The jellyfish is in the Phylum Cnidaria and has a unique secretion of complex intracellular organelles called cnidae [1]. They are relatively simple, diploblastic creatures with radial symmetry and a sac-like body structure. The only space in the body is called the gastrovascular cavity which branches into gastrovascular canals which run along the body and tentacles (**Figure 1(a)** and **(b)**). The gastrovascular cavity has functions associated with digestion and nutrition, sex cell release and/or uptake, and larvae incubation, as well as the partial collection and exclusion of metabolic wastes. Generally jellyfish go through a "polyp stage" in their life-cycle. A polyp is the tubular body, sessile form of jellyfish which is able to increase its number asexually through different kinds of 'budding', such as transverse budding (**Figures 1(a)** and **3**). Specialized polyps called gonozooids 'bud' the young medusae. The medusa is the flattened mouth-down version of the polyp [2]. The medusae, when mature, produce sex cells (sperm and/or eggs) which are released into the surrounding media (water), where external fertilization takes place (**Figures 1(b)** and **3**). The zygotes (fertilized eggs) develop into ciliated planular larvae (**Figure 2**) which can swim in the water. Remarkably, the zygotes of some hydrozoans are capable of remaining dormant in order to maintain a resistance to deteriorating conditions [2]. For a period of time - the length depends on the species - planular larvae attach themselves to the substrate and transform to become polyp individuals. To complete the life-cycle, jellyfish combine the medusa stage (sexually reproductive stage) and polyp stage (asexual reproductive stage). This mode of life-cycle is sometimes called "alternation of sexual and asexual generation" (**Figure 3**). In addition, the reproduction rate, development rate and activities of jellyfish have been observed to strongly relate to increasing temperature in the surrounding water [3-5].

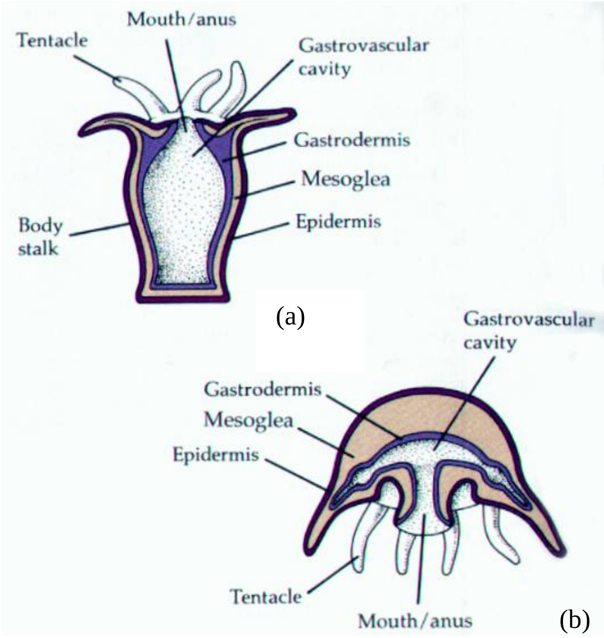

Figure 1 Body parts of a typical cnidarian (a) polyp form, (b) medusa form. **Source:** http://biology.unm.edu/ccouncil/Biology_203/Summaries/SimpleAnimals.htm, accessed August 2012.

Figure 2 An *Aurelia* planula. The planula is the first larval stage of *Aurelia*, and is formed soon after the egg and sperm combine to form a zygote. The planula is lined with cilia and eventually settles, forming a scyphistoma. Planula larval stages are common to many Cnidarians.
Image by: Marc Perkins, ~400× magnification (for permission see copyright/ educational use)
Source: http://faculty.orangecoastcollege.edu/mperkins/zoo-review/aurelia/aurelia2.html, accessed August 2012.

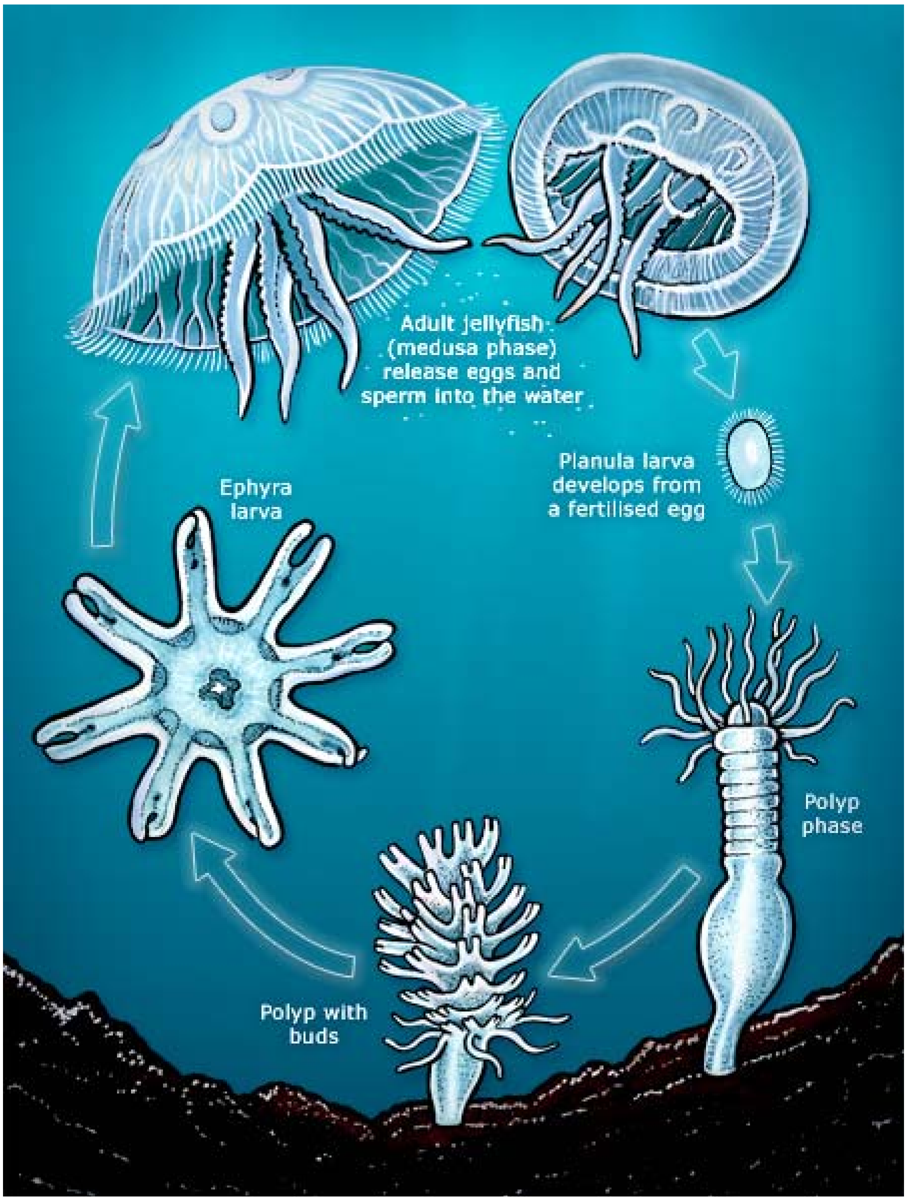

Figure 3 The typical life-cycle of a coastal scyphozoan.
Source: http://www.teara.govt.nz/en/open-ocean/2/2, accessed August 2012.

All jellyfish are carnivorous. They feed on varieties of zooplankton or even small fish. They catch prey using their tentacles which contain nematocyst batteries (assemblies of sting cells or cnidae). The stung prey is then brought to the mouth opening and totally swallowed into the gastrovascular cavity. There are nutritive muscle cells (cells respond for feeding and body movement), lining the gastrodermis, using enzymes to digest prey extracellularly. Cnidocytes are also present on the gastrovascular lining to paralyze the swallowed prey [1]. The digested prey (ready for intracellular digestion) is distributed though the gastrovascular cavity through the cilia lining of the walls of the gastrovascular cavity canals. At this stage phacocytosis (eating by cell) occurs. The undigested carcass waste is excluded from the body through the mouth opening. This route is sometimes called the "incomplete digestive tract".

Like other invertebrates, some jellyfish gain energy and exchange common metabolics with their symbiotic algae known as Zooxanthallae (*Symbiodinium microadriaticum*) (**Figure 4**) [6]. Zooxanthallae is a dinoflagellate algae. It is located in the endodermal cells of the host, (e.g. *Cassiopeia xamachana*) [7]. The number of *Symbiodinium* can range from one cell per host cell to over 60 in some species of hydroids [8,9].

Figure 4 The Cnidaria's symbiosis dinoflagellate (*Symbiodinium microradiaticum*).
Source: http://microbewiki.kenyon.edu/index.php/Zooxanthellae. Photo by Scott R. Santos, accessed August 2012.

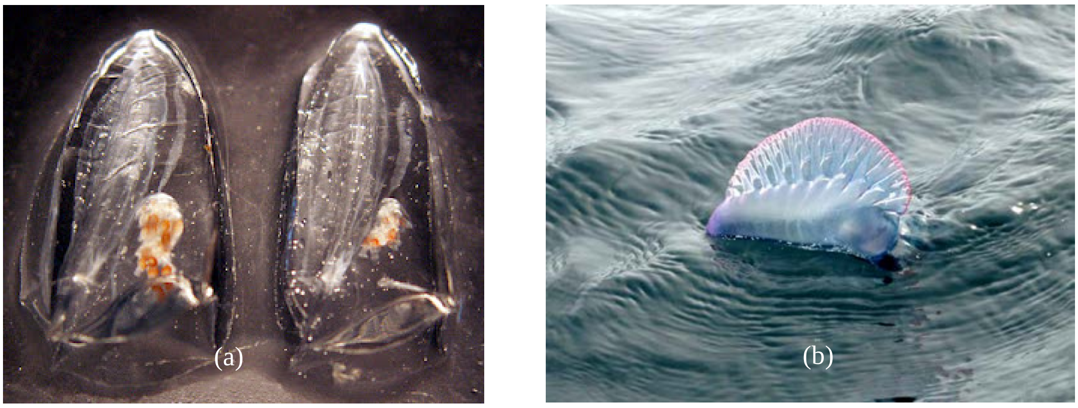

Figure 5 (a) Swimming bells of the siphonophore *Diphyes antarctica*. Photo Ryan Driscoll (AMLR, SWFSC, NOAA).
Source: http://antarcticsalpgenomics.blogspot.com/2011/11/my-favorite-zooplankton.html, accessed Aug 2012. (b) Floating pneumatophore of a live colony of *Physalia physalis*. **Source:** http://www.marlin.ac.uk/speciesinformation.php?speciesID=4126, accessed August 2012.

Impacts of jellyfish on humans

Cnidarians are named after their unique characteristic "cnidae". Cnidae (G: a nettle, a sting thread) are the remarkable organelles secreted within cells called cnidoblasts [1]. Cnidarians use their cnidae primarily to capture prey. Each cnidae consists of a fluid-filled capsule containing a thread that can be quickly ejected. The thread may be sticky or armed with spines or even barbs and some cnidae contain protein-digesting enzymes [10-12] (**Figure 1**). The toxins of cnidarians vary between groups and their activities as the examples in **Table 1** show.

Human fatalities arising from the venom of jellyfish species such as *C. flexkeri*, *Ca. bernesi*, *Chiropsalmus* spp., *Physalia physalis* and *Stomolophus nomurai* have been documented [28]. Deaths from jellyfish stings have been documented throughout tropical and temperate waters (more details are cited in [28,34]) (**Table 2**).

Table 1 Examples of Cnidarians' toxins and sources.

Toxin	Animal taxa and source(s)	Activities and Source(s)
Phospholipase A2	*Rhopilema nomadic* ; [13]	Stimulate amylase release from pancreas; [14]
Nematocyst fluorescence	*Cassiopea xamachana* ; [15]	Hemolytic, cytosensing activity; [15]
Proteins	*Cyanea nozakii* ; [16]	Neurotoxin; [16]
Proteins	*Chironex fleckeri* * ; [17]	Cardiotoxin; [17]
Proteins	*Phyllodiscus semoni*; [18].	Hemolytic; [18]
Proteins	*Actinaria villosa* ; [19]	Membrane-attack complex (perforin); [19]
Proteins Crude venom extract (CVE)	*Carukia barnesi* * ; [20]	Cardiotoxin; [20]
Proteins	*Physalia* sp.; [21]	Cardiotoxin;[21]
Proteins	*Chiropsalmus sp*.; [22]	Cardiotoxin; [22]
Proteins	*Chrysaora quinquecirrha*; [23]	Apoptosis; [23]
Proteins	*Stomolophus meleagris*; [24]	Proteolytic; [24]

Proteins	*Rhopilema esculentum*; [25]	Hemolytic activity; [25]
Crude extract	*Anemonia salcata*; [26]	Depolarization of muscle; [26]
Extract	*Aurelia aurita*; [27]	Proteolytic enzymes (irritant to skin and eyes); [27]
Venom	*Aurelia aurita*; [27]	Irreversible block of indirectly and directly elicited muscle; [27]
Phospholipase A2	*Aurelia aurita*; [27]	Neurotoxicity, myotoxicity, hemolysis; [27]
Fraction	*Chrysoara hysoscella*; [27]	Itching, erythema, edema, burning [27]
Venom	*Chrysoara hysoscella*; [27]	Hemolytic activity; [27]
Crude extract	*Chrysoara hysoscella*; [27]	Mortality of keratinocytes, inhibition of mitochondrial dehydrogenase; [27]
Fraction	*Pelagia noctiluca*; [27]	Erythema, oedematous and nodular/nacrotic phenomena with leukocyte, scarce activity on cardiac frequency, toxicity on neuromuscular synapses; [27]
Venom	*Pelagia noctiluca*;[27]	Cardiotoxic activity, cytotoxic to mammalian cells;[27]
Venom	*Rhizostoma pulmo*;[27]	Cytotoxic (Rhizolysin as cytolysin) ; [27]
Extracted proteins	*Rhizostoma pulmo*;[27]	Kill V79 cells, hemolysis of human erythrocytes; [27]
Venom	*Rhopilema nomadica*; [27]	e-chymotrypsin-like serprotease activity, phospholipase A2 activity, temperature-dependent haemolytic activity; [27]

Table 2 Published reports of severe stinging events by jellyfish around the world. Species indicated with an asterisk (*) are holoplanktonic; all others have a benthic stage. Pref. = Prefecture. Adapted from [8].

Species	Year (months)	Location	Stinging effects	Source / Year
Asia				
Gonionemus oshoro	1961–63 (Jul–Aug)	Hokkaido, Japan	175 swimmers (88 severe)	Yasuda / 1988
*Physalia physalis**	1961 (June)	Kanagawa Pref., Japan	15000 swimmers	Yasuda / 1988
Chrysaora elanaster	1961–63 (Jul–Aug)	Hokkaido, Japan	175 swimmers (88 severe)	Yasuda / 1988
C. melanaster	1976 (Jul–Aug)	Kyoto Pref., Japan	300 swimmers (20 severe)	Yasuda / 1988
C. melanaster	1979 (Jul–Aug)	Fukui Pref., Japan	Several tens of swimmers and fishermen (5 severe, 1 dead)	Yasuda / 1988
C. melanaster	1999 (Apr–Aug)	Sea of Japan coast	Several hundred swimmers and fishermen	Yasuda / 2003
Carybdea rastoni, *Gonionemus vertens*	1978 (Jul)	Hyogo Pref., Japan	Several tens of swimmers	Yasuda / 1988
Olindias formosa	1979 (Jul)	Nagasaki Pref., Japan	Several tens of	Yasuda / 1988

			swimmers (3 severe, 1 dead)	
Chiropsalmus quadrigatus	1981 (Jul–Sep)	Okinawa Pref., Japan	1 severe	Yamaguchi / 1982
*Agalma okeni**	1995 (Jul–Aug)	Fukui Pref., Japan	Several tens of swimmers (3 severe)	Yasuda / 2003
Euphysora bigelowi	2000 (Jul–Aug)	Fukui Pref., Japan	Several tens of swimmers	Yasuda / 2003
Nemopilema nomurai	1991–96	Qingdao, China	8 deaths	Fenner & Williamson / 1996
N. nomurai	2002 and after	Sea of Japan coast	Several hundred fishermen	Kawahara *et al.* / 2007, S. Uye
*Porpita porpita**	2002 and after	Northern Sea of Japan	Swimmers	Oiso *et al.* / 2005
Australia/Indo-Pacific				
Chironex fleckeri	Annual	Australia, Malaysia, Philippines	67 deaths 2–3 deaths yr–1; 20–40 deaths yr–1 (1884–1996)	Fenner & Williamson / 1996, Bailey *et al.* / 2003
Carukia barnesi and other species	2002, peak (Jan–Apr)	Tropical Australia; NW Australia	Irukandji syndrome Increasing, 88 in 2001–03	Bailey *et al.* / 2003, Macrokanis *et al.* / 2004
Physalia sp.*	Annual, 2005–07	Tropical waters	10000 annually, 30000 in 2006, 1200 in one weekend in 2007	Fenner & Williamson / 1996, de Pastino / 2007
Cubozoa (unconfirmed species)	2003-2008	Gulf of Thailand, Andaman sea	54 injured, 10 severe, 4 deaths	Epidemiological Surveillance [29] / 2008 and 2009
Europe				
*Pelagia noctiluca**	1984–87, 2004, summer	French Riviera, Monaco	2500 treated, 45000 treated	Bernard *et al.* / 1988
*P. noctiluca**	2006, (Aug)	Spain, east & south coasts	>14000 treated	Pingree & Abend / 2006
Cotylorhiza tuberculata, *Rhizostoma pulmo*	Annual After 1993	Coastal lagoon, Spain	Concern	Pagés / 2001
Rhopilema nomadica	After 1980	Eastern Mediterranean		Lotan *et al.* / 1993, Gusmani *et al.* / 1997
North America				
Chrysaora quinquecirrha	Annual	Chesapeake Bay	Considered painful	Burnett / 2001
Chirodropids	Before 1996	Gulf coast of Texas, USA; Puerto Rico	1 death, serious stings	Fenner & Williamson / 1996
Linuche unguiculata	Annual	Southeast coast USA, Brazil	Seabathers eruption	Segura-Puertas *et al.* / 2001
*Physalia physalis**	Before 1996	Florida & North Carolina, USA	3 deaths	Fenner & Williamson / 1996

In Thailand, medical records show 4 deaths from unconfirmed species of jellyfish between 1999 and 2008. Strikingly there were 7 victims of jellyfish stings in the 5 months period from December 2007 to April 2008 and some were foreign tourists [29]. While it would appear reasonable that not all the victims and deaths were of Thai people, information from a field survey (organised through a cooperation between a Phuket Marine Biological Center team and the Bureau of Epidemiology) showed that many more Thai people (fishermen, tourists, sailors and seamen) have been seriously stung by unknown jellyfish. However, many of them, including myself, did not seek medical attention (personal communication). Many of the Thai victims of jellyfish stings, it seems, are not likely to appear on medical records.

Some species of jellyfish leave serious scars on the victim's skin (see example in **Figure 7**). However, the most serious stings tend to be to tourists who are stung when swimming in shallow coastal water as well as, occasionally, sailors and seamen who also sometimes immerse themselves in the sea. The stings to fishermen are rarely as severe as they are usually stung on their hands and feet. Jellyfish stings to swimmers can be to the chest, the back, the neck, the inner legs etc which can lead to drowning or other fatal accidents.

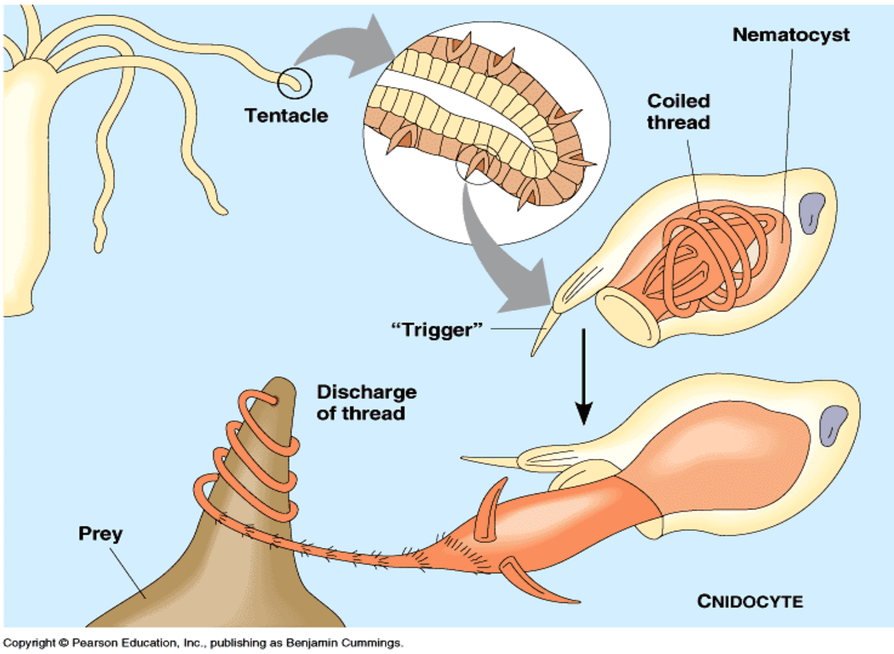

Figure 6 The drawing shows detail of cnida, unfired and fired cnida.
Source: http://www.bio.miami.edu/dana/106/106F06_11print.html, accessed August 2012.

Figure 7 The horrific scar caused by an unknown jellyfish sting.
Source: http://www.pa-divingidc.com/2008/03/blog-post.html, accessed August 2012.

Can we see and avoid jellyfish before being stung?

In many situations, victims can see jellyfish prior to being stung, though responses can be influenced through panic or misunderstanding. In a panic people may try to avoid the jellyfish's umbrella by swimming away from jellyfish but inadvertently make contact with the tentacles which have drifted up-current. It is often almost impossible to see the tentacles because they can be transparent and very long.

Many sting treatments are suggested on the internet, particularly in relation to Irukandji syndrome (see Huynh *et al.* 2003 for more detail or [30] herein). However, it is advisable for the reader to seek the most suitable information for themselves in order to best protect themselves and others. "LS13-Marine stinger (Risk management) Best practice Guidelines" updated: 23 August 2008 is recommended. It is available at http://www.lifesaving.com.au/downloads/Policies/MEMBERS%20HUB%20P%20LS13%20-20Marine%20Stinger%20Risk%20Management%2023-08-08%20FINAL.pdf.

Usefulness to human

Chinese people have been eating jellyfish for over a thousand years. In Asian countries, semi-dried salted jellyfish is a multi-million dollar seafood business [31]. The processing of semi-dried salted jellyfish is not a highly technological process but it is somewhat labor intensive (see more detail in Li and Hsieh, 2004 and/or Hsieh *et al.* 2001 or [31,32] herein) (see pictures of jellyfish marketed through http://www.alibaba.com/showroom/dried-jellyfish.html).

In 2001 Hsieh and his colleagues analysed the nutritional qualities of the cannonball jellyfish (the fresh animal and some products from this and other jellyfish) and found it to be composed mainly of moisture and protein but few calories and little fat (**Table 3**). To supply the high demand for jellyfish for human consumption, production has increased sharply worldwide. Commercial jellyfish farming has been taking place on a significant scale since 2003 (**Figure 8**).

Table 3 Chemical composition, calorific value, and pH of fresh cannonball jellyfish, *Stomolophus meleagris*, desalted ready-to-use (RTU) processed cannonball products, and a RTU commercial Malaysian *Rhopilema* product. Numbers are means (+) one standard deviation of 3 determinations from composite samples.

Composition	**Fresh Cannonball umbrella**	**RTU Malaysian umbrella**	**RTU Cannonball umbrella**	**RTU Cannonball leg**
Moisture (%)	96.10 (0.06)	95.63 (0.01)	95.04 (0.04)	94.08 (0.02)
Ash (%)	1.25 (0.16)	0.69 (0.00)	0.33 (0.00)	0.34 (0.01)
Protein (%)	2.92 (0.04)	4.13 (0.01)	4.69 (0.03)	5.60 (0.02)
Fat (%)	< 0.01	< 0.01	< 0.01	< 0.01
Total (%)	100.27	100.45	100.06	100.02
Cal 100 g-1	11.68	16.52	17.84	22.4
PH	6.67 (0.01)	4.64 (0.01)	4.46 (0.01)	4.46 (0.01)

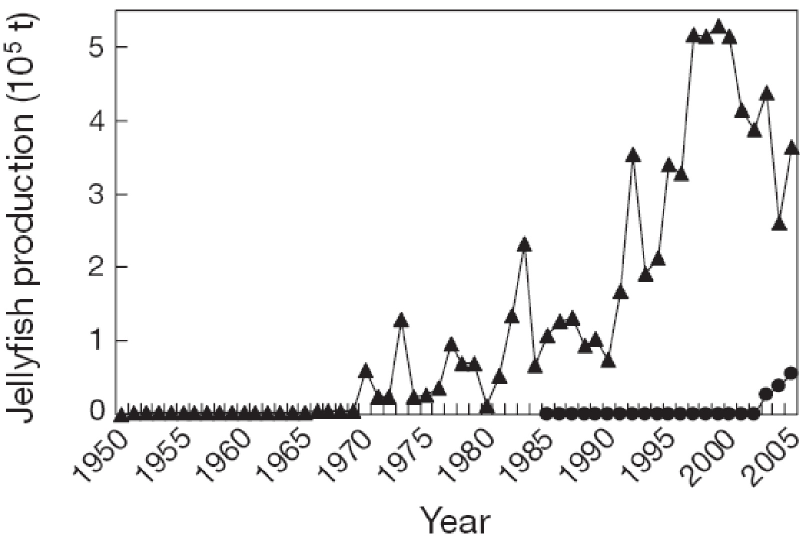

Figure 8 Global jellyfish aquaculture (●) and total (▲) production from 1950 to 2005 (FAO 2007). Aquaculture production was zero before 2003.

Asian people and some Australian natives traditionally believe jellyfish to have some properties beneficial for health. They believe jellyfish to be an effective cure for arthritis, hypertension, back pain and ulcers, for softening skin, improving digestion, remedying fatigue and exhaustion, and stimulating blood flow during the menstrual cycle of women. It is also believed to ease some types of swelling and to be a helpful treatment for burns. Novel compounds and compounds from jellyfish and Cnidarian members with potentially useful pharmaceutical products have been studied, particularly since the expansion of interest in the health benefits deriving from natural products. Some of the potential pharmaceutical uses of jellyfish are shown in **Table 4** below.

Problems caused to humans by jellyfish

Generally, jellyfish are considered to be a risk to public health (*Chrysoara hysoscella* and *Cotylorhiza tuberculata*). Their stings range from itchy to seriously painful or even fatal (*Chironex fleckeri*) depending on the species. During incidents of blooming, they are capable of damaging fishery activities (set, trawl and gill nets - associated with species such as *Aurelia aurita* and *Rhopilima nomadica*) [8,34,35].

Jellyfish aquaculture can result in the dumping of nutrients into the coastal zone (associated with *Aurelia aurita*) [8,36].

Jellyfish blooms have caused problems in power plants in European countries including France, Italy and The Netherlands, where the intake of water cooling systems have been clogged with jellyfish and other organisms [8,34,35].

Between 1978 and 1981, a fluctuation in the stock of young medusae of *Aurelia aurita* was inversely related to the fluctuation in the larval stock in the spawning ground of the herring (*Clupea harengus*) in fjords [36]. In the Northern California Current, 2 species of jellyfish (*Chrysaora fuscescens* and *Aurelia labiata*) are potential competitors of 4 planktivorous fishes: Pacific sardines (*Sardinops sagax*), Pacific herring (*Clupea pallasi*), Pacific saury (*Cololabis saira*) and northern anchovy (*Engraulis mordax*) (**Table 8**) [37].

Table 4 Compounds of jellyfish with potential for pharmaceutical uses.

Taxa	Activities	Source
Crambionella stuhalmanni *Chrysaora quinquecirrha*	Central Nervous System depression; Anti inflammatory	[33]
Aurelia aurita	Highly effective in treatment of cancer cells (liver carcinoma; colon carcinoma; myosarcoma; breast adenocarcinoma; lung carcinoma; leukemia), antimicrobial (gram positive; gram negative)	[27]
Pelagia noctiluca	Free radical scavenger, antioxidant, contains melatonin, reduces inflammation	[27]

Table 5 Overlap index (OI) of potential inter-specific competition based on geostatistical spatial overlap and dietary overlap for the dominant fish and jellyfish species in August 2002 off southern Oregon and northern California. (Brodeur *et al.* 2008).

Fish species	*Chrysaora fuscescens*	*Aurelia labiata*
Juvenile Chinook salmon	0.24	0.08
Juvenile coho salmon	0.18	0.04
Jack mackerel	0.17	0.02
Whitebait smelt	0.36	0.07
Surf smelt	0.19	0.47
Pacific herring	0.41	0.50
Pacific saury	0.34	0.38
Northern anchovy	0.46	0.35
Pacific sardine	0.51	0.36

Values are calculated as [OI = (spatial overlap + diet overlap)/2] which yields a value ranging from 0 to 1, with higher values indicating greater potential for competition between the species. Perfect spatial and dietary overlap yields a value of 1 and no spatial or dietary overlap yields a 0.

Table 6 Summary of possible contributory factors to major jellyfish blooms around the world. Species indicated with asterisk (*) are holoplanktonic; all others have a benthic stage. + = probable, ? = unknown or not examined, – = unlikely. Adapted from [8].

Bloom location	Main species	Possible factors contributing to bloom						Source / Year
		Climate	**Eutrophication**	**Fishing**	**Aqua-culture**	**Construction**	**Invasion**	
Tokyo Bay, Seto Sea (2004)	*Aurelia aurita* (s. l.)	+	+	+	+	+	+	Ishii / 2001, Uye & Ueta
East Asian marginal seas	*Nemopilema nomurai*	+	+	+	?	+	–	Uye
Yangtze River estuary	*Aequorea* sp., *Cyanea* sp., *Sanderia malayensis*	+	+	+	?	+	+	Ding & Cheng / 2005, Cheng *et al*. / 2005, Xian *et al.* / 2005
Black Sea	*Mnemiopsis leidyi**	+	+	+	–	+	+	Oguz / 2005a,b
Mar Menor	*Cotylorhiza*, *Rhizostoma*	?	+	+	+	+	+	Pagés / 2001
Mediterranean and Adriatic seas	*Pelagia noctiluca**	+	–	+	–	–	–	Goy *et al*. / 1989, Purcell *et al*. / 1999b
Benguela Current	*Chrysaora hysoscella*, *Aequorea forskalea*	?	–	+	–	–	–	Lynam *et al*. / 2006
Chesapeake Bay	*Chrysaora quinquecirrha*, *Mnemiopsis leidyi**	+	+	+	–	–	–	Purcell & Decker / 2005
Bering Sea	*Chrysaora melanaster*	+	–	+	–	–	–	Brodeur *et al.*
Lurefjorden	*Periphylla periphylla*	?	–	?	–	–	–	Eaine *et al*. / 1999
Gulf of Thailand (Nakhorn Si Thammarat, Songkla and Pattani)	*Phopilema histidum*	?	?	?	?	?	?	Aongsara *et al*. / 2011
Andaman Sea (Phuket)	*Physalia utriculus*	?	?	?	?	?	?	Phuket marine biological center (private communication) / 2012

Analysis of output from the ECOTRAN model showed the reverse results between the increased predation on jellyfish by five times compared with the 5 % increase in flow to jellyfish. The result of increased predation on jellyfish by five times presented the positive fraction change in production on carnivorous zooplankton, planktivorous fish, piscivorous fish and finally fisheries. By contrast, the results of a 5 % increase in jellyfish numbers had a negative impact on fractional change in production on planktivorous fish, piscivorous fish and fisheries (**Figure 9**) [38].

Recent studies have pointed out that jellyfish have a high Carbon-Nitrogen ratio (app. 25-31C:1N) and produce matter - "jelly-C" - which is released into seawater. This matter can either locally alter or shunt the microbial loop and water column food web (**Figure 10**) or increase microbial biomass and production (e.g. Turk *et al*. 2010 [39]; Condon *et al*. 2011 [36]). The deposition of jellyfish biomass can also cause potent changes in the deep-sea benthic ecosystem [40] (detail as in Billett *et al*. 2006).

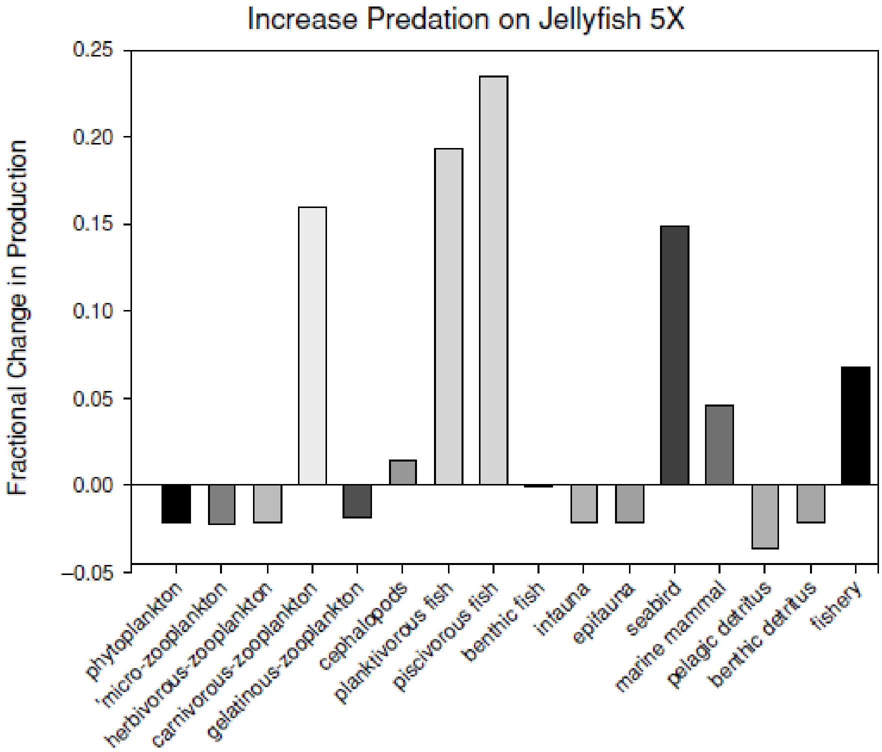

Figure 9 Output (fractional change in production of each trophic group) of a scenario in which the predation of jellyfish is increasing five-fold (left) and where the amount of food going to jellyfish is increased by 5 % (right) compared to the base model, without any increase in the total productivity of the model.

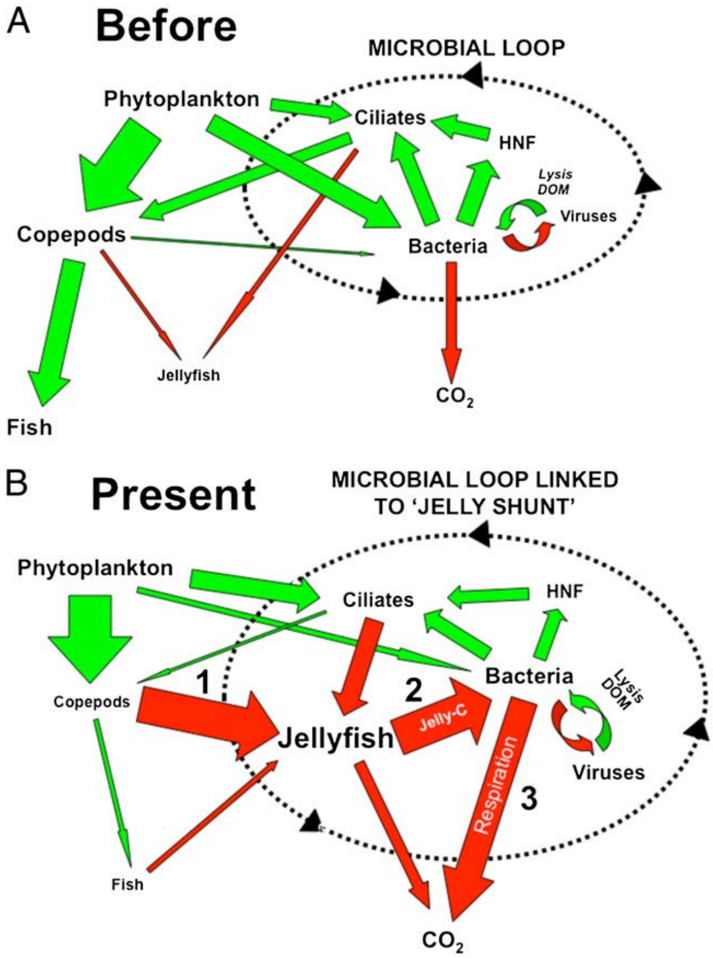

Figure 10 The effect of the presence and absence of jellyfish on a water column food web.

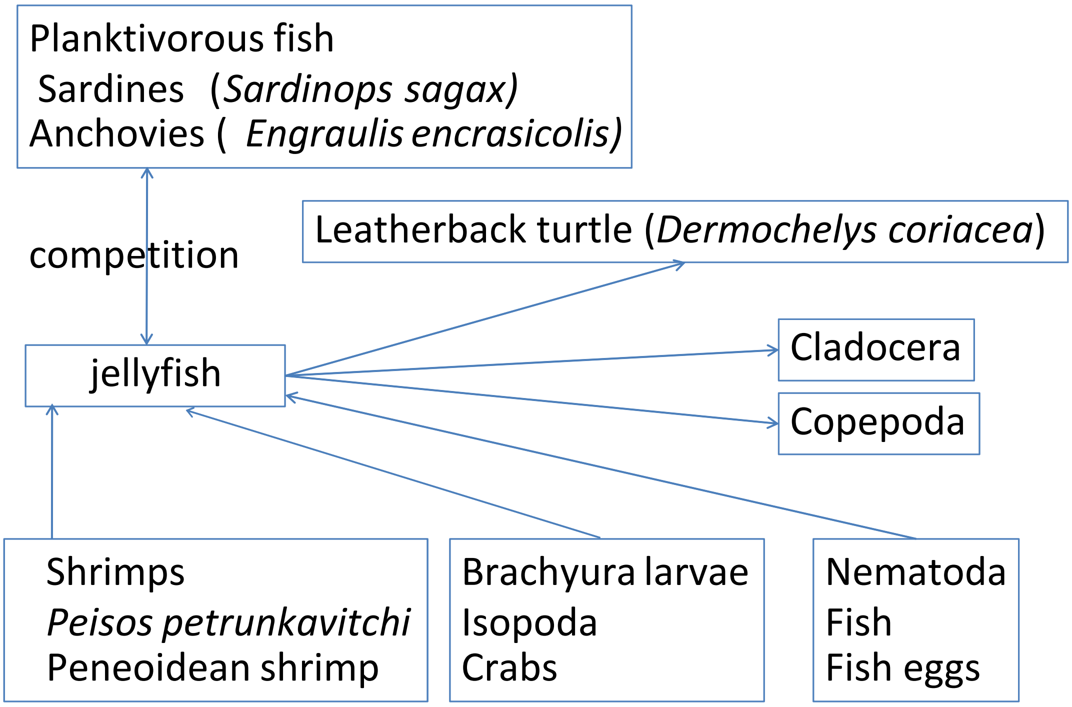

Figure 11 The food web in a water column, including jellyfish, compiled from various sources.

Jellyfish in Thailand

Jellyfish harvesting currently takes place along the coast of Thailand. The bloom of edible jellyfish varies spatiotemporally. In Trang province, for example, jellyfish are intensively harvested from April to May while in Krabi province they are harvested throughout the year. (Yee Ja Emb*, personal communication).

Fishermen usually harvest jellyfish during the daytime when the sea surface is calm and the sunlight is strong. In 2009, OnKaew** found that two species of jellyfish are commercially harvested along Thailand's Andaman coast, *Rhopiloma hispidum* and *Lobonema smithii* (personal communication).

The products made from jellyfish in Thailand are similar to those produced in Thailand's Asian neighbours. The main product is desalted, ready-to use (RTU) jellyfish [38]. The production of food may be the only benefit derived in Thailand from jellyfish.

As mentioned above, jellyfish in Thai waters range from a nuisance to being very harmful. Jellyfish blooms that have engaged public interest have usually been of nuisance species (*Lobonema* spp. and *Netrostoma setouchina*). Where human fatalities have occurred, these have not received publicity, perhaps because the authorities are fearful of creating a panic which could impact the tourist industry. (see http://thailandboxjellyfish.wordpress.com/).

Based on this information review, I think the Thai Government and other stakeholders (researchers, tourist organizations, fishermen, NGOs etc.) should be better prepared for the potential issues associated with blooming of jellyfish (particularly the inshore coastal species such as *Lobonema* spp., *Netrostoma setouchina*, *Chrysaora* sp., *Chironax* spp. in Phuket, Thailand) (personal survey). In temperate coastal areas certain species such as *Aurelia aurita*, *Cyanea lamarckii*, *C. capilata*, *Chrysaora hysoscella* and *Rhizostoma octopus* bloom in different places and at different times (spatio-temporal variance) [41]. Jellyfish blooms are likely to be larger and, potentially, more damaging, following the major flooding in Thailand in 2011 and a combination of other factors (as listed in Purcell *et al.* 2007). (**Table 6** shows examples from various locations around the World).

Conclusions

Jellyfish can be described as either simple or complex creatures, depending on the researcher's perspective. Their life-cycle combines benthic and pelagic forms. They are intermediate in the trophic levels and feed on a variety of preys [42-47] (**Figure 11**). People in many coastal areas have utilized jellyfish for food over thousands of years and their use has, more recently, been extended to the production of gelatinous proteins for pharmaceutical purposes.

Anthropogenic activities have been shown to promote the local blooming of some species. These blooms may cost thousands of millions of dollars to the fishery, aquaculture, electricity production and tourist industries (see Purcell, 2007).

In Thailand, there is a large gap in knowledge and understanding about jellyfish that needs to be filled. Initially, these researches should include a species inventory of jellyfish in Thailand and their spatio-temporal distribution patterns plus further study of the factors promoting the blooming of jellyfish in the region. The potential hazards of jellyfish to public health and the (ecological and economical) costs associated with blooms of jellyfish in Thailand are also important areas for study. These researches may be funded by stakeholders such as the Thai government (locally, centrally), electricity production companies, tourist organizations and universities.

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