

Title:

Towards the science-based jellyfish observing system

Acronym: JOS

Summary/Abstract

The environmental consequences of jellyfish blooms and their impact on some ecosystem services in several marine areas is recognized as a hot topic in several research programs, but much of historical information on jellyfish is anecdotal and obtained using methodology that was not adapted to study this group of marine organisms. Moreover, even currently there is a lack of standardized methodology to assess quantitative field data of both polyp and medusa abundance. The lack of standardized approaches and methodologies was also recognised as important issues during recent International Workshop 'Coming to grips with the jellyfish phenomenon in the Southern European and other seas'. Further, during discussions it was also stressed that jellyfish need to be monitored on a regular basis and make observations mandatory.

This proposed SCOR Working Group is established with the aim of standardizing and increasing rigour in jellyfish methodology. It will build on interdisciplinary competences of Working Group members what will facilitate the design and development of the proper jellyfish observing system that will encompass modelling and new and emerging technologies. This work will be achieved over a 4 year time period, with a team composed of senior, mid and early career researchers, from both developed and developing countries, what will facilitate capacity building activities. The whole group will focus in particular on field methodology and the establishment of a robust system of observation and forecasting network, towards a reference guide for best practice.

Scientific Background and Rationale

Research into gelatinous organisms has a long tradition and the period at the end of the 19th and beginning of the 20th century is seen as the first golden age of 'gelata' (Haddock 2004), when famous naturalists that studied in particular morphological taxonomy, were fascinated by their beauty and fragility. The environmental consequences of jellyfish blooms and their impact on some ecosystem services in several marine areas during last decades echoed in the popular and news press headlines (Gibbons & Richardson 2013) and refreshed interest in jellyfish research.

Jellyfish blooms have increased in some coastal areas around the world, the outbreaks becoming more severe and frequent over the past few decades (Kogovšek *et al.* 2010). The detrimental socioeconomic impacts on human wellbeing are numerous: some jellyfish are powerful stingers and represent a human health threat (Fenner *et al.* 2010) which also affects tourism (Gershwin *et al.* 2010); they interfere with ship operations and block cooling intakes of coastal industry, power and desalination plants (Dong *et al.* 2010); they interfere with fishing causing economic losses to the fishing industry (Quiñones *et al.* 2012); they damage farmed fish (Baxter *et al.* 2011) and act as vectors of fish pathogens (Delannoy *et al.* 2010). Further, they cause a reduction in commercial fish due to predation and competition (Purcell & Sturdevant 2001). In addition to the socioeconomic impact on human wellbeing, it has recently been shown that jellyfish blooms can modify trophic webs and organic matter cycling (Tinta *et al.* 2012). Although there is no clear direct evidence that anthropogenic drivers were responsible for increases, a large amount of correlative evidence suggests such connections and, globally, six of the top ten highly disturbed marine systems (Halpern *et al.* 2008) coincided with locations that have had jellyfish blooms (Purcell 2012).

On the other hand, jellyfish can provide beneficial ecosystem services such as regulating service through carbon sequestration (Lebrato *et al.* 2012), providing food for humans and being a source of novel compounds (Chudakov *et al.* 2010). Jellyfish may serve as prey (Heaslip *et al.* 2012), as a nutrient source (Pitt *et al.* 2009) give shelter (Gasca & Haddock 2004), serve as pelagic biological engineers (Breitburg *et al.* 2010) and host algal symbionts. And finally, jellyfish offer cultural services and attract eco-tourists to places like Jellyfish Lake at Palau (Graham *et al.* 2015).

Among gelatinous marine taxa large pelagic cnidarians and ctenophores seem to be most noxious to humans and a recent review of world oceans listed jellyfish as a mounting threat for future oceans. Medusae that appear "en masse" (bloom) are found primarily within the Scyphozoa which have a bipartite (metagenetic) life cycle (exchange of attached benthic polyp and pelagic medusa) though holoplanktonic species also may form large aggregations (Hamner & Dawson 2009).

Analysis of long-term records (200 years) in the northern Adriatic carried out by Slovenian research group lead by co-proposer of the SCOR WG revealed past periodicity of jellyfish outbreaks and indicated an increasing recurrence pattern in last few decades (Kogovšek *et al.* 2010). Frequent jellyfish blooms were observed in some other productive areas and enclosed

seas such as for example East Asian marginal seas (Uye 2008), the Benguela upwelling region (Roux et al. 2013). On the other hand, there has been a hot debate in the literature about global trends in jellyfish populations and interpretations from the available data remained ambiguous (Condon *et al.* 2013). This is partly due to the fact that much of historical information on jellyfish is anecdotal and obtained using methodology that was not adapted to study this group of marine organisms. Moreover, even currently there is a lack of standardized methodology to assess quantitative field data of both polyp and medusa abundance. The lack of standardized approaches and methodologies was also recognised as important issues during recent International Workshop 'Coming to grips with the jellyfish phenomenon in the Southern European and other seas' (Prieto *et al.* 2015). Further, during discussions it was also stressed that jellyfish need to be monitored on a regular basis and make observations mandatory.

This SCOR Working Group is established with the aim of standardizing and increasing rigour in jellyfish methodology. It will build on interdisciplinary competences of WG members what will facilitate the design and development of the proper jellyfish observing system that will encompass modelling and new and emerging technologies.

The proposed working group is composed of senior and some early career researchers what will facilitate capacity building activities. In addition to creation of best practice manual we foresee one open session associated with the International Jellyfish Bloom Symposium (2019) that is attended by senior and younger researchers from developed and developing countries.

Terms of Reference

- 1) To review and evaluate past and present methodology of jellyfish field surveys.
- 2) To review 'instrumental' approaches for jellyfish collection and abundance determination.
- 3) To identify new/emerging technologies that may improve jellyfish monitoring.
- 4) To identify formulae, parameters and approaches to model jellyfish.
- 5) To develop protocols/methodology for global comparisons.
- 6) To develop priorities and recommendations for future monitoring efforts.

Working plan

We outlined 6 Terms of Reference for the JOS SCOR Working Group (WG). These Terms of Reference will each be fulfilled as actions items between and/or during WG meetings. In order to minimize travel costs, we will run each meeting alongside international conferences (January 2017, June 2019) and the training course (September 2020) that are outlined in the Timetable below.

Year 1

Kick-Off Meeting for the JOS Working Group

Even that the activities for the first year of the Working Group (WG) are mainly on review processes (see Timetable and Deliverables), we consider very important to have a Kick-Off Meeting in order to stir up the WG. We have explore three possibilities to run such a Meeting and they are not ordered by preference:

1) The ASLO Aquatic Science Meeting to be held in Honolulu (Hawaii, USA) on 27 February to 3 March 2017. The session proposals are due 2 May 2016, but as the resolution of the funded SCOR WG will not be known before that deadline, in case of funded and only if a high percentage of JOS Members will plan to attend it, then we will decide that the Kick-Off Meeting to be held followed of ASLO ASM 2017. <http://aslo.org/meetings/sessions/>

2) The Third Xiamen Symposium on Marine Sciences (XMAS-III) to be held in Xiamen (China) on 9-11 January 2017. This Symposium is very early on the First year but as Professor Sun is Chief Scientist of a Key action of NSFC (XMAS-III is half organized by NSFC) and the program is still open, then is easy to organize a along-side session of our WG. <http://mel.xmu.edu.cn/conference/3xmas/>

3) In case any of the two previous options can be performed (either for time schedule or because the percentage of WG attendees to those symposiums would be two low), then the Kick-Off Meeting will be held through WebEx (or similar platforms) during January 2017.

Activities:

The proposed WG will focus on Terms of Reference #1 and #2 to develop the point of departure for JOS. At the beginning, the two Co-Chairs will initiate this state-of-the-art so a draft can be circulated to stimulate discussion at our inaugural meeting. During the rest of the year, the WG will work on Deliverable 1 (see list of the deliverables) in order to summarize the state-of-the-art methodologies and instrumental approaches of jellyfish field surveys.

Year 2

Activities:

The proposed WG will focus on the Term of Reference #3. The WG will work on the achievement of Deliverable 2 “Synthesis new/emerging technologies”. Due to the fast developing ocean technology together with the fact that jellyfish are delicate organism, hard to sample and to preserve (characteristics that have may its field of study difficult until just recently), this issue is on main importance for the JOS WG.

Based in the experience of Co-Chair Dr. Malej and Dr. Schiariti on new and emerging technologies, together with the experience in this matter in 6 of the Associate Members (Dr. Tintoré, Houghton, Uye, Kampel, Purcell and Hosia), the means to achieve successfully this action of the proposal are ensured.

Year 3

Activities:

During this third year, the group will work on the Term of Reference #4, specifically focused in the formulae, parameters and approaches to model jellyfish. This issue demands not only the expertise of the modelers of the Working Group (Professor Oguz as Full Member and Diego Macías as Associate Member), but also the knowledge of the whole team, including the experts on field research, laboratory experiments, population dynamics, environmental drivers, trophic connections and impact on socioeconomics (i.e. fisheries and tourism). All this work will be mirrored in the Deliverable 4.

The second JOS Working Group Meeting will be held followed by JBS 2019 (see Timetable and Capacity Building), but along-side the JBS, we will perform the Deliverable 3 “Presentation of JOS WG actions at JBS 2019” in order to ensure that the new methods and technics for jellyfish research will reach the large community of jellyfish researchers as well as new generations of scientist.

Year 4 and looking beyond the lifetime of the JOS WG

Activities:

The final two Terms of Reference (#5 and #6) will be fulfilled in year 4, and together with prior Terms of Reference #3 and #4, will provide a range of protocols/methodology for global comparisons, including priorities and recommendations for future monitoring efforts.

Looking beyond the lifetime of the JOS Working Group, a training course (Deliverable 5) will be performed in one of the developing countries that form part of this proposal (see Capacity Building section) in order for the WG to perform teaching and training activities. This training course will be performed along-side the third and last WG Meeting. The fact that we plan to do it in October, we can work in the wrap up of the JOS WG to achieve the last Deliverable 6.

Even that Dr. Issidri and Dr. Schiariti are task to lead the Capacity Building activities of the group, in case that the Training Course could not be performed finally neither in Morocco nor Argentina, then these two Full Members will act as part of the Organization Committee and the Training Course could be performed in Sao Paulo (Brazil) as two of the Associate Members, Dr. Morandini and Dr. Kampel, are from that site.

Finally, there is the possibility that, instead of performing the Deliverables #1, #2, #4 and #6 as separate articles, we will performed a join effort to concentrate the outcomes of the JOS WG in just one issue with several articles steaming from the work performed in a special open-access issue in a refereed scientific journal of very high impact. This potential possibility will be discussed with the Full Members in order to check for potential funds among us during year 1. In case we do have the funds, then we will contact the target journals and we will inform the SCOR Committee regarding this change in the timetable of the planning work before the end of

year1.

Timeline

Calendar Year	Key Dates	WG activity
2016	April: Submission of proposal Nov-Dec: Decision by SCOR on support	Preparation of JOS WG proposal
2017	Jan-Feb: kick-off meeting Oct: publish state-of-the-art of the topic	We will work on Deliverable 1 “Summarize the state-of-the-art methodologies and instrumental approaches of jellyfish field surveys”
2018	Oct: publish synthesis new technologies	The WG would focus on Deliverable 2 “Synthesis new/emerging technologies”
2019	May-June: JBS 2019 (the place to be held will be decided during June 2016 in the JBS 2016). Working Group meeting followed by JBS2019 Oct: publish synthesis modeling	Performed the Deliverable 3 “Presentation of JOS WG actions at JBS 2019” as a along-side session During this year the WG would release Deliverable 4 “Synthesis of formulae, parameters and approaches”
2020	Sept-Oct: Working Group meeting in a developing country followed by the training course. Nov-Dec: crystalize the wrapping up of the Working Group achievements.	Training course in a developing country (Deliverable 5) The WG presents its conclusions through Deliverable 6 “Publication of a reference handbook of protocols/ methodology for global comparisons and for future monitoring”, including the means to future update of it

Deliverables

Deliverable D1: associate to the Terms of Reference # 1 and 2. Communicate this state-of-the-art as a Review paper to a refereed scientific journal as an open-access article (end of year1).

Deliverable D2: associate to the Term of Reference # 3. Communicate this state-of-the-art as a Synthesis paper to a refereed scientific journal as an open-access article (end of year2).

Deliverable D3: associate to the Terms of Reference # 1, 2, 3 and 4. Coordinate an along-side “session” at the international Jellyfish Bloom Symposium (JBS) 2019 to attract and disseminate our WG actions to other young researchers and to the broader jellyfish community (middle of

the year3).

Deliverable D4: associate to the Term of Reference # 4. Communicate this state-of-the-art as a Synthesis paper to a refereed scientific journal as an open-access article (end of year3).

Deliverable D5: Training Course in a developing country, organized by either Dr. Issidri or Dr. Schiariti, where the JOS WG plans teaching and training activities in conjunction with the working group meeting.

Deliverable D6: associate to the Terms of Reference # 5 and # 6. The outcome and conclusions of these two actions will be published either as a handbook of reference (with its ISBN) that can be free-downloaded or as Synthesis paper to a refereed scientific journal as an open-access article (end of year4). In order to those protocols can be readily updated and accessed on line, the WG will provide the means (i.e. web site) to achieve it.

Capacity Building (How will this WG build long-lasting capacity for practicing and understanding this area of marine science globally)

The primary need from the jellyfish community in order to standardize protocols and advance in the study of field abundance estimates is to create a manual that can be applied globally, easily and with low cost. Given the need for long-term (i.e., well beyond the lifetime of a 4 year WG) and sustained international research into abundance estimates of jellyfish on the field, we have in part detailed some of our longer term aspirations in our working plan under the section “Year 4 and looking beyond the lifetime of the JOS WG”.

Our Full Member team already includes young scientists from developing countries (Dr. Issidri from Morocco), from countries with economies in transition (Dr. Schiariti from Argentina) and also from well develop countries (Lucas Brotz from Canada). This new generation of scientist, together with the senior scientist of the team (Professors Malej, Oguz, Song and Shiganova) and the mid carrier scientist (Drs. Prieto, Pitt and Gibbons), makes the JOS a solid based WG that will ensure the knowledge to be maintain further on.

Dr. Issidri and Dr. Schiariti are task to lead the capacity building activities of the group. The combination of one Training Course for early career scientists to be held almost at the end of the year 4 in either Morocco, Argentina or Brazil (see more details in the working plan), being developing countries or with economies in transition, with the fact that the next Jellyfish Bloom Symposium (JBS) will be in 2019 (around the middle of the year 3 of this SCOR WG) can ensure that the new methods and technics for jellyfish research will reach the large community of jellyfish researchers as well as new generations of scientist. In this line, the JOS WG we plan an along-session during the JBS 2019 and invite early career scientists to join the session. The JOS WG will meet meeting as a second time followed of JBS 2019. In the training workshop held in the developing country, the JOS WG plans teaching and training activities in conjunction with the third working group meeting.

Furthermore, the JOS WG will bring Associate Members from developing countries (Drs.

Morandini and Kampel) to WG meetings, together with the possible maximum of the rest of the Associate Members team.

Therefore, we expect that the outcomes of this proposal WG will ensure a new generation of scientists, from a wide range of countries, with comprehensive skillsets to further evolve the field of jellyfish research, taking into account the new and fast developing ocean technologies. For that, the JOS WG will published a handbook reference to standardized methodology for field jellyfish research, but providing the means (web site or a jellyfish network) in order to those protocols can be readily updated and accessed on line by the emerging international community of both established and emerging early career researchers.

Working Group composition

Full Members

Name	Gender	Place of work	Expertise relevant to proposal
1 Laura Prieto (Co-chair)	Female	CSIC, Cadiz, Spain	Population dynamics of jellyfish and multiple drivers
2 Alenka Malej (Co-chair)	Female	NIB, Piran, Slovenia	Field survey and jellyfish abundance new technologies
3 Agustin Schiariti	Male	INIDEP, Mar del Plata, Argentina	Jellyfish ecology and implications for fishery management
4 Hounaida Farah Idrissi	Female	INRH, Casablanca, Morocco	Coastal field surveys and zooplankton
5 Kylie Pitt	Female	Griffith University, Southport, Australia	Trophic ecology of jellyfish, field surveys and meta-analysis
6 Lucas Brotz	Male	University of British Columbia, Canada	Jellyfish populations trends and jellyfish fisheries
7 Mark Gibbons	Male	University of the Western Cape, South Africa	Jellyfish dynamics and climate change
8 Tamara Shiganova	Female	RAS, Moscow, Russia	Field survey and laboratory experiments of gelatinous plankton
9 Temel Oguz	Male	Middle East Technical University, Turkey	Ecosystem modeler to study the impact of gelatinous plankton on food webs
10 Sun Song	Male	Institute of Oceanology Chinese Academy of Sciences, China	Jellyfish blooms, mechanism, processes and ecological consequences

Associate Members

Name	Gender	Place of work	Expertise relevant to proposal
1 Aino Hosia	Female	University of Bergen, Norway	Jellyfish field survey sampling and optical platforms
2 Andre Morandini	Male	Universidade de São Paulo, Brasil	Biodiversity of jellyfish
3 Areti Kontogianni	Female	University of Aegean, Greece	Socio-economics impact of Jellyfish.
4 Diego Macías	Male	JRC, Ispra, Italy	Ecosystem and IBM modeler of jellyfish
5 Ferdinando Boero	Male	Università del Salento / CoNISMa / CNR-ISMAR, Italy	Zoology, ecology and citizen science of jellyfish
6 Jennifer Purcell	Female	Western Washington University, U.S.A.	Field research on jellyfish for 40 years, including new optical approaches
7 Joaquín Tintoré	Male	SOCIB, Palma de Mallorca, Spain	Physical oceanographer. Operational oceanography and new ocean technologies
8 Jonathan Houghton	Male	Queen's University Belfast, U.K.	Ship-borne, aerial surveys and lab-based techniques to study jellyfish
9 Milton Kampel	Male	Instituto Nacional de Pesquisas Espaciais – INPE, Brasil	Remote sensing (color oceanic indicator of swarms)
10 Shin-ichi Uye	Male	Hiroshima University, Japan	Jellyfish biology/ecology and technological development in early forecast of bloom

Working Group contributions

Laura Prieto (Spain, Co-chair). Dr. Prieto research focuses on the influence of multiple drivers (climate, atmospheric, oceanographic) on jellyfish population dynamics. Her last publication (top 5% by Altmetric, 1 week cover of JRC web of the European Commission), untangled the reasons why a swarm of dangerous jellyfish entered on the Mediterranean basin.

Alenka Malej (Slovenia, Co-chair). Dr. Malej has been involved in field and laboratory research of jellyfish for more than 30 years. Her research is focused on trophic interactions, population dynamics, temporal and spatial distribution including connectivity of populations (genomic approach) and, more recently, their socioeconomic impacts.

Agustin Schiariti (Argentina). Dr. Schiariti is particularly interested in the potential effects of

these organisms on the recruitment of fishing resources and their implications for fishery management, including the development of a jellyfish fishery in Argentina.

Hounaida Farah Idrissi (Morocco). Dr. Idrissi works on gelatinous macrozooplankton in the Moroccan ecosystem: species identification, spatial occurrences of the observed species, trophic interactions and their environment. Now, her team is exploring how to integrate ROVs technology in the jellyfish observation in coastal waters.

Kylie Pitt (Australia). Dr. Pitt expertise focuses in population dynamics of jellyfish, their response to climate change, their trophic ecology and roles in nutrient cycling. Her research spans local to global scales and utilizes experiments (field and laboratory) and meta-analyses of existing global data.

Lucas Brotz (Canada). Brotz has expertise in population trends for jellyfish around the globe and in the factors that influence jellyfish populations, as well as the monitoring of jellyfish from a wide range of spatial/temporal scales. His most recent work is focus on jellyfish fisheries and on developing a protocol for monitoring jellyfish bycatch.

Mark Gibbons (South Africa). Dr. Gibbons has worked to collate fisheries-dependent and fisheries-independent data on jellyfish populations, and to describe their dynamics over a variety of temporal/spatial scales. He has also stimulated research into the use of hydroacoustic tools to map jellyfish biomass and distribution.

Tamara Shiganova (Russia). Dr. Shiganova has been working from more than three decades with gelatinous plankton focusing on invasive ctenophores in the Mediterranean, Caspian and Baltic Seas and their impact on ecosystem. She is involved in field and laboratory research.

Temel Oguz (Turkey). Prof. Oguz is a leading ecosystem modelers to study the impact of gelatinous predators on functioning of food web structures. His fundamental contribution is modeling the response of top-down control exerted by gelatinous carnivores on the Black Sea pelagic food web and a coupled plankton–anchovy population dynamics model assessing relative roles on the nonlinear controls of small pelagic fishes and gelatinous species.

Sun Song (China). Prof. Sun research is focused in zooplankton and ecosystem dynamics. He is the Chief Scientist of the National Basic Research Program of China: “Jellyfish bloom in the Chinese waters, mechanism, key processes and ecological consequences”, of the Key NSF of China: “Zooplankton functional group variation and ecosystem dynamics in the Yellow Sea and East China Sea” and of the Pioneer research project of CAS: “Western Pacific Ocean System: Structure, Dynamics and Variation”.

Relationship to other international programs and SCOR Working groups

The proposed Working Group is a good mechanism to advance in this topic (Towards the science-based jellyfish observing system) at global scale as it will provide a network of scientist from all the continents that would be unlikely to be supported through different national sources.

In this sense, this proposal aims to consolidate and improve the methodology for jellyfish research and to increase our capacities to forecast nuisance jellyfish phenomena. WG will focus in particular on field methodology and the establishment of a robust system of observation and forecasting network, towards a reference guide for best practice. This proposal stemmed from a last year IMBER endorsed initiative, lead by Dr. Prieto (Co-Chair), titled “Coming to grips with the jellyfish phenomenon in the Southern European and other Seas: research to the rescue of coastal managers”, an International Jellyfish Workshop funded by IOC-UNESCO, UE and CEIMAR (http://www.perseus-net.eu/site/content.php?locale=1&locale_j=en&artid=2539).

The proposed team is formed with active members in different international programs:

Dr. Malej (Co-Chair) is a Board Member of the Bureau Central de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée (CIESM) (<http://ciesm.org/people/board/index.htm>) and in the past she served as chairperson of the National Committee for the Intergovernmental Oceanographic Commission (IOC) and national MED POL co-ordinator of UNEP MAP (United Nations Environmental Programme, Mediterranean Action Plan).

Prof. Sun, is Executive Member of Partnership for Observation of the Global Oceans (POGO) (<http://www.ocean-partners.org/>) and Member of The Global Ocean Observing System (GOOS) Steering Committee (IOC-UNESCO) (<http://www.ioc-goos.org/>). At national level, he is the Chairman of China Oceanology and Limnology Society; vice chairman of the China Marine Fisheries Society; and Vice Chairman of the Chinese Oceanographic Society.

Dr. Shiganova is actually one of the Committee Chairs of CIESM for “Living Resources and Marine Ecosystems” (<http://ciesm.org/people/chairs/index.htm>).

Dr. Uye has been a co-chair of PICES (North Pacific Marine Science Organization) WG on “Jellyfish blooms around North Pacific Rim: Causes and consequence” that recently submitted its final report. In that group were also Dr. Jennifer E. Purcell and Lucas Brotz.

Dr. Tintoré is Vice-Chairman of the Marine Board of the European Science Foundation (<http://www.marineboard.eu/>) and he is Director of the Spanish Large Scale Marine Infrastructure, SOCIB (Balearic Islands Coastal Ocean Observing and Forecasting System) (<http://www.socib.eu/index.php?seccion=home>).

Key References

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Purcell J.E., M.V. Sturdevant. 2001. Prey selection and dietary overlap among zooplanktivorous jellyfish and juvenile fishes in Prince William Sound, Alaska. *Mar. Ecol. Prog. Ser.* 210:67-83

Quiñones J. et al. 2013. Jellyfish by catch diminishes profit in an anchovy fishery off Peru. *Fish. Res.* 139:47-50

Roux, J.-P. et al. 2013. Jellification of marine ecosystems as a likely consequence of overfishing small pelagic fishes: lessons from the Benguela. *Bull. Mar. Sci.*, 89:249-284

Uye S.-i. 2008. Blooms of the giant jellyfish *Nemopilema nomurai*: a threat to the fisheries sustainability of the east Asian Marginal Seas. *Plank. Benthos Res.* 3:125-131

Appendix

For each Full Member, indicate 5 key publications related to the proposal.

Laura Prieto

Prieto L., D. Astorga, G. Navarro, J. Ruiz (2010). Environmental control on Phase Transition and Polyp Survival of a Massive-Outbreaker Jellyfish. PLoS ONE 5(11): e13793.

Astorga D., J. Ruiz, L. Prieto (L. Prieto as corresponding author) (2012) Ecological aspects of the early life stages of *Cotylorhiza tuberculata* (Scyphozoa: Rhizostomae) affecting its pelagic population success. Hydrobiologia 690: 141-155.

Ruiz J., L. Prieto, D. Astorga (2012) A model for temperature control of jellyfish (*Cotylorhiza tuberculata*) outbreaks: a causal analysis in the Mediterranean coast. Ecological Modelling 233: 59-69.

Prieto L., A. Armani, D. Macías (2013) Recent strandings of the giant jellyfish *Rhizostoma luteum* Quoy and Gaimard, 1827 on the Atlantic and Mediterranean coasts. Marine Biology 160(12): 3241-3247.

Prieto L., D. Macías, A. Peliz, J. Ruiz (2015) Portuguese Man-of-War (*Physalia physalis*) in the Mediterranean: A permanent invasion or a casual appearance? Scientific Reports (Nature) 5: 11545. <http://www.nature.com/articles/srep11545>

Alenka Malej

Malej A. (1989) Behaviour and trophic ecology of the jellyfish *Pelagia noctiluca* (Forsskål, 1775). Journal of experimental marine biology and ecology 126: 259-270.

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