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Interim Report of the Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT)

23 March 2018

Helsinki, Finland



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Executive summary

The ICES Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT) met at the Finnish Environment Institute (SYKE), Helsinki, Finland, on 24 March 2018. The meeting was hosted by Maiju Lehtiniemi, chaired by Naiara Rodriguez-Ezpeleta (Spain) and Elaine Fileman (UK) and attended by 18 scientists representing 10 countries. During the meeting, WGIMT members reviewed progress on multi-annual ToRs, reports, and recommendations; evaluated progress and sought opportunities for partnerships in the ICES science and advisory communities.

WGIMT membership currently totals 47 members from 17 countries; new members were added again this year, continuing the steady increase in membership numbers each year since 2013. This trend is consistent with WGIMT goals to recruit and welcome new members [ToR a)], in order to enhance our capacity for developing and using molecular and morphological approaches to taxonomic analysis of zooplankton. Initial development of the WGIMT web platform has been completed, [ToR b)], it will continue to be updated and expanded as WGIMT continues into the future. WGIMT continued work to initiate and support provision of standards, preparation of training materials, and organization of formal workshops [ToR c)]. WGIMT members are named as expert instructors and/or organizers for two workshops in the coming year; several proposals for taxonomy workshops are pending. WGIMT promoted and encouraged the continuing integration of molecular and morphological taxonomy by organizing special sessions at national and international conferences, including the ICES 2018 Annual Science Conference and ASLO/AGU 2018 Ocean Sciences, among others [ToR d)]. WGIMT is seeking avenues via the Ecosystem Processes and Dynamics Steering Group and SCICOM EGs to advise on implications and applications of integrative taxonomy for marine science and management [ToR e)]. During 2017/2018, WGIMT members published at least 15 relevant peer-reviewed articles directly related to the core mission and goals of the EG [ToR f)]. WGIMT collaborated with WGZE on a joint ToR to determine the status of microzooplankton time-series data collection within the ICES area, which assessed progress made in this area over the last ten years [ToR g)].

Next year, WGIMT proposes to meet in association with the Working Group on Zooplankton Ecology (WGZE) and the Working Group on Microbial and Phytoplankton Ecology (WGPME); this meeting will be hosted by the Instituto de Oceanografía y Cambio Global, Universidad de Las Palmas de Gran Canaria, Spain, on 15 March 2019. Additional work will be carried out by correspondence and videoconferencing.

1 Administrative details

Working Group name Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT)
Year of Appointment within current cycle 2017
Reporting year within current cycle (1, 2 or 3) 2
Chair(s) Elaine Fileman, UK Naiara Rodriguez-Ezpeleta, Spain
Meeting dates 24 March 2018
Meeting venue Helsinki, Finland

2 Terms of Reference

- ToR a)** Ensure balanced morphological – molecular expertise among membership of WGIMT;
- ToR b)** Fully populate the WGIMT web platform with information, protocols and resources to support progress in research and development;
- ToR c)** Initiate and support provision of standards, training materials, and taxonomy workshops;
- ToR d)** Demonstrate leadership in promoting and encouraging use of integrative taxonomic approaches for assessment of pelagic biodiversity;
- ToR e)** Advise on the implications of developments for marine science and management;
- ToR f)** Publish high-profile peer-reviewed articles that provide documented evidence of advances in metagenetic analysis of zooplankton diversity, distribution, and abundance;
- ToR g)** Determine the status of microzooplankton time-series data collection within the ICES area.

3 Summary of Work plan

ToR a) WGIMT will continue to add new members, who are experts in morphological and molecular taxonomy for major zooplankton groups; 2 members in common with other SCICOM EGs. (Years 1,2,3).

ToR b) WGIMT will complete and fully populate all areas of WGIMT.net web portal (Year 1). Specially-designed elements and deep links will be completed to support and promote use of technologies (Years 1, 2, 3).

ToR c) WGIMT will design, organize and offer integrative taxonomy workshops, including requesting support via ICES Taxonomy Workshop funds (Year 2).

ToR d) Organize special sessions at national and international conferences, including ASLO/AGU Ocean Sciences Meetings and the ICES Annual Science Conferences, among others. (Years 1, 2, 3).

ToR e) WGIMT will report via SSGEPD and SCICOM EGs on the promise, progress and pitfalls of integrative morphological – molecular taxonomy and metagenetics or metabarcoding (i.e., high throughput sequencing of environmental samples) for integrated ecosystem assessments (Years 2,3).

ToR f) WGIMT members will publish at least two papers each year focused on integrative taxonomy of zooplankton, using state-of-the-art molecular approaches, including overview, review, and perspective articles (Years 1, 2, 3).

ToR g) Compile a list of scientists and laboratories measuring microzooplankton groups within time-series datasets; comparison of sampling and analysis methods and identify any gaps in data collection; database input; webpage update (Years 2,3).

4 List of Outcomes and Achievements of the WG in this delivery period

Relevant Publications by WGIMT members

Aguirre M, Abad D, Albaina A, Goñi-Urriza MS, Estonba A, Zarraonaindia I. (2017) Unraveling the environmental and anthropogenic drivers of bacterial community changes in the estuary of Bilbao and its tributaries. PLoS ONE 12(6):e0178755. doi:10.1371/journal.pone.0178755

Cornils, A., B. Wend-Heckmann, C. Held (2017) Global phylogeography of *Oithonasimiliss*.l. (Crustacea, Copepoda, Oithonidae) – A cosmopolitan plankton species or a complex of cryptic lineages? MolecPhylogEvol 107: 473–485

Bode, M, S Laakmann, P Kaiser, W Hagen, H Auel, A Cornils (2017) Unravelling diversity of deep-sea copepods using integrated morphological and molecular techniques. Journal of Plankton Research 39 (4), 600-617

Bradford-Grieve JM, Blanco-Bercial L, Boxshall GA (2017) Revision of Family Megacalanidae (Copepoda: Calanoida). Zootaxa 4229:183.

Bradford-Grieve JM, Blanco-Bercial L, Prusova I (2017) *Calanoides natalis* Brady, 1914 (Copepoda: Calanoida: Calanidae): identity and distribution in relation to coastal oceanography of the eastern Atlantic and western Indian Oceans. J Nat Hist 51:807-836 Bucklin A., K. DiVito, I.

- Smolina, M. Choquet, J.M. Questel, G. Hoarau, and R.J. O'Neill (2018) Population Genomics of Marine Zooplankton. In: Population Genomics. Springer, Cham. DOI https://doi.org/10.1007/13836_2017_9 . Submitted manuscript version of the chapter is available pre-publication at: <https://hdl.handle.net/1912/9562> .
- Cuende E, Mendibil I, Bachiller E, Álvarez P, Cotano U, Rodríguez-Ezpeleta N (2017). A Real-time PCR approach to detect predation on anchovy and sardine early life stages. *Journal of Sea Research* 130: 204-209.
- Khodami S, McArthur JV, Blanco-Bercial L, Martínez Arbizu P (2017) Molecular Phylogeny and Revision of Copepod Orders (Crustacea: Copepoda). *Scientific Reports* 7:9164
- Laakmann S, Boos K, Knebelberger T, Raupach MJ, Neumann H (2017) Species identification of echinoderms from the North Sea by combining morphology and molecular data. *Helgoland Marine Research* 70: 18.
- Madoui MA, Poulain J, Sugier K, Wessner M, Noel B, Berline L, Labadie K, Cornils C, Blanco-Bercial L, Stemmann L, Jamet JL, Wincker P (2017) New insights into global biogeography, population structure and natural selection from the genome of the epipelagic copepod *Oithona*. *Molecular Ecology* 26: 4467-4482
- Rey A, Basurco OC, Rodríguez-Ezpeleta N (2017). The challenges and promises of genetic approaches for ballast water monitoring. *Journal of Sea Research*. 133: 134-145
- Tricarico E, Borrell YJ, Garcia-Vazquez E, Rico JM, Rech S, Scapini S, Johovic I, Rodríguez-Ezpeleta N, [...], Garcia de Leaniz C, Consuegra S. (2017) Developing innovative methods to face aquatic invasions in Europe: the Aquainvad-ED project. *Management of Biological Invasions*. 8: 403:408
- Villarino E, Watson JR, Jönson B, Gasol JM, [...] Rodríguez-Ezpeleta N, [...], Duarte C, Irigoien X, Chust G (2018). Large-scale ocean connectivity and planktonic body size. *Nature Communications* 9:142
- Weydmann A., Przyłucka A., Lubośny M., Walczyńska K., Serrão E.A., Pearson G.A., Burzyński A. (2017) Postglacial expansion of the Arctic keystone copepod *Calanus glacialis*. *Marine Biodiversity*, DOI: 10.1007/s12526-017-0774-4.
- Weydmann A., Przyłucka A., Lubośny M., Walczyńska K., Serrão E.A., Pearson G.A., Burzyński A. (2017) Mitochondrial genomes of the key zooplankton copepods Arctic *Calanus glacialis* and North Atlantic *Calanus finmarchicus* with the longest crustacean non-coding regions. *Scientific Reports*, DOI: 10.1038/s41598-017-13807-0.

Theme Sessions and Workshops Organized by WGIMT Members

WGIMT, WGZE and WGPME co-sponsored a Theme Session at the ICES 2017 Annual Science Conference (Fort Lauderdale, Florida, USA), *Microbes to Mammals: Metabarcoding of the Marine Pelagic Assemblage*, co-convened by Ann Bucklin (USA), Rowena Stern (UK), Katja Metfies (Germany).

WGIMT member Rowena Stern (UK) was an organizer of an international workshop, in partnership with WGPME, *Symposium on High Throughput Methods Applied to Marine Biodiversity Time-Series*, 11–13 October 2017 Hannover, Germany.

WGIMT members Ann Bucklin (USA) and Leocadio Blanco-Bercial (Bermuda) convened a session, *Rediscovering Marine Biodiversity: Progress, Promise, and Challenges of*

Metabarcoding of Microbes to Mammals, at the 2018 Ocean Sciences Meeting (Portland, Oregon, USA; February 10-16, 2018).

5 Progress report on ToRs and workplan

5.1 ToR a) Ensure balanced morphological – molecular expertise among membership of WGIMT

The WGIMT membership has grown consistently each year since the creation of SGIMT in 2012. WGIMT membership now totals 47 members from 17 countries (as of March 31, 2018) and a number of these are members of other ICES SCICOM WGs, including WGZE, WGPME, WGBOSV, WGITMO, WGAGFA, WGCEPH, WGINOR, WGIAB, WGDIG.

A total of 18 members and guests attended the WGIMT 2018 Annual Meeting in person and attendance showed a good balance between morphological and molecular experts.

WGIMT balance at 2018 meeting

	Number	%
Morphological	8	44.4
Molecular	3	16.7
Both	5	27.8
None	2	11.1
Zooplankton	14	87.5
Phytoplankton	1	6.3
Fish	0	0.0
Eukaryotes	1	6.3

WGIMT has now largely met the goals of this ToR for expanded membership. New members are still welcome, especially those who develop and use molecular and/or morphological approaches to taxonomic analysis of zooplankton. Membership in WGIMT extends to scientists working in any ocean region, in addition to the ICES area.

5.2 ToR b) Fully populate the WGIMT web platform with information, protocols and resources to support progress in research and development

Todd O'Brien reported that the WGIMT web platform (<http://wgimt.net>) is online, and that "menu buttons" and page materials have been added for all current sub-topics of the WGIMT working group. Todd reminded the group that this web platform will be most useful if its content is kept updated and relevant to the groups work and areas of expertise. WGIMT members, and especially the ToR leaders, were encouraged to look through the WGIMT web pages and to send Todd any updates, additions, or corrections. Even though initial development of this web platform is completed, it will continue to be updated and expanded as WGIMT continues into the future.

5.3 ToR c) Initiate and support provision of standards, training materials, and taxonomy workshops

As a response to the expected deliverables of this ToR, several initiatives have been presented:

- M. Grazia Mazzocchi reported on The Marine Organism Taxonomy Service (MOTax), a Stazione Zoologica Anton Dohrn (SZN, Naples, Italy) initiative aimed to promote, maintain and develop taxonomy among marine scientists. Taxonomy has been revitalized in the last years by the molecular tools to improve our understanding of marine biodiversity, ecosystem functioning and services. SZN has a long tradition in taxonomic studies since its foundation in 1872 and has still numerous taxonomic experts on marine organisms, especially for plankton and benthos as well as a Molecular Biology and Bioinformatic Unit. SZN is the hub of national MOTax network to coordinate and promote a range of taxonomy initiatives and provide specialized services based on integrated morphological and molecular taxonomy as part of EMBRC-IT. During the kick off meeting in October 2016 at SZN, problems and strategies were discussed. After the meeting, the Italian taxonomists were “censed” to identify a national reference community for systematics and taxonomy of marine organisms (from bacteria to fish) and to provide a common portfolio of taxonomic services and skills as a distributed service. A quarterly newsletter is published on the SZN website to report and update about events, references, congresses and meetings. The MOTax Service is going to provide: 1) integrated morphological and molecular identification, 2) isolation and cultivation of target marine organisms, 3) access to, and supply of, certified marine organisms, 4) revision and update of checklists, 5) advanced training and courses.
- The 1st Advanced Zooplankton Course (AZC1), organised by M. Grazia Mazzocchi, will be held on 22 October -2 November 2018 at SZN, on the traces of the “Advanced Phytoplankton Course (APC)” that is regularly organized at SZN, almost every three years, since 1990. The MOTax at SZN intends to start a series of courses on zooplankton taxonomy by integrating morphological and molecular approaches. For this first year, the course will be focused on marine copepods, it will last two weeks and will be sponsored by Leica, with endorsement by ICES and the World Copepod Association (WAC). AZC1 will aim to increase and update the expertise in the taxonomy and species identification of selected copepod families commonly and abundantly distributed in epipelagic and/or mesopelagic waters, by integrating morphological and molecular approaches.
- The EUROBUS workshop “Towards an European observatory of the invasive calanoid copepod *Pseudodiaptomus marinus*” was held at SZN on 29-30 January 2018. Biological invasions represent a serious threat to aquatic ecosystems, and are presently a big issue in the scientific community. Among invasive copepods, *P. marinus*, native to the Indo-Pacific region, shows a great invasive attitude. Over the last 10 years, its presence has been documented in European waters and the number of recordings is steadily increasing. The aims of the workshop were agreed with ICES: 1) define the present status of the European invasion by *P. marinus* and identify the potential means of primary and sec-

ondary introduction; 2) provide a forum for real-time monitoring of the distributional range, abundance and/or biomass of this species in European waters and the environmental conditions in the invaded environment; 3) establish a group dedicated to promoting knowledge sharing and sustaining international collaborations; 4) make country-level introduction events information of *P. marinus* available through AquaNIS; 5) identify future research perspectives of this species, including ecosystem impact, systematics and taxonomy. The topic of EUROBUS is directly related to research and advisory goals of several ICES WGS, (WGZE, WGIMT, WGITMO, WGBOSV). A total of 22 people participated from 7 different countries and another 5 people from two additional countries could not participate. The first part of the meeting was dedicated to 12 presentations, which reported about the occurrence of *P. marinus* in areas with different environmental conditions: coastal/neritic areas (Southern North Sea, Baltic Sea, Southern Tyrrhenian Sea, Adriatic Sea, Black Sea), estuaries (Bilbao estuary, Mondego estuary), lagoons (Berre lagoon, Lake Faro, Lake Fusaro, Venice lagoon). As a result, new localities have been added to the map of *P. marinus* distribution in European waters. In addition, first evidences derived from molecular approaches on this species were presented, mostly in terms of ITS2 sequencing. The second day of the workshop was dedicated to open discussion on results, problems and future perspectives, including 1) possible uses of *P. marinus* as model species to applied research (ecotoxicology, aquaculture), 2) the preparation of a position paper, and 3) the creation of an ICES Expert Group (EG) parented by the Ecosystem Processes and dynamics Steering Group.

- The workshop Plankbios “Present and future plankton biogeography and the link between community structure, marine ecosystem functioning and ecosystem service provision” was held at ATZI (Spain) on 13–15 June 2017. Relevant topics presented and discussed at the workshop were biogeography, biodiversity, ecological niches and connectivity, and the numerical tools to address the databases to answer questions related to these topics. Invited talks were given by WGIMT members: Xabier Irigoien: How much fish in the ocean? And where?; Sakina Ayata: Towards molecular oceanography: linking omics to communities and multi-scale processes in the ocean; NaiaraRodriguez-Ezpeleta: The promise of genomic approaches for plankton biodiversity assessment.
- A symposium entitled “High Throughput Methods Applied to Marine Biodiversity Time Series: Addressing their Challenges to Fulfill their Promises” was held in Hannover (Germany) in October 2017; it was organized by Alex Kraberg, KatjaMetfies, Nicole Poulton (WGPME), and WGIMT member Rowena Stern. Experts in high throughput imaging and genetic methods were invited to develop a framework that will integrate high throughput methods into long-term marine observations. A direct outcome of the meeting was an EU Marie Curie Training network proposal led by Alex Kraberg (WGPME) in which students will be trained in a variety of genetic, microscopic and imaging methods to observe marine microbes for their individual projects. The data will be cross compared to develop a standardised protocols and understand biases in observations.

5.4 ToR d) Organize special sessions at national and international conferences, including Ocean Sciences Meetings, ICES Annual Science Conference, others

As a response to the deliverables of this ToR, during 2017/2018, WGIMT members organized successful sessions related to morphological – molecular integrative taxonomy of zooplankton at two conferences:

- ICES 2017 Annual Science Conference (Sept. 2017, Fort Lauderdale, FL); Theme Session C: Microbes to mammals: metabarcoding of the marine pelagic assemblage; co-convenors: Ann Bucklin (USA), Rowena Stern (UK), Katja Metfies (Germany)
- ASLO/AGU 2018 Ocean Sciences Meeting (Feb. 2018, Portland, OR); SE41/E44: Rediscovering marine biodiversity: progress, promise, and challenges of metabarcoding of microbes to mammals; co-chairs: Ann Bucklin (USA); Leocadio Blanco-Bercial (Bermuda); Ryuji Machida (Taiwan)

For the future, a theme session organized by WGIMT and WGZE members has been approved by ICES and has received a total of 19 abstracts submitted, including 12 oral presentations and 7 posters:

- ICES 2018 Annual Science Conference (Sept. 2018, Hamburg, Germany); Session M: Molecules and morphology: Integrative taxonomic analysis of marine planktonic assemblages; co-convenors: Pennie Lindeque (UK); Lidia Yebra (ES); Ann Bucklin (USA)

5.5 ToR e) Advise on the implications of developments for marine science and management

Metabarcoding has the potential to rapidly detect and describe marine biodiversity, and can consequently contribute to improve our understanding of the impacts of climate change and anthropogenic effects on marine ecosystems. Yet, before this is possible, standardization and validation of metabarcoding analytical approaches is necessary for development of practical indicators and useful applications for assessment and management of pelagic ecosystems, including calculation of biotic indices, targeted detection of indicator species, food-web analysis, and detection of introduced, non-indigenous species.

This ToR aims at i) promoting and facilitating the use of integrative morphological – molecular taxonomy as a foundation for assessing species diversity and abundance of marine organisms, especially zooplankton, in integrated ecosystem assessments, ii) leading to standardization of metagenetic and metabarcoding approaches to fulfil requirements of biodiversity assessments and indicators defined in the Marine Strategy Framework Directive (MSFD). For that aim, members of the WGIMT have shared the work they are performing in this field as well as that carried out in collaboration with other Working Groups such as the WGPME and WGAGFA.

During the development of this ToR, members of the group discussed applications of metabarcoding that are related to marine management while highlighting the challenges for a routine use of this technique. The topics addressed were:

- Detection of non-indigenous species (NIS) in ballast water and performing port baseline surveys this work is being performed within the project Aquainvad-ED (<https://www.aquainvad-ed.com/>).
- Determining environmental status through the measurement of indicators included in the MSFD. This work has been performed through the already finished project DEVOTES (<http://www.devotes-project.eu/>), but is being continued through collaboration with local agencies. The analyses have mostly focused on benthic macroinvertebrate metabarcoding, but endeavours including zoo and phytoplankton have also started.
- Analysis of trophic relationships and food web dynamics: this work has been performed using two different approaches: i) the metabarcoding analysis of stomach contents and the detection of specific species (anchovy, sardine) using quantitative PCR (qPCR).

Technical challenges for the routine implementation of metabarcoding to the above mentioned applications have been raised. The most urgent to be addressed being:

- To produce a reference DNA sequence databases for target species, groups, and regions: WGIMT should consider development of proposals to support creation of comprehensive reference databases to support identification of taxa (Operational Taxonomic Units, or OTUs) resulting from metabarcoding analysis. Consideration should be given to coordination and collaboration with the Barcode of Life Database (BOLD, see URL <http://www.boldsystems.org/>); Ocean Genome Legacy (see <https://www.northeastern.edu/ogl/>); and others.
- To work towards standardization of sampling, laboratory and data analysis protocols: WGIMT can and should provide useful leadership in identifying topics and areas of high priority for new research and application of integrative morphological - molecular taxonomic approaches.
- To work towards collaborative work among morphological taxonomists and geneticists. This will help to identify 1) impacts of gene marker of choice for identification of taxa; and 2) gap analysis to evaluate taxonomic constituents in reference databases.

5.6 ToR f) Publish high-profile peer-reviewed articles that provide documented evidence of advances in metagenetic analysis of zooplankton diversity, distribution, and abundance

A list of relevant publications by members of the group for the reporting period has been produced (see list in Section 4, above).

Ongoing work on diet characterization of sardina and on global ocean plankton distribution, carried out by two members of the group has been presented.

- Diet of *Sardina pilchardus* larvae in the Bay of Málaga (Alboran Sea, SW Mediterranean) - Lidia Yebra. The most common small pelagic fish species in Málaga Bay (SW Mediterranean Sea) is the sardine (*Sardina pilchardus*). Despite its commercial importance in the region, little is known about the ecology of their early life stages and their role in the trophic web dynamics. However, the importance of zooplankton in the diet of sardine larvae in productive regions of the Mediterranean Sea and Iberian Atlantic littoral has been recognized. We did a 26 hours survey during which we followed a shoal of sardine larvae (ranging 6–21 mm standard length) and the associated zooplankton community in the northern Alboran Sea. The diet of the sardine larvae was analyzed by multiplex-PCR targeting the 5 most abundant copepod species during the sampling, and compared with the zooplankton community composition, analyzed morphologically. Diel variability was observed in plankton abundance, both in the field and in larval gut contents, suggesting an opportunistic foraging behaviour, rather than a selective one.
- Analysis of global ocean zooplankton distribution and ocean basin connectivity – Naiara Rodriguez-Ezpeleta . Using metabarcoding, it is possible to compare communities present in different locations, giving us information about the existing connectivity among different areas and about the differential drift potential of each taxonomic groups. Initiatives to avoid habitat fragmentation and definition of marine protected areas could benefit from this application of the techniques and were discussed. Two studies on micro and mesozooplankton global ocean distribution were presented and members of the group were encouraged to participate so that the final output benefits from the varied and multidisciplinary knowledge of the group.

5.7 ToR (g) Determine the status of microzooplankton time-series data collection within the ICES area

This is a new ToR carried out in collaboration with WGZE. This effort builds upon previous WGZE efforts, including a 2007 review of the role of microzooplankton in the marine food web, which called for inclusion of both micro-and mesozooplankton experts in the EG, and encouraged microzooplankton time-series sampling and monitoring within the ICES area. This new ToR will assess progress made in this area over the last ten years and strengthen collaboration of WGIMT with WGZE and identify gaps or overlap with other EGs. Prior to the meeting, a survey on microzooplankton time-series was circulated; responses received to date were collated and presented but it is anticipated that more responses will be received over the coming months. A suggestion was made to add Flowcytobot to the list of imaging methods presented for enumerating microzooplankton. The team at Woods Hole lead by Heidi Sosik should also be able to provide time-series information. Todd O'Brien offered to compile a map showing areas where microzooplankton time-series exist.

6 Revisions to the work plan and justification

Although in 2017, WGIMT recommended a new ToR to be carried out jointly WGPME ToR h): *Review and evaluate methodologies used for metagenetic or metabarcoding analysis of plankton*], coordination with WGMPE for this aim has not been possible due to other priority ToRs and difficulty in meeting during the same time period. The discussion will be undertaken again in 2019, where a joint meeting of the two working groups has been proposed, but no commitments for ToRs will be advanced this year.

7 Next meetings

During Year 3 (2019), WGIMT proposes to meet in association with the Working Group on Zooplankton Ecology (WGZE) and the Working Group on Microbial and Phytoplankton Ecology (WGPME) at ULPGC, Las Palmas de Gran Canaria, Spain on 15 March 2019.

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
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Annex 2: WGIMT Multi-annual Terms of Reference 2017–2019

The **Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT)**, chaired by Naiara Rodriguez-Ezpeleta, Spain, and Elaine Fileman, UK, will work on ToRs and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2017	31 March	Boulogne-sur-Mer, France	Interim report by 1 June to SSGEPD	
Year 2018	24 March	Helsinki, Finland	Interim report by 1 June to SSGEPD	Change of Chair: Outgoing: Ann Bucklin Incoming: Elaine Fileman and Naiara Rodriguez-Ezpeleta
Year 2019			Final report by 1 June to SCICOM	

ToR descriptors

ToR	DESCRIPTION	BACKGROUND	SCIENCE PLAN		EXPECTED DELIVERABLES
			TOPICS ADDRESSED	DURATION	
A	Ensure balanced morphological – molecular expertise among membership of WGIMT	a) Integrative taxonomy requires experts in both morphological and molecular taxonomic approaches. b,c) Members in common will facilitate coordination between WGIMT and SCICOM EGs and help ensure goals are met.	1,2,9,10,27,28,31	Year 1,2,3	WGIMT will continue to add new members, who are experts in morphological and molecular taxonomy for major zooplankton groups; 2 members in common with other SCICOM EGs.
B	Fully populate the WGIMT web platform with information, protocols and resources to support progress in research and development	a) Locating and accessing morphological and molecular taxonomic information can be difficult: some classical taxonomic references are out-of-print; molecular data are not released prior to publication. b,c) Open access to data and information will expand use of state-of-the-art molecular technologies (e.g., High-	27,28,31	Years 1,2,3	Complete and fully populate all areas of WGIMT.net web portal (Year 1). Complete specially-designed elements and deep links to support and promote use of technologies

		Throughput Sequencing) for integrative taxonomy of zooplankton.			(Years 1, 2).
C	Initiate and support provision of standards, training materials, and taxonomy workshops	a,b) Workshops, including ICES Taxonomy Workshops, are very effective in engaging target audiences and ensuring trained technicians and researchers for applications in fisheries and ecosystem management. c) Co-sponsored workshops and meetings with other SCICOM EGs will increase impact and likelihood of application for advisory applications.	27,28,31	Year 2	Design, organize and offer integrative taxonomy workshops; request support via ICES Taxonomy Workshop funds (Year 2)
D	Demonstrate leadership in promoting and encouraging use of integrative taxonomic approaches for assessment of pelagic biodiversity	a,b,c) Integrative taxonomy is an emergent field; uses and applications for fisheries and ecosystem management should be explained in high-visibility settings in ICES and other organisations through special sessions	1,2,9	Years 1,2,3	Organize special sessions at national and international conferences: ASLO/TOS Ocean Sciences Meetings; ICES ASC (Years 1, 2, 3).
E	Advise on the implications of developments for marine science and management	b,c) Integrative taxonomy (e.g., 'library' of DNA sequences for accurately-identified species) can provide a foundation for genetic methods for assessing species, diversity and abundance in integrated ecosystem assessments. c) Standardized metagenetic data can fulfill requirements of biodiversity assessments (WGPME) and indicators defined in the Marine Strategy Framework Directive (WGAGFA).	28,31	Years 2,3	Report via SSGEPD and SCICOM EGs on promise, progress and pitfalls , of metagenetics (metabarcoding) for integrated ecosystem assessments (Years 1, 2, 3).
F	Publish high-profile peer-reviewed articles that provide documented evidence of advances in metagenetic analysis of	a) Stronger foundation and visibility in primary research literature is needed to establish the validity of metagenetic approaches for analysis of zooplankton diversity. b) Publication in peer-reviewed scientific journals will demonstrate	1,2,9,10	Years 1, 2, 3	Publish two papers focused on integrative taxonomy of zooplankton using state-of-the-art molecular approaches,

	zooplankton diversity, distribution, and abundance.	validity of data, protocols, and results, and allow dissemination and new applications in ecosystem management.			including overview, review, and perspective articles (Years 1, 2, 3).
G	Determine the status of microzooplankton time-series data collection within the ICES area.	a, c) Determine the status of microzooplankton time-series data collection within the ICES area, assess progress made in this area over the last ten years, and identify collaboration, gaps or overlap with other WGs (WGZE, WGPME).	1,2,9,10	Years 2, 3	List of scientists and laboratories measuring microzooplankton groups within time-series datasets; data table to compare sampling and analysis methods, indicate which groups are regularly counted or routinely missed; database input; webpage update.
H	Review and evaluate methodologies used for metagenetic analysis of plankton.	a, c) Recommend development of standardized protocols for applications in fisheries management and ecosystem assessment.	1,2,9,10	Years 2, 3	Present findings at scientific conferences (Year 2); Report to EG members and ICES community (Year 2, 3); prepare manuscript for publication in peer-reviewed journal (Year 3).

Summary of the Work Plan

Year 1	Recruit new members for WGIMT, ensuring balanced membership (ToR a); fully populate all areas of web portal (ToR b). Cooperate with other SCICOM EGs to promote and accelerate use of state-of-the-art molecular approaches for biodiversity assessment and applications for management and assessment goals (ToR e).
Year 2	Carry out collaborative activities with other SCICOM EGs to promote integrative taxonomy (ToR c). Publish peer reviewed scientific articles on topics central to the WGIMT mission (ToR f). Compile and disseminate information on microzooplankton (ToR g).
Year 3	Recommend, encourage, and enable use of integrated morphological and molecular taxonomic analysis of zooplankton in integrated ecosystem assessments in ICES area seas (ToRs d,e,f,h).

Supporting information

Priority:	This Working Group will assist ICES and its Expert Groups with issues related to the development, dissemination and application of taxonomic knowledge and
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	skills in support of Integrated Ecosystem Understanding. Accurate identification of species and characterization of species-level diversity are and will remain foundations of integrated ecosystem assessments of function and state. Integrated taxonomic approaches – including morphological, molecular, optical, and other – may enhance and accelerate progress toward rapid, automatable, and near-real-time identification of species for fisheries and integrated ecosystem assessments; detecting of the impacts of climate change on species diversity, distribution, abundance; and understanding alterations in food web structure and function, and associated biogeochemical cycles. The availability of and need for new technology and techniques in taxonomic analysis make WGIMT's goals and activities important and high priority.
Resource requirements:	No additional resources are requested or required for planned activities.
Participants:	The Expert Group now includes 42 members from 15 countries, with strong representation among experts in morphological and molecular taxonomic approaches. We continue to seek additional members, including especially members from partner ICES Working Groups and other scientists with needed expertise and knowledge. The goal is to maintain balance and coverage of varied taxonomic approaches (including morphological taxonomists for the full range of taxonomic groups) and ICES geographic regions.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to ACOM and groups under ACOM:	None.
Linkages to other committees or groups:	WGIMT arose as a Study Group from the WGZE in response to perceived need, meeting in association with WGZE during 2012 and 2013. WGIMT will remain in close partnership with WGZE and is pursuing additional partnerships (e.g., WGPME, WGAGFA), while promoting and supporting integrated morphological and molecular taxonomy science for the benefit of the ICES science and advisory communities as a whole.
Linkages to other organizations:	The work of this group relates to and is connected to a diversity of other projects and organisations, e.g., EU DEVOTES (DEvelopment Of innovative Tools for understanding marine biodiversity and assessing Good Environmental Status), BONUS BIO-C3 project, NOAA COPEPOD and COPEPODITE, GOBI, and others.

Annex 3: WGIMT 2018 Agenda

Friday March 23, 2018

- 9:00-9:15** Welcome and Introductions; Review of the Agenda
- 9:15-9:30** Overview of WGIMT status and multi-annual ToRs 2017-2019
- 9:30-9:45** ToR A) Ensure balanced morphological – molecular expertise among membership of WGIMT
Deliverables: WGIMT will continue to add new members, who are experts in morphological and molecular taxonomy for major zooplankton groups; 2 members in common with other SCICOM EGs (Years 1,2,3)
- 9:45-10:15** ToR D) Demonstrate leadership in promoting and encouraging use of integrative taxonomic approaches for assessment of pelagic biodiversity
Deliverables: Organize special sessions at national and international conferences: ASLO/TOS Ocean Sciences Meetings; ICES ASC (Years 1, 2, 3).
- 10:15-10:45** *Coffee Break*
- 10:45-12:00** ToR B) Fully populate the WGIMT web platform with information, protocols and resources to support progress in research and development
Deliverables: Complete and fully populate all areas of WGIMT.net web portal (Year 1). Complete specially-designed elements and deep links to support and promote use of technologies (Years 1, 2).
- 12:00-13:15** *Lunch Break*
- 13:15-13:45** ToR C) Initiate and support provision of standards, training materials, and taxonomy workshops
Deliverables: Design, organize and offer integrative taxonomy workshops; request support via ICES Taxonomy Workshop funds (Year 2)
- 13:45-14:45** ToR F) Publish high-profile peer-reviewed articles that provide documented evidence of advances in metagenetic analysis of zooplankton diversity, distribution, and abundance
Deliverables: Publish two papers focused on integrative taxonomy of zooplankton using state-of-the-art molecular approaches, including overview, review, and perspective articles (Years 1, 2, 3).
- 14:45-15:15** ToR E) Advise on the implications of developments for marine science and management
Deliverables: Report via SSGEPD and SCICOM EGs on promise, progress and pitfalls of metagenetics (metabarcoding) for integrated ecosystem assessments (Years 2, 3).
- 15:15-15:45** *Tea Break*

- 15:45-16:15** ToR G) Determine the status of microzooplankton time-series data collection within the ICES area
Deliverables: List of labs measuring microzooplankton groups, comparison of sampling methods and routine measurements; database input and webpage update (Years 2,3)
- 16:15-16:45** ToR H) Review & evaluate methodologies used for metagenetic analysis of plankton (Years 2,3)
Deliverables: present scientific findings at conferences (Year 2). Report to EG members & ICES community (Years 2,3); prepare manuscript for publication in peer-reviewed journal (Year 3)
- 16:45-17:30** Discussion to include Action Items and Planning for the Year Ahead
- 17:30** **ADJOURN**