

ICES SGIMT REPORT 2013

SCICOM STEERING GROUP ON ECOSYSTEM FUNCTIONS (SSGEF)

ICES CM 2013/SSGEF:07

REF. WGZE, SSGEF, SCICOM

Report of the Study Group on Integrated Morphological and Molecular Taxonomy (SGIMT)

14-16 March 2013

Lowestoft, UK



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Recommended format for purposes of citation:

ICES. 2013. Report of the Study Group on Integrated Morphological and Molecular Taxonomy (SGIMT) , 14-16 March 2013, Lowestoft, UK. ICES CM 2013/SSGEF:07. 22pp. <https://doi.org/10.17895/ices.pub.8848>

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Executive summary

Since its inception by the WGZE and set up at the ASC in 2009, the Study Group on Integrated Morphological and Molecular Taxonomy (SGIMT) has encouraged and facilitated discussions among concerned scientists and at ICES Expert Group meetings. During 2013, SGIMT met in association with the ICES Working Group on Zooplankton Ecology (WGZE) meeting in Lowestoft, UK. The meeting included a presentation and update to the WGZE on 12 March 2013 and a dedicated meeting during March 14-16, 2013. The primary goals of the meeting were to review progress the group's ToRs, reports and recommendations; consider guidance and suggestions from WGZE; plan SGIMT activities and efforts for the coming year; and discuss and agree upon ToRs for 2014.

The SGIMT membership has continued to grow during 2012-2013, with a total of 22 members (ToR a). The group agreed upon marked expansion and enhancement of our web portal (ToR b), which seeks to facilitate access to useful websites, materials, and online publications related to morphological, optical, and molecular approaches to species identification of zooplankton. SGIMT made specific plans for workshops dedicated to morphological, molecular, and integrative taxonomy (ToR c). SGIMT members will seek to facilitate and enhance web access to resource materials for species identification of zooplankton via the SGIMT portal, but will not seek to prepare new documents (ToR d will be folded into ToR b, above). SGIMT will continue efforts toward a review of molecular approaches to zooplankton taxonomy, framed initially as an update and expansion of the useful *ICES Zooplankton Methodology Manual*, written by WGZE members and published by ICES in 2000; also planned are white papers resulting from the workshops (ToR e). The WGZE-SGIMT contribution to the ICES 2013 ASC (Session E) will provide advice for marine science and management; a follow-up white paper from the session is planned (ToR f). For the coming year, ToR d was ended and a new ToR was added to cooperate with ICES WGITMO and WGBOSV on molecular identification of invasive and transported species.

Next year, SGIMT will meet in association with the annual WGZE meeting, planned for Reykjavik, Iceland in late March. Additional work will be carried out by correspondence, including WEBEX and SKYPE videoconferencing.

Opening of the meeting

SGIMT met in association with the 2013 WGZE meeting in Lowestoft, UK. The meeting included a plenary session with the Working Group on Zooplankton Ecology (WGZE) on 12 March 2013 and a dedicated meeting on 14-16 March 2013. The primary goals of the meeting were to: 1) hear suggestions and presentations from SGIMT members; 2) review the group's progress on ToRs, reports and recommendations; 3) consider guidelines and suggestions from WGZE; and 4) prioritize future ToRs in relation to the expertise of SGIMT members. The SGIMT 2013 meeting was attended by nine of the current 22 SGIMT members (Annex 1).

1 Adoption of the agenda

The agenda was circulated among SGIMT and WGZE members prior to the meeting to allow coordination and consideration of suggestions and comments. The meeting began on the afternoon of March 14th, immediately after the end of the WGZE meeting, and ended at 12:00 Noon on March 16th. The original agenda, with scheduled all-day meetings on 15-16 March 2013, was modified accordingly and adopted by acclaim (Annex 2).

The group gave careful consideration and discussed realistic planning for the SGIMT ToRs for the 2014 meeting.

2 ToRs (a)-(f)

2.1 ToR (a) Expand participation and membership for the 2013 SG meeting to ensure a balance of expertise between morphological and molecular taxonomic approaches and across taxonomic groups (*Ann Bucklin*)

The SGIMT membership has grown during 2012-2013, with a current total of 22 members (Annex 3). A SGIMT goal is to continue to expand membership by individual invitations; suggestions can be sent to Ann. Possible invitees might include Robert Jennings (UMass-Boston) and Simon Creer (Bangor University, UK). Ann will seek to recover the original invitation list from Steve Hay or Kathryn Cook. New members are welcome who work on issues significant for SGIMT in any ocean region, not only from the ICES region.

2.2 ToR (b) Develop a web platform for promotion and exchange of relevant scientific information (*Jasmin Renz, Silke Laakmann, Astrid Cornils, Todd O'Brien*)

Over the last year, a web portal for the study group was developed and hosted under the website of the ICES Working Group for Zooplankton Ecology (see <http://wgze.net/sgimt>). This web portal currently contains information about the goal of the study group as well a list of links to other taxonomic websites that present material (photos, identification keys, methodology manuals, and others) for the identification of marine zooplankton organisms. The Study Group discussed the current content of the website and decided on several actions that will be taken to enhance the content of the site, as described below:

Todd O'Brien purchased the SGIMT.net domain (<http://sgimt.net>) to officially host the web portal under its own domain address. After the SGIMT web content is migrated to this new site, the current WGZE/SGIMT sub-page (<http://wgze.net/sgimt>) will become a link to the new site, keeping the collaborative (as well as web) link active between WGZE and SGIMT.

As it is planned to include a large amount of information on the SGIMT web portal, Jasmin Renz will develop together with Todd O'Brien a website structure with headers and sub headers to facilitate the navigation through the contents for users. Ann Bucklin, Jasmin Renz and Silke Laakmann will get a user account to include information on the web portal. A disclaimer will be developed to explain that SGIMT seeks to provide links and access to information, but is not responsible for and cannot independently verify the accuracy of the information provided.

The Census of Marine Zooplankton website (see <http://cmarz.org>) contains extensive information relevant to the SGIMT mission, but has been inactive since the end of this large project (2010). Todd O'Brien and SGIMT members will coordinate the transfer of useful materials to the SGIMT web portal, including non-copyrighted PDF files, Internet links for species identification, as well as photos of living zooplankton. Ann Bucklin will ask Nancy Copley (WHOI, CMarZ website manager) to assist Todd with the transfer of the website content. Individual owners of photos on the CMarZ website will be consulted prior to transfer of the files to the SGIMT web portal. A link will be included on the old CMarZ website that the site is frozen but content can be now found under the new SGIMT web portal. Most of the material on molecular techniques on the CMarZ website are outdated and will not be transferred to the new portal.

Silke Laakmann and Astrid Cornils will continue working on the table covering techniques useful for species identification by molecular methods – this table will then be included in the web portal. Silke will get access to update the table if desirable. The current status of the table is appended to this report (Annex 4).

The inclusion of information of optical methods for species identification will be postponed until Mark Benfield, who holds the expertise, can assist with this task.

An official request will be sent to ICES by Piotr Margonski in communication with Todd O'Brien to ask whether the ICES fiches can be made accessible via the SGIMT web portal. Currently, a number of URL links to PDFs are not functional.

Information on relevant projects will be included in the SGIMT web portal:

- 1) Claudia Castellani (SAHFOS) is nearing completion of an identification key to North Atlantic Zooplankton that contains ecological and taxonomic information for all taxa, as well as methodological explanations. The book is expected to be published next year, after which information can be included on the web portal.
- 2) Ruth Böttger Schnack (Senckenberg Institute) is now focusing on the taxonomic resolution of the marine microcopepod family Oncaeidae and development of an interactive identification system.
- 3) Antonina Santos (IPMA) is updating identification keys for decapod larvae.
- 4) Maiju Lehtiniemi (SYKE) is organizing a workshop on Baltic Sea zooplankton species identification; information about the workshop will be included on the SGIMT portal.

2.3 ToR (c) Design and submit a proposal for an ICES taxonomy workshop to promote integrated morphological and molecular approaches to zooplankton taxonomy, with a focus on identifying species boundaries using molecules and morphology; prepare appropriate and necessary training materials, species keys. (*Janna Peters, Jasmin Renz, Claudia Castellani, Ann Bucklin, Silke Laakmann*)

SGIMT will encourage and facilitate the organization and announcement of taxonomy workshops, and especially seek to promote an integrative approach to molecular and morphological techniques. Comprehensive information on previous workshops will be sought to identify successful models and to avoid duplication. For example, see <http://www.taxonomytraining.eu/>

Among the proposed workshops are the following:

- 1) *SAHFOS-MBA Zooplankton Taxonomy Workshop (Claudia Castellani)*: A hands-on morphological-molecular workshop is anticipated, focusing on introductions to analytical methods (software) for analysis of DNA sequences. Initial plans are to schedule the workshop during summer 2015 at SAHFOS in Plymouth, UK.
- 2) *Future of Integrative Taxonomy (Janna Peters, Jasmin Renz, Silke Laakmann, Astrid Cornils)*: A multi-day workshop focused on a theoretical case-studies approach, with presentations and discussions invited distinguished researchers, will be held during Summer 2014 at the University of Hamburg or Senckenberg Institute (Germany). SGIMT members will coordinate effort to seek funds for the workshop to pay costs of travel and lodging of invited speakers, and ideally to provide funding for student attendees. The

organizing committee will prepare a Community White Paper from the “SGIMT Workshop on Integrative Taxonomy” that will focus on theoretical issues of integrative taxonomy, including appropriate use and approaches to integration of morphological, molecular, biochemical, ecological and biogeographical data.

- 3) *Baltic Zooplankton expert network (ZEN; Maiju Lehtiniemi)*: Working under Helsinki Commission (HELCOM), ZEN will discuss and consider plans for taxonomic taxon-specific workshops (e.g. cladocerans and copepods) that include hands-on training in morphological (microscopy) identification of species. These workshops will be announced and advertised by WGZE and SGIMT, with encouragement to members of both groups. Question whether possible to add either seminars or hands-on laboratory training in basic molecular approaches (e.g. barcoding)?

2.4 ToR (d) Assist in the revision and development of zooplankton species identification keys.

SGIMT members will seek to facilitate and enhance web access to resource materials for species identification of zooplankton via the SGIMT portal, but will not seek to prepare new documents. This ToR will be removed for 2014; the relevant goals and objectives will be met through addition of a special section of the SGIMT Web Portal (ToR b; Section IIB and IIC).

2.5 ToR (e) Develop the continuing integration of molecular and morphological taxonomy by preparing a review article, methodology manual, or other peer-reviewed summary of available techniques, approaches, and protocols; to be jointly authored by SG members; (*Ann Bucklin, Silke Laakmann, and others*)

SGIMT will consider approaches to publishing an update to the *ICES Zooplankton Methodology Manual (Chapter 11, Population Genetic Methods for Zooplankton)*. Ann Bucklin will review relevant scientific literature to ensure a unique niche; query journal editors about possible publication; prepare an outline of an overview paper; and ask for volunteers to accept writing assignments. Suggested timeline for this activity is: outline sent to contributors by June 1st; section contributions provided by Sept. 1st; and manuscript submitted by Mar 1st. Consistent with our mission, SGIMT will remain focused on primary mission of taxonomy and systematics.

Suggested concepts for the article will include ground-truthing for molecular approaches to characterizing zooplankton communities, with focus on taxonomy (species identification) and systematics (evolutionary and phylogenetic relationships). Work toward “gold standard” for integrated molecular-morphological analysis, as used for barcoding. Agree that species diversity and abundance measures are currently outside the current scope of the methodology update.

2.6 ToR (f) Advise on the application and use of recent developments in integrated morphological/molecular approaches to zooplankton identification for marine science and management.

ASC 2013 Special Session on Pelagic Foodwebs

SGIMT members and co-conveners Ann Bucklin and Janna Peters will prepare a white paper or publication from this session to evaluate and encourage new molecular approaches for quantification of zooplankton in predator/prey relationships and

assessment of selective feeding by comparison with prey species distribution and abundances in the pelagic environment.

A proposal for a special session at the Ocean Sciences Meeting 2014 was submitted, entitled, *Integrative Taxonomy of Marine Animals: Progress, Prospects and Pitfalls*. Submitted by: Ann Bucklin (University of Connecticut, USA), Dhugal Lindsay (JAM-STEAC, Japan), and Simon Creer (Bangor University, UK).

3 Recommendations

The next SGIMT meeting will be in association with the WGZE 2014 meeting planned for Reykyavik, Iceland during late March 2014. We plan to meet at the Icelandic Marine Research Institute (with permission from our hosts) for 1.5 days, beginning immediately at the end of the WGZE meeting. Additional work, including planning for summer 2014 and 2015 workshops, will be carried out by correspondence.

SGIMT is requesting that WGZE consider adopting SGIMT ToR (d) Assist in the revision and development of zooplankton species identification keys. SGIMT will remove this ToR (d) for 2014; folding this effort into ToR b (Sections IIB and IIC), entailing addition of a section of the SGIMT Web Portal with links to extant keys, guides, and other materials for species identification of zooplankton

New ToR (f) to cooperate with WGITMO (Henn Oljaveer, EST, Chair) and WGBOSV (Sarah Bailey, CA, Chair) to encourage and facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water.

Members in common among the groups (including Maiju Lehtiniemi) will facilitate cooperation. SGIMT efforts will include information and advice on molecular approaches and protocols for species identification, access to vouchered and/or type specimens, as desired; and assistance with addition of identifying DNA sequences (e.g. COI barcodes) for invasive species listed on AquaNIS (see <http://www.corpi.ku.lt/databases/index.php/aquanis>), with cross-referencing on the SGIMT web portal.

New ToR (g) to prepare the SGIMT request to ICES for either another term for SGIMT (2014-2017) or establishment of a WG on this topic. The proposed WGIMT will retain the primary mission of integrated molecular and morphological approaches to taxonomy and systematics. Specific goals of this ToR include SGIMT discussion and deliberation on issues of scope and focus, including:

- 1) Whether to expand the SGIMT scope beyond zooplankton;
- 2) Whether to include wholly molecular approaches to assessment of species diversity and abundance (e.g. high throughput next-generation sequencing of environmental samples);
- 3) Whether to include goals related to the application of molecular approaches for trophic ecology, foodweb structure and dynamics, detection of predator-prey relationships and prey selectivity.

Annex 1. List of SGIMT 2013 Annual Meeting Participants

NAME	E-MAIL
Ann Bucklin	E-mail ann.bucklin@uconn.edu
Claudia Castellani	E-mail cxc@sahfos.ac.uk
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Maiju Lehtiniemi	E-mail maiju.lehtiniemi@ymparisto.fi
Amy Maas (via Internet)	E-mail : amaas@whoi.edu
Piotr Margonski	E-mail pmargon@mir.gdynia.pl
Todd O'Brien	E-mail Todd.OBrien@noaa.gov
Jasmin Renz	E-mail jrenz@senckenberg.de

Annex 2. SGIMT Membership as of March 16, 2013

	First Last Name	Email Address	Membership	Start Date	Nomination
1	Christina Augustin	christina.augustin@io-warnemuende.de	Chair-invited Member	15/03/2012	Other
2	Dorte Bekkevold	db@aqua.dtu.dk	Member	01/01/2011	DK
3	Mark Benfield	mбенfie@lsu.edu	Chair-invited Member	29/03/2012	Other
4	Ann Bucklin	ann.bucklin@uconn.edu	Chair	01/01/2012	USA
5	Claudia Castellani	cxc@sahfos.ac.uk	Chair-invited Member	15/03/2013	Other
6	Kathryn Cook	kathryn.cook@scotland.gsi.gov.uk	Chair-invited Member	29/03/2012	Other
7	Astrid Cornils	Astrid.Cornils@awi.de	Chair-invited Member	15/03/2012	Other
8	Xabier Irigoien	Xabier.irigoyen@kaust.edu.sa	Chair-invited Member	15/03/2012	Other
9	Silke Laakmann	slaakmann@senckenberg.de	Chair-invited Member	15/03/2012	Other
10	Maiju Lehtiniemi	maiju.lehtiniemi@ymparisto.fi	Chair-invited Member	15/03/2012	Other
11	Pennie Lindeque	PKW@pml.ac.uk	Chair-invited Member	15/03/2012	Other
12	Amy Maas	amaas@whoi.edu	Chair-invited Member	11/03/2013	Other
13	Piotr Margonski	pmargon@mir.gdynia.pl	Chair-invited Member	27/03/2012	Other
14	Sanna Majaneva	Sanna.majaneva@gmail.com	Chair-invited Member	15/03/2012	Other
15	Vijayalakshmi R. Nair	vijayalakshmi40@hotmail.com	Chair-invited Member	15/03/2012	Other
16	Einar E. Nielsen	een@dfu.min.dk	Member	01/01/2011	DK
17	Todd D. O'Brien	Todd.O'Brien@noaa.gov	Chair-invited Member	29/03/2012	Other
18	Janna Peters	janna.peters@uni-hamburg.de	Chair-invited Member	15/03/2012	Other
19	Uwe Piatkowski	upiatkowski@geomar.de	Chair-invited Member	15/03/2012	Other
20	Jasmin Renz	jrenz@senckenberg.de	Chair-invited Member	15/03/2012	Other
21	Antonina Santos	antonina@ipma.pt	Chair-invited Member	30/03/2012	Other
22	Lidia Yebra	lidia.yebra@ma.iao.es	Chair-invited Member	27/03/2012	Other

Annex 3. SGIMT 2013 Meeting Agenda

Study Group on Integrated Morphological and Molecular Taxonomy

SGIMT – SSGEF07

Annual Meeting March 14-16, 2013

Hotel Victoria, Lowestoft, UK

AGENDA

Meeting place*: Coastside Room, Hotel Victoria, Lowestoft, UK

*Arrangements will be made as desired for remote access via SKYPE

Thursday, March 14th

1400 ToR (b) Develop a web platform for promotion and exchange of relevant scientific information (Jasmin Renz, Silke Laakmann, Todd O'Brien)

1530 Coffee break

1545 ToR (d) Assist in the revision and development of zooplankton species identification keys. (Ann, Todd, Claudia)

1630 ToR (c) Design and submit a proposal for an ICES taxonomy workshop to promote integrated morphological and molecular approaches to zooplankton taxonomy, with a focus on identifying species boundaries using molecules and morphology; prepare appropriate and necessary training materials, species keys. (Janna Peters, Jasmin Renz, Claudia Castellani, Ann Bucklin)

1700 Adjourn for the day

1900 Group dinner

Friday, March 15th

0900 Review of SGIMT 2012 ToRs, reports, and recommendations

1000 SGIMT members' updates and statement of interests

Individual presentations as desired (PPT, PDF, DOC)

- Areas of interest and expertise related to SGIMT
- Description and update of recent activities or programs related to SGIMT goals

Suggestions for specific activities that you wish to propose for SGIMT

1100 ToR (a) Expand participation and membership for the 2013 SG meeting to ensure a balance of expertise between morphological and molecular taxonomic approaches and across taxonomic groups (Ann Bucklin)

1545 ToR (e) Develop the continuing integration of molecular and morphological taxonomy by preparing a review article, methodology manual, or other peer-

reviewed summary of available techniques, approaches, and protocols; to be jointly authored by SG members; (Ann Bucklin, Silke Laakmann, and others)

- Review topics and develop outline
- Review relevant scientific literature
- Decide writing assignments

1700 Adjourn for the day

1900 Group dinner

Saturday, March 16th

0900 ToR (f) Advise on the application and use of recent developments in integrated morphological/molecular approaches to zooplankton identification for marine science and management. (Astrid Cornils)

1030 Afternoon coffee and tea break

1045 Detailed planning of activities, action items, next steps

- Ocean Sciences 2014 Special Session

- Next SGIMT meeting

1200 Adjourn

SGIMT SUGGESTED READING and BACKGROUND INFORMATION

SGIMT Background Documents

Please find meeting and background documents of interest on the SGIMT-2013 Sharepoint at: <https://groupnet.ices.dk/SGIMT2013/default.aspx> (login required)

- SGIMT Presentation to WGZE (March 12, 2013): PDF conversion of PPT
- SGIMT 2012 Report

ICES Zooplankton Species ID pages (ZIMNES): see <http://192.171.193.133/>

ICES webpages: see <http://info.ices.dk/products/fiche/Plankton/START.PDf>.

Annex 4. Table of PCR Primers and References (Draft for Comments)

					Primer for Amplification and Sequencing			
Taxon		Marker	Primer Name	Direction	Sequence (5'-3')		Reference	Amplification in combination with
Various Marine Invertebrates								
		Mitochondrial COI	LCO-1490	Forward	GGTCAACAAATCATAAAGATATTGG		Folmer et al., 1994	HCO2198, Nancy
		Mitochondrial COI	HCO-2198	Reverse	TAAACTTCAGGGTGACCAAAAAATCA		Folmer et al., 1994	LCO1490
		Mitochondrial COI	Nancy	Reverse	CCCGGTAAAAATATAATAAACTTC		Simon et al., 1994	LCO1490
		Mitochondrial cyt b	UCYTB151F	Forward	TGTGGRCNACYGWATYACTAA		Merritt et al., 1998	UCYTB270R
		Mitochondrial cyt b	UCYTB270R	Reverse	AANAGGAARTAYCATYCTNGYTG		Merritt et al., 1998	UCYTB151F
		Nuclear 28S	28S-F1a	Forward	GCGGAGGAAAAGAACTAAC		Ortman, 2008	28S-R1a
		Nuclear 28S	28S-R1a	Reverse	GCATAGTTTCAACATCTTTCCGG		Ortman, 2008	28S-F1a
		Nuclear 28S	D9/10 Forward	Forward	CGCGGGAGTAACCTATGACTCTCTTAAGGT		Zardoya et al., 1995	D9/10 Reverse
		Nuclear 28S	D9/10 Reverse	Reverse	CCGCCCAACCAAACTCCCA		Zardoya et al., 1995	D9/10 Forward
		Nuclear 18S	18A1 mod	Forward	CTGGTTGATCTCGCAGTCATATGC		Raupach et al., 2009	1800
		Nuclear 18S	1800 mod	Reverse	GATCCTTCGCCAGGTTCACCTACG		Raupach et al., 2009	18A1
		Nuclear 18S	18SE	Forward	CTGGTTGATCTCGCAGT		Hillis and Dixon, 1991	18SL
		Nuclear 18S	18SL	Reverse	CACCTACGGAAACCTTGTTACGACTT		Hamby and Zimmer, 1988	18SE
Crustacea								
Copepoda								
		Mitochondrial COI	Cop-COI-2189R	Reverse	GGGTGACCAAAAAATCARAA		Bucklin et al., 2010a	LCO1490
		Mitochondrial COI	Cop-COI-1498F	Forward	AAYCATAAAGAYATYGGDAC		Bucklin et al., 2010a	HCO-2198
		Mitochondrial COI	Cop-COI-2105R	Reverse	CGRTCHGTHARNARYATDGTAAATDGC		Bucklin et al., 2010a	LCO1490
		Mitochondrial COI	Crus-COI-2198R	Reverse	CCHACDGTAAAAYATRTGRTG		Bucklin et al., 2010a	LCO1490
		Mitochondrial COI	Crus-COI-2428R	Reverse	TTAAHCHGTDGGNACVCGAAT		Bucklin et al., 2010a	LCO1490
		Mitochondrial COI	HCO-Co-2358	Reverse	CCHACDGTAAAAYATRTGRTG		Bucklin et al., 2010b	LCO1490
	Eucalanidae	Mitochondrial COI	COL_RNI	Forward	GTAGT(AGCT)GTAACTAT)GCTCATGC		Goetze and Bradford-Grieve, 2005	COL_VH
	Clausocalanus	Mitochondrial COI		Forward	GAGCCTGGTCAAGGAATAATCG		Blanco-Bercial and Álvarez-Marqués, 2007	
	Clausocalanus	Mitochondrial COI		Reverse	GGTCTCTCTCTCTCCACAT		Blanco-Bercial and Álvarez-Marqués, 2007	
	Calanoida	Mitochondrial COI	LCO-1703	Forward	CTATTGTGATGGAGGATTTTGG		Hill et al., 2001	internal primer
	Calanoida	Mitochondrial COI	LCO-1719	Forward	GGATTGGTAACTGATTATGTC		Hill et al., 2001	internal primer
		Mitochondrial COI	H2612-COI	Reverse	AGGCCTAGGAAATGTATAGGAA		Figueroa, 2011	L592-RCOI
		Mitochondrial COI	L592-RCOI	Forward	AACCTTAATACATCTTTTATGATG		Figueroa, 2011	H2612-COI
	Pleuromamma	Mitochondrial COI	PLXI_VH		CCAAACGTTCTTCTTCTTCC		Goetze, 2011	PLXI_VL
	Pleuromamma	Mitochondrial COI	PLXI_VL		TCAGCCAGGGTCTTTAATTGG		Goetze, 2011	PLXI_VH
	Calanus helgolandicus	Mitochondrial COI	ChelgCOI-F	Forward	GGCCAAACAACGGGAGAGATA		Papadopoulos et al., 2005	ChelgCOI-R
	Calanus helgolandicus	Mitochondrial COI	ChelgCOI-R	Reverse	CGGACTCAGTATAATTATTCGTTCTA		Papadopoulos et al., 2005	ChelgCOI-F
	Eucalanidae	Mitochondrial 16S	16SAR	Forward	CGCCTGTTTATCAAAAAACAT		Braga et al., 1999	16SCB
	Eucalanidae	Mitochondrial 16S	16SCB	Reverse	ATTCAACATCAGGATGCACAA		Braga et al., 1999	16SAR
	Acartia	Mitochondrial 16S	16S-167	Forward	GACGAGAAGACCCCTATGAAG		Bucklin et al., 1998	16sbr-H
	Acartia	Mitochondrial 16S	16sbr-H	Reverse	CCGGTTTGAACCTCAGATCATGT		Palumbi, 1996	16S-167
	Pareucalanus	Mitochondrial 16S	16S_PAR1		GCTAAGTACATAATAATATAGTT		Goetze, 2003	
	Subeucalanus	Mitochondrial 16S	16S_SUB2		AAGTCTAAGGTAGCATAAT		Goetze, 2003	
	Eurytemora	Mitochondrial 16S	16SA2	Forward	CCGGTCTTCTGCTAAGGTAG		Lee, 2000	16SB2
	Eurytemora	Mitochondrial 16S	16SB2	Reverse	CAACATCGAGGTCCGACGTAA		Lee, 2000	16SA2
	Skistodiaptomus	Mitochondrial 16S	Skisto-1	Forward	TGTTAAGGTACGATAATAAT		Thum and Harrison, 2009	Skisto-2
	Skistodiaptomus	Mitochondrial 16S	Skisto-2	Reverse	CCGGTTTGAACCTCAGATCATGT		Thum and Harrison, 2009	Skisto-1
	Calanidae, Eucalanidae	Mitochondrial cyt b	L10319-CYB	Forward	CCTTGGGKCAAGTGTCTTTTGGG		Machida et al., 2004	H10648-CYB
	Calanidae, Eucalanidae	Mitochondrial cyt b	H10648-CYB	Reverse	GATAAAATTTTCGCGTCT		Machida et al., 2004	L10319-CYB
	Neocalanus cristatus	Mitochondrial cyt b	Necr-CYB-L1	Forward	TTGGTGGTGACCTTGTACAGTGG		Machida et al., 2004	
	Oncaids, Tigriopus	Mitochondrial 12S	L13337-12S	Forward	YCTACTWTGATACGACTTATCTC		Machida et al., 2002	H13842-12S
	Oncaids, Eucalanidae, Calanidae	Mitochondrial 12S	H13842-12S	Reverse	TGTGCCACASCTCCGGTTAKAC		Machida et al., 2004	L13337-12S
	Disseta	Nuclear 28S	F352-28S	Forward	AGACCGATAGTMAACAAGTACCGT		Machida and Tsuda, 2010	
	Disseta	Nuclear 28S	R768-28S	Reverse	TAGACTCTTSGTCCGTTTCA		Machida and Tsuda, 2010	
	Calanoida	Nuclear 18S	18S-693R	Reverse	AAACCTCTGGCAAAACACTACG		Bucklin et al., 2003	18SE
	Calanoida	Nuclear 18S	F1665-18S	Forward	CCGTGCTACTACCGATTGAACG		Machida (unpubl) in Figueroa, 2011	R73-5.8S
	Calanoida	Nuclear 18S	R73-5.8S	Reverse	GTGTGATGTTCACTGTCTCTGC		Machida (unpubl) in Figueroa, 2011	F1665-18S
	Diaptomidae	Nuclear 18S	18S-1F	Forward	AACTGTGTTGATCTCTGCCATG		Thum, 2004	18S-1R
	Diaptomidae	Nuclear 18S	18S-1R	Reverse	TGGTGCCCTTCGTCAATTCCT		Thum, 2004	18S-1F
	Diaptomidae	Nuclear 18S	18S-2F	Forward	CTGGTGCCACGACGCCGCG		Thum, 2004	18S-2R
	Diaptomidae	Nuclear 18S	18S-2R	Reverse	TTGATCCTTCTCGAGGTTCACTAC		Thum, 2004	18S-2F
	Mesocyclops	Nuclear 18S	18s-329	Forward	TAATGATCTTCCGACGTT		Spears et al., 1992	18s-L
	Mesocyclops	Nuclear 18S	18s-L	Reverse	AAC(T)JAAAGGAATTGACGG		Spears et al., 1992	18s-329
	Eucalanidae	Nuclear ITS2	ITS3F	Forward	GCATCGATGAAGAACGCAAC		White et al., 1990	ITS10R
	Eucalanidae	Nuclear ITS2	ITS10R	Reverse	TACGGGCTATCAACCTCTTACG		Geerken and Wyngaard, unpubl. Data in Goetze, 2003	ITS3F
	Acartia	Nuclear ITS2	ITS-4	Reverse	TCTCTCCGCTATTTGATATGC		White et al., 1990	IST-5
	Acartia	Nuclear ITS2	IST-5	Forward	GGAAATAAAGTGTAAACAAAG		White et al., 1990	ITS-4
	Paracalanidae	Nuclear Histone H3	H3aF		ATGGCTCGTACCAAGCAGACVGC		Colgan et al., 1998	H3aR
	Paracalanidae	Nuclear Histone H3	H3aR	Reverse	ATATCTTTRGGATRTRTGTGAC		Colgan et al., 1998	Forward
Euphausiacea								
		Mitochondrial COI	Eup-COI-2000R	Reverse	CADACAAAAYARWGGDATTCGGTCTAT		Bucklin et al., 2010a	LCO1490
Ostracoda								
		Mitochondrial COI	Ost-COI-1535F	Forward	GQDQCHTGAAGWGCWATGYTAGG		Bucklin et al., 2010a	HCO-2198
Decapoda (Larvae)								
		Mitochondrial COI	CrustF1	Forward	TTTCTCAAAATCATAAAGACATTGG		Costa et al., 2007	HCO2198
		Mitochondrial COI	CrustF2	Forward	GGTCTCTTCCACCAACCAACARGAYATHGG		Costa et al., 2007	HCO2198
Ctenophora								
		Mitochondrial COI	HCO-2424	Reverse	TTAATACCTGTAGGAACGGCAATAATTAT		Ortman, 2008	LCO1490
Cnidaria								
Hydrozoa								
		Mitochondrial COI	MedCOIR	Reverse	GGAACCTGCTATAATCATAGTTC		Ortman et al., 2010	LCO1490
		Mitochondrial COI	HCO-2607	Reverse	ACATAGTGGAAAATGTCTACAAACATA		Ortman, 2008	LCO1490
		Mitochondrial 16S	SHA		ACGGAATGAACCTCAAATCATGT		Cunningham and Buss, 1993	SHB
		Mitochondrial 16S	SHB		TCGACTGTTTACCAAAAACATA		Cunningham and Buss, 1993	SHA
		Mitochondrial 16S	F2		TCGACTGTTTACCAAAAACATACG		Cunningham and Buss, 1993	R2
		Mitochondrial 16S	R2		ACGGAATGAACCTCAAATCATGTAAG		Cunningham and Buss, 1993	F2
Scyphozoa								
		Mitochondrial COI	LCOJf	Forward	GGTCAACAAATCATAAAGATATTGGAAC		Dawson, 2005	HCO2198
		Mitochondrial COI	HCOJato	Reverse	CCTCCACGAGATCAAAAGAAAG		Dawson, 2005	LCOJf
		Nuclear 28S	Aa L28S_21	Forward	GAAACRCGTCAAGCTTTRAAATCT		Bayha et al., 2010	Aa_H28S_1078
		Nuclear 28S	Aa_H28S_1078	Reverse	GAAACTTCGAGGGAACCAAGCTAC		Bayha et al., 2010	Aa L28S_21
		Nuclear ITS1	jITS1-5f	Forward	GGTTTCGGTAGGTGAACCTCGCGGAAGATC		Dawson and Jacobs, 2001	jITS1-3r
		Nuclear ITS1	jITS1-3r	Reverse	CGACGAGCCGAGTGATCCACCTTAGAAG		Dawson and Jacobs, 2001	jITS1-5f
	Aurelia spp.	Mitochondrial COI	L5		CTCTTGTAAGGTGAAGCC		Schroth et al., 2002	H5
	Aurelia spp.	Mitochondrial COI	H5		CATAATTCAACATCGAAGG		Schroth et al., 2002	L5
Pisces (Ichthyoplankton)								
		Mitochondrial COI	FishF1	Forward	TCAACCAACCAACAAAGACATTGGCAC		Ward et al., 2005	FishR1
		Mitochondrial COI	FishF2	Forward	TCGACTAATCATATAAGATATCGGCAC		Ward et al., 2005	FishR2
		Mitochondrial COI	FishR1	Reverse	TAGACTTCTGGGTGCCAAAGAAATCA		Ward et al., 2005	FishF1
		Mitochondrial COI	FishR2	Reverse	ACTTCAGGGTGACCGGAAGATCAGAA		Ward et al., 2005	FishF2
Mollusca, Gastropoda								
		Mitochondrial COI	dgLCO-1490	Forward	GGTCAACAAATCATAAAGAYATYGG		Meyer, 2003	dgHCO-2198
		Mitochondrial COI	dgHCO-2198	Reverse	TAAACTTCAGGGTGACCAARAAYCA		Meyer, 2003	dgLCO-1490

Annex 4. (Continued) References for PCR Primer (Draft for Comments)

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Further Links for primer information:

<http://connect.barcodeoflife.net/group/marinebarcoding/forum/topics/primer-combinations-for-marine>

Annex 5. Draft Terms of Reference for 2014

2014/1/SSGEF: 07 The Study Group on Integrated Morphological and Molecular Taxonomy (SGIMT), chaired by Ann Bucklin, USA, will meet by correspondence and in association with the 2014 meeting of the ICES Working Group on Zooplankton Ecology (WGZE).

ToR (a) Expand membership of the SG to ensure a balance of expertise between morphological and molecular taxonomic approaches and across taxonomic groups;

ToR (b) Develop a web platform for promotion and exchange of relevant scientific information;

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

ToR (d) Develop the continuing integration of molecular and morphological taxonomy;

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

ToR (f) Cooperate with WGITMO and WGBOSV to encourage and facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water;

ToR (g) Prepare request to ICES for another term for SGIMT (2014-2017) or establishment of WGIMT, which will retain the primary mission of integrated molecular and morphological approaches to taxonomy and systematics

SGIMT will report by 15 June 2014 (via SSGEF) for the attention of SCICOM and WGZE.

Supporting Information

Priority:	The activities of this Group will assist ICES and its Expert Groups with issues related to the development, dissemination and application of taxonomic knowledge and skills. These skills underpin much of the work of ICES and ICES expert marine scientists, and policy demands are driving increased need for taxonomy in ecosystem management, affects of fisheries and contaminants, impacts of climate change, etc. The continuing need for accurate species identification, near-real-time characterization of biodiversity and biogeography, and application of new technology and techniques, scarce expertise and data quality issues; these make the study group's activities important and high priority.
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Scientific justification	Taxonomy is a fundamental discipline in general and evolutionary biology, ecology, and environmental
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and relation to action plan:

management. As such, this discipline is critical to successful understanding, assessment and management of the species diversity and relationships in both undisturbed ecosystems and those affected by natural or human activities such as climate change, ocean acidification, industrial pressures, and/or eutrophication. There are globally increasing demands on this science. There are also many efforts to reverse the decline in marine taxonomic expertise and to advance traditional morphology-based phylogenies into the new frontiers opened up by molecular genetics. WGZE has sponsored and arranged plankton taxonomic workshops and has strong associations with several of these global initiatives. Taxonomic experts are relatively few in many but not all ICES nations and they tend to specialise in certain taxa rather than generally across the diversity of plankton species.

ICES major role is in the collation, archiving, and dissemination of scientific data, analyses and evidence based advice to support policy-making, regulatory control. These activities support the conservation and sustainable use of marine resources and ecosystems and ICES facilitates international collaborative science to achieve these aims. ICES has critical supporting and training roles in global marine science, through promoting scientific standards, new research and developments and training opportunities. Taxonomic standards and descriptions are subject to constant change and development. Particularly, taxonomy grows with new molecular approaches to species phylogeny, evolution, species adaptive capacities, environmental sensitivities and community diversity. These are highly significant new developments that in a few years will have revolutionised the monitoring and study of marine species and ecosystems. It essential that ICES adopts a positive supporting role in assessing taxonomic methods, information and potential new techniques by coordinating and promoting developments and information feedback to the scientific community that supports ICES data provision, analyses, and advice.

To this end the SGIMT would work with the WGZE web manager, ICES staff, and other Expert Groups to manage and deliver data, information, and information products related to the science of taxonomy, with a particular focus on promoting the coordination and integration of morphological and molecular taxonomic approaches. This may include news of developments, current issues, meetings, training opportunities, and workshops. The goal would be to provide access and links to knowledge, resources, research initiatives and expertise via the www, e-mail listservs, and in the scientific literature.

Considering the plethora of Internet and other developments in taxonomic information (e.g. CoML/CmarZ, EU MARBEF, EDIT, GBIF, and PESI networks), ICES can best assist with coordination to ensure continued development and evolution through these and other short-term efforts. ICES has a role in conserving and developing the gains these programs have made and ensuring the dissemination of results to ICES scientists and their colleagues. Collectively and individually, these global efforts focused on traditional and molecular taxonomy amount to a valuable and developing resource. ICES as a stable, long lived and international institution has a major role to play in the collation, review, and application of these efforts, in promoting best practices and standards while coordinating development and dissemination of such information.

Resource requirements:	The research programs and Expert Group activities that provide input and are stakeholders for this group are already in place. The additional resources required for SGIMT to pursue the planned activities are: 1) effort by an ICES web manager to help SGIMT create and maintain a web presence with taxonomic information and links; and 2) approval of a planned SGIMT meeting in association with the 2014 WGZE meeting.
Participants:	The Study Group expanded membership in preparation for the 2013 meeting and is expected to continue grow during 2013 to include scientists from other ICES Expert Groups and other related programs and initiatives with appropriate skills. The goal is to ensure that the membership is balanced across taxonomic groups, ICES geographic regions, and morphological-molecular expertise and knowledge.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	There are no direct linkages with the advisory committees.
Linkages to other committees or groups:	The Study Group arose from the WGZE as a response to a perceived need. This was to promote and support morphological and molecular taxonomy science for the benefit of many ICES Expert Groups and marine science generally.
Linkages to other	The work of this group relates to and is connected to a diversity of other projects and organizations, e.g. EU

organizations: MARBEF, EDIT, GBIF, PESI, GOBI, and others.

Annex 6. SGIMT Recommendations for 2014

Recommendation	Adressed to
1. SGIMT recommends that the 2014 meeting be held in association with the WGZE 2014 meeting, now planned for Reykjavik, Iceland during 24-27 March 2014. SGIMT will meet at the Icelandic Marine Research Institute during 27-28 March 2014, immediately following the WGZE meeting.	WGZE
2. SGIMT recommends that WGZE adopt SGIMT ToR (d), to assist in the development, revision and updating of zooplankton species identification keys and ensuring their availability via the web, including especially ICES Zooplankton Identification Leaflets.	WGZE
3. SGIMT recommends that an ICES Taxonomy Workshops be established entitled, <i>Perspectives on the Future of Integrative Taxonomy</i> , to promote integrated morphological and molecular approaches to zooplankton taxonomy, with a focus on identifying species boundaries using molecules and morphology. A proposal for a multi-day workshop focused on a theoretical case-studies approach, with presentations and discussions by invited distinguished researchers, is being prepared by SGIMT members Janna Peters, Jasmin Renz, Silke Laakmann, Astrid Cornils (all from Germany). The proposed venue is the University of Hamburg or Senckenberg Institute (Hamburg, Germany) during Summer 2014.	ICES Secretariat SCICOM