

2021 Report of PICES/ICES Working Group on *Impacts of Warming on Growth Rates and Fisheries Yields*

The Joint PICES/ICES Working Group on *Impacts of Warming on Growth Rates and Fisheries Yields* (WG 45/WGGRAFY) held its annual PICES meeting virtually on September 7 at 5 PM Pacific Daylight Time under the joint chairing of Drs. Shin-ichi Ito (Japan, PICES), Paul Spencer (USA, PICES) and John Morrongello (Australia, ICES). The purpose of the meeting was to discuss Working Group objectives and progress on the research activity, and, in particular, communicate to representatives from PICES member countries who may not have been able to attend previous meetings due to time-zone limitations. Due to the wide range time zones for the ICES and PICES members of this joint Working Group, an additional meeting was held on October 6, 2021 (hosted by ICES; *WG 45 Endnote 3*).

AGENDA ITEM 1

Introduction by Co-Chairs

The meeting began with a brief review of expected patterns in length at age that would result from the Temperature-Size Rule (TSR), and a review of the WG Terms of Reference (ToR). In the past year, subgroups have been created to work on each of the 4 ToRs.

AGENDA ITEMS 2 AND 3

Introduction of members and adoption of agenda

After introduction of members (*WG 45 Endnote 1*) and adoption of the agenda (*WG 45 Endnote 2*), the bulk of the meeting consisted of reports from the ToR subgroup representatives and discussion for each of the ToRs (see <https://meetings.pices.int/members/working-groups/wg45>).

AGENDA ITEM 4

Reports on activities and accomplishments and future perspectives

Dr. Spencer summarized statistical models that incorporate temperature-dependency of growth (ToR 1). State-space and dynamic factor analysis models have been developed and applied to fish size at age data from the California Current as a demonstration of modeling capabilities. In particular, a state-space modeling approach indicates that the von Bertalanffy growth rate parameter k in the first year of life was positively related to the bottom temperature anomalies for six of the seven California Current species examined.

Dr. Morrongiello presented an initial analysis of growth patterns across two large marine ecosystems (Gulf of Alaska and the North Sea) (ToR 2). Multiple factors can affect the size of fish, and can act differentially for adult and juvenile fish. For example, the size of adult fish could decrease due to increases in either temperature (via the temperature size rule (TSR)), biomass (via competition), and exploitation (via size-selective harvest). However, the size of juvenile fish would be expected to increase with temperature (via the TSR), decrease with biomass, and be indifferent with exploitation (if juvenile fish are not selected by the fishery). In the North Sea, Atlantic cod and haddock fit the pattern of decreased adult size, and increased juvenile size, with temperature. But sprat do not (increased juvenile body size with temperature, but no effect on adult body size). This work was conducted with Sarah Willington, a student of Dr. Morrongiello's, and offers a preview of the type of analysis to be applied to data sets for additional marine ecosystems.

Dr. Alan Baudron (WGGRIFY Co-Chair, ICES) was unable to attend to the meeting, but produced a pre-recorded presentation on assessing the impacts of warming on past yield-per-recruit (YPR) of commercial fisheries, and forecasting trends in yield given plausible future warming scenarios (ToR3). The ToR 3 subgroup is examining yield-per-recruit analyses, applied to regional data sets, as a relatively simple tool for assessing impacts, with the expectation of developing more complex management strategy evaluations in the future. A YPR function has been developed and applied to several data sets from Alaska, the North Sea, and the Barents Sea. A next step is to gather information on the impact of temperature of growth rates for various stocks (which may involve coordination with ToRs 1 and 2), and incorporate these mechanistic relationship into the YPR function.

Dr. Ito presented potential options for expanding access to the global size-at-age data that are fundamental for much of the work of WG 45. Because biological data such as fish otoliths and records of size-at-age typically result from region-specific sampling programs, these observations have not been as efficiently organized relative to broad-scale studies of physical and chemical characteristics. In the WG 45/WGGRIFY kickoff meeting in 2020, an inventory of potential data available for various marine regions was developed. Data formats may also differ between regions, with some areas allowing access to the mean length at age rather than the raw observations for individual fish. Due to confidentiality, fishery-independent data would be used for WG analysis, and it is preferable that local scientists be engaged in data analysis and modeling (as opposed to a smaller set of modelers working with a centralized data base). Future activities for this ToR are:

- 1) Updating the metadata tables to describe formats, accessibility, *etc.*;
- 2) Exploring options for data storage (working with ToR2); and
- 3) Recruit modelers at institutes with significant data to be involved in data analysis (working with ToR2).

AGENDA ITEM 5

Future schedules

After the kickoff meeting in 2020, the WG held 9 ToR subgroup meetings (ToR1 on January 12, ToR3 on January 20, ToR2 on January 21, ToR1 on April 20, ToR1 on July 9, ToR1 on August 5, ToR3 on August 17, ToR1 on September 15, and ToR1 on October 22) The future schedules for WG 45/WGGRIFY largely consist of the meetings and research of the ToR subgroups. Although these ToR subgroups have met throughout the year since the WG 45/WGGRIFY kickoff meeting in September 2020 and have made progress, the WG is still at an early stage of development, so there is room for additional contributions. The WG Co-Chairs encouraged people to contact the ToR subgroup leads to become further involved.

WG 45 is paying attention to the collaboration with Early Career Ocean Professionals (ECOPs). Several ECOPs are already attending WG 45 activities in a variety of capacities, including official members and observers (including postdoctoral researcher and students). In addition, Dr. Ito attended the workshop (W5) of SG-ECOP on “*Engaging Early Career Ocean Professionals in PICES to further the next generation of integrated ocean sustainability science*” at PICES-2021. WG 45 will continue to engage and collaborate with ECOPs.

WGGRIFY Co-Chairs have attended a meeting held by the ICES EPDSG (Ecosystem Processes and Dynamics Steering Group) aiming at fostering collaborations between WGs. Several possible collaborations were identified for WGGRIFY: with WGEVO (Working Group on Fisheries-Induced Evolution) and WGSPF (Joint ICES/PICES Working Group on Small Pelagic Fish). Contact has been made with the chairs of these 2 WGs.

AGENDA ITEMS 6-7

WG requests and other business

Several requests to PICES were discussed. WGGRAFY submitted a proposed theme session “*Temperature impacts on fish growth and the consequences for fisheries*” for the 2022 ICES Annual Science Conference; if accepted, we request PICES co-sponsorship. Additionally, we should request travel support for WG 45 members to attend the ICES ASC:

- Travel support for two PICES invited speakers

Finally, we should request some membership changes to better recognize the contributions of individuals who are not currently listed as WG 45 members, and to ensure representation from all PICES member countries.

- Dr. Saang-Yoon Hyun (Korea) to replace Dr. Sukjeun Jung who has stepped down;
- Appointment of two members representing Russia;
- Appointment of two members representing USA.

After the meeting concluded, these requests were presented to Science Board by FIS.

WG 45 Endnote 1**PICES WG 45 meeting participation list (Sept 7, 2021)**Members

Shin-ichi Ito (Japan, PICES Co-Chair)
 Paul Spencer (USA, PICES Co-Chair)
 John Morrongellio (Australia, Co-Chair)
 Yue Jin (China, PICES)
 Shuyang Ma (China, PICES)
 Yongjun Tian (China, PICES)
 Takeshi Tomiyama (Japan, PICES)
 Ralf van Hal (Netherlands, ICES)
 Cody Szuwalski (USA, ICES)

Observers

Christine Stawitz (USA)
 Melissa Haltuch (USA)
 Yury Kovalev (Russia)
 Zhen Lin (Japan)
 Masaya Iida (Japan)
 Saang-Yoon Hyun (Korea)

PICES/ICES members unable to attend

Alan Baudron (UK, ICES Co-Chair)
 Tara Marshall (UK, ICES Co-Chair)
 Sean Anderson (Canada, PICES)
 Daniel Duplisea (Canada, ICES)
 Rick Rideout (Canada, ICES)
 Kunihiro Fujiwara (Japan, PICES)
 Sukgeun Jung (Korea, PICES)
 Jochen Depestele (Belgium, ICES)
 Johanna Fall (Norway, ICES)
 Alfonso Perez Rodriguez (Norway)
 Valerio Bartolino (Sweden, ICES)
 Einar Hjorleifsson (Iceland, ICES)
 Bryony Townhill (UK, ICES)
 Max Lindmark (Sweden, ICES)
 Daniel Howell (Norway, ICES)
 Edda Johannessen (Norway, ICES)
 Malin Pinsky (USA, ICES)
 Rodrigo Wiff (Chile, ICES)
 Natalia Yaragina (Russia, ICES)
 Matthieu Veron (USA, ICES)
 John Pinnegar (UK, ICES)
 Asta Audzijonyte (Australia, ICES)

WG 45 Endnote 2

ICES WGGRAFY meeting participation list (Oct 6, 2021)

Members

Shin-ichi Ito (Japan, PICES Co-Chair)
Paul Spencer (USA, PICES Co-Chair)
Alan Baudron (UK, ICES Co-Chair)
John Morrongellio (Australia, Co-Chair)
Asta Audzijonyte (Australia, ICES)
Shuyang Ma (China, PICES)
Daniel Duplisea (Canada, ICES)
Einar Hjorleifsson (Iceland, ICES)
Ralf van Hal (Netherlands, ICES)
Johanna Fall (Norway, ICES)
Edda Johannessen (Norway, ICES)
Natalia Yaragina (Russia, ICES)
Max Lindmark (Sweden, ICES)
John Pinnegar (UK, ICES)
Bryony Townhill (UK, ICES)
Malin Pinsky (USA, ICES)
Matthieu Veron (USA, ICES)

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Takeshi Tomiyama (Japan, PICES)
Sukgeun Jung (Korea, PICES)
Rick Rideout (Canada, ICES)
Jochen Depestele (Belgium, ICES)
Alfonso Perez Rodriguez (Norway)
Valerio Bartolino (Sweden, ICES)
Daniel Howell (Norway, ICES)
Rodrigo Wiff (Chile, ICES)
Cody Szuwalski (USA, ICES)

Observers

Saang-Yoon Hyun (Korea)
Tim Miller (USA)
Sarah Willington (Australia)
Henry Wooton (Australia)

WG 45 Endnote 3

WG 45 meeting agenda

1. Introduction (5 mins) (John/ Paul/ Shin-ichi)
2. Introduction of members
3. Adoption of Agenda
4. Reports on 2021 WGGRAFY Activities & Accomplishments and future perspectives

This is the first business meeting of WGGRAFY at the PICES Annual Meeting. We held the kick-off meeting of WGGRAFY in September 2020 and have continued to hold ToR subgroup meetings. However, because of the time-zone limitation, not all members could attend the meetings. The objective of the report is to share aims and current status of WGGRAFY within the WGGRAFY members in the PICES member countries.

ToR 1: Statistical models to incorporate temperature-dependency of growth (Paul Spencer, talk and discussion ~20 mins)

ToR 2: Exploring empirical evidence for fish body size change in the world’s oceans (John Morrongiello, talk and discussion ~20 mins)

Break (5 mins)

ToR 3: Assess the impacts of warming on past yield per recruit of commercial fisheries (Alan Baudron, talk and discussion, ~20 mins)

ToR 4: Expanding scientific community access to global length-at-age data (Shin-ichi Ito, talk and discussion, ~20 mins)

Conclusion (5 mins) (John/ Paul/ Shin-ichi)

Each of ToR 1-3 relies on collaborators providing access to empirical size-at-age data. We have begun compiling some of this data and are now hoping to expand our research activity to other areas. Please consider where you know of data that could meet the criteria below

	ToR 1	ToR 2	ToR 3
Geographic range	Looking to develop a new case study area comprising multiple stocks	Global	Global
Data needs	Temporally resolved size-at-age data	Temporally resolved size-at-age data, biomass estimates and/or exploitation rate for each stock	Size-at-age, natural mortality and maturity data for each stock

5. Future schedules
6. Requests to PICES/ICES
7. Other Business
8. Close of Meeting