Book of Abstracts

23RD INTERNATIONAL PECTINID WORKSHOP

APRIL 24TH - 30TH 2024

DOUGLAS, ISLE OF MAN

Official website of the conference:

https://internationalpectinidworkshop.org

Welcome message from the IPW organisers

We are very excited to welcome you all to the Isle of Man for the very-long overdue 23rd International Pectinid Workshop. It has been five years since we last all met in Santiago de Compostela with unexpected delays from global pandemics in the interim. It feels like so much has changed in the world in that time, but some things remain constant; our undying love for all things scallop!

It is therefore with great pleasure that we can all meet again in person and, thanks to your wide and varied contributions, provide a conference full of scallop research and innovations that have taken place since 2019.

It is also exciting for us to welcome you back to the Isle of Man, following the third workshop back in 1980. Scallops (kings and queens) remain amongst the Island's most important and valuable fisheries and so it is great that we can involve local/regional industry members to join us at the Friday fishing industry session as well. Of course, in keeping with the long traditions of the IPW, we have tried to provide you with ample opportunities to see and indulge in the fantastic sites, views, wildlife and local food and drink that the island has to offer.

We hope you all enjoy your time on the Isle of Man.

Failt erriu gys Ellan Vannin, as yn 23oo co-choyrle eddyrashoonagh son roagan!

(Welcome to the Isle of Man, and the 23rd International Scallop Workshop!)

Peter, Isobel, Andy and Bryce

WORKSHOP PROGRAMME 19/4/2024

Wednesday 24th April: Registration and Evening Reception

Start	End	Item	Location
14:00	18:00	Workshop registration desk open	Empress Hotel Lobby
18:00	20:00	Evening Reception with welcome drinks and finger buffet With special presentations by Fynoderee Distillery and Bushy's Ales of Man	Empress Hotel Lobby

Thursday 25th April: Fisheries Session

Item	Start	End	Speaker	Title
Housekeeping	09:30	09:35	Isobel Bloor	Agenda, breaks & lunch, fire safety, toilets etc.
Welcome	09:30	09:45	Minister Clare Barber	Isle of Man Ministerial Welcome to IPW 2024 and the Isle of Man
Opening of Conference	09:45	10:00	Andy Brand/Peter Duncan	Welcome and Introduction to the IPW 2024
Fisheries Session 1:				
Talk 1	10:00	10:20	Eric Foucher	A marine rotational harvest area in the Bay of Seine (Eastern English Channel), France: effects on king scallop (*Pecten maximus*) population dynamics
Talk 2	10:20	10:40	Melissa Smith	Rotational management of Maine's state waters scallop fishery: a ten-year review
Talk 3	10:40	11:00	Connor Buckley	Adapting to a New Paradigm: Atlantic Sea Scallop Management Under Climate Change
Coffee	11:00	11:20		
Talk 4	11:20	11:40	Kevin Stokesbury	The United States sea scallop resource: its historic success and present decline
Talk 5	11:40	12:00	Jonathon Peros	Bonanza and Bust: management lessons from an extraordinary recruitment event
Talk 6	12:00	12:20	Mario Lasta	The Patagonian scallop (*Zygochlamys patagonica*) fishery: 20 years of fishing in 20 minutes. Why didn't it collapse?
Talk 7	12:20	12:40	Juan Alberti	The complete footprint of the Patagonian scallop bottom-trawl fishery on the Argentine shelf
Lunch	12:40	13:40		
Fisheries Session 2:				
Talk 8	13:40	14:00	Marcelo Kittlein	Effects of resource spatial distribution and tow overlap in the accuracy and precision of common methods used to estimate dredge efficiency for bottom trawl.
Talk 9	14:00	14:30	Guillermo Martin	Progress in high-resolution spatial-temporal data analysis for use in scallop fisheries management
Talk 10	14:20	14:40	Jessica Sameoto	Spatial approaches to adapt to emerging challenges in fisheries management
Coffee	14:40	15:00		
Talk 11	15:00	15:20	Skylar Bayer	An analysis of reproduction and recruitment spatio-temporal dynamics of Iceland scallops in Breiðafjörður bay after a fishery collapse
Talk 12	15:20	15:40	Isobel Bloor	Enhanced data collection and near real-time spatial monitoring of the Isle of Man scallop fishery
Talk 13	15:40	16:00	Lynda Blackadder	ICES WGScallop: International collaboration for scallop science
Speedy Scallops:				
Speedy scallops 1	16:00	16:10	James Williams	NZ scallop AI: Developments in camera-based surveying and machine-learning detection and sizing of New Zealand scallops (*Pecten novaezelandiae*)
Speedy scallops 2	16:10	16:20	Deborah Hart	Long-term changes in growth and meat yield in U.S. sea scallop populations
Speedy Scallops 3	16:20	16:30	Skylar Bayer	Alaskan weathervane scallop (*Patinopecten caurinus*) fishery
Close	16:30	16:40		

Friday 26th April: Fisheries Industry Day

Speaker	Title	Time	Session
Peter Duncan	Welcome	09:00 - 09:05	
Bryce Stewart	Casting into the future of scallop fisheries	09:05 - 09:25	**Future of Scallop Fisheries:** Chair Peter Duncan
Everyone	Discussion	09:30 - 09:40	
David Beard	Isle of Man industry vision (& co-management)	09:35 - 09:45	**Industry and Management perspectives on scallop fisheries (UK/IoM):** Chair Bryce Stewart
Andrew Brown	Macduff Shellfish (UK) vision for the future	09:45 - 09:55	
Jack Emmerson	Regulator's perspective of scallop fishery management	09:55 - 10:05	
Annabel Stockwin	Next steps for (English/Welsh) Scallop Fisheries Management Plan (FMP)	10:05 - 10:15	
Mairi Fenton	Management approach 'clustering'	10:15 - 10:25	
Everyone	Discussion - Panel	10:25 - 10:40	
Everyone	Coffee break	10:40 - 11:10	
Mario Lasta	Patagonian scallop fishery (Argentina)	11:10 - 11:20	**Lessons from Global Scallop Fisheries:** Chair Isobel Bloor
Eric Foucher	*Baie de Seine* scallop fishery (France)	11:20 - 11:30	
Jonathon Peros	Sea Scallop: boom – bust (USA)	11:30 - 11:40	
Everyone	Discussion - Panel	11:40 - 12:00	
Everyone	Lunch	12:00 - 13:00	
Charlotte Coombes	Marine Conservation Society: Good Fish Guide	13:00 - 13:10	**Environmental Impacts, Marine Space and harvesting innovations:** Chair Peter Duncan
Mairi Fenton	Strategies for Mitigating Seabed Impact	13:10 - 13:20	
Dagny-Elise Anastassiou	Scallop Remote Harvesting	13:20 - 13:30	
Rob Enever	Scallop Potting Trials	13:30 -13:40	
Kevin Stokesbury	Scallops and windfarms	13:40 - 13:50	
Everyone	Discussion - Panel	13:50 - 14:10	
Everyone	Coffee break	14:10 - 14:30	
Andrew Brown	Scallop Shucking at Sea	14:30 - 14:40	**Industry research for scallop fisheries:** Chair Bryce Stewart
David Beard	Industry Research Isle of Man - surveys, excess scallop scheme	14:40 - 14:50	
Everyone	Discussion - Panel	14:50- 15:00	
Everyone	Round up and Summary of key points/issues	15:00 - 15:30	
Everyone	Conference Photo	15:30-15:40	

Everyone	**Poster session with drinks and nibbles**	**15:40 - 16:40**	

Poster Session: throughout and Friday 26th, 15:30 - 16:30 (approx.) – Drinks and nibbles

Presenter	Title
Skylar Bayer	Knowledge gaps and research opportunities in the Alaskan weathervane scallop (*Patinopecten caurinus*) fishery
Isobel Bloor and Lynda Blackadder	ICES WG Scallop
Leander Harlow, Mark James and Katja Ovchinnikova	Neural networks for scallop (*Pecten maximus*) identification in natural marine habitats
Ivan Župan, Rino Stanić and Melita Peharda	Age and growth studies of scallop species living in the Mediterranean Sea – a review of methods, find-ings and opportunities for sclerochronology research
Max Zavell, **Sandra Shumway**, Odd Lindahl and Ramon Filgueira	An estimate of carbon storage capabilities of wild and cultured shellfish in the Northwest Atlantic and their potential inclusion in a carbon economy.

Saturday 27th April (1/2 Day): Fisheries, Gear and Survey Developments, Other Wild Harvest Methods

PLEASE NOTE, THIS SESSION WILL BE HELD IN THE CONNAUGHT ROOM (NOT IN THE MAIN LECTURE ROOM)

Item	Start	End	Speaker	Title
Welcome	09:00	09:10		
Fisheries Session 3:				
Talk 1	09:10	09:30	James Williams	Dive, dredge and camera surveys and assessment of New Zealand scallops (*Pecten novaezelandiae*)
Talk 2	09:30	09:50	Adam Delargy	A comparison of survey designs for marine benthic invertebrate sampling
Talk 3	09:50	10:00	Amber Lisi	Investigating recent improvements to the SMAST Atlantic Sea Scallop, *Placopecten magellanicus*, drop camera survey.
Talk 4	10:00	10:20	Sally Roman	Modifications to a scallop dredge twine top to reduce flatfish catch
Coffee	10:20	10:40		
Talk 5	10:40	11:00	Ellen Sofie Grefsrud	Diver-Based Fishery of the Scallop *Pecten Maximus* in Norway
Talk 6	11:00	11:20	Phoebe Jekielek	eDNA: Dragging a new dredge for sea scallop (*Placopecten magellanicus*) fisheries monitoring
Talk 7	11:20	11:40	Craig Lego	Small-scale spatial dynamics of sea stars, *Asterias* spp., and Atlantic sea scallops, *Placopecten magellanicus,* in the Nantucket Lightship area
Talk 8	11:40	12:00	Esteban Felix-Pico	Fluctuations in Pacific calico scallop (*Argopecten ventricosus*) and other small-scale fisheries associated with mangrove areas in the Magdalena Bay, Baja California Sur, Mexico
Talk 9	12:00	12:20	Ivan Župan	Seasonal variations of condition, gonad somatic and adductor muscle indices of the Mediterranean scallop *Pecten jacobaeus* L. from the Adriatic Sea (Croatia)
Speedy Scallops:				
Speedy Scallop 1	12:20	12:30	Gyda Christophersen	Alive, dead or in-between – how to deal with future welfare demands?
Speedy Scallop 2	12:30	12:40	Florian Breton	Tinduff Hatchery (France) From Science to Hatchery
Speedy Scallop 3	12:40	12:50	Phoebe Jekielek	Scallop larval supply study, Maine, USA
Close	12:50	13:00		
Lunch (Hotel)	13:00	14:00		

Monday 29th April: Biology, Environment and Aquaculture

Item	Start	End	Speaker	Title
Welcome	09:30	09:40		
Bio, Eco & Genetics Session 1:				
Talk 1	09:40	10:00	Bryce Stewart	Marine protected areas: can they really provide benefits for both conservation and scallop fisheries?
Talk 2	10:00	10:20	Carl Huntsberger	Is growth slower or is it us? Growth estimates and their implications from a tagging study in Penobscot Bay Maine, USA
Talk 3	10:20	10:40	Maya Harries	Annual growth marks within the calcareous plate of *Aequipecten opercularis*
Coffee	10:40	11:00		
Talk 4	11:00	11:20	Deborah Hart	Collapse of Mid-Atlantic Bight Sea Scallop (*Placopecten magellenicus*) Populations Due to Warming Temperatures
Talk 5	11.20	11.40	Halle Berger	Assessing Vulnerability of the U.S. Atlantic Sea Scallop to ocean acidification and warming: a dynamic energy budget modeling approach
Talk 6	11:40	12:00	Deborah Hart	Cross-generational effects of ocean acidification on a third generation of bay scallops
Lunch	12:00	13:00		
Bio, Eco & Genetics Session 2:				
Talk 7	13:00	13:20	Halle Berger	Dynamic Pathway to Transition from Vulnerable to Resilient Fisheries Social-Ecological Systems: A Transdisciplinary Case Study of the U.S. Atlantic Sea Scallop
Talk 8	13:20	13:40	Roger Mann	Moving Baselines: managing scallop fisheries in a period of climate change
Talk 9	13:40	14:00	Ellen Sofie Grefsrud	Scallop (*Pecten maximus*) moving northward
Talk 10	14:00	14:20	Luz Pérez-Parallé	The fall in the production of scallops in Spain
Coffee	14:20	14:35		
Talk 11	14:35	14:55	Eline Le Moan	Linking life traits and Dynamic Energy Budget parameters to better understand domoic acid contamination in five pectinid species
Talk 12	14:55	15:15	Kaitlyn Kowaleski	Extreme Population Densities Impact Reproductive Effort and Oocyte Development in Atlantic Sea Scallops
Talk 13	15:15	15:35	Karin Lohrmann	Is *Francisella halioticida* to blame for mortalities of adult scallops (*Argopecten purpuratus*) in Tongoy Bay, Chile?
Speedy Scallops				
SS 1	15:35	15:45	Kaitlyn Kowaleski	Fine-scale Variation in Atlantic Sea Scallop Reproductive Activity in the Mid-Atlantic Bight from Spring 2015
SS 2	15:45	15:55	Florian Breton	Tinduff Hatchery: Title: From Hatchery to Science
SS 3	15:55	16:05	Luz Pérez-Parallé	Aquatic One Health Research Center (former Institute of Aquaculture)
Close	16:05			

Tuesday 30th April: Biology, Environment and Aquaculture

Item	Start	End	Speaker	Title
Welcome	09:30	09:40		
Ranching and Aquaculture: Session 1:				
Talk 1	09:40	10:00	Phoebe Jekielek	A comparative study of sea scallop (*Placopecten magellenicus*) energy investment
Talk 2	10:00	10:20	Ellen Sofie Grefsrud	Scallop (*Pecten maximus*) sea ranching in Norway – lessons learned
Isle of Man Scallop review:				
Talk 3	10:20	10:40	Peter Duncan	Scallop management in the Manx marine environment (a retrospective and future
Coffee	10:40	11:00		
IPW Future	11:00	11:20	All	
Next meeting	11:20	11:40	All	
Wrap up	11:40	12:00		

FISHERIES (A)			
A1	01.	A marine rotational harvest area in the Bay of Seine (Eastern English Channel, France): effects on King scallop (*Pecten maximus*) population dynamics *Jade Mogeon, Morgane Amelot, Fanchon Varenne and* ***Eric Foucher***	
A2	02.	Rotational management of Maine's state waters scallop fishery: a ten-year review ***Melissa D. Smith*** *and Carl J. Huntsberger*	
A3	03.	Adapting to a New Paradigm: Atlantic Sea Scallop Management Under Climate Change ***Connor Buckley*** *and Jonathon Peros*	
A4	04.	The United States sea scallop resource: its historic success and present decline ***Kevin D. E. Stokesbury,*** *Adam J. DeLargy, and Brian J. Rothschild*	
A5	05.	Bonanza and Bust: Management lessons from an extraordinary recruitment event. ***Jonathon Peros****, Connor Buckley, Cate O'Keefe*	
A6	06.	The Patagonian scallop (*Zygochlamys patagonica*) fishery: 29 years of fishing in 20 minutes. Why didn't it collapse?	
A7	07.	The complete footprint of the Patagonian scallop bottom-trawl fishery on the Argentine shelf ***Juan Alberti*** *and Manuela Funes*	
A8	08.	Effects of resource spatial distribution and tow overlap in the accuracy and precision of common methods used to estimate dredge efficiency for bottom trawl. **Marcelo Kittlein** and Juan Alberti	
A9	09.	Progress in high-resolution spatial-temporal data analysis for use in scallop fisheries management **Guillermo F. Martin Gonzalez**, Oliver Tully and Sarah Clarke.	
A10	10.	Spatial approaches to adapt to emerging challenges in fisheries management **Jessica A. Sameoto,** S.M. Keith, R.R. McDonald, Y.Yin, M. Durant and J . Mills Flemming	
A11	11.	An analysis of reproduction and recruitment spatio-temporal dynamics of Iceland scallops in Breiðafjörður bay after a fishery collapse ***Skylar R. Bayer*** *and Jónas P. Jónasson*	
A12	12.	Enhanced data collection and near real-time spatial monitoring of the Isle of Man scallop fishery	

FISHERIES (A)			
A13	13.	ICES WGScallop: International collaboration for scallop science ***Lynda Blackadder** and Isobel S.M. Bloor*	
A14	33.	Dive, dredge and camera surveys and assessment of New Zealand scallops (*Pecten novaezelandiae*)	
A15	34.	A comparison of survey designs for marine benthic invertebrate sampling ***Adam J. Delargy**, Kyle S. Cassidy, Amber D. Lisi and Kevin D.E. Stokesbury.*	
A16	35.	Investigating recent improvements to the SMAST Atlantic Sea Scallop, *Placopecten magellanicus*, drop camera survey. ***Amber Lisi**, Adam Delargy, Craig Lego, and Kevin Stokesbury , Benjamin Woodward, N. David Bethoney and Kyle Cassidy*	
A17	36.	Modifications to a Scallop Dredge Twine Top to Reduce Flatfish Catch ***Sally A. Roman**, David B. Rudders, Dan Watson and Tom Rossiter*	
A18	37.	Diver-Based Fishery of the Scallop *Pecten maximus* in Norway ***Ellen Sofie Grefsrud**, Tore Strohmeier, Øivind Strand*	
A19	38.	eDNA: Dragging a New Dredge for Sea Scallop (*Placopecten magellanicus*) Fisheries Monitoring ***Phoebe E. Jekielek,** Heather Leslie and Nichole Price*	
A20	39.	Small-scale spatial dynamics of sea stars, *Asterias* spp., and Atlantic sea scallops, *Placopecten magellanicus,* in the Nantucket Lightship area ***Craig A. Lego**, Kevin D.E. Stokesbury, N. David Bethoney and Daphne M. Munroe*	
A21	40.	Fluctuations in Pacific Calico Scallop (*Argopecten ventricosus*) and others small-scale fisheries associated with mangrove areas in the Magdalena Bay, Baja California Sur, México ***Esteban Fernando Félix-Pico**, Mauricio Ramírez-Rodríguez and Sofía Ortega-García*	
A22	41.	Seasonal variations of condition, gonad somatic and adductor muscle indices of the Mediterranean scallop *Pecten jacobaeus* L. from the Adriatic Sea (Croatia) Valentina Šebalj, Lav Bavčević, Tomislav Šarić, Petar Zuanović and **Ivan Župan**	
A23	63.	Scallop management in the Manx marine environment (a retrospective and future look) ***Peter Duncan***	NA

Biology, Ecology and Genetics (B)

B1	45.	Marine protected areas: Can they really provide benefits for both conservation and scallop fisheries? *Lucy McMahon, Megan Walmsley, Lauren James Will Notley,Howard Wood and Lucy Kay, Leigh Howarth and* ***Bryce D. Stewart***	
B2	46.	Is growth slower or is it us? Growth estimates and their implications from a tagging study in Penobscot Bay Maine, USA **Carl J. Huntsberger**, Phoebe Jekielek, Madison Maier and Amber Lisi	
B3	47.	Annual growth marks within the calcareous plate of *Aequipecten opercularis* **Maya A. Harries,** Phillip Hollyman, Isobel Bloor, Stuart Jenkins	
B4	48.	Cross-Generational Effects of Ocean Acidification on a Third Generation of Bay Scallops *Katherine McFarland, Samuel Gurr, Genevieve Bernatchez, Mark Dixon, Lisa Guy, Isaiah Mayo, Lisa Milke, Matthew Poach, Dylan Redman, Georges Sennefelder, Sheila Stiles, David Veilleux, Gary Wikfors, Shannon Meseck, Dianna Padilla,* Louis Plough and ***Deborah R Hart.***	
B5	49.	Assessing Vulnerability of the U.S. Atlantic Sea Scallop to Ocean Acidification and Warming: A Dynamic Energy Budget Modeling Approach ***Halle Berger****, Samantha Siedlecki, Catherine Matassa, Felipe Soares, Emilien Pousse, Dvora Hart, Antonie Chute and Shannon Meseck*	
B6	50.	Collapse of Mid-Atlantic Bight Sea Scallop (*Placopecten magellenicus*) Populations Due to Warming Temperatures **Deborah R Hart** and Jui-Han Chang, Sally A. Roman and David B. Rudders	
B7	51.	Dynamic Pathway to Transition from Vulnerable to Resilient Fisheries Social-Ecological Systems: A Transdisciplinary Case Study of the U.S. Atlantic Sea Scallop ***Halle Berger****, Samantha Siedlecki, Catherine Matassa, Zhoumin Chen, and Felipe Soares, Shannon Meseck, Lisa Colburn, James LaChance, N. David Bethoney and Susan Inglis, Emilien Pousse, Dvora Hart and Antonie Chute*	
B8	52.	Moving Baselines: Managing Scallop Fisheries in a Period of Climate Change ***Roger Mann****, David B. Rudders, Sally A. Roman, Kaitlyn R. Kowaleski, Alexis Hollander, Garrett Bellin and Shannon White*	
B9	53.	Scallop (Pecten maximus) Moving Northward	
B10	55.	Linking life traits and Dynamic Energy Budget parameters to better understand domoic acid contamination in five pectinid species ***Eline Le Moan****, Laure Pecquerie, Hélène Hégaret, Paulo Lagos, Léo Heyer, Fred Jean, Jonathan Flye-Sainte-Marie' Laure Régnier-Brisson,* Salvador Lluch-Cota	

Biology, Ecology and Genetics (B)

B11	56.	Extreme Population Densities Impact Reproductive Effort and Oocyte Development in Atlantic Sea Scallops **Kaitlyn R. Kowaleski**, Sally A. Roman, Roger Mann, and David B. Rudders	
B12	57.	Is *Francisella halioticida* to blame for mortalities of adult scallops (*Argopecten purpuratus*) in Tongoy Bay, Chile? **Karin B. Lohrmann**, Roxana González, Rosanna Rojas, Carla Trigo	

Ranching and Aquaculture (C)

C1	54.	The fall in the production of scallops in Spain ***M. Luz Pérez-Parallé****, José L. Sánchez and Antonio J. Pazos*	
C2	61.	A Comparative Study of Sea Scallop (*Placopecten magellanicus*) Energy Investment Strategies in Farmed and Wild Environments ***Phoebe E. Jekielek****, Lucy Williams, Madison Maier, Esther Martin, Anya M. Hopple, Heather Leslie, Nichole Price and Jack Hopkins*	
C3	62.	Scallop (*Pecten maximus*) Sea Ranching in Norway – Lessons Learned	

Speedy Scallops (D)

D1	14.	NZ scallop AI: Developments in camera-based surveying and machine-learning detection and sizing of New Zealand scallops (Pecten novaezelandiae) ***James Williams***	NA
D2	15.	Long-term Changes in Growth and Meat Yield in U.S. Sea Scallop Populations **Deborah R Hart**, Antonie S Chute, Sally A. Roman and David B. Rudders	
D3	16.	Alaskan weathervane scallop (*Patinopecten caurinus*) fishery ***Skylar R. Bayer***	NA
D4	42.	Alive, dead or in-between – how to deal with future welfare demands? ***Gyda Christophersen***	NA
D5	43.	Tinduff Hatchery (France) From Science to Hatchery ***Florian Breton***	NA
D6	44.	Scallop larval supply study, Maine, USA ***Phoebe Jekielek***	NA
D7	58.	Fine-scale Variation in Atlantic Sea Scallop Reproductive Activity in the Mid-Atlantic Bight from Spring 2015	NA
D8	59.	Tinduff Hatchery: Title: From Hatchery to Science ***Florian Breton***	NA
D9	60.	Aquatic One Health Research Center (former Institute of Aquaculture) ***Luz Pérez-Parallé***	NA

Posters (E)

E1	64.	Age and growth studies of scallop species living in the Mediterranean Sea – a review of methods, findings and opportunities for sclerochronology research ***Ivan Župan****, Rino Stanić and Melita Peharda*	
E2	65.	Neural networks for scallop (*Pecten maximus*) identification in natural marine habitats ***Leander Harlow****, Mark James and Katja Ovchinnikova*	
E3	66.	An estimate of carbon storage capabilities of wild and cultured shellfish in the Northwest Atlantic and their potential inclusion in a carbon economy. *Max Zavell,* ***Sandra Shumway****, Odd Lindahl and Ramon Filgueira*	
E4	67.	Knowledge gaps and research opportunities in the Alaskan weathervane scallop (*Patinopecten caurinus*) fishery ***Skylar Bayer***	
E5	68.	ICES WG Scallop ***Isobel Bloor and Lynda Blackadder***	NA

Industry Day (F)

F1	17.	Casting into the future of scallop fisheries ***Bryce Stewart***	
F2	18.	Isle of Man industry vision (& co-management) ***David Beard***	NA
F3	19.	Macduff Shellfish (UK) vision for the future ***Andrew Brown***	NA
F4	20.	Regulator's perspective of scallop fishery management ***Jack Emmerson***	NA
F5	21.	Next steps for (English/Welsh) Scallop Fisheries Management Plan (FMP) ***Annabel Stockwin***	NA
F6	22.	Management approach 'clustering' ***Mairi Fenton***	NA
F7	23.	Patagonian scallop fishery (Argentina) ***Mario Lasta***	NA
F8	24.	*Baie de Seine* scallop fishery (France) ***Eric Foucher***	NA
F9	25.	Sea Scallop: boom – bust (USA) ***Jonathon Peros***	NA
F10	26.	Marine Conservation Society: Good Fish Guide ***Charlotte Coombes***	NA
F11	27.	Strategies for Mitigating Seabed Impact ***Mairi Fenton***	NA
F12	28.	Scallop Remote Harvesting ***Dagny-Elise Anastassiou***	NA
F13	29.	Scallop Potting Trials ***Robert Enever***	NA
F14	30.	Scallops and windfarms ***Kevin Stokesbury***	NA

Industry Day (E)			
F15	31.	Scallop Shucking at Sea ***Andrew Brown***	NA
F16	32.	Industry Research Isle of Man - surveys, excess scallop scheme ***David Beard***	NA

Fisheries (A)

- **Session 1: Thursday 24th April (am)**
- **Session 2: Thursday 24th April (pm)**
- **Session 3: Saturday 24th April (am)**
- **Session 4: Tuesday 30th April (am)**

A1 [01]

A marine rotational harvest area in the Bay of Seine (Eastern English Channel, France): effects on King scallop (*Pecten maximus*) population dynamics

Jade Mogeon[1,3], Morgane Amelot[1,2], Fanchon Varenne[1] and **Eric Foucher**[1]

[1] *IFREMER, Laboratoire Ressources Halieutiques (Port en Bessin, France);* [2] *Centre d'Ecologie et des Sciences de la Conservation, UMR 7204 MNHN-CNRS-Sorbonne Université, Muséum national d'Histoire naturelle de Paris, (Paris, France);* [3] *Nantes Université, Institut des Substances et Organismes de la Mer, ISOMer, UR2160, (Nantes, France*

Rotational harvesting of marine areas is a spatial fisheries management tool that aims to improve fishing sustainability (e.g. protect fishing resources while maintaining fishing yields). It consists of dividing fishing grounds into areas that are alternatively closed for a period. In November 2016, a marine rotational harvest area was implemented in the Bay of Seine (Eastern English Channel, French coast) (Figure A1.1), one of the main King scallops (*Pecten maximus*) fishing grounds in Europe.

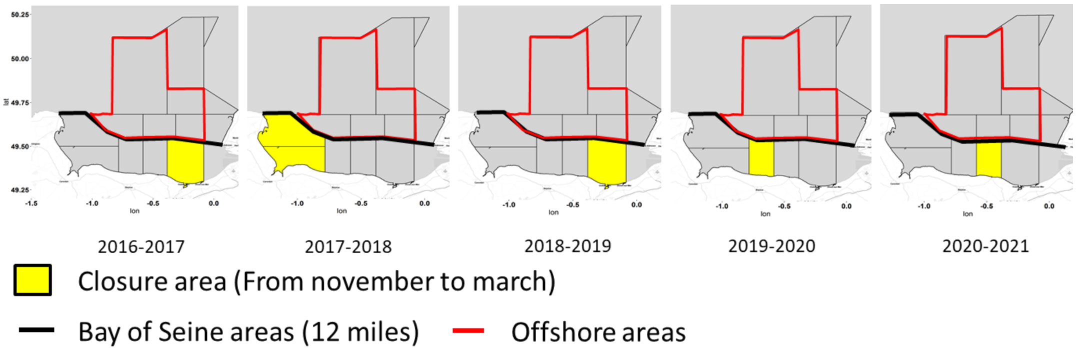

Figure A1.1: Closed areas in the Bay of Seine (France) from 2016 to 2021

The King scallop is the most valuable commercial species landed and sold in France. Since this marine rotational harvest area was established, the King scallop's biomass in the Bay of Seine has multiplied by three (Figure A1.2).

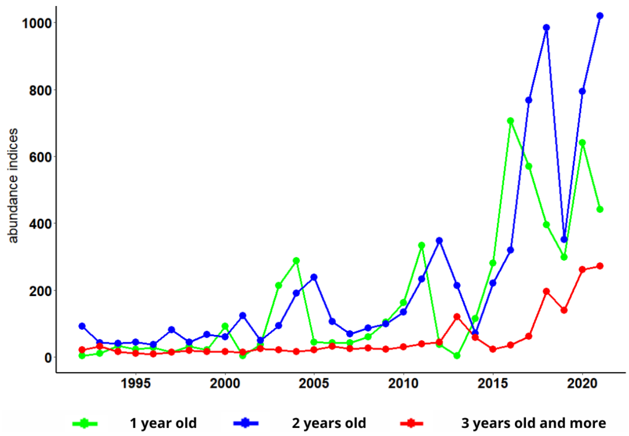

Figure A1.2: Trends (1992-2021) of abundance indices (number per nautical mile multiplied by dredge width, i.e. number of scallops per 3704m²) of King scallop cohorts in the Bay of Seine from COMOR surveys data.

Using a 30-year dredge survey time series, a General Linear Model (GLM) was developed to assess the impact of this marine rotational harvest area on the King scallop's rising biomass in the Bay of Seine. This statistical analysis demonstrated the rotational closure area's relevance in improving *Pecten maximus* stock sustainability. However this management tool had contrasted effects depending on *Pecten maximus* life stages, environmental conditions as well as fishing effort strategy modifications.

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A2 **[02]**

Rotational Management of Maine's State Waters Scallop Fishery: a Ten-Year Review

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Historical landings for sea scallops (*Placopecten magellanicus*) in Maine extend back to 1950. Landings have ranged widely; a record setting peak in 1981 of 3,813,685 pounds (meat weight) to a low of 33,141 pounds (meat weight) in 2005.

In the early 2000's, management and conservation measures had become inadequate to promote growth, recovery and inter-annual sustainability within the inshore scallop fishery. Efforts to rebuild an ailing fishery began with limiting entry to the fishery, establishing a daily harvest limit, reducing the season and establishing a series of 13 3-year closures interspersed along the coast. These closures were established with the hope that scallops would rebuild and therefore substantiate the efficacy of closed areas in Maine's inshore waters. During this recovery period, in-depth discussions with industry commenced to revise management measures in anticipation of the reopening of these spatial closures. The result was nearly half of Maine's coastal waters (Zone 2, Figure A2.1) embarking on a 10-year rotational management plan for the winter scallop fishery commencing with the 2012-2013 scallop season.

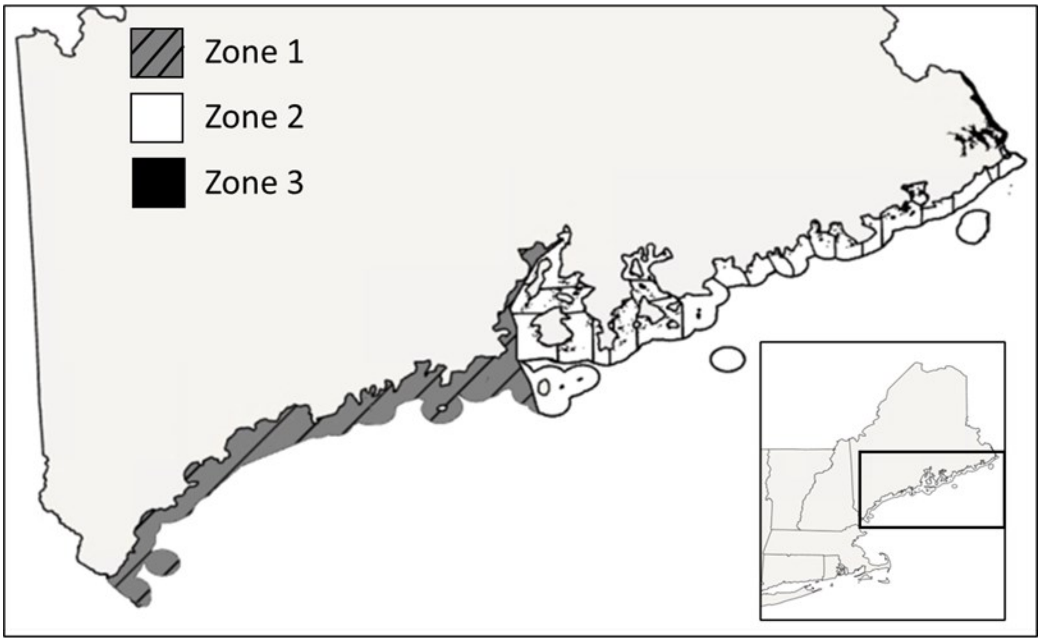

Figure A2.1: The coast of Maine is divided into three scallop zones, with zone 2 in the eastern portion of the state managed by a rotational plan. Inset: Maine relative to the northern New England coastline of the USA.

Maine's inshore scallop fishery is a mobile fishery. Harvesters are not legally restricted to fishing in one particular zone, but the relatively low daily limit (90 to 135 pounds), coupled with tradition and individual preferences, results in most harvesters fishing close to their home port. There are also regional differences in geography, bathymetry and ocean current regime that create at least 3 different scallop environments: highly, and consistently, productive Cobscook Bay; patchy, less productive, Western Maine; and, the more consistently productive, but also somewhat patchy, areas of Downeast Maine. During the initial collaborative conversations, these differences yielded different recommendations from the fishermen in each of these three regions, and different styles of management were eventually established. Only one of these areas (Zone 2: Downeast Maine) adopted

A2 **[02] Cont.**

rotational scallop management. While imperfect, the two additional zones (Figure A2.1) within the inshore scallop fishery that were not designated as rotational management areas allowed for broad scale relative comparisons. Analysis of scallop harvester landings from 2010 through 2023 were evaluated against four established goals to determine relative success of the implementation of rotational management.

After nine years of following a one-third open, two-thirds closed rotational management plan for Zone 2, landings data illustrate clear and obvious benefits to the resource as well as the fishery: the number of active fishermen has risen, as has the average pounds landed per fishermen. Despite these clear benefits, a vocal minority of fishermen has launched a campaign to abolish rotational management. Many harvesters question whether the perceived positive trends are a result of the management strategy or are the natural cycle of scallops along the coast. The main argument is such that scallop populations would receive less fishing pressure without rotational management as the fleet would be able to spread out over a larger spatial area.

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A3 **[03]**

Adapting to a New Paradigm: Atlantic Sea Scallop Management Under Climate Change

Connor Buckley and Jonathon Peros

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The Atlantic sea scallop (*Placopecten magelanicus*) fishery is one of the most economically important fisheries in the United States. Management measures in this fishery have consisted of limited entry, effort controls (days-at-sea), gear and crew regulations, and rotational area management. Under rotational area management, vessels are allocated several trips with a set catch limit to specific areas where annual surveys have tracked high densities of scallops of commercial size. While rotational management of the Atlantic sea scallop fishery has been widely regarded as a success, climate change is challenging the tenets of this model. The fishery is facing declining biomass in historically productive areas, and increasing ocean warming and acidification are likely to maintain that trend. Fishery managers and the industry need to adapt to this new paradigm with creative approaches to organize the fishery and promote sustainable harvesting.

Recently, scallop beds in the southern part of the resource have experienced low recruitment, increased incidence of disease and poor meat quality, and substantial mortality events. A review of annual survey data between 1999 and 2023 suggests a successive truncation of the southern and inshore extent of the scallop resource in the Mid-Atlantic. Annual surveys have detected large mortality events, including a die-off of a large year-class of incoming recruits detected in 2022. Recruitment in this region has been below average since 2013, while adult scallops of commercial size are now rarely observed. The fishery has also seen a decline in meat quality and a higher incidence of clappers, while surveys have observed a higher prevalence of nematodes and shell blister disease. This observed increase in natural mortality in the Mid-Atlantic is thought to be driven by changing environmental conditions consistent with climate change.

Within the management process, higher than expected natural mortality in the Mid-Atlantic has led to the recent systematic overestimation of exploitable biomass, and therefore fishing effort, in the region. In 2023, upwards of 99% of scallop fishing effort was directed to Georges Bank, resulting in a concentration of fishing mortality that may lead to localized overfishing. The Atlantic sea scallop fishery is considered the gold standard of U.S. fishery management, but fishery managers need to develop more adaptive approaches to respond to rapidly changing conditions across the range of the resource.

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A4 **[04]**

The United States sea scallop resource: its historic success and present decline

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The sea scallop (*Placopecten magellanicus*) resource in the United States experienced an unprecedented increase from 1999 to 2004. Several factors led to this including revised management approaches, investments in improved survey technologies, data-rich stock assessments, favorable environmental conditions, and some luck. These conditions may have led to two extremely large scallop recruitment events. In 2003, about 12 billion recruits were observed in the Mid-Atlantic, while the total population was about 21 billion scallops. This resulted in the Elephant Truck closed area, which sustained the fishery for the next 6 years. The scallop resource remained stable until 2014. In 2014, about 31 billion scallops recruited in Georges Bank, the largest abundance ever recorded, and the total population increased to 39 billion scallops. Recently, despite the data rich surveys and well-funded scientific efforts the scallop resource has undergone a substantial decline. The possible reasons for this decline include over-optimistic model projections for the biological reference points, poor harvesting practices, inaccurate spatially specific growth models, increased predation, and no comprehensive understanding of density-dependent relationships. Understanding these factors may help halt and reverse this decline.

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A5 **[05]**

Bonanza and Bust: Management lessons from an extraordinary recruitment event

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The Atlantic sea scallop (*Placopecten magelanicus*) fishery, prosecuted off the East Coast of the United States, is among the most valuable in nation. Exceptional recruitment events in 2012 and 2013 buoyed scallop landings from the Mid-Atlantic and Georges Bank to record highs, with nearly 60 million pounds moved across the docks in 2018 and in 2019. However, in the absence of continued strong recruitment, landings failed to stabilize at these high levels, declining in each of the following years. By 2022, fishery landings had declined to 50% of their 2019 high.

Managed using a hybrid system of input and output controls, the U.S. Atlantic sea scallop fishery is largely considered to be a management success, with the majority of harvest coming from vessels that receive a mix of days-at-sea and allocations that can be fished in specific areas. The primary method of managing these record recruitment events was through rotational management with specified possession limits (output controls). Adopted in 2004, this time-tested strategy aims to improve yield per-recruit by closing areas with high densities of juvenile scallops for a period and re-opening the areas for fishing several years later. While the extraordinary recruitment in 2012 and 2013 arguably led to a windfall for the U.S. scallop fishery, the unique circumstances proved challenging for scientists, managers, and the fishing industry to navigate over successive years.

A major challenge of the recruitment bonanza was tracking and forecasting scallop populations as they were heavily fished. With billions of scallops dispersed across dense beds off New England and the Mid-Atlantic, the exceptional recruitment event required fishery scientists and policy makers to re-think key assumptions about scallop biology in attempts to accurately characterize growth and other key parameters. The management situation was further complicated by poor meat quality and elevated levels of mortality within the rotational areas. Despite best efforts to adapt to the unique situation, in multiple cases fishery allocations were not realized as areas depleted faster than predicted, with direct impacts on the fishing industry and total landings.

Recent experience with rotational management in the Atlantic sea scallop fishery underscores the continued need to evaluate uncertainties associated with surveys and projections, as well as environmental drivers, and better characterize fishery impacts on the resource. These improvements, coupled with interest from the fishing industry to change practices, can improve management outcomes.

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A6 **[06]**

The Patagonian scallop (*Zygochlamys patagonica*) fishery: 29 years of fishing in 20 minutes. Why didn't it collapse?

Mario L. Lasta

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The Patagonian scallop fishery started in 1996 after a 1-year experimental fishing program. In 2006 the fishery was certified against the MSC. Fishing occurs throughout the year employing 4 high-tech high-cost factory vessels (~ 50 m long) landing up to 11,000 t (2006) of muscles meat (IQF) obtained from some 80,000 t of commercial (> 55 mm height) scallop (Figure. A6.1). The production is exported to Canada, USA and EEC. At a macro-scale, there is a clear spatial correspondence between the fishing grounds and oceanographic frontal systems in the Argentinean Shelf. The main fishing area (39Ŝ to 45Ŝ; at depths of 90-120 m) is under the influence of the shelf break front. Beds are on muddy-sandy substrates. Yearly, the fleet performs 31 to 54 trips (20-40 fishing days each) doing 40-60 tows/day using two otter trawl nets (22 m foot rope). The fishing gear initially non-selective for scallops changed both in design and the size of the meshes. It currently presents selectivity for both scallops and accompanying fauna. Efficiency was estimated between 21 – 31 %. Towing time and speed range on 12-17 min and 4.6 knots. Assuming these values, the fleet daily sweep area is about 7 km^2. The historically swept area considering the overlap of the hauls is 14.100 km^2 (48.000 km^2 without overlap). The area swept annually has a median of less than 5 % of the areas authorized for fishing.

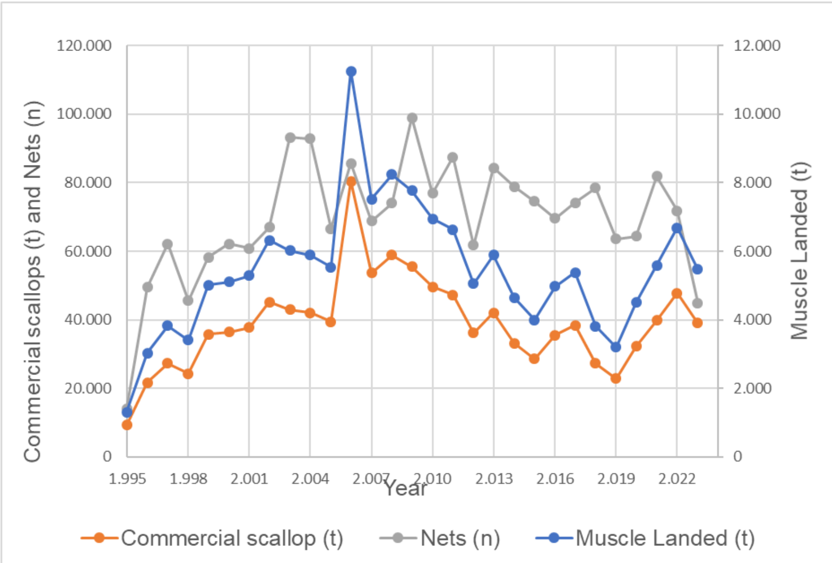

Figure. A6.1: Evolution of some descriptive data. Data until December 2023.

The first fishing years (1996-99) were characterized by random search ("exploratory fishing") alternated with systematic trawling ("regular fishing") once high-density areas were encountered. However, at present the spatial distribution of the beds are well known by the fleet and the factories on board are already tuned according to the muscle size and seasonal consistency.

Last years the production (muscle kg by fishing day and vessel) is in the range of 8,000-10,000 t (Figure. A6.2). Exploitation rates are close to 10 % and 18 % considering total scallop sizes and only commercial stock respectively.

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All these evidences suggest that fishing pressure is not particularly high, leading to a stable fishery after more than 29 years of continuous fishing. An emerging question is how this was achieved?

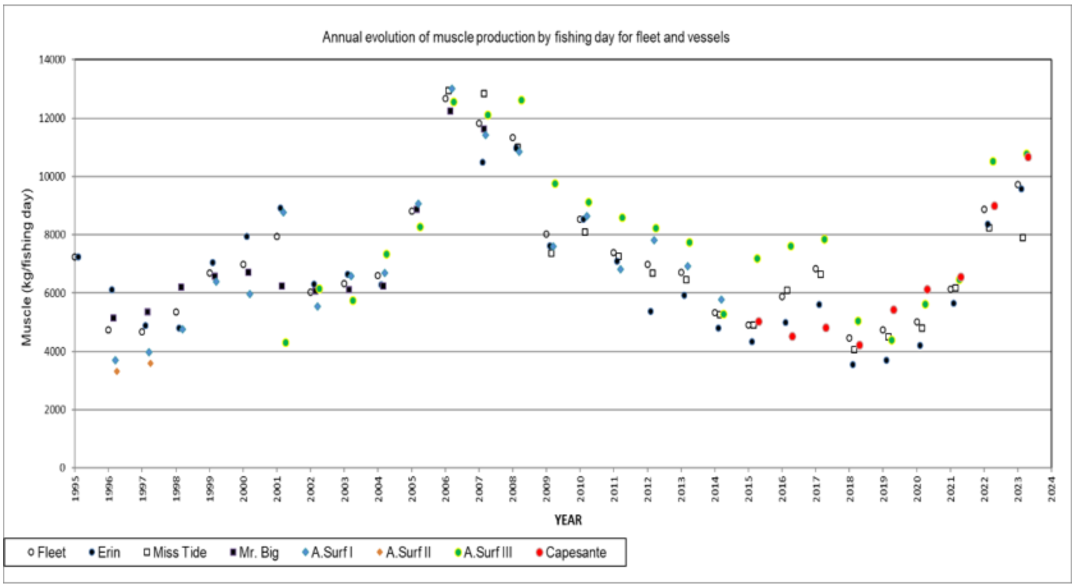

Figure A6.2: Annual evolution of muscle production per fishing day for fleet and vessel.

Sedentary resources are highly vulnerable and fisheries operate producing serial depletion that start with the densest patches, and leading to hyperstability in CPUE trends. Thus, a proper management is essential to avoid sudden collapse of the fishery after some years of apparently sustainable fishing. This management can be challenging when there is no much background information. From the biological and operational point of view, the central questions were how to balance between reduction in abundance due to fishing, fishing effort, the biomass increases by recruitment and growth of new cohorts and the possible (if detectable) impact of disturbances. From the "legal" side, two classic and known ideas should be taken into account: avoiding the "tragedy of the commons" and minimizing the "race for fish". In order to attain a sustainable scallop fishery, several management rules were strongly recommended to the Argentinean national fishing authorities.

The main fishing regulations established in 1996, and still ongoing were: a) beds were identified as management units; b) minimum legal size of 55 mm of total height (4-6 years old); c) no-take zones in each bed for parental stock protection ; d) no-take zones in each bed for research purposes; e) a minimum relation of juvenile – commercial scallops established at 1:1 in order to open for fishing; f) the harvest rate is fixed at 0.4 (or lower) of commercial sized scallops in those areas were 1:1 in order to establish the TAC; g) there is no fishing season imposed; h) the fishing effort is fixed at four vessels; i) mandatory immediate return to the sea of all individuals smaller than 55 mm; j) Technical Commission composed by manager, scientific and company representatives that analyze and monitor the fishery. These restrictions helped to avoid strong fishing pressures granting sustained production.

I will present results that I understand give proof of the "healthy" state of the fishery beyond the intrinsic uncertainty of unpredictable "recruitment", along with a review of the management regulations.

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A7 **[07]**

The complete footprint of the Patagonian scallop bottom-trawl fishery on the Argentine shelf

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Human footprint on terrestrial and aquatic ecosystems began long ago, increasing faster during the last centuries. Particularly, concerns about the potential impacts of fishing have since magnified. For example, bottom-trawl fisheries gained attention due to their potential impacts on target and non-target benthic species and climate change (since sediment disturbance could release greenhouse gasses into the atmosphere). Thus, one key aspect to properly evaluate these impacts is to know the spatial extent of the fishing ground, along with the frequency of disturbances in previously fished areas. With the advent of new technologies (such as vessel monitoring systems), scientists could determine that the footprint of bottom-trawl fisheries on continental shelves around the globe, and in recent years, is highly variable. Long-term fine-grained trawling data could provide valuable background information to evaluate bottom-trawl fishing impacts. In this context, logbooks still play a central role in evaluating the whole impact of most fisheries on the seafloor.

Here we provide a brief description of the Patagonian scallop fishery database populated with curated logbooks and publicly available information. We used its high-precision information for the entire set of tows from the fleet (since the beginning of the fishery) to estimate the shelf surface disturbed by trawling and the frequency of trawling disturbances.

The Patagonian scallop's database contains information on all fishing tows from a fishery that started in 1995 and is still ongoing. This database has more than a million fishing tows registered, with highly precise information for more than 80% of them. The aggregated swept area by all tows during these 29 years reached 48,769 km^2, which represents a minor portion (~3%) of the Argentine continental shelf (approximately 1,530,000 km^2). The swept area by those tows with precise information reaches 39,734 km^2. Interestingly the shelf surface effectively disturbed was 14,137 km^2 (almost a third) due to the overlap of tows within and between years (Figure. A7.1). Notably, the intra-annual overlap of tows is the highest frequency of trawling disturbance. Overall, during the entire history of the fishery, less than 1% of the Argentine continental shelf was affected, with 50% of interannual overlaps occurring on a time lag lesser or equal to 6 years.

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A8 **[08]**

Effects of resource spatial distribution and tow overlap in the accuracy and precision of common methods used to estimate dredge efficiency for bottom trawl fisheries

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Effective fisheries management relies heavily on accurate and unbiased estimates of stock status, primarily derived from measurements of relative abundance. Inaccuracies in this complex assessment process can lead to unsustainable management practices. A crucial element in stock assessment is the precise estimation of gear efficiency, which is the fraction of the target species in the gear path that are captured and retained. This is particularly important for species that are difficult to sample by other means. The evolution of methodology in evaluating fishing gear efficiency includes initial approaches that postulate a simple relationship between catch per unit effort (CPUE) and cumulative catch or effort. Successive studies have built upon these approaches, introducing new adaptations and extensions to enhance accuracy, despite the inherent limitations such as the need for a defined population limit and assumptions about individual mixing after each extraction. The advent of high-resolution geopositioning technologies has facilitated the development of novel methods and strategies, such as the patch model. This spatially explicit approach, successfully applied in various fisheries, combines tow positions and their temporal sequence to assess spatial depletion accurately. It identifies areas within each tow that have been previously swept at different frequencies, quantifying the proportion of each tow's area that has been swept multiple times.

Here we evaluate various methods, including the Leslie-Davis and DeLury models and the k-pass depletion method and the patch model, for their precision and bias in estimating gear efficiency. These methods have their own set of assumptions and limitations, from requiring a closed population to assuming constant capture probability for all individuals. The patch Model stands out for its ability to incorporate the spatial distribution of fishing effort, offering a more nuanced correction of expected catch based on an area's fishing history.

We simulated different scenarios populated with shellfish exhibiting different spatial patterns to assess the performance of these methods. The patch model demonstrated superior precision and minimal bias in estimating gear efficiency across a variety of challenging conditions, including irregular resource distribution and varying degrees of experimental trawl overlap. In contrast, the other methods often underestimated or overestimated efficiency depending on the trawl overlap level, highlighting the importance of considering spatial heterogeneity and fishing effort distribution (Figure A8.1).

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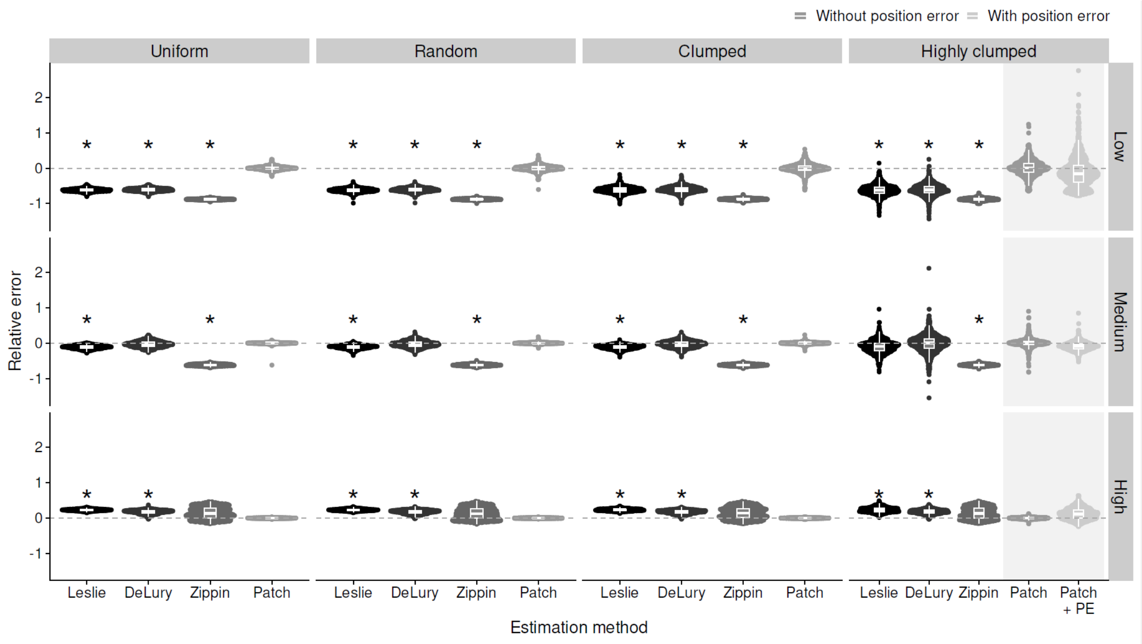

*Figure A8.1. Results from simulations of depletion experiments and different estimation methods used to estimate gear efficiency. The grayed part highlights the influence of extremely high position error on the patch model. * cases in which > 95 % estimations either under or overestimated the true efficiency.*

Despite its reliability, the patch model, like all methods, is subject to uncertainties that impact its variability and bias. The study emphasizes the critical nature of cautious interpretation of findings and consideration of real-world scenarios and their implications for stock management. Advances in technology and the adoption of sophisticated models may mitigate the challenges of positional errors, enhancing the application of such models in estimating efficiency in depletion experiments. This comparative analysis underscores the strengths and limitations of different estimation methods, providing valuable insights for informed decision-making in fisheries management.

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A9 **[09]**

Progress in high-resolution spatial-temporal data analysis for use in Scallop fisheries management

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Highly resolved geopositional data from fishery commercial sources (e.g. AIS, VMS) has multiple applications relevant to scallop fisheries including developing indices of abundance (Murray et al., 2013), fishing aggregation studies (Hintzen et al., 2019) or swept-area ratio estimation (Gerritsen et al., 2013). The density and spatial-temporal resolution of these fisheries-dependent data sources is far superior to survey-based datasets, although they also have known challenging statistical features (Gonzalez et al., 2021). Commercial data sets can provide information at a much finer scale than fishery-independent sources, particularly relevant in a species such as scallops, known to exhibit spatially variable biology and growth patterns. Taking as a case study the Irish Scallop fishery in the Celtic Sea, we present a workflow for the analysis of these datasets. Steps include the collation, trip definition, fishing state classification, and combination with logbook datasets. Further refinement of the methodology is needed, particularly in the fishing state classification, but complex modelling frameworks such as Hidden Markov Models or machine learning techniques are already being applied with promising results in other fisheries (ICES, 2023). This work opens the room for discussion about how to make better use and integration of available commercial datasets, potential areas of research and consideration of alternative approaches to scallop fisheries management.

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A10 **[10]**

Spatial approaches to adapt to emerging challenges in fisheries management

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The Canadian Maritimes Scallop fishery focuses on Sea Scallop (*Placopecten magellanicus)* and is the largest wild scallop fishery in Canada supporting > $170 million in annual landings (meats). The sustainable management of scallop has relied on multiple management measures (including limited entry, minimum shell height, meat counts, dockside monitoring, VMS) combined with annual fishery independent science surveys and science advice to inform removal limits. Traditionally, the role of scallop fisheries science has been to monitor and assess scallop populations, and to advise on sustainable harvest scenarios. More recently, expanded interest in activities such as aquaculture, marine conservation, and offshore wind have resulted in new demands on the Canadian Maritimes scallop science program. Management questions increasingly include the need to assess overlap, impacts, and risks related to scallop stocks and their associated fisheries in the face of other ocean uses, on scales varying from a few kms to 10s of kms. The common theme amongst these new requests for advice is the need for more spatially explicit information. These demands have necessitated an increasingly spatially explicit approach in the derivation of scallop science products, to be flexible and adaptable to the emerging needs of management. Resulting research has focused on applying novel spatio-temporal modelling frameworks to traditional scallop monitoring data. This talk will discuss recent challenges and present case studies on how new spatio-temporal approaches are being leveraged to inform effective decision making.

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A11 **[11]**

An analysis of reproduction and recruitment spatio-temporal dynamics of Iceland scallops in Breiðafjörður bay after a fishery collapse

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Since the mid-20th century, the Iceland scallop (*Chlamys islandica*) had been a thriving and economically important fishery in Iceland, particularly in West Iceland. This fishery was not only economically very valuable with an annual net worth of 730 ISK (~7 million USD), but provided many stable jobs to local coastal communities. However, the fishery suffered a major decline at the beginning of the 21st century. Breiðafjörður bay in West Iceland has the largest population of Iceland scallops, accounting for ~85% of cumulative catch between the onset of the fishery in 1969 and 2003. Between 2000 and 2003, the stock size index of the Breiðafjörður scallop population dropped 70%; subsequently, the fishery was closed in 2004.

Overfishing, disease outbreak, and recruitment failure are all thought to have contributed to the population collapse. While research has been conducted extensively on the disease outbreak, the recruitment failure component of the collapse is not been well understood. Spat biomass can be a helpful estimate for larvae, which is a critical life stage connecting reproducing adults and subsequent recruits, but is difficult to quantify. Since 2005, the Marine Freshwater Research Institute (MFRI) has collected data on Iceland scallop population surveys, gonad indices, and spat in different locations across Breiðafjörður bay.

Analyzing the datasets collected by MFRI and other available environmental data, our two primary objectives in this study were to 1) identify spatial and temporal relationships between spawning adults and spat in the scallop population and 2) determine if gonad indices, spat biomass, or environmental factors are associated with the presence of recruits. We determined that while the reproduction potential of adults has recovered significantly in more than 15 years since the fishery collapse, the spat abundance does not correlate, indicating there is likely a bottleneck between larvae and spat. However, we found statistically significant small-scale spatial dynamics between spat and subsequent recruits in certain areas of the bay over many years. In this presentation, we present our data explorations and significant correlations.

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A12 **[12]**

Enhanced data collection and near real-time spatial monitoring of the Isle of Man scallop fishery

Isobel S.M. Bloor, Matthew Coleman, Jennifer Shepperson and Stuart Jenkins

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In 2011 the Isle of Man queen scallop fishery was at a peak of biomass and was certified to the Marine Stewardship Council Standard. In 2014 following a significant decline in biomass, the fishery was suspended as the biomass had dropped below the point at which recruitment was thought to be impaired. As part of the rebuilding strategy a number of new data collection requirements were introduced in order to increase the resolution of data for monitoring Isle of Man scallop fisheries. In addition to EU logbooks any vessel fishing for queen scallops within Isle of Man territorial waters had to complete a tow by tow daily catch return form declaring the exact location, time and landings from each tow. In addition to 2 hour polling VMS vessels were also required to carry and operate a GPS logger recording positional data at 30 second intervals. In November 2015, the requirement to carry GPS loggers was replaced by an increased VMS polling rate of 15 minutes for all king and queen scallop vessels fishing in Isle of Man waters. In July 2017 paper daily catch returns were replaced by a phone app where fishers could report electronically. The automation of locational and fishing activity data recued the staff resource required to input data and has enabled almost real time monitoring of our scallop fisheries.

This fundamental step change in scallop data collection has enabled the precise monitoring of landings from within Isle of Man territorial waters against total allowable catch (previously landings were reported to ICES rectangles which have areas inside and outside Isle of Man waters). It has enabled landings and landings per unit effort (LPUE) to be monitored at the level of fishing ground and it has enabled weekly reviews of these fisheries.

Since 2017 weekly automated reports have been produced in R Markdown using the data downloaded from the fishing app (DCR) and from Citrix (VMS). These weekly reports are discussed at weekly meetings with the Scallop Management Board subgroup and decisions on the king and queen scallop fisheries, once approved by the Minister are then implemented efficiently using licence conditions.

The latest innovation for this near real-time data monitoring is a fisheries dashboard created in R Shiny which updates from the data inputs and has a simplified version available to the general public and a complex version available to fisheries managers and the scallop management board. The fisheries dashboard allows more in depth exploration and interaction for the user with the data.

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A13 **[13]**

ICES WGScallop: International collaboration for scallop science

Lynda Blackadder[1] and Isobel Bloor[2]

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The International Council for the Exploration of the Sea (ICES) is an intergovernmental marine science organization, with a global network of scientists who are focussed on better understanding marine ecosystems and sharing that knowledge. In 2013, the Scallop Assessment Working Group (WGScallop) was formed and have convened annually since then. The group now has 40 registered members from 20 different institutes and continues to grow each year.

Collaboration between institutes, with work spanning multiple administrative jurisdictions, has been key to the progression on the main work areas over the last ten years. This work includes scallop fisheries data collation, surveys and survey design optimisation, stock assessment, age determination workshops and mapping of scallop stocks. International collaboration has strengthened our understanding of scallop fisheries and led to valuable outputs (published papers, data tables and reports) which have been used to directly inform science projects, PhD studies, stock assessments and management decisions for scallop fisheries.

Scallop species continue to be of commercial importance and this group anticipates future advice requests to meet conservation, management and sustainability goals for the benefit of the stock, the fishing industry and the associated marine ecosystem. We encourage new scientific members and further collaboration so please use this opportunity to find out more about the work we do and how you can get involved as we set out our goals for the future.

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A14 **[14]**

Dive, dredge and camera surveys and assessment of New Zealand scallops (*Pecten novaezelandiae*)

James Williams

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Scallops (*Pecten novaezelandiae*) play an important role in ecosystem functioning and are highly-valued by customary, recreational, and commercial fishers in New Zealand. Scallop fisheries productivity has substantially deteriorated, as illustrated by declines in commercial landings (Figure A14.1), likely resulting from a combination of overfishing and habitat degradation. Research surveys provide fishery-independent estimates of the scallop populations, which form the basis of science advice to fisheries management. Fishery closures have been implemented in recent years due to sustainability concerns raised by the surveys.

The purpose of this talk is to provide an update on the latest developments in scallop fisheries research in New Zealand. This will include reporting the key findings of dive and dredge surveys and a dredge efficiency experiment in 2021, a camera survey in 2021, and scallop-habitat investigations. New research is underway to further develop camera survey methods (including machine-learning detection and sizing of scallops), to evaluate historical scallop fishery and survey data, and to develop reference points (management targets and limits) for scallops that appropriately consider fishery effects (e.g., benthic habitat damage from dredging) as well as non-fishery effects (e.g., land-based sedimentation) that can influence scallop productivity. These research efforts aim to provide improved monitoring and assessment of scallops in future.

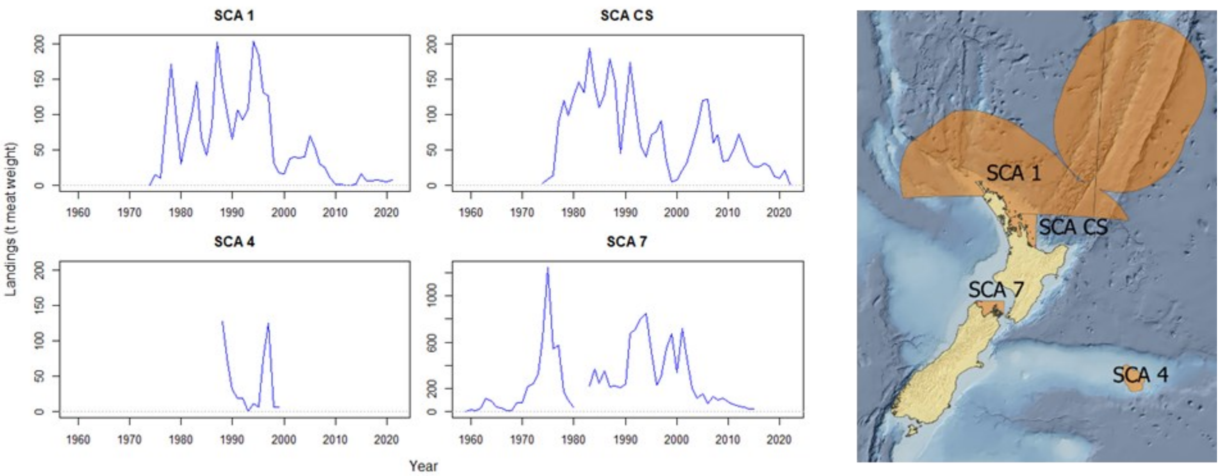

Figure A14.1: Landings of scallops (t meat weight) from 1959 to 2022 from New Zealand commercial scallop dredge fisheries in the four main scallop Quota Management Areas (QMAs): SCA 1, Northland; SCA CS, Coromandel; SCA 7; Southern; and SCA 4, Chathams

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A15 **[15]**

A comparison of survey designs for marine benthic invertebrate sampling

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Marine organism survey designs can take a wide range of forms, and one of the most important decisions is how to spread limited sampling effort over space. This study compared four methods for doing so, which were systematic, simple random, stratified random, and a sophisticated spatially balanced technique called generalized random tessellation (GRT) sampling. The comparison was performed using data from a long running optical survey of sea scallop (*Placopecten magellanicus*) populations in the northwest Atlantic Ocean. Two field studies showed limited differences in the performance of simple random and systematic sampling, despite considerable differences in sample sizes. Simulations expanded this study considerably by analyzing all four techniques over a greater range of scallop populations. The simulations involved drawing samples from fine scale density maps generated from fitting kriging models to scallop survey data. The performance of the techniques was assessed through the mean scallop density estimate and the variance of this mean. Some properties of the design of the strata in the stratified random sampling were also examined, including the length of time between strata being created and sampling taking place, and the number of years of prior data combined to generate the strata. Both the GRT and systematic techniques had high accuracy and precision throughout, although the systematic technique was inaccurate in one of 15 areas studied. The simple random technique was accurate but imprecise, and the stratified random technique was inaccurate in a handful of situations and imprecise in larger areas. The stratified random technique performance was largely unchanged by the configurations of prior data used to create the strata boundaries. These results lend support to both the current systematic design of the survey and the GRT technique because they were both highly accurate and precise. These results also contrast other studies that have shown stratified random to be among the best performing techniques, and therefore highlights how optimal statistical survey design is highly specific to the spatial nature of the species being targeted.

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A16 **[16]**

Investigating recent improvements to the SMAST Atlantic Sea Scallop, *Placopecten magellanicus*, drop camera survey.

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A critical component of stock assessment is fishery-independent data, which often come from scientific surveys that track population trends. The University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST) has reliably provided this information for the Atlantic sea scallop (*Placopecten magellanicus*) through drop camera surveys on the western Atlantic continental shelf since 1999. The drop camera survey collects photos and video footage of the sea floor according to a centric systematic design to generate sea scallop abundance and distribution estimates for use in management. This well-established image-based survey allows samples to be revisited and is non-invasive compared to towed fishing gear survey methods.

SMAST drop camera survey protocols and image analysis software have improved over the last five years to provide an additional means for quality control and assurance of scallop identification, enable the continuation of survey activity despite the COVID-19 pandemic, and provide supplemental data needed to fill gaps in survey coverage from other institutions. The web-based video platform, Tator, was developed with CVision.AI to permit students and staff to process images remotely. This valuable software maintained the ability to identify and measure organisms within one program and increased connectivity and quality control options to produce reliable estimates faster. The use of a deep learning scallop autodetection algorithm has continued over the last five years via Tator. This effort aimed to increase the productivity and speed of image processing to reduce optical survey costs. The automatic scallop detection algorithm serves as a tool to aid human image processors. However, human annotators are currently still responsible for the generation of data used in estimates by reviewing each image multiple times for quality assurance. The drop camera survey continued to expand through these digitizing improvements, served as the sole scallop survey offshore in the Gulf of Maine in recent years, and it has extended into offshore wind impact research.

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A17 **[17]**

Modifications to a Scallop Dredge Twine Top to Reduce Flatfish Catch

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The sea scallop dredge fishery has sub-annual catch limits for windowpane flounder and yellowtail flounder stocks on Georges Bank. The fishery has limited access to eastern Georges Bank in Closed Area II during a fishing year as well as gear restrictions to mitigate catches of these flatfish and minimize the possibility of exceeding the sub-annual catch limits. There is a need to further reduce bycatch of both flatfish, as the sub-annual catch limit for windowpane flounder has been exceeded since 2020, and the yellowtail flounder stock is in poor condition. Sea trials were conducted in 2022 and 2023 to test square mesh escape panels and SafteyNet's Pisces LED light system installed in the twine top of a scallop dredge to reduce the catch of these flatfish. In 2022, three Pisces light colors, two flash rates, and two brightness levels were tested with and without a square mesh escape panel (Figure A17.1). The escape panel was also tested in two locations in the twine top. In 2023, a two-row and a three-row escape panel configurations were tested. Catch data indicated reductions in flatfish catch across all light colors, flash rates, and brightness levels. The location of the square mesh panel was also determined to be important, with greater reductions in catch observed when the panel was lower in the twine top. Less flatfish escaped the twine top with a three-row escape panel compared to the two-row panel. No reductions in sea scallop catch were observed for any experimental gear configuration.

Figure A17.1. Two-row square mesh escape panel tested in 2022 and 2023.

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A18 **[18]**

Diver-Based Fishery of the Scallop *Pecten maximus* in Norway

Ellen Sofie Grefsrud, Tore Strohmeier, Øivind Strand

Institute of Marine Research, Bergen, Norway

A commercial diver-fishery was initiated during the1990s in the main distribution area/scallop grounds in Mid Norway (63-64°N). From 2013 the fishing area has expanded northward to Northern Norway (67°N). The total catch has varied between 300 to 800 metric tons in the last 15 years. In-shore dredging is banned in Norway, and today the only measure of the fishery is a minimum landing size of 100 mm shell length for both commercial and leisure catch. The self-imposed rotational harvest applied in this diver-based fishery imply a maximum exploitation rate at densities divers find unprofitable. Here we present the development of the fishery, diver regulations, today's harvest policy, and possible challenges due to an increased interest in exploiting scallops using new technology, such as non-invasive bottom harvester, and by recreational diving.

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A19 **[19]**

eDNA: Dragging a New Dredge for Sea Scallop (*Placopecten magellanicus*) Fisheries Monitoring

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Genetic material captured in aqueous or other environments, i.e., environmental DNA (eDNA), can be quantified to provide ecological inferences (Creer et al., 2016; Goldberg, Strickler, & Pilliod, 2015; Deiner et al., 2017; Thomsen & Willerslev, 2015). This material includes whole genomes of intact microorganisms (e.g., gametes or larvae) to free DNA fragments shed from cells of larger organisms. Quantitative eDNA assays for sea scallops have been developed based on ITS gene fragments (Bayer et al. 2019). Bayer and colleagues (2019) established that gene copy number, determined through quantitative PCR (qPCR) primers and size fractionation protocols, can be used as a proxy for sea scallop gamete number, specifically sperm, in the water column. These relationships have not been validated for sea scallop eggs or larvae and have not been tested in the field over wild scallop beds or on scallop aquaculture farms.

We also do not know how sampling at different depths and points in time influences one's ability to distinguish eDNA from adults vs. gametes and larvae. eDNA detection rates and degradation rates vary seasonally, experience high sampling variability between sites, and may be species-specific (Pierce 2020, Troth et al. 2021). eDNA has the potential to be used for adult stock assessments, larval transport models, and to estimate recruitment potential, if these patterns in eDNA occurrence and their significance were understood (Alexander et al 2021, Kirtane 2021), but this frequent disconnect makes stock assessments challenging. Understanding larval supply of sea scallops is further challenged in that their microscopic gametes and larvae cannot be distinguished taxonomically from other bivalves, and are difficult to track in situ (Pechenik, 1999). eDNA approaches may finally disentangle the supply-side of sea scallop recruitment ecology by providing a direct approach for species distinction and enumeration of gametes or larvae in the water column. Knowledge gaps that still need to be filled are quantifying rates of scallop eDNA generation and degradation and whether targeted water sampling at various depth strata and during various points of the spawning season can be used to spatially isolate gene copy number from adults and gametes/larvae. If so, carefully constructed sampling designs could allow this eDNA tool to be used both for adult stock assessments and to estimate recruitment potential. eDNA based data on the temporal and spatial patterns of spawning and larval transport also has the potential to help inform or validate particle tracking models used in fishery assessments.

Here we share results of lab experiments and field applications. Firstly, using a controlled mesocosm experiment, the eDNA generation and degradation rates of scallops at different biomass densities over a 48-hour period will be quantified. Positive linear relationships between eDNA generation rates and biomass and negative linear relationships between eDNA degradation rates and biomass over time are expected. Secondly, using a vertically stratified sampling design above a wild scallop bed, the spatial and temporal variability in scallop eDNA presence over a 6-month period is evaluated. During spawning and larval transport seasons, the eDNA signal is expected to be distributed throughout the water column. Outside of these seasons, the eDNA signal is expected to be limited to the benthos. Results from this work may inform the use of carefully constructed sampling designs to conduct adult stock assessments or to estimate recruitment potential and will identify benefits and shortcomings of eDNA as a tool for assessing commercially important species.

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A20 **[20]**

Small-scale spatial dynamics of sea stars, *Asterias* spp., and Atlantic sea scallops, *Placopecten magellanicus,* in the Nantucket Lightship area

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[3]*Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ, USA*

The Atlantic sea scallop (*Placopecten magellanicus*) fishery is one of the most lucrative fisheries on the East Coast of the United States. Dense aggregations of sea stars (*Asterias* spp.), a primary predator of scallops, have been observed in the Nantucket Lightship (NL) area of Georges Bank. Sea star density can affect sea scallop population growth and distribution through consumption of spat, juvenile, and adult scallops. Sea star abundance and density in the NL declined during an abnormally warm winter in 2012 coinciding with the successful settlement of scallop spat from an extreme recruitment event, doubling the estimated abundance of the entire U.S. scallop population from the prior year. Understanding the reaction of sea stars to this increase of sea scallops by investigating small scale spatial distributions of each population could provide insight into their predator-prey interactions. The School for Marine Science and Technology (SMAST) drop camera survey data from 2010 to 2018 was used to investigate sea star and sea scallop distributions on multiple spatial scales before, during, and after the scallop recruitment event. Morisita's indexes and Ripley's *K*-function indicated that both sea stars and sea scallop distributions were aggregated at a scale of tens of meters, meters, and centimeters within the same species (i.e. scallops compared to other scallops) and between species (scallops compared to sea stars) during most years examined. Nearest neighbor frequencies suggest sea stars are found near scallops <75mm and scallops >75mm similarly implying they may not actively target a certain sized scallop. Characterizing spatial relationships of sea stars and sea scallops and how they change over time may help understand natural mortality events and track recruitment success of sea scallops associated with sea stars in fisheries management areas.

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A21 **[21]**

Fluctuations in Pacific Calico Scallop (*Argopecten ventricosus*) and others small-scale fisheries associated with mangrove areas in the Magdalena Bay, Baja California Sur, México

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Interdisciplinary Center for Marine Sciences, National Polytechnic Institute, La Paz, Baja California Sur, Mexico.

In the Magdalena Bay region, on the southwestern coast of the Baja California Peninsula, small scale fishing activities target various mollusk species associated with mangrove forests. Catches include Pacific calico scallops (*Argopecten ventricosus*), black ark (*Anadara tuberculosa*), squalid callista clam (*Megapitaria squalida*), Californian venus clam (*Chione californiensis*), pen shells (*Pinna rugosa* & *Atrina maura*), and Chinese snails (*Hexaplex nigritus* & *Chicoreus erythrostomus*). Blue and brown shrimp (*Penaeus stylirostris, P. californiensis*) and green swimcrab (*Callinectes bellicosus*) are also harvested.

Variations in the catches of these species have been linked to the effects of fishing and changes in environmental conditions affecting resource availability, leading to conflicts in fisheries interactions. This study proposes that environmental effects are the key to these fluctuations, analyzing production data recorded by the National Commission of Aquaculture and Fisheries from 1992 to 2021. Capture trends were correlated with sea surface temperature data (1993-2020) obtained from satellite images from the Copernicus Marine Service. Both series were smoothed with a moving average of order 3, and a cross-correlation analysis was applied, revealing a significant correlation (r = 0.64) with a lag of 8 years.

The temperature series identified periods of the El Niño-Southern Oscillation (ENSO) phenomenon, distinguishing those dominated by warm temperatures (El Niño) and cold temperatures (La Niña) according to NOAA reports. These periods were superimposed on the capture series for each species or species group. The results indicate variability among the series of each fishery, with positive trends for black arks, Californian venus clams, and Chinese snails, and negative trends for Pacific calico scallops (Fig. A21.1), squalid callista clams, and shrimps. Changes that occur more frequently seem to be cyclic and apparently related to variations in environmental conditions. However, it is concluded that it is challenging to differentiate and quantify the possible effects on resource availability due to fishing or modifications in mangroves, habitat conditions, and their impact on biological processes such as reproduction, feeding, growth, mobility, and recruitment.

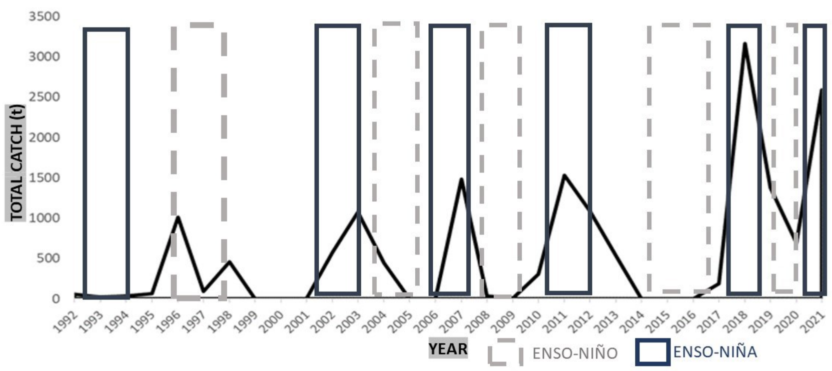

Figure A21.1.- Annual catches of Argopecten ventricosus in tonnes (Whole weight) from mangroves areas of the Magdalena Bay-Almejas 1992-2021. The rectangles denote the duration of El Niño and La Niña periods.

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A22 **[22]**

Seasonal variations of condition, gonad somatic and adductor muscle indices of the Mediterranean scallop *Pecten jacobaeus* L. from the Adriatic Sea (Croatia)

Valentina Šebalj[1], Lav Bavčević[2], Tomislav Šarić[2], Petar Zuanović[2] and **Ivan Župan**[2]

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[2]*University of Zadar, Department of ecology, agronomy and aquaculture, Zadar, Croatia*

In the recent decades, aquaculture has been one of the fastest growing sectors in food production in the world (FAO, 2022). Although the vast majority of bivalves on the market comes from the aquaculture, the production is limited to a small number of species. For example, in EU, bivalve farming is mainly dominated by the cultivation of mussels and oysters. Therefore, there is a strong need to introduce new candidate species from aquaculture to the market, since the wild populations of commercially interesting species are heavily exploited by fisheries and uncontrolled collection, which along with the other anthropogenic and climate impacts, lead to the decline of their populations.

The Mediterranean scallop *Pecten jacobaeus* (Linnaeus, 1758) is the largest bivalve of the Pectinidae family that lives in the Mediterranean and the Adriatic Sea. Due to its high market value, it is an interesting species for the introduction into the aquaculture, especially since the wild populations are considered to be overexploited.

In the research by Baždarić et al (2018), high growth rates without the mortality issues were recorded in Novigrad Sea, Croatia for *P. jacobaeus* held in lanterns on mussel farm site. The production period from the mentioned study can be estimated to be completed within 2 years period, which is a good potential for the candidate species for commercial production. However, there is a severe lack and unitability of the spat collection within the whole Eastern Adriatic coast. Therefore, it is crucial to understand the reproductive biology of this species as a first step for development of controlled hatchery production and/or more successful spat collection from the wild.

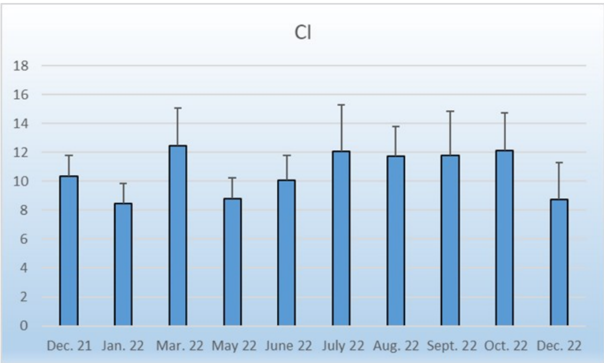
The aim of the research was to investigate several *P. jacobaeus* physiological indices which are crucial to understand species reproductive biology, as a first phase for the potential controlled reproduction and adequate spat collection management. Specifically, we monitored the condition index (CI), gonadosomatic index (GSI) and adductor muscle index (AMI) on individuals collected from the wild on the central part of eastern coast of the Adriatic Sea (Croatia).

We collected 20 specimens monthly from the Krka River estuary from December 2021 to December 2022. The parameters measured included shell dimensions (length, height and width (mm)), total mass of the shell and of the soft tissue, wet and dry weight (g), after processing in the dryer at 60 °C for 48 h. CI, GSI and AMI were calculated by the following methods (Lucas & Beninger, 1985): *CI= (soft tissue dry weight (g)/shell dry weight (g)) x 100; GSI= = gonad dry weight (g)/ total tissue dry weight (g) x 100; AMI= muscle adductor dry weight (g)/ total tissue dry weight (g) x 100*.

A22 **[22]**

Highest CI values were recorded in March ‘22 (M= 12.45, SD= 2.64), Oct. ‘22 (M= 12.11, SD= 2.63) and July ‘22 (M=12.06, SD= 3.22) while lowest values were detected in Jan. ‘22 (M= 8.48, SD= 1.37) and May ‘22 (M=8.78, SD= 1.48). Highest GSI values were recorded in March ‘22 (M= 23.03, SD= 10.12), Dec. ‘22 (M= 16.85, SD= 9.44) and Dec. ‘21 (M= 15.22, SD= 7.22), while lowest in June ‘22 (M= 3.80, SD= 7.22) and July ‘22 (M= 3.98, SD= 1.61). Highest AMI values were recorded in July ‘22 (M= 58.35, SD= 3.89), Oct. ‘22 (M= 57.86, SD= 3.97) and Aug. ‘22 (M= 57.77, SD= 3.80) while lowest in March ‘22 (M= 39.77, SD= 5.44).

The results of CI and GSI indicate that the main spawning period is during early spring season. Accordingly, the spring season would be the most favorable period for setting up collectors for wild spat collection, as well as for collecting and conditioning of broodstock under laboratory conditions. Elevated GSI in Sept. ‘22 and also in Dec. ‘21 and Dec. ‘22 with following decline in values indicate that there were two additional possible spawning periods, but further research is necessary. AMI values indicate that there is inversely proportional relationship between GSI and AMI mean values (Figure A22.1.), suggesting that food reserves from adductor muscle are potentially used for gonad development in the periods of food shortage and replenished again when gonads are dormant and food is abundant. Given that the size and quality of the adductor muscle is important for the marketing of the species, the products quality would accordingly be the most favorable in the summer period when the AMI reaches its highest values.



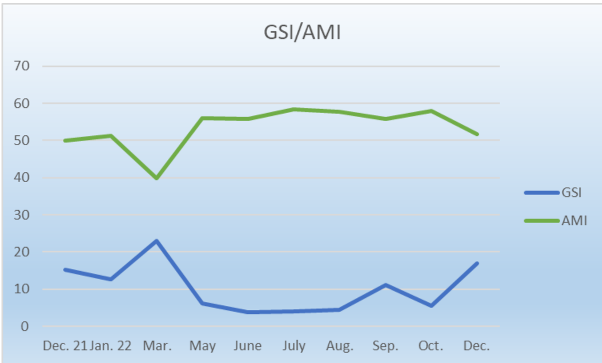


***Figure A22.1. Condition index (mean** and sd) and GSI/AMI relationship during the research period*

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Biology, Ecology and Genetics (B)

- **Session 1: Monday 29th April (am)**
- **Session 2: Monday 29th April (pm)**

B1 **[45]**

Marine protected areas: Can they really provide benefits for both conservation and scallop fisheries?

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[4]*Cawthron Institute, Nelson, New Zealand.*
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Scallop populations are known to generally respond well to protection from certain types of fishing, but exactly what level of protection and size of protected area produces the best results, and how long recovery takes, is less clear. The Isle of Arran, off the west coast of Scotland, provides a unique opportunity to investigate these questions for scallop populations in temperate marine ecosystems. Arran features the Lamlash Bay No Take Zone (NTZ) established in 2008, an area of restricted fishing open only to divers and static gear within the boundaries of the South Arran Marine Protected Area (MPA) established in 2016, and other areas that continue to be open to all types of fishing including scallop dredging and trawling. The different ages of the protected areas should provide further insights into the dynamics of recovery of scallops and the wider ecosystem.

This presentation reports on the results from the latest SCUBA diving surveys of these areas, undertaken in July and August 2022. This research built on previous data collected by annual dive surveys from 2010-2015 and in 2019. Fifty-eight underwater SCUBA survey transects were completed within the NTZ, the MPA and in a fished area open to scallop dredging in 2022. All king scallops (*Pecten maximus*) were counted on each transect, the first ten were aged and measured, and a subsample were collected for dissection to quantify exploitable and reproductive biomass. King scallop density was over twice as high in the NTZ (21.8 scallops/100m^2) and Far Control area in the south of the MPA (22.8/scallops/100m^2) than in the Dredged area (10.7/100m^2). In the Near Control area around the NTZ, which was open to dredging until 2016, the density was almost 50 scallops/100m^2, dramatically higher than all the other sites. Across the South Arran MPA overall, mean scallop density was 10 times higher than during baseline surveys conducted in 2014 and 2015, prior to protection from dredging.

Settlement of juvenile scallops was highest in the NTZ and Near Control areas and significantly associated with the presence of kelp and macroalgae. Analysis of videos taken during the dive surveys demonstrated an 8-fold greater coverage of macroalgae in Lamlash Bay NTZ compared to a greater coverage of bare substrate in the dredged zone. The recovery of macroalgae in the NTZ was observed shortly after designation and has since increased over time, showing distinct spatial and temporal recovery as a result of ecosystem protection. Several other sessile benthic species (hydroids, anemones, and echinoderms) were also significantly more abundant in the NTZ than in the dredged area. The increased structural complexity of the seabed offered by macroalgae and these other species has likely amplified the recovery of marine life in the NTZ by providing vital settlement and nursery areas for juvenile scallops among many other species.

B1 **[45] Cont.**

With increasing levels of protection, king scallops were also significantly older and larger in terms of shell length, biomass and reproductive biomass. For example, the exploitable and reproductive biomass of king scallops per unit area in the Near Control area was over 5 times higher than that in the dredged area. Given the higher reproductive potential per unit area in the protected zones, these scallops are likely to be exporting high levels of larvae to surrounding areas, especially if you consider that the high density of scallops will also have enhanced fertilization rates.

Overall, this ongoing research has provided increased support for the role of protected areas for restoring scallop populations and other ecosystems, and potentially for helping to boost fisheries. The long term nature of the data we have gathered is providing further insights. Spatial and temporal variation was a real feature of our findings, with some younger and less protected areas recovering more quickly and substantially than the older protected area which offers more protection. However, that comparison is confounded by the smaller size of the highly protected area. A better understanding of the importance of these different design features of protected areas will help inform spatial management of scallop fisheries into the future.

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B2 **[46]**

Is growth slower or is it us?
Growth estimates and their implications from a tagging study in Penobscot Bay Maine, USA

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[2]*Hurricane Island Center for Science and Leadership, Rockland, ME, USA.*
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Growth is one of the most important biological parameters in understanding and managing fisheries populations. These estimates are essential for our understanding of predicting when similar sized cohorts will recruit into the fishery and reach certain biological milestones. In the case of the Atlantic sea scallop (*Placopecten magellanicus*) shell growth occurs by depositing new shell material along the shell margin, and can be modeled with the traditional von Bertalanffy growth model. There is considerable variability in growth not only on a regional scale but also on a small spatial scale closely related to depth, temperature, and the availability of food.

Growth parameters have been estimated along the range of the Atlantic sea scallop, documenting relatively similar growth in the early years of approximately 2-3 cm/year. The maximum size, and the size at which growth begins to slow down is where the regional variability is most evident. For the past decade, the Maine state scallop fishery has operated with rotational closures for large portions of the fishery. This rotational plan closes fishing areas for two seasons to enhance the recovery of the resource. To evaluate the success and maximize the efficiency of this management plan these estimates of growth are essential.

We measured, tagged, and released 803 scallops (90-129mm SH) in an area that had growth parameters previously estimated by measuring shell growth between annual rings. These tagged scallops were released in depths approximately 20m, near their capture location in Penobscot Bay, Maine, USA. Fleet members returned 101 shells with capture location and date. There was no notable movement of these scallops. Instantaneous growth equates to an average growth of 11 mm/ year. The estimated growth from these scallops was notably slower than the previous estimates calculated from this area using the growth ring measurement method (Figure B2.1).

Additionally, 200 scallops were tagged and held in lantern nets at 5m depth in a nearby scallop aquaculture site. There was no difference of shell height growth between the wild scallops and the aquaculture scallops, however aquaculture scallops grew significantly faster in shell width. Mortality was 20% for the first year after tagging and 4% in the second year. Tag loss of the aquaculture scallops was relatively low for the first year (2%) and was significantly higher in the second year (21%).

The slower growth in our study, compared with the earlier studies, raises questions about how to best manage the scallop resource for this region. Assuming these growth estimates are both accurate, these results document a slower growth in recent years. The suggested slower growth may help explain the observed serial depletion of the historic scallop beds.

B2 **[46] Cont.**

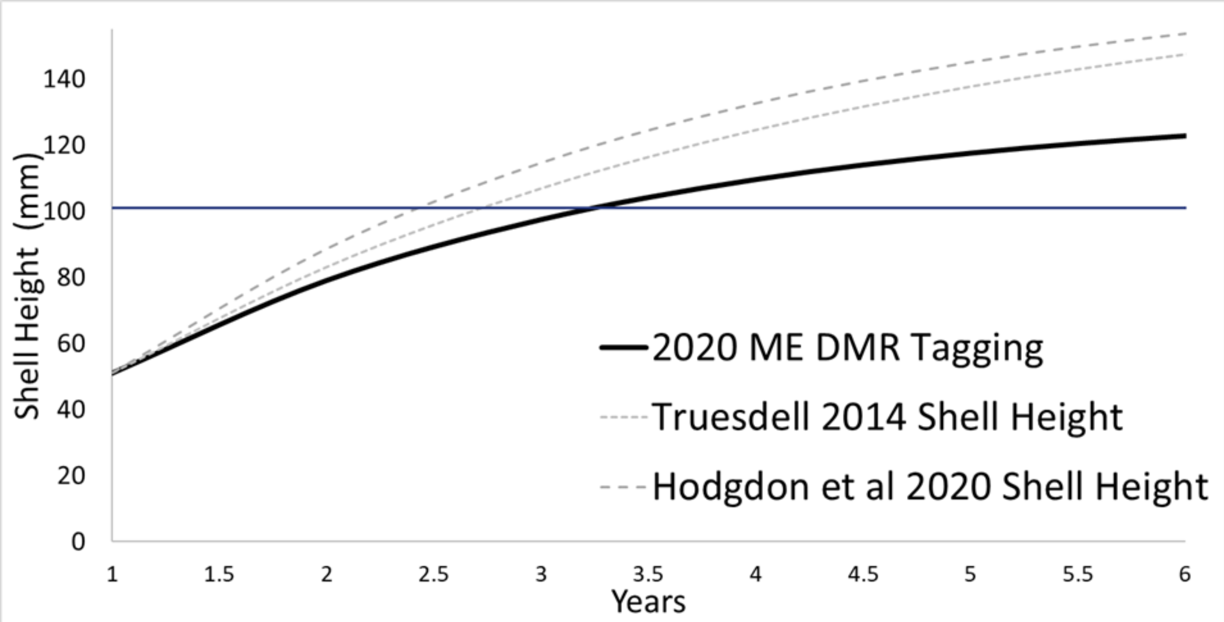

Figure B2.1. *Predicted shell height from von Bertalanffy growth parameters from this study (black) and previous studies in the general area (gray). The starting size used for these projections was 51mm (approx. 2-year old). The horizontal line represents the minimum legal size.*

Alternatively, this difference could simply be errors between the two methods, or limitations of the data not capturing the true variability. These unknowns raise important questions about what levels of variability in growth should be accounted for in management. Moving forward to expand our knowledge of growth along the coast we have additional ongoing tagging projects.

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B3 **[47]**

Annual growth marks within the calcareous plate of *Aequipecten opercularis*

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Understanding life history traits, including growth rates, is a crucial component of fisheries science. Efficient management of economically significant species relies on accurate ageing techniques to record age and evaluate growth rates, thereby providing valuable insight for fisheries stock assessment. Reliable and cost-effective ageing techniques for *Aequipecten opercularis* are currently lacking. The traditional approach of examining annual growth rings on the outer shell is not feasible for *A. opercularis*, as their ring formation can be weakly formed and disrupted by disturbance marks. To address this issue, this preliminary study examined the calcareous hinge plate of *A. opercularis* to identify the presence of true annual markings and develop an alternative ageing technique. The hinge plate was examined from two viewpoints - a medial dissection and a frontal inspection - to identify annual marks. A comparative image analysis of the external shell, medial dissection, and frontal plate was then used to determine the method with the highest accuracy. When compared to an estimated age from a Von Bertalanffy growth function, frontal plate reading of the hinge plate was found to be the method with the least variability in reading annual growth marks. Further research is planned through trace element analyses of Mg/C within the hinge plate, in order to confirm that hinge plate readings are a reliable and affordable method of ageing scallops. This information can then be applied to fisheries stock assessment of growth rates in various sites around the Isle of Man.

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B4 **[48]**

Cross-Generational Effects of Ocean Acidification on a Third Generation of Bay Scallops

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Ocean Acidification (OA; elevated ρCO_2) is accelerating in coastal ecosystems and threatens many organisms, especially during early larval development. Transgenerational plasticity is a possible mechanism conferring resilience to rapid environmental change. To better understand the effects of OA exposure across generations, and the potential for transgenerational plasticity, bay scallops were raised from embryogenesis to sexual maturity, under one of three OA conditions (ρCO_2 = 500, 800, 1200 µatm) for two generations. The third generation offspring of these scallops were grown in a full factorial design (parental history × larval exposure) under the three OA conditions. Survivorship, growth rate, and larval physiology were measured from prodissoconch I to metamorphosis. Shell abnormalities in D-stage larvae and the number that had successfully metamorphosed by day 19 post fertilization were quantified. Respiration rates were also measured from prodissoconch I to metamorphosis to assess changes in metabolism related to growth and survivorship. We found differences among treatments that will be discussed in the context of acclimation to rapid environmental change. Graphical trends suggest that transgenerational plasticity may confer some resilience to OA under some conditions and additional transcriptomic analysis is underway.

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B5 **[49]**

Assessing Vulnerability of the U.S. Atlantic Sea Scallop to Ocean Acidification and Warming: A Dynamic Energy Budget Modeling Approach

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The U.S. Atlantic sea scallop (*Placopecten magellanicus*) fishery is a fisheries management success and is one of the most valuable fisheries in the US. However, changing ocean conditions driven by climate change and ocean acidification (OA) may cause declines in scallop availability, harvest, and revenue. Scallop habitats in the Northeast and Mid-Atlantic already experience suboptimal temperature and carbonate chemistry conditions episodically. Regional oceanographic models predict that these conditions will continue and worsen in the future under the most severe climate change scenario, predicting that most scallop habitats will experience stressful conditions for most of the year by the end of the century. Here, we project the effects of ocean acidification and warming on sea scallop growth and reproduction potential historically and over the next century using a dynamic energy budget (DEB) model forced by a regional ocean model. Simulations reveal that the combined effects of end-of-century OA and warming will vary spatially and temporally. For example, the results suggest that declining scallop populations in the southern extent of their range will not be able to recover due to continued thermal stress predicted for the future, whereas the growth of populations further north may be more variable, with some areas potentially acting as refuges, due to spatiotemporal heterogeneity in subsurface conditions. Our future work will couple the DEB model to a larval transport model to also simulate potential changes in recruitment. This novel combination of approaches will allow us to quantitatively relate changing ocean conditions to changes in sea scallop population vulnerability and inform fisheries management by estimating changes in growth and identifying areas that are candidates for future fishing zones.

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B6 **[50]**

Collapse of Mid-Atlantic Bight Sea Scallop (*Placopecten magellenicus*) Populations Due to Warming Temperatures

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The Mid-Atlantic Bight (from Cape Hatteras, NC to Long Island NY) has historically been a productive area for sea scallops, with harvests often valued in the hundreds of millions of dollars. However, this area marks the southern limit of the sea scallops' range, making them vulnerable to increasing temperatures.

Increases in mortality of adult scallops off of Virginia (36.5˚- 37˚N) began in 2001. Since then, although recruitment in this area continues to be observed, their survival to adulthood has become increasingly poor. Over time, this pattern has spread further northward as well as to shallow water populations. By 2023, elevated mortality was observed in the Elephant Trunk area (38.17˚to 38.83˚N) and in shallow water populations as far north as Long Island (40.5˚to 41˚N).

Bottom temperatures in Mid-Atlantic Bight shelf waters have increased as much as 4˚C over the last 25 years, in part due to changes in the Gulf Stream. Adult sea scallop mortality appears to increase once maximum annual bottom temperatures cross a threshold of about 18˚C. Mortality may be due to negative scope for growth at these high temperatures, combined with a depletion of reserves after spawning. It is likely that the trends towards higher mortality and decreasing biomass of sea scallops in the Mid-Atlantic Bight region will likely continue, with concomitant negative economic and ecological impacts.

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B7 **[51]**

Dynamic Pathway to Transition from Vulnerable to Resilient Fisheries Social-Ecological Systems: A Transdisciplinary Case Study of the U.S. Atlantic Sea Scallop

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Dynamic social ecological systems (SES) built around fishing stocks with potential for sustainable catch and flexibility to respond to environmental change are key to achieving multiple U.N. Sustainable Development Goals. Atlantic sea scallops have demonstrated the potential for sustainable yield but are increasingly threatened by effects of ocean acidification (OA) and warming. As calcifiers with limited mobility and high revenue potential, this fishery is particularly suited to a transdisciplinary approach combining coastal fishing community assessments with ocean models, sea scallop physiological response, and population dynamics. The vulnerability and resilience of fishing communities to the effects of OA and warming is dependent on their adaptive capacity in relation to social and environmental exposure and sensitivity factors. In the Northeast U.S., the contribution of sea scallops to total regional landed value has steadily increased over recent decades to more than $500 million US per year. As a result, the dependence of the regional fisheries SES has shifted to this species. This dependence and the predicted shift in sea scallop distribution and biomass decline make this study particularly relevant. Here, we provide regional projections of changes within sea scallop fishing zones based on ocean models and physiological assessments. These projections have been combined with social indicators of fishing community vulnerability and resilience to structure workshops with fishery managers and fishing-dependent communities. The workshops assist stakeholders in exploring scenarios to build resilience to future change. Challenges, lessons learned, and next steps toward achieving a transdisciplinary understanding of SES vulnerability in this fishery are explored.

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B8 **[52]**

Moving Baselines: Managing Scallop Fisheries in a Period of Climate Change

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Sustainable management of a fishery is generally portrayed as requiring knowledge of stock distribution, size and demographics, and rates of recruitment, growth, and mortality to develop estimates of allowable catch. The formulations of quantitative estimators of these entities are well entrenched in current management practices. Climate change has, however, created additional challenges. Oceanographic processes that in part determine zoogeographic ranges are changing with warming; thus spatial determinants in assessment surveys, area management protocols, and more are fluid. Growth rates are not uniform across stocks of sessile species, varying along latitudinal and depth gradients that also change over time frames of years, often in time frames approaching single generations of longer lived target species. Gametogenic cycles are driven by temperature, but phytoplankton productivity cycles remain queued by day length. Spawning and hence recruitment to the benthos are subject to temporally variable temperature cycles. How then, in this seascape of changing baselines, are we to delineate changes in the context of inputs to quantitative estimators? Of equal importance, how do we portray this multiplicity of varying elements in management reviews where appointed citizen committees, who may not be familiar with these complex data, are tasked with voting on management actions?

Herein we draw from the sea scallop, *Placopecten magellanicus*, fishery of the US mid-Atlantic and Georges Bank regions, together with clam and cod fisheries that occupy an overlapping footprint, to illustrate both the complexity of the climate driven data and proffer some GIS-based options to its portrayal to facilitate management discussions. The Mid-Atlantic Bight (MAB) of the US eastern continental shelf is supplied with cold water from the north that originates in the Labrador current and warmer water that originates to the south in the Gulf Stream. It is a seasonally stratified system with warmer water overlaying a "Cold Pool" in the summer months. The footprint of the cold pool dictates the distribution of boreal benthic fauna, including the sea scallop. The cold pool is shrinking (https://vimeo.com/505266510/20c9dfbdcd) with associated movement of the southern distributional limit in an offshore and northerly direction. This is well illustrated in time series distribution maps such as the NEFSC scallop surveys (https://apps-st.fisheries.noaa.gov/dismap/). Recently completed examination of growth rate and maximum length (von Bertlanffy k and L_{inf} respectively) in the surfclam (ranges partially overlap with sea scallops and are similarly cold pool dependent) indicate multidecadal trends largely driven by temperature as estimated from retrospective temperature reconstructions of the MAB (du Pontavice et al. 2023, https://doi.org/10.1016/j.pocean.2022.102948). The Story Map format of data presentation in GIS can be employed to overlay temperature and distribution data for wide public dissemination. A recent example for cod distribution by Garrett Bellin is available at https://storymaps.arcgis.com/stories/924bd9132f6b49df955bc4061b026a9f. Changes in growth rate and maximum length of sea scallops are the subject of ongoing age at length studies throughout the range. It is reasonable to predict similar spatial and temporal variation in both, underscoring the limitations of employing single, stock wide age at length descriptors in management, and encourage consideration of

B8 **[52] Cont.**

smaller unit area approaches. Given the rotational area approach employed in sea scallop management, implementation may be tractable. Complexity abounds.

Can we distill all of these time and space dependent data sets into summary units that incorporate all quantitative elements, including growth and productivity projections, and display the summaries with GIS tools to facilitate reasoned management decisions? We argue that the answer to this question is yes.

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B9 **[53]**

Scallop (*Pecten maximus*) Moving Northward

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The great scallop (*Pecten maximus*) is distributed along the Norwegian coastline up to 67°N, with the main harvesting areas being at Hitra/Frøya in Mid-Norway (63°N) and Helgeland in Northern Norway (66°N). The northward expansion of the great scallops' distribution is believed to be limited by low winter temperatures, but since the mid-2000s, small populations of *P. maximus* appear to have established themselves beyond the previous distribution boundaries along the coastline and in the mid-western part of the Lofoten Islands. The Norwegian coastline spans from 58°N to 71°N and exhibits an environmental gradient with decreasing temperatures from south to north. Over the past 15 years, coastal water temperatures have increased by approximately 1°C from 12°C to 13°C. At the same time, the number of days with winter temperatures below 4°C at 10 m depth have decreased. In this study, we utilize environmental surveillance data on hydrodynamic conditions along the Norwegian coastline, along with observations from scientific mapping surveys, age distribution analysis, and landing data along the coast, to argue that the observed temperature increase has expanded the northward living area of the great scallop. These results align with the broader trend of polar shifts in species distributions observed in response to climate change.

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B10 **[55]**

Linking life traits and Dynamic Energy Budget parameters to better understand domoic acid contamination in five pectinid species

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Species of the Pectinidae family are among the most fished and cultured molluscs species worldwide. By their filtration activity, pectinid species can accumulate toxins produced by their prey. Particularly, domoic acid (DA), the amnesic shellfish toxin produced by diatoms of the genus *Pseudo-nitzschia*. However, levels of contamination and depuration rates are species-specific. Species can be placed on a gradient from “slow depurator” to “fast depurator”. Processes to explain these differences are not yet known. Here, five socio-economically important species for which life traits data is available were compared. The king scallop, *Pecten maximus*, accumulates the highest concentrations and when contaminated retains the toxin for a very long time. The Atlantic deep-sea scallop, *Placopecten magellanicus*, also bioaccumulates and relatively slowly decontaminates DA. They are known as “slow depurators”. In contrast, the variegated scallop, *Mimachlamys varia*, the Chilean scallop, *Argopecten purpuratus* and the giant lion’s paw, *Nodipecten subnodosus* are known as “fast depurators” with lower DA concentrations accumulated and faster depuration. While some hypotheses have been made to explain the long retention of *P. maximus* and the differences between species, processes are not yet established. This is why, comparing “slow depurators” and “fast depurators” may help understanding these processes. Toxin kinetics are linked to the organism metabolism, and it is hypothesised that differences in the toxin retention between species can be explained by physiological differences. To investigate physiological differences, species were compared within the same conceptual and quantitative framework provided by a bioenergetic model based on Dynamic Energy Budget (DEB) theory. DEB models already exist for *P. maximus*, *A. purpuratus* and *P. magellanicus* and two new species were added to the DEB species collection: *M. varia* and *N. subnodosus*. One of the strengths of DEB theory, is the possibility to compare species based on parameter values which are linked to physiological traits. In this study, we want to see if it is possible to identify one or several DEB parameters that could drive the “slow” and “fast depurators” traits of pectinid species. The originality of our method is to compare how different are DEB parameters when estimated for a single species and for several species at the same time. After a comparison of life traits, particularly age and length at life cycle transitions and reproduction strategy, physiological hypotheses were defined to base the estimation of DEB parameters. Then, emphasis was made on specific assimilation and maintenance costs parameters for toxin kinetic. Species comparison and hypothesis on parameters that could explained the differences between “slow” and “fast depurators” will be presented in this communication.

Keywords: Pectinidae, life traits, Dynamic Energy Budget theory, Amnesic Shellfish Poisoning

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B11 **[56]**

Extreme Population Densities Impact Reproductive Effort and Oocyte Development in Atlantic Sea Scallops

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The Atlantic sea scallop, *Placopecten magellanicus*, supports one of the most valuable fisheries in the United States. The fishery is managed through a suite of innovative strategies, including rotational area management which protects juvenile sea scallops to increase yield-per-recruit and spawning potential. While generally successful, area management was challenged by two extremely high-density recruitment events which did not respond as expected to fishing protection. Juveniles at both sites, the Nantucket Lightship Closed Area and the Elephant Trunk Closed Area, persisted at high population densities and initially exhibited varying degrees of impacted performance. The effect of sea scallop population density on reproduction was investigated through quarterly sampling during 2018–2020 in high, medium, and low-density portions of both areas. Reproductive effort, the proportion of energy devoted to gamete production compared to somatic processes, was quantified to investigate differences in energy allocation. Female gonads were retained to directly investigate impacts on oocyte development using histology. Overall, reproductive activity occurred over a shorter window in the Nantucket Lightship high-density stratum, where the percentage of sea scallops staged as mature or spawning reached 50% during only one of seven sampling trips. Population density was an important factor in predicting reproductive effort, with sea scallops at the highest densities exhibiting a 28% reduction in reproductive effort compared to typical population densities. Preliminary histology results indicate higher rates of oocyte resorption at elevated population densities, suggesting fewer oocytes were released during spawning in high-density areas. Total oocyte production will be estimated for individual scallops and per m^2 of ocean bottom to investigate impacts on fecundity across study areas and population densities. These results illustrate the complexities of managing fisheries for heterogenous populations of sessile benthic invertebrates. Future extreme recruitment events may not respond as expected to rotational area management due to the presence of density-dependent effects.

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B12 **[57]**

Is *Francisella halioticida* to blame for mortalities of adult scallops (*Argopecten purpuratus*) in Tongoy Bay, Chile?

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Introduction

The scallop *Argopecten purpuratus* Lamarck 1819 is distributed along the Eastern Pacific coast from Sechura Perú to Tongoy Bay, Chile. A permanent fishing ban exists since 1986 and is still in force for wild populations. Tongoy Bay is the single most important bay for cultivated scallop production, accounting for about 90% of it. Scallops from Tongoy Bay are fairly healthy, and very few parasites are known to be harboured by them (Lohrmann 2009). However, mortalities of adult, harvest ready scallops occurred in November (austral spring) 2006, and then again in the same month in 2007. Thirty scallops were histologically surveyed on each occasion, the most notorious feature was hemocytic infiltration in digestive gland, gonads and mainly in gills. The hemolymphatic vessel of the gill filament was full of hemocytes, and many filaments got ruptured. Mortalities have continued to occur sporadically, and a monthly sampling was undertaken using molecular tools to assess the microbiota and histology.

Materials and methods

Adult scallops (16 months old, with a shell height of 60-70 mm) were collected from the UCN aquaculture facilities in Tongoy Bay, Chile (30°16’ S, 71° 35’W) during 12 months, starting in October 2021, till the same month 2022. The gills and hemolymph of 6 sampled scallops were preserved in 100% ethanol and stored at -20°C for subsequent extraction of genomic DNA (gDNA). Furthermore, tissue samples from the same individuals plus another 6 individuals were collected from the gills, mantle, digestive gland, nephridium, muscle, and gonad and fixed in Davidson´s fluid for subsequent histological processing. Five µm thick sections were stained with haematoxylin and eosin and analysed using a Nikon eclipse microscope with images being captured using an EOS Rebel T6 camera.

Genomic DNA (gDNA) present in the gills and hemolymph was extracted with the Wizard Genomic DNA purification kit (Promega), following the manufacturer's instructions. The 16S rRNA gene of bacterial communities was amplified and sequenced, targeting the variable regions V3-V4 on a MiSeq system (Illumina®).

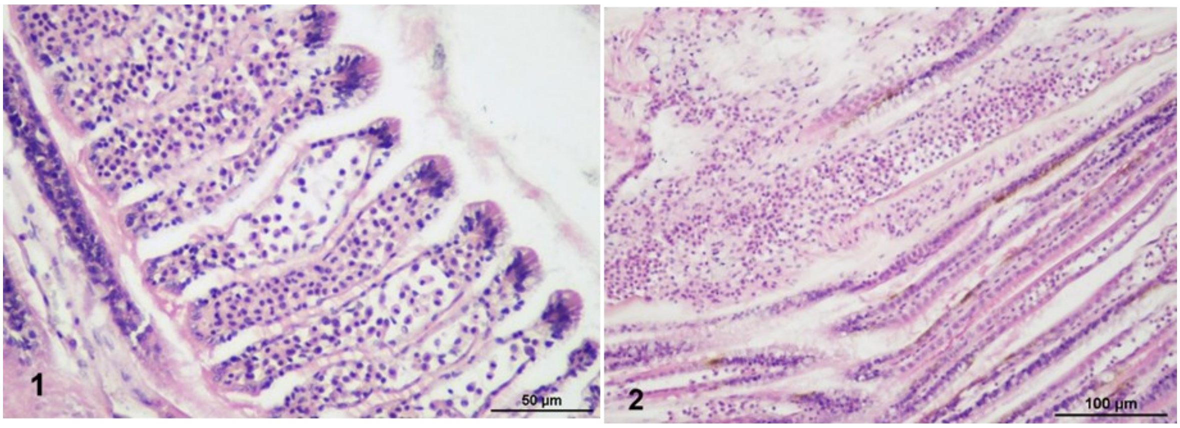
Results and discussion

The bacterial communities of gills and hemolymph consisted mostly in symbionts, but also some pathogenic genera were detected, *Vibrio*, *Photobacterium* and *Francisella halioticida,* being the latter the most important of them. It was detected only in one month, November, in 5/6 individuals, with its presence confirmed through sequencing a specific 423 bp fragment of the *F. halioticida* 16S rRNA gene (González et al. *in press*).

B12 **[57] Cont.**

This microorganism has caused mortalities in abalone, scallops (Kawahara et al. 2019) and mytilids. It is very difficult to detect with light microscopy, since it does not form colonies. Histopathology of the scallops sampled in November 2021 was very similar to what had been observed in 2006 and 2007: high hemocytic infiltration in several tissues, hemolymphatic vessel of the gill filament filled with hemocytes (fig. 1) and further destructionof the gill filament (fig. 2). Other findings were granulomas and IMCs at moderate - to high intensities. *In situ* hybridization was undertaken to detect the presence and location of *F. halioticida* in the tissues.

November is a month with strong upwelling in Tongoy Bay, these abiotic conditions may depress the immune system of the scallops, giving room for infections with different pathogens, such as *Francisella halioticida*.



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Ranching and Aquaculture (C)

- **Session 1: Tuesday 30th April (am)**

C1 **[54]**

The fall in the production of scallops in Spain

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The world aquaculture production has been increasing in the past fifty years, increasing 7.5% in the period 1970-1980, 8.6% in the period 1980-90, 10.5% in 1990-2000, 17% in 2000-2010, 36% in 2010-2020. Live weight aquaculture production reached 45 million tonnes (t.) in the year 2000, 78 million t. in 2010 and 120 million t. in 2020. In total aquaculture production, fish represent 50.4%, molluscs 26.2%, aquatic plants 19,5%, crustaceans 3.6% and others 0.3%.

If the total production of fishery products is analysed, capture fisheries represented 54% and aquaculture 46% in 2018, although the production forecast for 2030 assumes an increase in aquaculture to 56% and a decrease in fisheries to 47%.

Analysing by region, in 2020, Asia produced 112 million tons of live weight, 91.61% of world production, America produced 4.4 million t. (3.59%), Europe produced 3.3 million t. (2.69%), Africa produced 2.4 million t. (1.92%) and Oceania produced 0.24 million t. (0.19%). If the evolution of production in the last decade is analysed, Europe has suffered a drop from 3.26% to 2.69% in the percentage contributed to world production.

Regarding the world production of molluscs, more than 42 different species are cultivated reaching a total of 17.3 million t. in 2020, however only 6 species represent 73% of the production: the oyster *Crassostrea gigas* (37%), the clam *Ruditapes phillipinarum* (16%), the scallop *Patinopecten yessoensis* (11%), the mussel *Mytilus edulis* and *Mytilus galloprovincialis* (4.6%) and the cockle *Anadara granosa* (3.1%). China is the world's largest producer of shellfish, mainly bivalves, with 14.4 million t., followed far behind by South Korea, Chile, Japan, Vietnam, Spain, USA, France and Italy.

Spain is the leading producer of bivalves in Europe, in fact 82.5% of the total Spanish production is bivalves. In 2020, the production of the Mediterranean mussel *M. galloprovincialis* represented approximately 98% of the total production, with 234,154 t., followed by the Manila clam *R. phillipinarum* with 2,874 t., the cockle *Cerastoderma edule* with 1,367 t., the pullet carpet shell *Venerupis corrugata* with 571 t., the Pacific oyster *Crassostrea gigas* with 494 t., the sword razor *Ensis arquatus* with 476 t., the grooved carpet shell *Ruditapes decussatus* with 268 t., the European flat oyster *Ostrea edulis* with 260 t., the queen scallop *Aequipecten opercularis* with 223 t., the grooved razor shell *Solen marginatus* 50 t. the great scallop *Pecten maximus* with 49 t. and the black scallop *Mimachlamys varia* with 25 t.

There are three species of scallops of commercial interest in Spain and whose production comes mainly from the exploitation of natural stocks: the queen scallop, the black scallop and the great scallop. However, its production has decreased in the last decades not only in Spain but also in the rest of Europe, decreasing from a total of 88 thousand t. in 2010 to 67 thousand t. in 2020. Spanish production of the great scallop went down from 1000 t. (1991), 77 t. (1997), 61 t. (2000), 153 t. (2010), 123 t. (2015), 101 t. (2020) to 83 t. (2022); queen scallop production went from 700 t in 1960, 347 t. (1997), 67 t. (2000), 97 t. (2005), 395 t. (2010), 103 t. (2015), 223 (2020) to 498 t. in 2022. In the case of the black scallop, the captures are smaller, 0.8 t. in 2010, 2.3 t. in 2015, 10 t. in 2017, 24 t. in 2020 and 30 t, in 2022, carried out almost entirely in the Ría de Ferrol. The lack of scallops for consuming is solved by importing pectinids from abroad, 94% of consumption in Spain is imported from abroad. In short, a low

C1 **[54] Cont.**

reasons for the decrease in scallop catches in Spain are due to different causes. The first one is the intense fishing pressure during the past decades, resulting in the reduction of the natural banks, especially in the case of *Chlamys varia*. The decline in natural scallop banks is also influenced by their limited range of natural habitats and their vulnerability to climate change. On the other hand, attempts to farm several scallop species have not been very successful. In addition, scallops, as filter-feeders, are very sensitive to pollutants in inshore bays and estuaries, they tend to accumulate heavy metals that can cause them toxicity and unsuitable for human consumption. It is also noteworthy the presence of toxic algae and the accumulation of their toxins in the different scallop species, especially worrying is the case of the amnesic toxin (ASP) and the low rate of detoxification of the great scallop. This accumulation prevents their fishing both for consumption and for using in research.

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C2 **[61]**

A Comparative Study of Sea Scallop (*Placopecten magellanicus*) Energy Investment Strategies in Farmed and Wild Environments

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The Atlantic sea scallop (*Placopecten magellanicus)* fishery is the largest and most valuable wild scallop fishery in the world and is among the most lucrative fisheries in the United States (NOAA 2022). Scallops are harvested in deep, offshore federal waters from Cape Hatteras, NC, to Newfoundland, Canada, and in shallow (up to 10m) inshore state waters along the Maine coast (NOAA 2022). In 2022, Maine's state-managed fishery brought in over $8.8 million dollars and yielded one of the highest state average prices for meat per pound (Maine Department of Marine Resources 2023). Although this fishery is increasing in value, the catch is variable from year to year, remains a fraction of large historical harvests, and is uncertain in the face of climate impacts. With a variable harvest of wild scallops and a forecast increase in demand, scallop aquaculture has emerged as a new industry along the coast of Maine with potential to supplement the wild scallop market. Aquaculture is viewed as a potential mitigation strategy for wild fisheries changes and losses in the coming decades, and more immediately, as a strategy for fishery-dependent communities to diversify the species, products and employment opportunities available (GMRI 2016, Maine Economic Recovery Plan 2020, Britsch et al. 2021, although also see Stoll et al. 2019). Scallops are grown in lantern nets or via ear hanging methods and both wild and cultured industries currently rely on wild spat as hatchery production of scallops is lacking. The co-location of farms within existing wild scallop habitats and the dual reliance on wild seed creates a unique opportunity to explore biological, ecological, and economic interactions among these wild and cultured populations and industries.

We assess the biological and ecological impacts of sea scallop aquaculture by comparing the morphometrics of farm-raised sea scallops to those of wild scallop populations in Penobscot Bay, Maine. Our objectives are to (1) compare morphometric data (shell length, shell mass, meat weight, and gonad mass) from farmed and wild scallops through time in Penobscot Bay, Maine, (2) develop individual tissue indices to explore energy allocation in cultured and wild scallops, (3) calculate the gonadosomatic index (GSI) to compare reproductive investment and indicate the onset and progression of spawning events, and (4) relate these data to environmental variables.

During June through October of 2020-2022, and in collaboration with industry and management partners, we conducted weekly collections of farm-raised scallops from lantern nets at three aquaculture sites in Penobscot Bay, Maine, and of wild scallops via SCUBA from wild scallop beds adjacent to each farm. During each sampling event we recorded shell height and adductor, gonad, total viscera and shell masses and calculated gonadosomatic index (GSI) as an indicator of progression, onset, and investment in reproduction. Singular vertical sonde casts collected temperature, salinity, pH, dissolved oxygen, and turbidity data at each sampling event and temperature loggers deployed on lantern nets collected continuous data.

C2 **[61] Cont.**

We find that farmed scallops have larger adductor, gonad, and viscera masses compared to their wild counterparts within size classes 80 - 110mm while wild scallops have larger shell masses (Figure C2.1). Scallops of these size classes have similar GSIs but scallops at smaller size classes (< 80mm) have higher GSIs and larger adductor, gonad, and viscera than their wild counterparts from this study and compared to historical data at these size classes (figure not shown). Gonadosomatic indices from wild and cultured scallops suggest that these populations are spawning within 2-3 weeks of each other within years and at similar times across years. However, spawning in cultured populations lasts a shorter period of time in comparison to wild spawning. Peak spawning in both populations also coincides with peak temperature. Additional analysis of environmental data is needed to explore these relationships further.

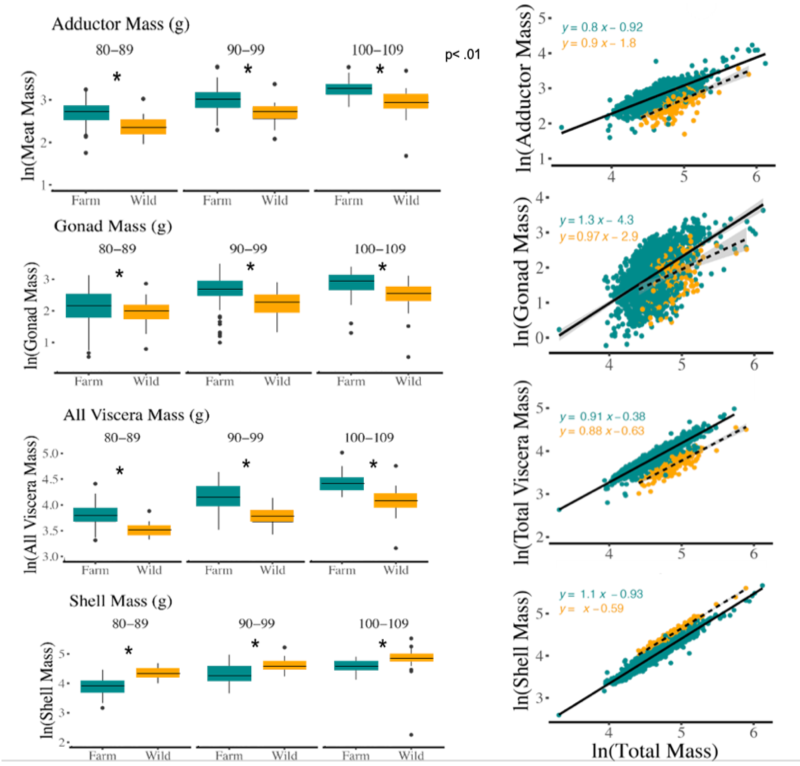

Figure C2.1: Box plots and tissue indices comparing adductor, gonad, total viscera and shell masses (g) from wild and farmed scallops of three different size classes from all farmed and wild populations sampled. Asterisks indicate significant differences ($p < 0.01$).

Larger meat yields from aquaculture-raised scallops offer a significant return on investment for scallop growers. Although this industry is still in the early adoption phase, an increased return on investment in the form of larger meat yield bolsters the potential benefits to those evaluating participation in the industry. Larger gonads in cultured scallops, in combination with high densities and supportive hydrodynamics for fertilization found on aquaculture farms, suggest an increased potential for reproductive output with ecological ramifications for both aquaculture and wild harvest industries. Future work quantifying larval output from farms can be incorporated into biophysical models to understand how aquaculture may be influencing population connectivity of wild and cultured populations. These results shed light on the complex interplay between aquaculture and the natural environment, highlighting the need to further investigate the ecological consequences of sea scallop cultivation for wild harvest industries.

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C3 **[62]**

Scallop (*Pecten maximus*) Sea Ranching in Norway – Lessons Learned

Ellen Sofie Grefsrud, Tore Strohmeier, Øivind Strand

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The development of sea-ranching in Norway has been based on intensive hatchery and nursery culture, followed by intermediate culture at sea to produce spat for releases on to the seabed for growth to market size. The initial experimental releases on to the seabed experienced high and unacceptable levels of crab (*Cancer pagurus*) predation and propelled the development of fences on the seabed to prevent crab access to the sea- ranched scallops. Different types of fences were tested by farmers, and a flexible, cost-efficient fence was eventually used for up-scaling production at two sea-ranching sites in south-western Norway.

The structure of the sea-ranching industry development changed from many farmers trialing scallop culture to an up-scaling phase with two companies partly integrated with the spat supplier and with an overall stronger financial situation from investors. These companies developed the sea- ranching operations on intermediate culture technology, cost efficiency of husbandry operations, predator control involving fishing of crabs and sea stars, product marketing, evaluation of site suitability, etc., while government-based research assessed the benthic environmental impact related to possible attractions and exclusion due to the fenced scallops. However, the commercialization of scallop sea-ranching failed, mainly due to factors like slower growth than expected, sub-optimal sites, and weakened interest from investors and governmental support. Nevertheless, the concept of combining released scallops from hatchery production and transferred scallops caught in the diver-based fishery to a sea-ranching area has been commercially applied for several years. The transferred fished scallops are sucessfully supporting consistent supply to the market, while the survival of the aquaculture scallops is still unknown. Concerns about the potential genetic and ecological impact of releasing hatchery-produced scallop spat will be discussed and examples of challenges that companies have met with local authorities when applying for sea-ranching areas will be given.

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Speedy Scallops (D)

- **Session 1: Thursday 24th April (pm)**
- **Session 2: Saturday 26th April (am)**
- **Session 3: Monday 29th April (pm)**

D2 **[15]**

Long-term Changes in Growth and Meat Yield in U.S. Sea Scallop Populations

Deborah R. Hart[1], Antonie S. Chute[1], Sally A. Roman [2]and David B. Rudders[2]

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Sea scallop growth declined in U.S. waters from the early 1980s until about 1995, then generally increased through around 2015, and then has decreased again. Similar patterns are seen in meat yields since those data became available in 1992. Possible drivers include fishing and environmental effects (e.g., phytoplankton food supply).

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Posters (E)

Friday 25th April (evening)

E1 **[64]**

Age and growth studies of scallop species living in the Mediterranean Sea – a review of methods, findings and opportunities for sclerochronology research

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Although scallops (family Pectinidae) are one of the most diverse, as well as one of the commercially most important bivalve taxa, knowledge of some aspects of their biology and ecology is still limited. Over 20 species of scallops inhabit the Mediterranean Sea, ranging in size from several millimetres (e.g. *Similipecten similis*) to over 15 cm - attained by the commercially most important scallop species in the basin - the Mediterranean scallop *Pecten jacobaeus*.

Published studies applied several methods to analyse scallop growth and age in the Mediterranean Sea including mark-recapture, analysis of growth marks on the external shell surface, and geochemical analysis of shell carbonate. This poster presents the advantages and disadvantages of different methods as well as challenges and opportunities for further research. While special attention is devoted to *P. jacobaeus*, available data for other scallop species of commercial interest, including *Aequipecten opercularis*, *Flexopecten glaber*, and *Mimachlamys varia*, are also presented.

In comparison to some other bivalve taxa, such as for example clams (family Veneridae), scallops have relatively fast shell growth rates and thereby present an interesting target taxa for high-resolution sclerochronology research. Analysis of variations in the deposition of striae, present on the external shell surface of some species, including *P. jacobaeus* and *A. opercularis*, can provide insight into temporal growth dynamics. Furthermore, geochemical analysis of shell carbonate material can enable the reconstruction of environmental conditions. The data presented are discussed in the context of sustainable exploitation and management.

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E2 **[65]**

Neural Networks for Scallop (Pecten maximus) Identification in Natural Marine Habitats

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The King scallop (Pecten maximus), also known as the Great Atlantic scallop, plays a significant role in the UK's fishing industry, securing the third position in first-sale value following mackerel and Nephrops. Notably, its landings have experienced substantial growth, making it the fastest-growing fishery in the UK over recent decades. Accurate scallop stock assessments are crucial for sustainable fisheries management, traditionally relying on fisheries-dependent and independent surveys, including underwater imaging and dredge sampling.

While traditional stock assessment methods, such as Virtual Population Analysis (VPA) and Time Series Analysis (TSA), have been employed, these approaches are constrained to areas actively fished, resulting in data gaps in other regions. This study investigates the potential of Artificial Intelligence (AI), specifically the NetHarn model within the VIAME toolkit, to identify and quantify king scallops from towed underwater video transects. Utilising video footage from NatureScot, captured using custom camera systems (DDV and miniDDV), the study encompasses a diverse dataset, considering variations in habitat, image quality, and camera specifications.

Previous AI studies focused on counting artificially placed scallops on the seabed, showcasing promising precision and recall results. However, this method lacked representation of scallops in their natural state due to insufficient recess time. In contrast, our research applies the same model to survey images featuring scallops in their natural setting. Results demonstrate that the NetHarn model, a Cascade Faster R-CNN, achieved moderate performance with an F1 score of 0.36 and a mean Average Precision (mAP) of 0.32 when classifying scallops into categories king, buried, queen, and dead. The study further compares model performance across diverse geographic locations, camera platforms, and habitat types, revealing variations in accuracy.

Error analysis reveals challenges related to image quality, particularly blurred images, and mislabelling of stones or similar objects as scallops. The study emphasises the necessity for enhanced data acquisition, standardised camera systems, and larger annotated datasets to improve AI model performance.

Despite modest outcomes, this research highlights the potential of AI in automating scallop stock assessments and marine habitat monitoring. Future endeavours should prioritise addressing image quality issues, expanding sample sizes, and optimising data collection to fully leverage AI in marine conservation and fisheries management.

References

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E3 **[66]**

An Estimate of Carbon Storage Capabilities of Wild and Cultured Shellfish in the Northwest Atlantic and their Potential Inclusion in a Carbon Economy.

Max D. Zavell[1], **Sandra E. Shumway[1]**, Odd Lindahl[2] and Ramon Filgueira[3]

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Production of bivalve molluscs has been proposed as a method to reduce carbon emissions as: 1) a low-emission protein source, and 2) via carbon stored within their shells. To address the fate of shell carbon for the northwest Atlantic, stored oceanic carbon equivalents (Eq), released CO_2 via calcification, and hypothetical carbon credit value (\$24 tCO_2), for both cultured and wild-captured bivalves (clams, mussels, oysters, & sea scallops) for New England and Canadian Provinces on the Atlantic between 2016 and 2020 were estimated. Bivalve shells do not sequester atmospheric CO_2, instead storing oceanic CO_2 Eq and cannot be included directly in a carbon sequestration scheme. Total annual estimates of stored oceanic CO_2 Eq were approximately 202,253 and 363,243 tons, with concurrent releases of approximately 121,255 and 217,771 tons of CO_2 to the atmosphere. Even if bivalve shells sequestered atmospheric CO_2, current shellfish production levels are inconsequential with regard to current anthropogenic greenhouse gas (GHG) emissions. Stored oceanic carbon Eq for bivalve aquaculture is equivalent to 0.001% and 0.0005% of Canadian and US annual anthropogenic CO_2 emissions, whereas wild-capture would store 0.028% and 0.005% of Canadian and US emission, respectively. Bivalve shell will not solve climate change, but the expansion of bivalve production provides a protein source with the lowest GHG emissions, which provides a multitude of environmental services.

E4 **[67]**

Knowledge gaps and research opportunities in the Alaskan weathervane scallop (*Patinopecten caurinus*) fishery

Skylar R. Bayer

Habitat Conservation Division, Alaska Regional Office, NOAA Fisheries

The weathervane scallop (*Patinopecten caurinus*) commercial fishery in Alaska is a relatively stable and data-poor fishery that ranges from Southeast Alaska to the Bering Sea and Aleutian Islands. Currently, there is not a functional stock assessment model for weathervane scallops in Alaska, although there are efforts to develop an age-based assessment. While some researchers have conducted studies and analyses on a large geographical scale of the fishery, there is a distinct lack of knowledge about the smaller scale processes in this species that is essential to managing the fishery more effectively. This poster will present what is (1) currently known and (2) major knowledge gaps essential to understanding the ecology, and life history that ultimately improves the fishery management of weathervane scallops. These knowledge gaps include research questions about (1) environmental and habitat data for individual scallops beds (<50 km), (2) population connectivity between individual scallop beds primarily in the Gulf of Alaska, and (3) life history including larval and juvenile behavior and survival, growth rates, feeding rates, and adult spawning behavior. Finally, this poster will identify types of projects that could help answer these questions in a way that will better inform fishery managers and improve any efforts towards building stock assessment or age-based models for weathervane scallops in Alaska.

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Industry Day (F)

Friday 25th April (all day)

F1 **[17]**

Casting into the future of scallop fisheries

Bryce D Stewart

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Fisheries for scallops are among the most valuable of all fisheries in the United Kingdom and are economically important in a number of other countries across the world including France, the USA, Canada, Australia and Argentina. However, scallop fisheries are known to be highly variable and difficult to manage, a feature which is being exacerbated by the effects of climate change. A number of countries have experienced significant stock declines, and in some cases, stock collapses, in recent decades.

One of the main ways of catching scallops is by towing heavy metal dredges along the seabed to rake them out of the sediment. While this is effective, the dredges can cause significant damage to sensitive ecosystems and also remove the settlement and nursery habitat which is essential for the survival of young scallops. Furthermore, this fishing method has gained the attention of multiple conservation groups, most of whom would like to see this method managed much more tightly, if not banned altogether.

Such conservation concerns are leading to the rapid and widespread implementation of marine protected areas which do ban scallop dredging. Furthermore, the accelerating development of offshore wind farms around coasts of the UK and Europe, with plans for similar schemes around the USA and Australia, are further restricting scallop fisheries. One analysis found that in a worse case scenario almost half of the UK seabed could be off limits to towed bottom fishing gear by 2050.

In light of these multiple challenges, I will introduce some of the potential solutions that might secure a more sustainable future for scallop fisheries. These include the possible use of 'go fish' areas which are reserved for scallop fisheries, stock assessments by fishermen, and the application of new technology and approaches such as scallop potting with lights, remote controlled underwater 'scallop hoovers' and even the development of autonomous underwater robots which collect scallops while having a minimal impact on the seabed.

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