Coregonids in the face of climate change: a collaborative global experiment

Kick-off workshop

Context:
Most coregonid species live in lakes and are of great socio--economical value. Coregonids are cold, stenothermic fish that are considered to be critically sensitive to the effect of climate change. Climate change may affect organisms throughout their distributional range and many studies highlight distributional shifts as key responses to warming. However, species that reside in lakes, such as coregonids, have few opportunities to easily shift habitats because of the isolated nature of lakes. Consequently, the persistence of coregonids depends on their plasticity and/or adaptive potential, which remain largely unknown. Large-scale studies along climatic (e.g., latitudinal) gradients are needed to understand and predict the plastic or adaptive response of populations to warming climates.

Aims and general method of the project:
In this context, an international scientific consortium is emerging to analyze the short-term adaptive response of cisco (*Coregonus artedi*) and lake whitefish (*C. clupeaformis*) in North America and vendace (*C. albula*) and European whitefish (*C. lavaretus*) in Europe to changing thermal regimes across a broad latitudinal gradient. As part of this consortium, we propose to experimentally identify latitudinal variation in early life stage survival and growth across a suite of congeners with similar and contrasting life history traits (e.g., benthic and pelagic resource use). Water temperature, growing season, and winter severity likely interact to influence coregonid growth rates and survival during the first year of life. High-latitude populations which experience lower water temperatures and shorter growing seasons are expected to (1) exhibit slower growth and (2) smaller size-at-age than populations at lower latitudes. However, a number of species (e.g., Atlantic cod, Atlantic silversides, Atlantic salmon) have demonstrated latitudinal compensation gradients (i.e., countergradient variation (CV)) resulting in better growth performance in northern versus southern populations when raised in similar environments. Thus, we hypothesize that northern populations of coregonids will be (counter-intuitively) more adaptable to warming thermal regimes than southern populations.

The objective of the consortium is to determine coregonid reaction norms to changing thermal conditions by identifying latitudinal variation in early life stage survival and growth within species and quantify optimal thermal conditions across populations (i.e., local adaptation versus countergradient variation). We will collect gametes from populations throughout each species' native distribution and raise eggs and larvae under a common garden experimental design. Eggs and larvae from each population will be reared in climate chambers under a range of water temperatures. Demographic data and genetic samples will be taken during incubation and post-hatch. Gene expression and epigenetic assays will be conducted to identify potential mechanisms underlying phenotypic response.

Our results can be used to guide management decisions on which stocks may perform best at different latitudes and help to identify key thermal/latitudinal refuge habitats for conservation. Such patterns are relevant in the context of the restoration of coregonid populations worldwide and the recent changes observed in lake temperatures and ice dynamics throughout the world.

Aims of the kick-off workshop:
The goals of the kick-off workshop are to gather researchers interested in the project and produce refined hypotheses, an agreed-upon experimental design and logistical plans to carry out the experiments, identify sources of current and potential funding on both continents to support the research, and plans for proposal writing.

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Kick-off Workshop Agenda
INRA UMR CARRTEL, 75 bis avenue de Corzent, 74203 Thonon-les-Bains, France

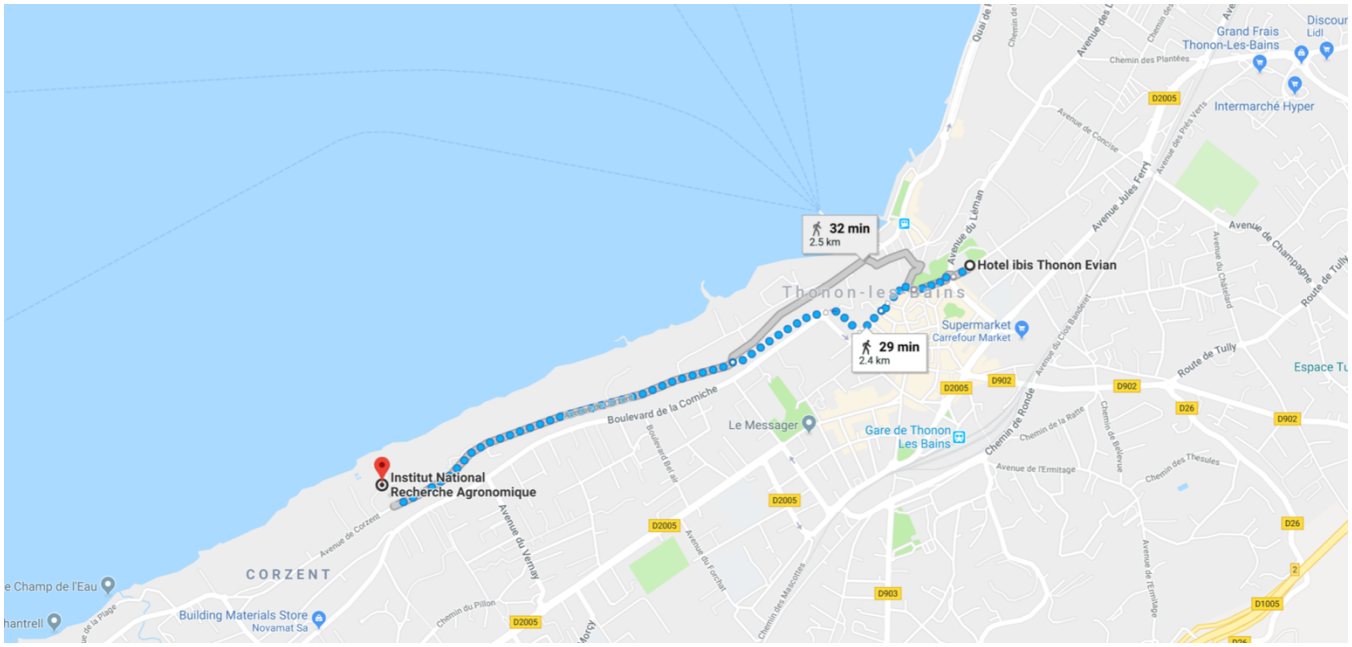
Date	Time	Description
14 Mar	0800 to 0830	Café/pâtisseries
	0830 to 0845	Welcome
	0845 to 0900	Ice-breaker
	0900 to 0920	Introduction: Project background
	0920 to 0940	Introduction: Genetics
	0940 to 1030	Group discussion on objectives and hypotheses
	1030 to 1100	Café Break
	1100 to 1230	Group discussion continued
	1230 to 1400	Lunch (*on site*)
	1400 to 1500	Break out groups discussion
	1500 to 1530	Groups report backs
	1530 to 1600	Pisciculture tour
	1600 to 1630	Café Break
	1630 to 1730	Wrap up day 1 discussions and plan for day 2
	1900	Dinner
15 Mar	0830 to 0900	Café/pâtisseries
	0900 to 0930	Revisit thoughts and ideas from day 1
	0930 to 1015	Funding/logistics discussion
	1015 to 1045	Café break
	1045 to 1215	SOP/Methods writing session
	1215 to 1330	Lunch (*on site*)
	1330 to 1530	*Ad hoc* time (continue writing, draft proposals, discussions, etc.)
	1530 to 1600	Café break
	1600 to 1630	Final discussion, future directions, assignments, and goals

Note: Agenda is flexible (e.g., ad hoc time on Day 2) to accommodate ideas as they develop during the workshop.

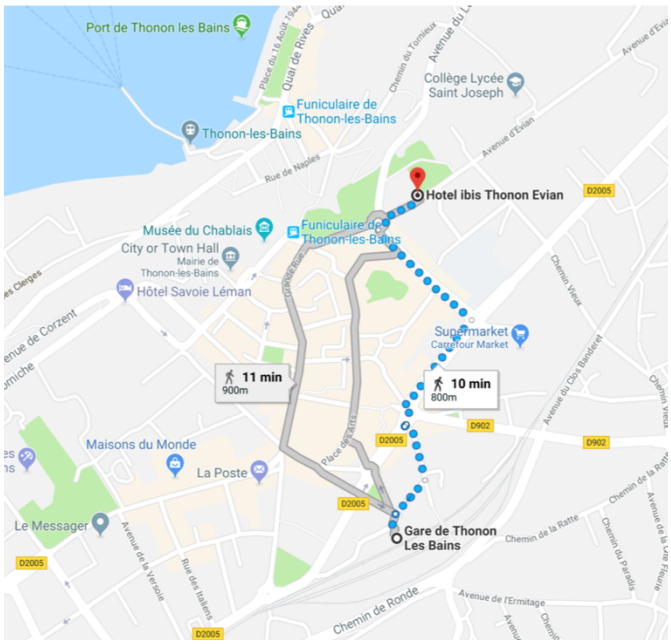
Outcomes:

- Defined objectives and hypotheses
- Standardized SOP and methods between continents
- Clarify populations involved and recognize gaps in latitudinal coverage
- Identify individual research interests and sampling needs
- Determine funding needs and sources
- Draft proposal(s)

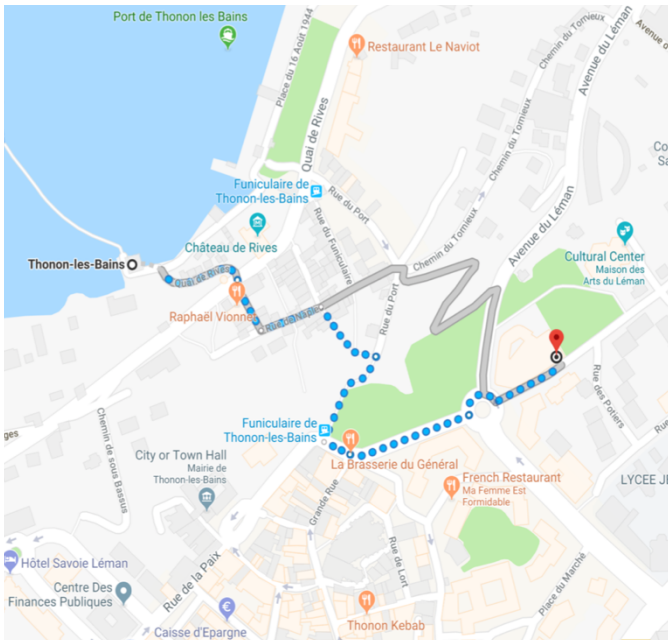
Hotel ibis Thonon Evian to Institut National Recherche Agronomique



Gare de Thonon Les Bains to Hotel ibis



Thonon-les-Bains Ferry to Hotel ibis



Participant Biographies

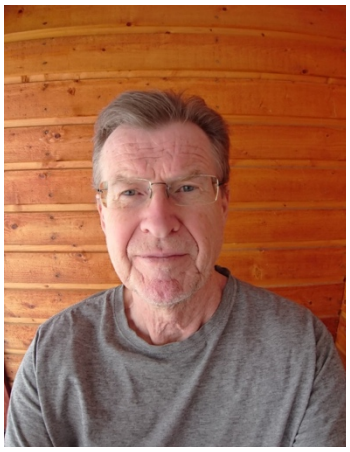
Name: Thomas Axenrot

Country: Sweden

Institute: Swedish University of Agricultural Sciences

Area(s) of Expertise: Aquatic systems ecology, hydroacoustics

Research Interests: Large lakes food webs and dynamics, stock assessment, effects of climate change on fish, hydroacoustic methods



Name: Dani Blumstein

Country: United States of America

Institute: University of Wisconsin – Stevens Point

Area(s) of Expertise: Conservation Genetics

Research Interests: Linkage mapping and QTL analysis to aid in understanding the genetic basis of cisco phenotypic diversity

Name: Andrew Chapelsky

Country: Canada

Institute: Fisheries and Oceans Canada (DFO)

Area(s) of Expertise: Ecology of freshwater ecosystems

Research Interests: Food webs, physiology, ecology, life history variation, telemetry

Name: Eva Enders

Country: Canada

Institute: Fisheries and Oceans Canada (DFO)

Area(s) of Expertise: Conservation Biology, Ecophysiology, Fish Behaviour and Bioenergetics, Fish Passage

Research Interests: My research areas include fish ecology, fish and habitat conservation and restoration, and environmental impact assessments of anthropogenic flow and climate changes on fish populations. I am particularly interested in issues regarding (1) the winter biology of freshwater fishes in respect to habitat use and availability, energetic costs of overwintering, survival, and activity patterns, (2) fish passage through fishways and culverts, and (3) the effects of turbulence on fish behaviour and energetics.

Name: Kevin Gallagher

Country: Northern Ireland

Institute: Agri-Food and Biosciences Institute

Area(s) of Expertise: Sustainable fisheries management; invasive Species impact assessment and control; fisheries population assessment and dynamics

Research Interests: My core work is to lead AFBI's lake fisheries research program in support of government departmental lake fishery (recreational and commercial) management obligations. This involves providing annual stock assessments of several lakes. Data from these research exercises allows me to propose and develop fishery management tools for both recreational and commercial fisheries. My current research interests are broad and include net selectivity modification to create a sustainable fishery, larval coregonid monitoring as a future indicator of cohort strength in pollan, quantification of bycatch in a commercial freshwater fishery and the detection and impacts of invasive species on fishes and ecosystems.

Name: Ellen George

Country: United States of America

Institute: Cornell University

Area(s) of Expertise: Early life history, spawning behavior, larval fish, population genetics, science communication

Research Interests: Restoration of cisco, *Coregonus artedi*, populations in the Laurentian Great Lakes

Name: Chloé Goulon

Country: France

Institute: UMR CARRTEL (INRA – USMB)

Area(s) of Expertise: Fish ecology, fish sampling methods

Research Interests: Ecology of fish in French peri-alpine lakes (salmonids, percids), hydroacoustics, fisheries management

Name: Jean Guillard

Country: France

Institute: UMR CARRTEL (INRA – USMB)

Area(s) of Expertise: Limnology - fish population

Research Interests: Freshwater fish population, hydroacoustics for fish studies, fisheries management and global change.

Name: Bella Japoshvili

Country: Georgia

Institute: Institute of Zoology, Tbilisi

Area(s) of Expertise: Fish ecology, freshwater ecosystems

Research Interests: Systematics, morphology, gametogenesis, ecology of freshwater fishes of Georgia. High mountain lakes. Macroinvertebrates.

Name: Juha Karjalainen

Country: Finland

Institute: University of Jyväskylä

Area(s) of Expertise: Fish biology

Research Interests: Life cycle traits, especially early stages.

Name: Trevor Krabbenhoft

Country: United States of America

Institute: University at Buffalo

Area(s) of Expertise: Functional genomics and epigenetics

Research Interests: Coregonids! I am interested in understanding how genetic variation relates to morphological and ecological variation in fish and how fish cope with environmental change.

Name: Hannah Lachance

Country: United States of America

Institute: University of Vermont

Area(s) of Expertise: Genetics

Research Interests: Climate change, genetics, conservation biology

Name: Wesley Larson

Country: United States of America

Institute: University of Wisconsin – Stevens Point

Area(s) of Expertise: Genetics

Research Interests: Population structure and adaptive diversity of coregonids

Name: Emilien Lasne

Country: France

Institute: INRA, Lab ESE, Rennes

Area(s) of Expertise: Evolutionary ecology of fish (salmonids, diadromous fish, lampreys)

Research Interests: Fish response to environmental stress, stress interaction, early stages, life history traits, plasticity, (local) adaptation adaptive potential, and experimental and field researches

Name: Verena Lucke

Country: United States of America

Institute: University of Vermont

Area(s) of Expertise: Bioacoustics, Biostatistics

Research Interests: Impacts of Climate Change, Bioacoustics, Marine/Aquatic Ecology

Name: Andrew Muir

Country: Canada – living and working in the USA.

Institute: Great Lakes Fishery Commission

Area(s) of Expertise: Fish ecology, biodiversity, food web structure and function

Research Interests: Coregonus, Salvelinus, large lakes, Arctic, fish passage, ecological and evolutionary diversity

Name: Trevor Pitcher

Country: Canada

Institute: University of Windsor

Area(s) of Expertise: Evolutionary, reproductive, and conservation biology

Research Interests: Genetic architecture of fitness using quantitative genetics; restoration ecology of fishes in the Great Lakes; selective forces involved in the evolution of mate choice for genetic quality; relative importance of genotypes in terms of determining the outcome of paternity

Name: Roland Rösch

Country: Germany

Institute: Fisheries Research Station Baden-Württemberg

Area(s) of Expertise: Fisheries management Lake Constance, salmonid aquaculture, welfare of fish in aquaculture, larval rearing of whitefish, re-oligotrophication and whitefish

Research Interests: Population dynamics of whitefish, effects of stocking on recruitment, welfare of fish in aquaculture

Name: Alfred Sandström

Country: Sweden

Institute: Swedish University of Agricultural Sciences

Area(s) of Expertise: Fisheries, fish ecology, spatial analyses, participatory research

Research Interests: Coregonid management under climate change, trophic magnification of contaminants, assessment models for data-poor fisheries, freshwater (and marine) protected areas

Name: Marek Šmejkal

Country: Czech Republic

Institute: Czech Academy of Sciences, Biology Centre

Area(s) of Expertise: Fish ecology and behavior

Research Interests: Fish reproduction; predator-prey relationships

Name: Taylor Stewart

Country: United States of America

Institute: University of Vermont

Area(s) of Expertise: Conservation biology, ecophysiology, fish biology

Research Interests: Coregonid development and early life stage survival, life history traits, environmental stressors, population structure

Name: Jason Stockwell

Country: United States of America

Institute: University of Vermont

Area(s) of Expertise: Food web dynamics, diel vertical migration, winter limnology

Research Interests: Ecology of cisco and other coregonids

Name: Lyubov Sukhanova

Country: Russia

Institute: LIN SB RAS (Limnological Institute of Siberian Branch of Russian Academy of Sciences)

Area(s) of Expertise: Ecology, genetics. evolution

Research Interests: Evolution & ecological genomics of coregonids with an emphasis on Lake Baikal; Coregonid fish aquaculture

Name: Josef Wazenböck

Country: Austria

Institute: Research Institute for Limnology Mondsee – University of Innsbruck

Area(s) of Expertise: Fish ecology, aquaculture

Research Interests: Ecology of fishes in peri-Alpine lakes, focus on larval and juvenile life stages, aquaculture related research of coregonids, percids, cyprinids.

Name: Ian Winfield

Country: United Kingdom

Institute: Centre for Ecology & Hydrology

Area(s) of Expertise: Coregonid population ecology and conservation management

Research Interests: Freshwater fish population and community dynamics, including interactions with non-native species, roles in lake ecosystems, effects of climate change, the use of hydroacoustics for studies of fish and their habitats, and the applied issues of the conservation of biodiversity and fisheries management. Also includes long-term population studies on the major fish species of Windermere, UK, which have been conducted since the 1940s and which now constitute a unique lake fish dataset of global standing leading to frequent international collaborations.

Name: Matteo Zucchetta

Country: Italy

Institute: Ca' Foscari University Venice

Area(s) of Expertise: Fish ecology; quantitative ecology

Research Interests: Climate changes effects on fish populations (currently working on a project on modelling whitefish *Coregonus lavaretus* population in Lake Garda in relation to fishery and temperature raise). Disentangling environmental and anthropogenic effects on fish assemblages. Modelling fish-habitat distribution. Fish as bio-indicators.

Participants without biographies:
Tomas Juza, Czech Republic
Timo Marjomäki, Finland
Thomas Mehner, Germany
Mark Vinson, USA