HIFMB NEWS #03/20

Top Story: Optimal Governance of Ecological Systems + Research: Transformative Change: What's in for marine biodiversity? + Research: Selected Publications + Editorial: Applicable or transformational + HIFMB Team Fun Fact

Photo © Peter Schupp

TOP STORY

Optimal Governance of Ecological Systems

While the primary aim of ecologists is to understand the interactions among organisms and their environment, we also have to be concerned about practical applications in the conservation of ecosystems, the protection of biodiversity, the regulation of composition of the biomass, the management of natural renewable resources – both in space and in time. Therefore, any positive analysis of an enhancement of the understanding of ecosystems should be accompanied by a normative analysis of identifying possible policies suitable to accomplish a society's objectives in conservation of the natural environment and sustainable development of mankind.

Given a sufficient understanding of the functioning of the ecosystem and the deduced ecological relationships, the formulation of mathematical optimisation problems may help select the most suitable policy measures (from a set of all available policies) to safeguard sustainable development. The mathematical tool that proves particularly helpful in the selection of, in the sense of a given (social) objective function, optimal policies is optimal control theory (OCT). OCT provides a powerful formal framework that can be applied to a vast variety of intertemporal choice problems, as they are typically present in ecological conservation and environmental protection. OCT represents a tool which is very helpful in solving problems with socio-ecological connectivity so that ecologists concerned with those problems may enormously benefit from its application. →

ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Carl von Ossietzky Universität Oldenburg

»For our research we use Pontryagin's maximum principle to find the best possible (optimal) control for taking a dynamical system from one state to another. The maximum principle was formulated in 1956 by the Russian mathematician Lev Pontryagin (1908 - 1988). «

Thorsten Upmann

→ OCT, originally developed in engineering, has revolutionized methods in intertemporal optimisation with applications now extending to all areas of human activity. Contrary to its predecessor, the calculus of variations, OCT directly incorporates relevant constraints associated with the problem in a natural way. To be able to formulate a meaningful mathematical model, OCT presumes that the interactions among organisms and their environment (i.e. the ecological aspects) as well as the co-operation and competition within and between the species under consideration can be quantified in functional relationships; and the same must be true for the available policy measures and their implied consequences. Any problem in OCT is genuinely intertemporal and dynamic such that the stocks of the different species evolve over time, and these processes can be modelled by either difference or differential equations.

The idea of OCT is that an agent, e.g. a regulator, a government, a regulatory agency, a firm etc., is able to control those stocks only indirectly by means of policy measures that allow to interfere with their growth conditions. Due to the intertemporal interdependencies any today's decision has an effect on future states and future dynamics, and thus on the future welfare and on the set of policies available in the future. – And it is this effect on the future that generically renders any intertemporal and in particular any spatio-temporal problem intricate.

We are specifically interested in these spatio-temporal ecological-economic problems. In those problems, we not only have to determine how policy measures (e.g. effort, financial resources, conservation measures) should be allocated in time, but also how to distribute them spatially. Examples are the management of fish moving stocks, distributed algae control, harvesting of spatially distributed renewable resources, forest management, sewage disposal, and many other ecological and environmental problems. Beyond these ecological problems, OCT can conveniently be used to identify optimal measures in epidemic control; and specifically – which is now highly topical – in the containment of the transmission and the spread of COVID-19, where the timing and the spatial targeting of cost-effective measures is particularly important. In any of those cases, a government or an agent seeks to manage stocks or the size of the sub-populations so as to either reach a given target at minimal cost or to maximize a given objective function.

While the specific results obtained by OCT differ between models, there is still one important general insight: Even in a completely homogeneous situation (homogeneous space, homogeneous growth dynamics etc.), it may happen that spatially homogeneous policies are not optimal. Specifically, it may be optimal to concentrate protective measures in some areas, leaving others less protected; or to focus activities at specific locations, leaving others subject to less exercise of influence.

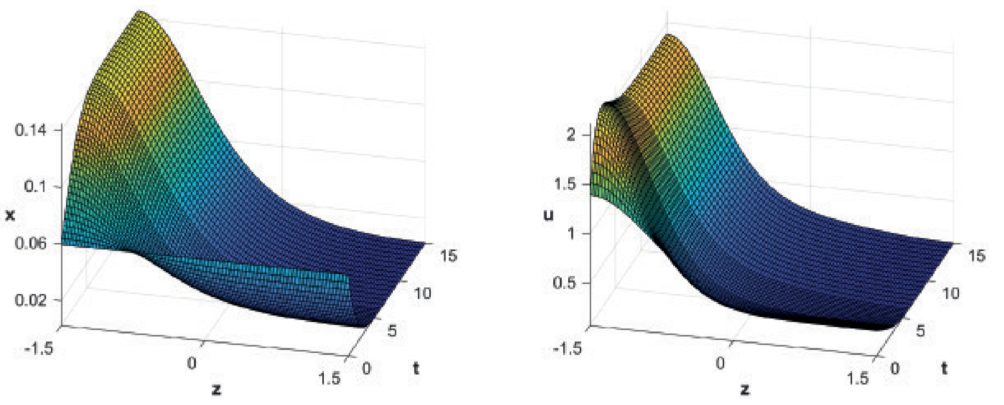


Figure 1: Optimal policy (u) in time (t) and space (z) governing the stocks (x) from a homogeneous situation to a patterned solution.

RESEARCH

TRANSFORMATIVE CHANGE: WHAT'S IN FOR MARINE BIODIVERSITY?

The IPBES Global Assessment has provided a full report of the negative consequences of human impact on nature, and at the same time proposed a solution: transformative change. The key question is "What is transformative change and how do we achieve it?"

Transformative change (or transformational change; the terms are used interchangeably) refers to a fundamental, system-wide change that includes consideration of technological, economic and social factors, including in terms of paradigms, goals or values (IPBES Deliverable 1c, 2019 IPBES 7/6), and it strongly relies on behavioural changes across all scales of society, for example, consumption and production pattern need to become sustainable, and governments and businesses need to orient their goals, within and across all government sectors and environmental agreements, to the diversity and prosperity of nature as the key to success. To achieve this, biodiversity needs to be mainstreamed, there needs to be a clear understanding of the direct links between biodiversity loss and food scarcity, poverty, and health impacts and goals, targets, action plans, and budgets must be defined and communicated in a way that all of society must believe, that the goals can be successfully implemented.

Transformative change in Marine Ecosystems

More than three billion people's livelihoods depend on marine and coastal biodiversity, while the global market value of marine and coastal resources and industries is estimated over US$3 trillion per year, marine ecosystems play a fundamental role in the global climate system and in supporting communities, jobs and livelihoods, food security, human health, biodiversity, economic prosperity and good quality of life, however, at the same time they are facing many challenges, illegal, unreported and unregulated fishing and overexploitation of fish stocks threaten entire species and food security. Ocean warming, acidification, rising sea levels, unsustainable fishing, pollution and development are compounding the threats faced already by degraded marine ecosystems and the services they provide. These stressors are expected to accelerate with severe consequences for marine biodiversity. Despite global policy commitments to preserve marine biodiversity, many species are still in a state of decline and although Governments are close to achieving the global coverage target of protection of 17% of land and 10% of the sea, the expansion of protected areas for marine biodiversity and existing policies that encourage responsible use of ocean resources, are still insufficient to combat the adverse effects of overfishing, growing ocean acidification and worsening coastal eutrophication.

photo © Dominik Gloe

The way forward towards a successful transformative change in marine ecosystems is to disentangle the interactions between environmental and human systems even more. The complexities in marine ecosystems means, SDG14 requires a multi-pronged approach that is ultimately cross-sectoral, and relies on building new partnerships, probing inter-disciplinary connections and placing a new emphasis on sharing and promoting knowledge.

Let's role up our sleeves and get to work!

You want to hear more on this?

Join us for our session „Aquatic functional biodiversity for human well-being" at the 2020 iDIV Conference lead by Karin Frank and Ilona Bärlund (UFZ), Helmut Hillebrand and Ute Jacob (HIFMB).

+ www.idiv.de/en/conference2020.html

PERSONALIA

DR. KATHERINE SAMMLER

Dr. Katherine Sammler, formerly assistant professor for Global Studies & Marine Affairs at California State University Maritime Academy, Vallejo, is now head of the new focus group "Marine Political Ecology" at HIFMB.
Kate is a trained geographer, with a background in atmospheric science and physics. She conducts research at the intersection of science and politics in the realm of oceans, atmospheres, and outer space. In all areas, her work considers the role of knowledge, law, and power in defining global commons, access, and environmental justice. The new focus group embraces the study of political, economic and social factors under environmental change.

Most research on political ecology has a terrestrial focus, but marine environmental changes have a strong political context as well, which is reinforced by the international status of the High Seas and the Area. With this group, HIFMB intends to establish research on marine political ecology to foster the understanding how political environment, economic pressure, and societal regulations affect the decisions made about the marine environment at different scale from regional over national to international levels. A special focus will be the political context of biodiversity management and conservation.

RESEARCH

6 Selected Recent Publications

Hillebrand, H., Donohue, I., Harpole, W. S., **Hodapp, D.**, Kucera, M., Lewandowska, A. M., Merder, J., Montoya J. M. and Freund, J. A. (2020): Thresholds for ecological responses to global change do not emerge from empirical data. Nat Ecol Evol.

Dahlke, F. T. , **Wohlrab, S.** , Butzin, M. and Pörtner, H. O. (2020): Thermal bottlenecks in the life cycle define climate vulnerability of fish , Science, 369 (6499).

Jones, M. W. , Coppola, A. I. , Santín, C. , **Dittmar, T.** , Jaffé, R. , Doerr, S. H. and Quine, T. A. (2020): Fires prime terrestrial organic carbon for riverine export to the global oceans , nature communications, 11 (2791).

Upmann, T. and Behringer, S. (2020): Harvesting a remote renewable resource. Theor Ecol.

Hüppe, L., Payton, L., Last, K., Wilcockson, D., Ershova, E. and **Meyer, B.** (2020): Evidence for oscillating circadian clock genes in the copepod Calanus finmarchicus during the summer solstice in the high ArcticBiol. Lett.1620200257.

Yeakel, J. D. , Pires, M. M. , de Aguiar, M. A. M. , O'Donnell, J. L. , Guimarães Jr., P. R. , Gravel, D. and **Gross, T.** (2020): Diverse interactions and ecosystem engineering can stabilize community assembly , nature communications, 11 (3307).

+ More on google scholar: bit.ly/HIFMB-publications

VIEW FROM NORTHWEST #5

Applicable or transformational

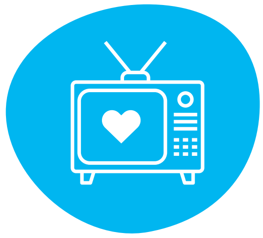
I like to listen to science communication programs on the radio and to read science pages in newspapers and magazines – except for the last 30 seconds or the final two sentences. Inevitably, it seems, each report has to end with a statement that these fundamental scientific results will contribute to a better medical treatment of [enter disease of your choice], enhance handling of [enter global crisis of your choice], or provide a technical solution for [enter problem of your choice]. These statements are not only superficial but actually dangerous because they fortify the argument that science has to be directly applicable to be useful, as such a direct link between scientific result and its application is rare if not absent in the history of science. Moreover, these statements lead to frustration in the non-science audience (how often can we promise to have solved problem x without solving it).

At the 2018 Annual Meeting of the Helmholtz Association, Daniel Zajfman, President of the Weizmann Institute of Science, made a plea for "Curiosity Driven Research" [1]. He argued that retrospectively one can trace back a common application (say GPS) to major scientific findings such as atomic clocks, magnetic resonance and theory of relativity. However, looking into the future, would somebody fund Albert Einstein's research based on the promise that based on his findings 100 years a car would be navigating using this knowledge? Let alone that cars were rather absent 1905, and the next steps towards GPS also were still unknown. Of course, it is easy to see how applicability helps a politician to motivate why public money is spent on science (instead of schooling, health, roads, etc), helps a journalist stressing the importance of a scientific results to a lay audience, and helps a scientist motivating her or his research. But just because it is an easy statement, it is not necessarily a better statement.

As an environmental scientist, I experience the distinction between fundamental and applied research as highly artificial. Even my most fundamental research receives application relevance in the context of global change and my most applied papers rely on basic theories and frameworks. Beyond artificiality, stressing the applicability of science also seems outdated given that the current challenges require transformation, not application. Science should (or must) be a promotor of transformational change as it informs decision for a sustainable development in environmental, societal, technological and economic dimensions. The question is no longer, whether science is applicable in the sense of leading to products, but whether it helps tackling the complexity of the fundamental changes lying ahead of us.

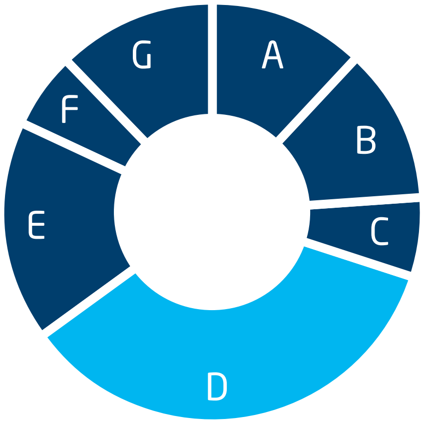
Sincerely, Helmut Hillebrand
Director — Professor of Pelagic Ecology
helmut.hillebrand@hifmb.de

1 www.helmholtz.de/fileadmin/user_upload/Daniel_Zajfman_Vortrag_Berlin_180909_EN.pdf

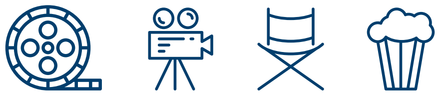


Fun Fact

Which movie resembles your summer vacation closest this year?



A	12 %	Summer in Berlin
B	12 %	Seacrow Island
C	6 %	Jaws
D	35 %	Groundhog Day
E	17 %	The Terminal
F	6 %	Cast away
G	12 %	Other • The Martian • I haven’t been on vacation yet



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