© 2025. Published by The Company of Biologists | Journal of Experimental Biology (2025) 228, jeb249867. doi:10.1242/jeb.249867

PERSPECTIVE

Harnessing physiological research for smarter environmental policy

Alexia Dubuc[1,2], Courtney M. Burns[2], Shamil F. Debaere[2,3], Carmen Dobszewicz[2], Joel H. Gayford[2,4], Luca J. Hoffecker[2], Isaac T. Marshall[2], Miriam D. Zanforlin[2] and Jodie L. Rummer[2,*]

ABSTRACT

Integrating physiological research into environmental policy is crucial for addressing the complex challenges faced by ecosystems. Despite their potential, physiological insights are often underutilised in policy and management decisions, leading to missed opportunities for more targeted and effective conservation strategies. This Perspective explores the role and integration of physiological research within environmental policy. We discuss successful case studies where physiological data have informed policy, as well as the barriers that hinder broader recognition and application of this research. Key challenges include the limited awareness of physiological findings among policymakers, the difficulties in translating complex scientific data into actionable policy, and the gap between physiological studies and ecological relevance. To bridge these gaps, we propose strategies for making physiological research more accessible and impactful, such as fostering interdisciplinary collaborations, enhancing science communication and aligning research with policy needs. We conclude with a call to action for researchers, institutions, policymakers and Indigenous communities – especially Traditional Custodians – to collaborate more closely, advocating for the inclusion of physiological expertise in advisory panels and the development of strategies to better incorporate physiological research into environmental policy. By embracing the insights provided by conservation physiology, we can develop more informed and effective policies that enhance the resilience of ecosystems in the face of rapid environmental change.

KEY WORDS: Conservation physiology, Climate change adaptation, Science–policy integration, Evidence-based policy, Science communication, Traditional knowledge, Interdisciplinary research, Physiological stressors, Knowledge co-production, Climate resilience

Introduction

Physiological research informs conservation and restoration policy by providing mechanistic understanding about species' responses to climate change and anthropogenic stressors, underpinning predictive conservation strategies (Chown and Gaston, 2008; Deutsch et al., 2020; Cooke et al., 2013). Understanding individual tolerance thresholds and stress responses is crucial, as they shape broader ecosystem dynamics (Illing and Rummer, 2017; Acevedo-Whitehouse, 2019; Petitjean et al., 2019). Recent research has identified key policy-relevant questions in conservation physiology, highlighting opportunities for its application while also outlining challenges that hinder effective integration into decision-making processes (Cooke et al., 2021).

The emergence of conservation physiology (see Glossary) as a discipline supports the integration of physiological insights into conservation efforts (see Glossary; Cooke and O'Connor, 2010). For example, by utilising biomarkers of health and resilience (see Glossary), it helps assess species' capacity to withstand anthropogenic pressures (Wikelski and Cooke, 2006; Madliger and Love, 2015; Madliger et al., 2018; Young et al., 2006; Jorgensen et al., 2012). However, despite its potential, its application in conservation efforts and policy implementation remains limited. A key challenge is simplifying complex cause-and-effect relationships to align with policy frameworks (Bothe et al., 2023). This challenge is further complicated by a scale mismatch: physiological research typically focuses on individuals and species, whereas policy addresses issues at the population and ecosystem levels (Cooke and O'Connor, 2010). Additionally, limited interdisciplinary collaboration and communication barriers between scientific disciplines and conservation practitioners hinder the full adoption of physiological insights (Coristine et al., 2014; Mahoney et al., 2018; Madliger et al., 2021). Consequently, policies often adopt a broad-brush approach, missing critical threats. Here, we examine how physiological research has shaped environmental policy, particularly in coastal marine ecosystems, highlighting successes, limitations and strategies to enhance its integration.

Bridging the gap between science and environmental policy

When considering marine ecosystems (which are our particular area of expertise), physiological studies provide critical, mechanistic insights into how species respond to environmental stressors such as ultraviolet (UV) radiation, temperature fluctuations, oxygen depletion and pollutants. This research is instrumental for conservation management and policy, which increasingly relies on ecophysiology (see Glossary) to set thresholds and guidelines for protecting marine ecosystems (Box 1). Although directly integrating physiology into conservation efforts is still relatively novel, several studies have demonstrated its potential (Cooke and O'Connor, 2010). Indeed, a growing number of studies has successfully correlated population status with organismal physiology, providing valuable insights for conservation and management (Cooke, 2019). For example, a recent review of 29 studies found that 72% correlated physiological biomarkers with individual-level demographic changes (Bergman et al., 2019), highlighting their relevance for both species management (e.g. Fry et al., 2023) and broader ecosystem restoration (Meyer and Sisk, 2001). Another example of physiological data influencing fisheries

[1]School of Life Sciences, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ UK. [2]College of Science and Engineering, James Cook University, Townsville, QLD 4811 Australia. [3]ECOSPHERE, Department of Biology, University of Antwerp, 2020 Antwerp, Belgium. [4]Shark Measurements, London, SW11 3RT, UK.

*Author for correspondence (jodie.rummer@jcu.edu.au)

S.F.D., 0000-0002-3951-3749; J.H.G., 0000-0002-0839-3940; J.L.R., 0000-0001-6067-5892

Journal of Experimental Biology (2025) 228, jeb249867. doi:10.1242/jeb.249867

Glossary

Aerobic scope
The difference between an organism's maximum and resting oxygen uptake rates, indicating its capacity for activities such as growth, reproduction and movement. A reduced aerobic scope under stressors such as warming or hypoxia can limit survival.

Conservation physiology
The study of physiological responses of organisms to environmental changes, informing conservation and management strategies.

Conservation efforts
Actions and strategies implemented to protect, manage and restore ecosystems.

Ecophysiology
The study of how environmental factors influence physiological processes in organisms.

Knowledge co-production
A collaborative process where scientists, policymakers and stakeholders work together to generate research that directly informs policy.

LD_{50}
Median lethal dose, a toxicology metric that represents the dose of a substance that is lethal to 50% of a test population.

NOEC
No observed effect concentration, the highest concentration of a substance in an experiment that does not cause detectable adverse effects on organisms.

Resilience
The ability of organisms, populations or ecosystems to recover from disturbances such as climate change, habitat destruction or pollution.

Traditional knowledge
The ecological and environmental knowledge held by Indigenous communities (i.e. Traditional Custodians), often passed down through generations.

Transdisciplinary research
Research that integrates multiple disciplines, including science, policy and social science, to address complex problems.

management comes from Nunavut, Canada, where biotelemetry and mark–recapture studies validated local ecological knowledge about fish movements. These studies revealed that the existing management area for Greenland halibut (*Reinharditus hippoglossoides*) did not adequately account for stock distribution (Brooks et al., 2019). This physiological evidence, alongside local ecological knowledge, was presented to the Nunavut Wildlife Management Board and Oceans Canada, prompting a shift in the management area to better reflect halibut movements (Laubenstein and Rummer, 2020). This case highlights how integrating physiological research with traditional knowledge (see Glossary) can enhance resource management and policy.

Despite its potential, integrating physiological research into environmental policy remains challenging. Scientific findings, particularly those focused on mechanistic knowledge, do not always align with the broader, generalised frameworks required for policy decisions. As a result, physiological data frequently fail to inform management practices, where decisions tend to rely more on expert opinion rather than published analyses (Tracy et al., 2006). Bridging this gap requires fostering stronger collaborations between scientists and policymakers through knowledge co-production (see Glossary), embedding scientific evidence directly into decision making (Norström et al., 2020). A prime example is the Pacific salmon project (Box 1), where early engagement with management agencies facilitated knowledge co-production (Cooke and O'Connor, 2010; Laubenstein and Rummer, 2020). This approach fosters stakeholder ownership, increasing the likelihood that findings will be applied in policy contexts (Norström et al., 2020). Additionally, co-produced knowledge is often perceived as more relevant, actionable and easier to integrate into decision frameworks (Singletary et al., 2022). Prioritising integrated approaches, including those that respect and incorporate Traditional Custodians' knowledge, is essential for aligning physiological research with conservation science and policy (Ens et al., 2012; Lyver et al., 2017). These approaches ensure research outcomes support both ecological sustainability and cultural values.

Below, we explore the challenges of incorporating physiological research into policy and subsequently offer potential solutions to improve the pathway from physiological research to policy implementation.

Scientists and policy makers have different definitions of success

The often-indirect science–policy relationship contributes to the perceived limited success in integrating research evidence, including physiological data, into policy. Scientific findings are typically communicated through non-governmental organisations (NGOs), governmental agencies and advisory bodies before reaching policymakers (Choi et al., 2005; Scott et al., 2019). Although these intermediaries help translate science into actionable insights, they may dilute the prominence of research in final legislative texts (Crowley et al., 2018). This process can lead to differing perceptions of success between scientists and policymakers. Scientists often view success as the direct incorporation of their findings into policy, whereas policymakers define success by the development and implementation of practical, scalable solutions informed by research. Moreover, the influence of scientific research is not always measured by explicit policy adoption but through gradual shifts in awareness, termed 'conceptual impact'. Conceptual impact leads to a gradual knowledge creep, whereby policymakers become more aware of emerging issues, which plays a crucial role in shaping long-term policy (see also Weiss, 1982; Weible et al., 2010). This can pose a challenge for scientists to demonstrate the utility of their work, particularly as some funding agencies and research councils now require direct, measurable policy impacts (Hicks, 2012).

Organisations such as the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO) demonstrate that physiological research can successfully inform high-level policy decisions (Cooke, 2019; IPCC, 2021). To better integrate physiology into policy and address the perception of its underutilisation, knowledge co-production must become the preferred approach. Early collaboration between scientists, policymakers and management agencies (as in the Pacific salmon project; Box 1), alongside clear communication, can help overcome the challenges of indirect science–policy relationships in conservation research.

Lack of infrastructure to integrate research into environmental policy

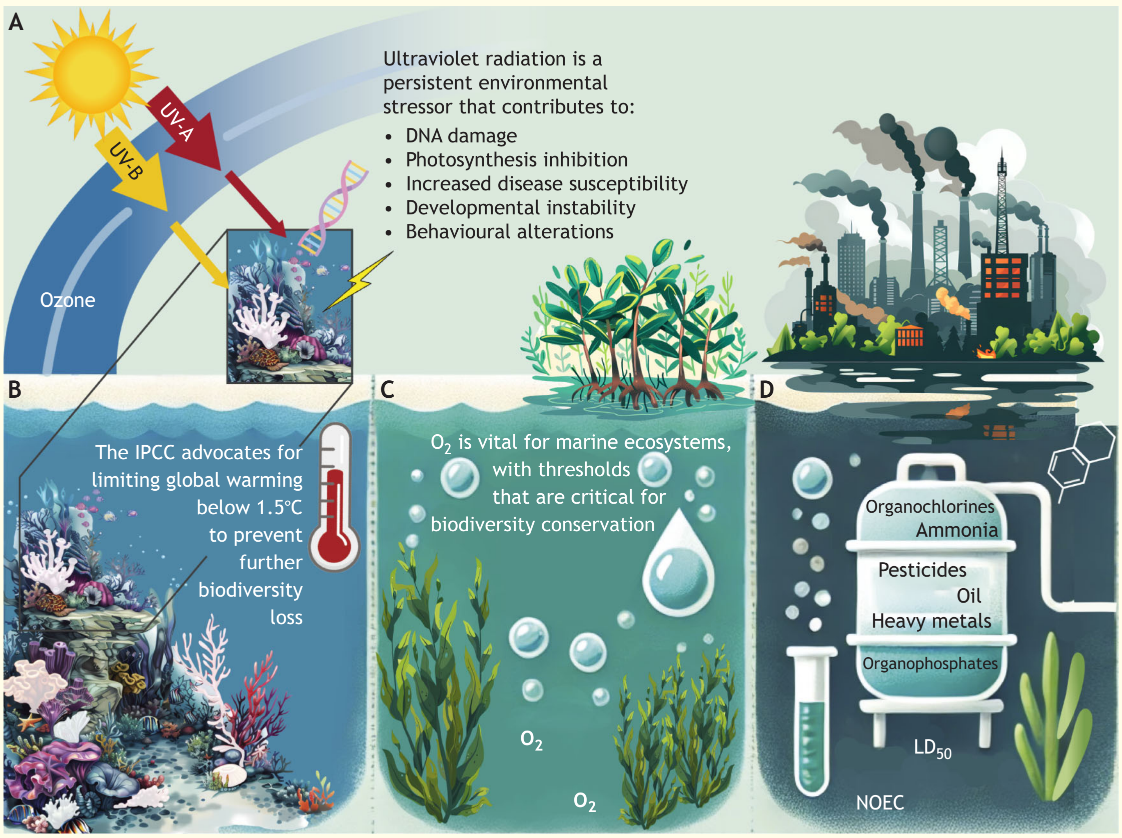
Despite the importance of physiological research in environmental management, its integration into policymaking is hindered by a lack of infrastructure for scientists to engage with policymakers (Scott et al., 2019). This challenge extends beyond physiology to most research fields (Khomsi et al., 2024). A major issue arising from a lack of engagement is the limited awareness of scientific data among policymakers, as well as a perception that it is overly complex and disconnected from broader ecosystem and societal needs (Choi et al., 2005). This perceived complexity, combined with the focus of academic institutions on fundamental research rather than applied or targeted studies, means that research is rarely designed or communicated with policy needs in mind (Scott et al., 2019; Khomsi et al., 2024).

Journal of Experimental Biology

Box 1. Integrating physiological studies in coastal marine environments into environmental policy

Ultraviolet (UV) radiation (A) is an often overlooked but a pervasive environmental stressor affecting marine ecosystems. Climate-driven changes in water clarity and ozone depletion increase UV exposure, causing various physiological challenges (Downie et al., 2023; Hird et al., 2024). Although marine organisms have protective mechanisms such as pigmentation and DNA repair, chronic UV exposure exacerbates stress, especially when combined with warming and deoxygenation (Downie et al., 2024). Coral studies reveal how UV interacts with multiple stressors, influencing reef health and resilience (Downie et al., 2024). Given its ecological significance, UV should be explicitly incorporated into climate and pollution models to improve marine biodiversity risk assessments.

Rising temperatures (B) pose significant threats to corals, fish, mangroves and seagrasses, with many species exhibiting narrow thermal tolerance ranges (Angiletta, 2009; Pörtner and Farrell, 2008; Fitt et al., 2001; Lachs et al., 2023). Even minor temperature increases can disrupt energy balance, growth, reproduction and survival (Doney et al., 2012; Penn and Deutsch, 2022). Species-specific responses, life stages and environmental conditions must be considered when developing adaptive management strategies (Huey et al., 2012; Habary et al., 2017; Wheeler et al., 2022). Long-term research has provided insights into temperature thresholds, such as those linked to mass coral bleaching events on the Great Barrier Reef in 1998, 2002, 2016, 2017, 2020, 2022 and 2024, highlighting the urgency for climate action (IPCC, 2021; AIMS, 2024). Physiological data have also informed fisheries management, with temperature stress models used to regulate Pacific salmon fisheries during warming events and population-specific studies on aerobic scope (see Glossary) guiding translocation policies under future temperature predictions (Patterson et al., 2007; Farrell et al., 2008; Cooke and O'Conner, 2010; Cooke et al., 2012; Eliason and Farrell, 2016).



Hypoxia (C) profoundly impacts marine species, affecting behaviour, reproduction and growth (Dubuc et al., 2024; Breitburg et al., 2018; Kennish et al., 2024). Identifying oxygen thresholds is critical for predicting ecological tipping points and informing conservation (Vaquer-Sunyer and Duarte, 2008; Keeling et al., 2009; Diaz and Rosenberg, 2008). Predictive models integrating temperature and oxygen needs support adaptive species management (Deutsch et al., 2020), and the United Nations' Global Ocean Oxygen Network (GO_2NE) programme exemplifies efforts to translate deoxygenation research into actionable policy. In the Baltic Sea, reoxygenation projects are underway to help cod populations recover, underscoring the value of physiological research in fisheries management (Chabot and Claireaux, 2008; Casini et al., 2016; Limburg and Casini, 2019).

Pollution (D) further stresses marine life, with physiological studies revealing sublethal effects on endocrine and immune function, behaviour, development and reproduction (Shahjahan et al., 2022; Wood et al., 2012; Fulton et al., 2013; Randall and Tsui, 2002). Tools such as LD_{50} (median lethal dose) and NOEC (no observed effect concentration) (see Glossary) have been critical in environmental risk assessments, shaping regulatory thresholds for pollutant exposure regulations worldwide (Komoroske and Birnie-Gauvin, 2022). For example, the *Deepwater Horizon* oil spill caused severe sublethal effects, including developmental abnormalities, immune suppression and cardiovascular dysfunction (Pasparakis et al., 2019). These findings provided critical data for future ecological damage assessment, habitat restoration efforts and the development of stricter long-term risk assessment frameworks in oil spill management.

Additionally, many research institutions lack formal training in policy engagement, and the role of scientists as policy advisors is often ambiguous (Scott et al., 2019; Khomsi et al., 2024). Although funding bodies such as UK Research and Innovation (UKRI) and the US National Science Foundation (NSF) increasingly emphasise policy relevance in research proposals, the infrastructure to support the transition from research to actionable policy remains underdeveloped.

Challenges in communication, timeframes, expectations and incentives

A key challenge in integrating research into policy is translating complex scientific findings into actionable and accessible insights for policymakers. This is particularly difficult for fields such as physiology where specialised and mechanistic knowledge may lack obvious connection to broader policy applications, making it harder for non-specialists to interpret and utilise findings effectively (Cooke and O'Connor, 2010). Many physiologists are not trained in applied conservation physiology or science communication, while policymakers may lack the background in biology to appreciate the relevance of physiological data (Laubenstein and Rummer, 2020). Moreover, the large body of mechanistic research published in peer-reviewed journals often remains inaccessible to policymakers and managers (Scott et al., 2019).

Communication is further complicated by misaligned timeframes between research and policymaking (Li, et al., 2023; Ashcraft et al., 2020). The research process, shaped by funding cycles, peer review and time required to generate robust empirical data, often spans several years (Sienkiewicz and Mair, 2020). In contrast, policymakers must make decisions within much shorter timeframes, often weeks or months, driven by election cycles, budget constraints and urgent issues (Sienkiewicz and Mair, 2020; Ashcraft et al., 2020).

The divide between scientists and policymakers extends to cultural differences in incentives and expectations (Friese and Bogenschneider, 2009). Researchers are motivated by long-term goals such as advancing knowledge and securing grants and peer-reviewed publications (Johann et al., 2024). In contrast, policymakers are driven by political pressures, prioritising timely, visible actions addressing societal issues (Choi et al., 2005). Their incentives include adhering to strict budgets, delivering concrete results and aligning decisions with political agendas to maintain public support. Researchers value depth and precision, whereas policymakers seek broadly applicable solutions that can be distilled into key takeaways, often favouring concise summaries over complex data. Additionally, policymakers often expect clear, definitive answers, whereas science inherently deals with uncertainty and variability. These differing priorities can create mistrust and disrespect between the two groups, further complicating the integration of scientific research into policy (Choi et al., 2005).

Call to action

Integrating research into policy requires collaboration among scientists, institutions, policymakers and Traditional Custodians, who have long safeguarded ecosystems. Working together can ensure policies are based on both scientific and cultural knowledge, fostering ecosystem resilience and sustainability (Isaac et al., 2024). To bridge the gap between research and policy, strategies should include identifying stakeholders, promoting interdisciplinary collaborations, ensuring effective communication and supporting research–policy linkages (Fig. 1). Focusing on high-impact research areas that align with conservation priorities and decision-making frameworks is crucial (see Cooke et al., 2021). Identifying research priorities that resonate with policymakers can enhance the relevance and impact of research. Here, we outline actions that can be undertaken by researchers, institutions and policymakers to improve the implementation of research into policy.

For researchers

Establishing strong connections between researchers and policymakers is key to successfully integrating research into policy, fostering knowledge co-production that is transdisciplinary (see Glossary; van der Arend, 2014; Harvey et al., 2019; Laubenstein and Rummer, 2020). Researchers should engage with relevant stakeholders early in project design through spaces where policymakers, NGOs and industry leaders operate, such as targeted conferences, policy workshops and decision-making forums (Khomsi et al., 2024). These interactions should aim to build trustful and long-lasting collaborations based on mutual respect and shared goals related to policy priorities (Scott et al., 2019). Group discussions in such settings have proven effective in solving problems and generating policy-relevant solutions (Toomey, 2023).

However, many researchers lack policy training, which hinders the kind of interactions outlined above. To address this, researchers should seek institutional, peer or external training opportunities (e.g. the UK's Royal Society pairing scheme or the Science & Technology Policy Fellowships offered by the American Association for the Advancement of Science). Such training programmes should focus on skills such as policy-relevant research, relationship building with policymakers, and an understanding of the socio-economic and political contexts in which decisions are made (Kadykalo et al., 2021). Although not all researchers need to be involved in direct policy engagement, recognising the value of participating in policy discussions – such as sitting on expert panels or collaborating with governmental advisory bodies – can amplify scientific impact. Policy engagement is not an inherent skill but one that can be developed through training, preparing researchers to influence decision-making effectively.

Another challenge is effectively communicating findings to policymakers. Traditional dissemination methods, such as peer-reviewed publications, are often inaccessible and not widely read by policymakers, reinforcing the perception that research is cumbersome and not applicable to real-world policy needs (Friese and Bogenschneider, 2009). Alternative communication strategies should be explored to ensure that research findings are presented in a clear and actionable manner. Research suggests that no single dissemination strategy is universally effective; instead, communication should be tailored to specific policymakers, with early engagement to determine their preferred formats (Ashcraft et al., 2020). Furthermore, funding agencies that support policy-relevant research should provide clearer guidelines on how they expect findings to be communicated to decision makers (McVay et al., 2016). Policy briefs, for example, distil research into concise actionable messages (Ashcraft et al., 2020). Hard copies of reports may be more effective in some contexts, while digital platforms and social media can enhance broader outreach (Laubenstein and Rummer, 2020). Face-to-face meetings with stakeholders have also been identified as an especially effective method for translating research into policy action (McVay et al., 2016). By improving engagement and communication, researchers can ensure their work is not only scientifically rigorous but also accessible, relevant and actionable for policymakers.

For institutions

Institutions must actively bridge the science–policy divide by establishing dedicated offices and resources to support policy engagement. Such initiatives include the Universities Policy Engagement Network (UPEN) in the UK, which has emerged as a central hub for academics, policymakers and professional staff working to strengthen evidence-informed policymaking. UPEN

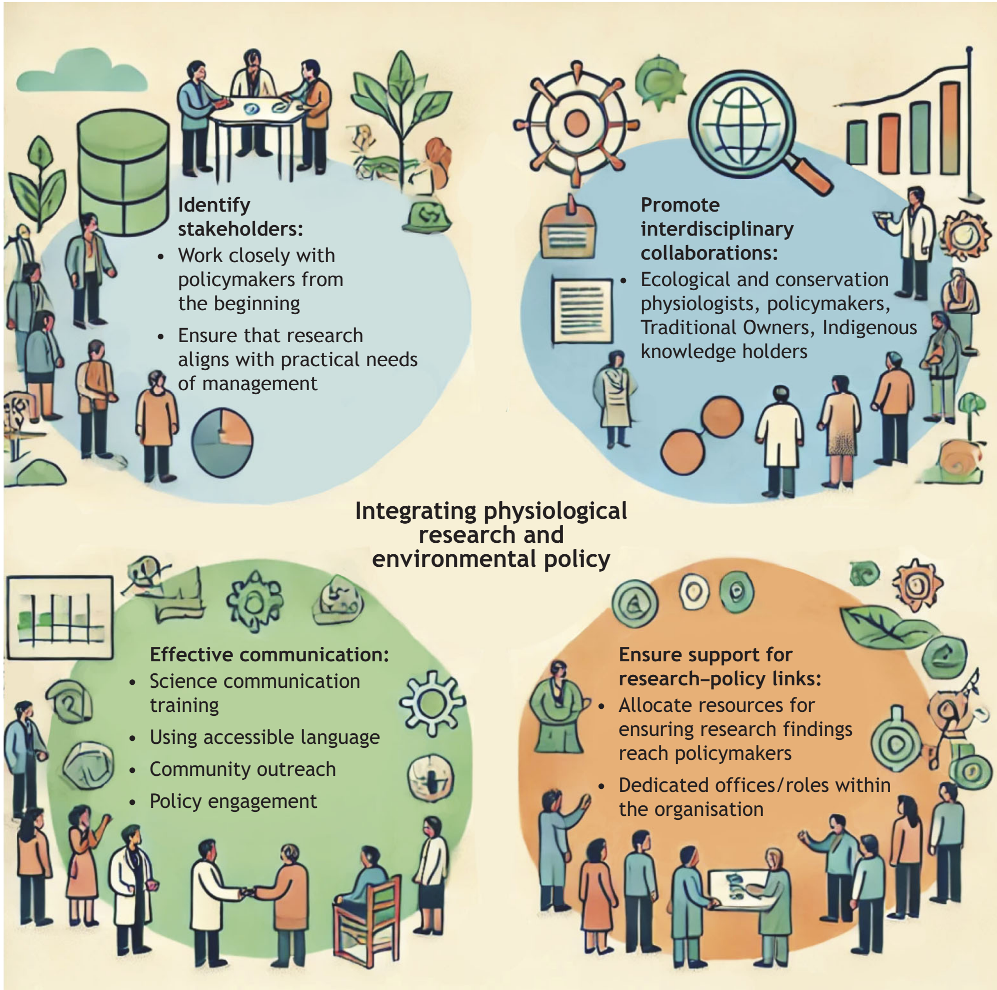


Fig. 1. Key strategies for integrating physiological research into environmental policy. The figure highlights the importance of stakeholder engagement, interdisciplinary collaboration, effective communication and organisational support. These components work collectively to bridge the gap between scientific findings and policymaking, ensuring that physiological insights are applied to enhance ecosystem resilience. Each strategy requires action from different groups. Identifying stakeholders is a key responsibility of scientists, ensuring that research aligns with management needs. Promoting interdisciplinary collaborations involves both scientists and policymakers, fostering connections with Traditional Owners and Indigenous knowledge holders. Effective communication is crucial for scientists, science communicators and policymakers to ensure research is accessible and actionable. Finally, ensuring support for research–policy links is primarily the role of institutions, requiring dedicated resources and roles to facilitate knowledge transfer.

offers guidance to members to develop effective engagement strategies. Its success has also inspired the development of clear guidelines to improve academic–policy collaboration (Walker et al., 2019).

Institutions should allocate funding (e.g. the University College London Policy Fellowship Programme) and time for science communication and policy engagement, ensuring that a scientist's contributions to policy are valued alongside academic publications. In many academic disciplines, appointments, tenure and promotions are still largely based on traditional metrics, such as peer-reviewed publications and grant acquisition. To foster a more engaged research community, universities should formally acknowledge policy engagement as a meaningful contribution in academic evaluations (McGuire and Perna, 2023). This would help to shift the academic culture toward meaningful engagement with decision makers. Institutions should also promote linkages between researchers and policymakers by providing workshops, seminars and interdisciplinary platforms to foster collaborative environments. Additionally, enhancing research accessibility through open-access publishing (e.g. Read and Publish Agreements) ensures policymakers can easily access relevant studies (McGuire and Perna, 2023). Institutions should also support the use of intermediary organisations that summarise academic research for policy audiences, offer training and facilitate partnerships between researchers and decision makers (Ashcraft et al., 2020; Harvey et al., 2019). Institutions could also provide grants or establish partnerships with organisations specialising in research translation to enhance their impact.

Finally, integrating policy engagement training into graduate and post-graduate education is essential (Scott et al., 2019). Courses on science communication, stakeholder engagement and policy development should be embedded in academic curricula to equip researchers with the skills needed to navigate the policy landscape.

For policymakers

Ensuring that scientific research is recognised, relevant and accessible to policymakers is essential for shaping effective policies (Ashcraft et al., 2020; Cooke, 2019). Policymakers must proactively engage with researchers and institutions to foster knowledge co-production. Guidelines, such as 'Engaging with academics: how to further strengthen open policy making', developed by the UK Government Office for Science, provide a framework for improving these interactions. Although many engagement strategies such as fellowships, training and secondment opportunities are primarily designed for researchers (e.g. the UPEN and the Royal Society's Pairing Scheme), they are also essential tools for policymakers to build direct connections with the scientific community. Programmes such as Australia's 'Science Meets Parliament' (SMP) provide structured mechanisms for policymakers to engage with scientists, ensuring they have access to up-to-date research and expert networks when making decisions. These initiatives help policymakers develop a broader understanding of emerging scientific challenges and enable them to seek targeted advice on policy-relevant issues. Beyond single events, sustained engagement is critical. The '2024 SMP Impact Report' highlighted record participation, with 267 delegates meeting with nearly 90 parliamentarians, demonstrating strong mutual interest in fostering science–policy connections. Notably, these initiatives encourage repeated interactions, allowing policymakers to maintain relationships with experts, develop ongoing dialogues and incorporate scientific evidence more effectively into policy decisions. To ensure that these engagements translate into long-term policy impact, policymakers can leverage advisory panels, interdisciplinary working groups and structured mentorship programmes to deepen their understanding of scientific issues and integrate this knowledge into decision-making processes. By proactively engaging with these mechanisms, policymakers can enhance their ability to make well-informed, evidence-based policy choices.

Improving accessibility to research is critical in strengthening science–policy linkages (Langer et al., 2016). Policymakers should familiarise themselves with the scientific landscape within their domain by engaging with relevant institutions and using systematic reviews, following guidelines from the Collaboration for Environmental Evidence (CEE). If such reviews are unavailable, policymakers should request them to ensure that decisions are based on comprehensive, high-quality evidence. Additionally, policymakers should have clear guidelines on how research findings are communicated, improving accessibility and usability. Sharing case studies of successful academic–policy engagements can help the process. Additionally, policymakers are often not trained to understand research, which can impede the incorporation of science into policy (Taschner and Almeida, 2024). This may be reduced by providing training and advice on how to interpret and apply scientific findings to policymaking. This can be achieved through direct exchanges with scientists, thanks to fellowships (e.g. the Science & Technology Policy Fellowships) or through services such as the Scientific Advice Mechanism to the European Commission that provides scientific advice to European policy stakeholders.

Establishing connections between policymakers and researchers is only the first step; maintaining long-term collaborations is equally crucial (Laubenstein and Rummer, 2020). Policymakers must clearly define research needs, policy challenges and long-term plans, while defining roles and responsibilities to enable research institutions to align their agendas with policy priorities. In Australia, the National Science and Research Priorities, regularly updated by the Australian Government, provide a framework for guiding research efforts toward national challenges. Similarly, policymakers should engage with institutions through calls for interest when specific expertise is needed, as seen in the UK Government Office for Science. Additionally, strengthening ties with major funding bodies, such as Horizon Europe and the Australian Research Council, ensures that research aligns with current policy priorities. Structured partnerships, dedicated funding and institutional support will cultivate a policy culture that integrates scientific evidence into decision making.

Conclusions

Physiological studies are essential for shaping effective environmental policies, providing critical insights into organismal thresholds, mechanisms of action and species- and life history stage-specific vulnerabilities to stressors such as UV radiation, warming, hypoxia and pollution. Despite their relevance, these insights remain underutilised in policy frameworks, highlighting the need to bridge the gap between research and decision making. In this Perspective, we have identified key barriers to integration and proposed solutions to enhance the uptake of physiological research into policy development. Ultimately, incorporating physiological insights into environmental policy can improve its practical application, strengthening efforts to conserve threatened species and build long-term ecosystem resilience in the face of global climate change.

Acknowledgements
We would like to acknowledge Professor Craig Franklin as well as another anonymous reviewer for their insightful critique, edits and suggestions that have helped to make this Perspective a stronger and more meaningful contribution.

Competing interests
The authors declare no competing or financial interests.

References
Acevedo-Whitehouse, K. (2019). Physiological thresholds in the context of marine mammal conservation. *Adv. Exp. Med. Biol.* **1200**, 163-186. doi:10.1007/978-3-030-23633-5_6

Angilletta, M. (2009). Thermal adaptation. In *A Theoretical And Empirical Synthesis*, p. 289. Oxford: Oxford University Press.

Ashcraft, L. E., Quinn, D. A. and Brownson, R. C. (2020). Strategies for effective dissemination of research to United States policymakers: a systematic review. *Implement. Sci.* **15**, 1-17. doi:10.1186/s13012-020-01046-3

AIMS (2024). *Annual Summary Report of Coral Reef Condition 2023/24*. https://www.aims.gov.au/monitoring-great-barrier-reef/gbr-condition-summary-2023-24

Bergman, J. N., Bennett, J. R., Binley, A. D., Cooke, S. J., Fyson, V., Hlina, B. L., Reid, C. H., Vala, M. A. and Madliger, C. L. (2019). Scaling from individual physiological measures to population-level demographic change: case studies and future directions for conservation management. *Biol. Conserv.* **238**, 108242. doi:10.1016/j.biocon.2019.108242

Bothe, T. L., Pilz, N., Patzak, A. and Opatz, O. (2023). Bridging the gap: the dichotomy between measurement and reality in physiological research. *Acta Physiol.* **238**, e14015. doi:10.1111/apha.14015

Breitburg, D., Levin, L. A., Oschlies, A., Grégoire, M., Chavez, F. P., Conley, D. J., Garçon, V., Gilbert, D., Gutiérrez, D., Isensee, K. et al. (2018). Declining oxygen in the global ocean and coastal waters. *Science* **359**, eaam7240. doi:10.1126/science.aam7240

Brooks, J. L., Chapman, J. M., Barkley, A. N., Kessel, S. T., Hussey, N. E., Hinch, S. G., Patterson, D. A., Hedges, K. J., Cooke, S. J., Fisk, A. T. et al. (2019). Biotelemetry informing management: case studies exploring successful integration of biotelemetry data into fisheries and habitat management. *Can. J. Fish. Aquat. Sci.* **76**, 1238-1252. doi:10.1139/cjfas-2017-0530

Casini, M., Käll, F., Hansson, M., Plikshs, M., Baranova, T., Karlsson, O., Lundström, K., Neuenfeldt, S., Gårdmark, A. and Hjelm, J. (2016). Hypoxic areas, density-dependence and food limitation drive the body condition of a heavily exploited marine fish predator. *R. Soc. Open Sci.* **3**, 160416. doi:10.1098/rsos.160416

Chabot, D. and Claireaux, G. (2008). Environmental hypoxia as a metabolic constraint on fish: the case of Atlantic cod, *Gadus morhua*. *Mar. Pollut. Bull.* **57**, 287-294. doi:10.1016/j.marpolbul.2008.04.001

Choi, B. C. K., Pang, T., Lin, V., Puska, P., Sherman, G., Goddard, M., Ackland, M. J., Sainsbury, P., Stachenko, S., Morrison, H. et al. (2005). Can scientists and policy makers work together? *J. Epidemiol. Community Health* **59**, 632-637. doi:10.1136/jech.2004.031765

Chown, S. L. and Gaston, K. J. (2008). Macrophysiology for a changing world. *Proc. R. Soc. B* **275**, 1469-1478. doi:10.1098/rspb.2008.0137

Cooke, S. J. (2019). From frustration to fruition in applied conservation research and practice: Ten revelations. *Socio Ecol. Pract. Res* **1**, 15-23. doi:10.1007/s42532-018-0002-x

Cooke, S. J. and O'Connor, C. M. (2010). Making conservation physiology relevant to policy makers and conservation practitioners. *Conserv. Lett.* **3**, 159-166. doi:10.1111/j.1755-263X.2010.00109.x

Cooke, S. J., Hinch, S. G., Donaldson, M. R., Clark, T. D., Eliason, E. J., Crossin, G. T., Raby, G. D., Jeffries, K. M., Lapointe, M., Miller, K. et al. (2012). Conservation physiology in practice: how physiological knowledge has improved our ability to sustainably manage Pacific salmon during up-river migration. *Philos. Trans. R. Soc. B* **367**, 1757-1769. doi:10.1098/rstb.2012.0022

Cooke, S. J., Sack, L., Franklin, C. E., Farrell, A. P., Beardall, J., Wikelski, M. and Chown, S. L. (2013). What is conservation physiology? Perspectives on an increasingly integrated and essential science. *Conserv. Physiol.* **1**, cot001. doi:10.1093/conphys/cot001

Cooke, S. J., Bergman, J. N., Madliger, C. L., Cramp, R. L., Beardall, J., Burness, G., Clark, T. D., Dantzer, B., de la Barrera, E., Fangue, N. A. et al. (2021). One hundred research questions in conservation physiology for generating actionable evidence to inform conservation policy and practice. *Conserv. Physiol.* **9**, coab009. doi:10.1093/conphys/coab009

Coristine, L. E., Robillard, C. M., Kerr, J. T., O'Connor, D. M., Lapointe, S. J. and Cooke, S. J. (2014). A conceptual framework for the emerging discipline of conservation physiology. *Conserv. Physiol.* **2**, cou033. doi:10.1093/conphys/cou033

Crowley, D. M., Scott, J. T. B. and Fishbein, D. (2018). Translating prevention research for evidence-based policymaking: results from the research-to-policy collaboration pilot. *Prev. Sci.* **19**, 260-270. doi:10.1007/s11121-017-0833-x

Deutsch, C., Penn, J. L. and Seibel, B. (2020). Metabolic trait diversity shapes marine biogeography. *Nature* **585**, 557-562. doi:10.1038/s41586-020-2721-y

Diaz, R. J. and Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science* **321**, 926-929. doi:10.1126/science.1156401

Doney, S. C., Ruckelshaus, M., Duffy, J. E., Barry, J. P., Chan, F., English, C. A., Galindo, H. M., Grebmeier, J. M., Hollowed, A. B., Knowlton, N. et al. (2012). Climate change impacts on marine ecosystems. *Ann. Rev. Mar. Sci.* **4**, 11-37. doi:10.1146/annurev-marine-041911-111611

Downie, A. T., Wu, N. C., Cramp, R. L. and Franklin, C. E. (2023). Sublethal consequences of ultraviolet radiation exposure on vertebrates: Synthesis through meta-analysis. *Glob. Change Biol.* **29**, 6620-6634. doi:10.1111/gcb.16848

Downie, A. T., Cramp, R. L. and Franklin, C. E. (2024). The interactive impacts of a constant reef stressor, ultraviolet radiation, with environmental stressors on coral physiology. *Sci. Total Environ.* **907**, 168066. doi:10.1016/j.scitotenv.2023.168066

Dubuc, A., Rummer, J. L., Vigliola, L. and Lemonnier, H. (2024). Coping with environmental degradation: physiological and morphological adjustments of wild mangrove fish to decades of aquaculture-induced nutrient enrichment. *Mar. Pollut. Bull.* **205**, 116599. doi:10.1016/j.marpolbul.2024.116599

Eliason, E. J. and Farrell, A. P. (2016). Oxygen uptake in Pacific salmon *Oncorhynchus spp.*: when ecology and physiology meet. *J. Fish Biol.* **88**, 359-388. doi:10.1111/jfb.12790

Ens, E., **Towler, G. M. and Daniels, C**., **the Yugul Mangi Rangers, and the Manwurrk Rangers** (2012). Looking back to move forward: Collaborative ecological monitoring in remote Arnhem Land. *Ecol. Manag. Restor.* **13**, 26-35. doi:10.1111/j.1442-8903.2011.00627.x

Farrell, A. P., Hinch, S. G., Cooke, S. J., Patterson, D. A., Crossin, G. T., Lapointe, M. and Mathes, M. T. (2008). Pacific salmon in hot water: applying aerobic scope models and biotelemetry to predict the success of spawning migrations. *Physiol. Biochem. Zool.* **81**, 697-708. doi:10.1086/592057

Fitt, W. K., Brown, B. E., Warner, M. E. and Dunne, R. P. (2001). Coral bleaching: Interpretation of thermal tolerance limits and thermal thresholds in tropical corals. *Coral Reefs* **20**, 51-65. doi:10.1007/s003380100146

Friese, B. and Bogenschneider, K. (2009). The voice of experience: How social scientists communicate family research to policymakers. *Fam. Relat* **58**, 229-243. doi:10.1111/j.1741-3729.2008.00549.x

Fry, T. L., Friedrichs, K. R., Ketz, A. C., Duncan, C., Van Deelen, T. R., Goldberg, T. L. and Atwood, T. C. (2023). Long–term assessment of relationships between changing environmental conditions and the physiology of southern Beaufort Sea polar bears (*Ursus maritimus*). *Glob. Change Biol.* **29**, 5524-5539. doi:10.1111/gcb.16883

Fulton, M. H., Key, P. B. and Delorenzo, M. E. (2013). Insecticide toxicity in fish. In *Fish Physiology* (ed. K. B. Tierney, A. P. Farrell and C. J. Brauner), Vol. 33, pp. 309-368. Academic Press.

Habary, A., Johansen, J. L., Nay, T. J., Steffensen, J. F. and Rummer, J. L. (2017). Adapt, move, or die – how will coral reef fishes cope with ocean warming? *Glob. Change Biol.* **23**, 566-577. doi:10.1111/gcb.13488

Harvey, B., Cochrane, L. and Van Epp, M. (2019). Charting knowledge co-production pathways in climate and development. *Envir. Policy Gov.* **29**, 107-117. doi:10.1002/eet.1834

Hicks, D. (2012). Performance-based university research funding systems. *Res. Policy* **41**, 251-261. doi:10.1016/j.respol.2011.09.007

Hird, C., Lundsgaard, N. U., Downie, A. T., Cramp, R. L. and Franklin, C. E. (2024). Considering ultraviolet radiation in experimental biology: a neglected pervasive stressor. *J. Exp. Biol.* **227**, jeb247231. doi:10.1242/jeb.247231

Huey, R. B., Kearney, M. R., Krockenberger, A., Holtum, J. A., Jess, M. and Williams, S. E. (2012). Predicting organismal vulnerability to climate warming: roles of behaviour, physiology and adaptation. *Philos. Trans. R. Soc. B* **367**, 1665-1679. doi:10.1098/rstb.2012.0005

Illing, B. and Rummer, J. L. (2017). Physiology can contribute to better understanding, management, and conservation of coral reef fishes. *Conserv. Physiol.* **5**, cox005. doi:10.1093/conphys/cox005

IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (ed. V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. and B. Zhou). Cambridge University Press.

Isaac, J., Mouda, R., Barrett, D., Gould, J., Smyth, D. and Vernes, T. (2024). Sea country indigenous protected areas: indigenous leadership in the protection of Australia's marine environments. *Mar. Policy* **170**, 106358. doi:10.1016/j.marpol.2024.106358

Johann, D., Neufeld, J., Thomas, K., Rathmann, J. and Rauhut, H. (2024). The impact of researchers' perceived pressure on their publication strategies. *Res. Eval.* rvae011. doi:10.1093/reseval/rvae011

Jorgensen, C., Peck, M. A., Antognarelli, F., Azzurro, E., Burrows, M. T., Cheung, W. W., Cucco, A., Holt, R. E., Huebert, K. B., Marras, S. et al. (2012). Conservation physiology of marine fishes: advancing the predictive capacity of models. *Biol. Lett.* **8**, 900-903. doi:10.1098/rsbl.2012.0609

Kadykalo, A. N., Buxton, R. T., Morrison, P., Anderson, C. M., Bickerton, H., Francis, C. M., Smith, A. C. and Fahrig, L. (2021). Bridging research and practice in conservation. *Conserv. Biol.* **35**, 1725-1737. doi:10.1111/cobi.13732

Keeling, R. F., Oschlies, A. and Orr, J. C. (2009). Atmospheric evidence for recent global ocean deoxygenation. *Geochim. Cosmochim. Acta* **73**, A632.

Kennish, M. J., Paerl, H. W., Crosswell, J. R. and Seibel, B. A. (2024). Animal response to hypoxia in estuaries and effects of climate change. In *Climate Change and Estuaries* (ed. M. J. Kennish, H. W. Paerl and J. R. Crosswell), pp. 545-562. CRC Press.

Khomsi, K., Bouzghiba, H., Mendyl, A., Al-Delaimy, A. K., Dahri, A., Saad-Hussein, A., Balaw, G., El Marouani, I., Sekmoudi, I., Adarbaz, M. et al. (2024). Bridging research-policy gaps: An integrated approach. *Environmental Epidemiology* **8**, e281. doi:10.1097/EE9.0000000000000281

Komoroske, L. M. and Birnie-Gauvin, K. (2022). Conservation physiology of fishes for tomorrow: successful conservation in a changing world and priority actions for the field. In *Fish Physiology* (ed. S. J. Cooke, N. A. Fangue, A. P. Farrell, C. J. Brauner and E. J. Eliason), Vol. 39, pp. 581-628. Academic Press.

Lachs, L., Donner, S. D., Mumby, P. J., Bythell, J. C., Humanes, A., East, H. K. and Guest, J. R. (2023). Emergent increase in coral thermal tolerance reduces mass bleaching under climate change. *Nat. Commun.* **14**, 4939. doi:10.1038/s41467-023-40601-6

Langer, L., Tripney, J. and Gough, D. (2016). *The Science of Using Science Researching the Use of Research Evidence in Decision-Making*. UCL.

Laubenstein, T. D. and Rummer, J. L. (2020). Communication in conservation physiology: linking diverse stakeholders, promoting public engagement, and encouraging application. In *Conservation Physiology: Integrating Physiology into Animal Conservation and Management* (ed. S. J. Cooke, C. L. Madliger, O. P. Love and C. E. Franklin), pp. 303-317. Oxford University Press.

Li, N., Luczak-Roesch, M. and Donadelli, F. (2023). A computational approach to study the gap and barriers between science and policy. *Sci. Public Policy* **50**, 15-29. doi:10.1093/scipol/scac048

Limburg, K. E. and Casini, M. (2019). Otolith chemistry indicates recent worsened Baltic cod condition is linked to hypoxia exposure. *Biol. Lett.* **15**, 20190352. doi:10.1098/rsbl.2019.0352

Lyver, P. O. B., Timoti, P., Jones, C. J., Richardson, S. J., Tahi, B. L. and Greenhalgh, S. (2017). An indigenous community-based monitoring system for assessing forest health in New Zealand. *Biodivers. Conserv.* **26**, 3183-3212. doi:10.1007/s10531-016-1142-6

Madliger, C. L. and Love, O. P. (2015). The power of physiology in changing landscapes: considerations for the continued integration of conservation and physiology. *Integr. Comp. Biol.* **55**, 545-553. doi:10.1093/icb/icv001

Madliger, C. L., Love, O. P., Hultine, K. R. and Cooke, S. J. (2018). The conservation physiology toolbox: status and opportunities. *Conserv. Physiol.* **6**, coy029. doi:10.1093/conphys/coy029

Madliger, C. L., Love, O. P., Nguyen, V. M., Haddaway, N. R. and Cooke, S. J. (2021). Researcher perspectives on challenges and opportunities in conservation physiology revealed from an online survey. *Conserv. Physiol.* **9**, coab030. doi:10.1093/conphys/coab030

Mahoney, J. L., Klug, P. E. and Reed, W. L. (2018). An assessment of the US endangered species act recovery plans: using physiology to support conservation. *Conserv. Physiol.* **6**, coy036. doi:10.1093/conphys/coy036

McGuire, M. and Perna, L. W. (2023). Connecting policymakers with academic research to inform public policy. *Change: The Magazine of Higher Learning* **55**, 15-20. doi:10.1080/00091383.2023.2263188

McVay, A. B., Stamatakis, K. A., Jacobs, J. A., Tabak, R. G. and Brownson, R. C. (2016). The role of researchers in disseminating evidence to public health practice settings: a cross-sectional study. *Health Res. Policy Syst.* **14**, 42. doi:10.1186/s12961-016-0113-4

Meyer, C. L. and Sisk, T. D. (2001). Butterfly response to microclimatic conditions following ponderosa pine restoration. *Restor. Ecol.* **9**, 453-461. doi:10.1046/j.1526-100X.2001.94014.x

Norström, A. V., Cvitanovic, C., Löf, M. F., West, S., Wyborn, C., Balvanera, P., Bednarek, A. T., Bennett, E. M., Biggs, R., de Bremond, A. et al. (2020). Principles for knowledge co-production in sustainability research. *Nat. Sustain* **3**, 182-190. doi:10.1038/s41893-019-0448-2

Pasparakis, C., Esbaugh, A. J., Burggren, W. and Grosell, M. (2019). Physiological impacts of Deepwater Horizon oil on fish. *Comp. Biochem. Physiol. C Toxicol. Pharmacol.* **224**, 108558. doi:10.1016/j.cbpc.2019.06.002

Patterson, D. A., Macdonald, J. S., Skibo, K. M., Barnes, D. P., Guthrie, I. and Hills, J. (2007). Reconstructing the summer thermal history for the lower Fraser River, 1941 to 2006, and implications for adult sockeye salmon (*Oncorhynchus nerka*) spawning migration. *Can. Tech. Rep. Fish. Aquat. Sci.* **2724**, 1-51.

Penn, J. L. and Deutsch, C. (2022). Avoiding ocean mass extinction from climate warming. *Science* **376**, 524-526. doi:10.1126/science.abe9039

Petitjean, Q., Jean, S., Gandar, A., Côte, J., Laffaille, P. and Jacquin, L. (2019). Stress responses in fish: From molecular to evolutionary processes. *Sci. Total Environ.* **684**, 371-380. doi:10.1016/j.scitotenv.2019.05.357

Pörtner, H. O. and Farrell, A. P. (2008). Physiology and climate change. *Science* **322**, 690-692. doi:10.1126/science.1163156

Randall, D. J. and Tsui, T. K. N. (2002). Ammonia toxicity in fish. *Mar. Pollut. Bull.* **45**, 17-23. doi:10.1016/S0025-326X(02)00227-8

Scott, J. T., Larson, J. C., Buckingham, S. L., Maton, K. I. and Crowley, D. M. (2019). Bridging the research-policy divide: pathways to engagement and skill development. *Am. J. Orthopsychiatry* **89**, 434-441. doi:10.1037/ort0000389

Shahjahan, M., Taslima, K., Rahman, M. S., Al-Emran, M., Alam, S. I. and Faggio, C. (2022). Effects of heavy metals on fish physiology: a review. *Chemosphere* **300**, 134519. doi:10.1016/j.chemosphere.2022.134519

Sienkiewicz, M. and Mair, D. (2020). Chapter 1, Against the Science–Policy Binary Separation: Science for Policy 1.0. In *Science for Policy Handbook* (ed. V Šucha and M. Sienkiewicz). Elsevier.

Singletary, L., Koebele, E., Evans, W., Copp, C. J., Hockaday, S. and Rego, J. J. (2022). Evaluating stakeholder engagement in collaborative research: co-producing knowledge for climate resilience. *Socio .Ecological. Pract. Res.* **4**, 235-249. doi:10.1007/s42532-022-00124-8

Taschner, N. P. and Almeida, P. (2024). Teaching scientific evidence and critical thinking for policy making. *Biol. Methods Protoc.* **9**, 1. doi:10.1093/biomethods/bpae023

Toomey, A. H. (2023). Why facts don't change minds: Insights from cognitive science for the improved communication of conservation research. *Biol. Conserv.* **278**, 109886. doi:10.1016/j.biocon.2022.109886

Tracy, C. R., Nussear, K. E., Esque, T. C., Dean-Bradley, K., DeFalco, L. A., Castle, K. T., Zimmerman, L. C., Espinoza, R. E. and Barber, A. M. (2006). The importance of physiological ecology in conservation biology. *Integr. Comp. Biol.* **46**, 1191-1205. doi:10.1093/icb/icl054

van der Arend, J. (2014). Bridging the research/policy gap: policy officials' perspectives on the barriers and facilitators to effective links between academic and policy worlds. *Policy Studies* **35**, 611-630. doi:10.1080/01442872.2014.971731

Vaquer-Sunyer, R. and Duarte, C. M. (2008). Thresholds of hypoxia for marine biodiversity. *Proc. Natl. Acad. Sci. USA* **105**, 15452-15457. doi:10.1073/pnas.0803833105

Walker, L., Pike, L., Chambers, C., Lawrence, N., Wood, M. and Durrant, H. (2019). Understanding and Navigating the Landscape of Evidence-based Policy. Recommendations for Improving Academic-policy Engagement. July, 38. https://www.bath.ac.uk/publications/understanding-and-navigating-the-landscape-of-evidence-based-policy/attachments/ipr-understanding-and-navigating-the-landscape-of-evidence-based-policy__1_.pdf

Weible, C. M., Sabatier, P. A. and McQueen, K. (2010). Themes and variations: Taking stock of the advocacy coalition framework. *Policy Stud. J.* **38**, 121-140. doi:10.1111/j.1541-0072.2008.00299.x

Weiss, C. H. (1982). Policy research in the context of diffuse decision making. *J. High. Educ.* **53**, 619-639. doi:10.1080/00221546.1982.11780501

Wheeler, C. R., Lang, B. J., Mandelman, J. W. and Rummer, J. L. (2022). The upper thermal limit of a tropical elasmobranch is conserved across life history stages and body sizes. *Conserv. Physiol.* **10**, coac074. doi:10.1093/conphys/coac074

Wikelski, M. and Cooke, S. J. (2006). Conservation physiology. *Trends Ecol. Evol.* **21**, 38-46. doi:10.1016/j.tree.2005.10.018

Wood, C. M., Farrell, A. P. and Brauner, C. J. (eds.) (2012). *Homeostasis and Toxicology of Essential Metals*, Vol. 1. Academic Press.

Young, J. L., Bornik, Z. B., Marcotte, M. L., Charlie, K. N., Wagner, G. N., Hinch, S. G. and Cooke, S. (2006). Integrating physiology and life history to improve fisheries management and conservation. *Fish. Fish* **7**, 262-283. doi:10.1111/j.1467-2979.2006.00225.x