Convegno CISBA, Reggio-Emilia 2-3 marzo 2023
ECOSISTEMI ACQUATICI E CAMBIAMENTI CLIMATICI

Deflusso ecologico e invertebrati acquatici in un contesto di climate change

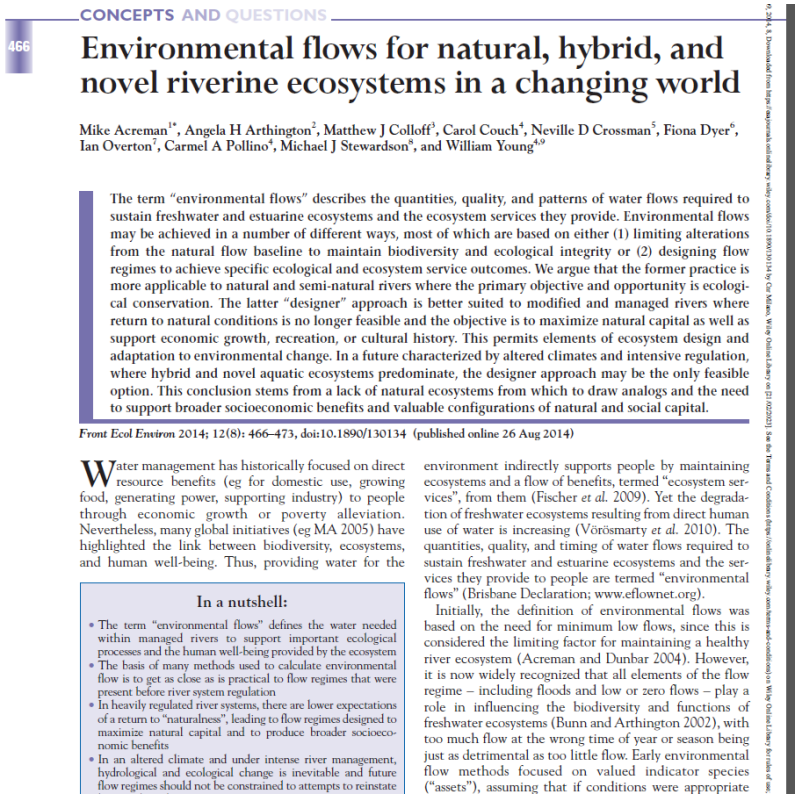
Stefania, ERBA; Marcello, CAZZOLA; Andrea BUFFAGNI

CNR-IRSA, Brugherio

Alcuni concetti chiave

Environmental Flow (1) → valori soglia di portata → *Minimum flow* → *salvaguardia di una specifica componente*

Environmental flow (2) → accezione più ampia e recente (relativamente) → mantenimento dell'integrità degli ecosistemi



Environmental flows for natural, hybrid, and novel riverine ecosystems in a changing world

Mike Acreman[1*], Angela H Arthington[2], Matthew J Colloff[3], Carol Couch[4], Neville D Crossman[5], Fiona Dyer[6], Ian Overton[7], Carmel A Pollino[4], Michael J Stewardson[8], and William Young[4,9]

The term "environmental flows" describes the quantities, quality, and patterns of water flows required to sustain freshwater and estuarine ecosystems and the ecosystem services they provide. Environmental flows may be achieved in a number of different ways, most of which are based on either (1) limiting alterations from the natural flow baseline to maintain biodiversity and ecological integrity or (2) designing flow regimes to achieve specific ecological and ecosystem service outcomes. We argue that the former practice is more applicable to natural and semi-natural rivers where the primary objective and opportunity is ecological conservation. The latter "designer" approach is better suited to modified and managed rivers where return to natural conditions is no longer feasible and the objective is to maximize natural capital as well as support economic growth, recreation, or cultural history. This permits elements of ecosystem design and adaptation to environmental change. In a future characterized by altered climates and intensive regulation, where hybrid and novel aquatic ecosystems predominate, the designer approach may be the only feasible option. This conclusion stems from a lack of natural ecosystems from which to draw analogs and the need to support broader socioeconomic benefits and valuable configurations of natural and social capital.

Front Ecol Environ 2014; 12(8): 466–473, doi:10.1890/130134 (published online 26 Aug 2014)

Water management has historically focused on direct resource benefits (eg for domestic use, growing food, generating power, supporting industry) to people through economic growth or poverty alleviation. Nevertheless, many global initiatives (eg MA 2005) have highlighted the link between biodiversity, ecosystems, and human well-being. Thus, providing water for the environment indirectly supports people by maintaining ecosystems and a flow of benefits, termed "ecosystem services", from them (Fischer *et al.* 2009). Yet the degradation of freshwater ecosystems resulting from direct human use of water is increasing (Vörösmarty *et al.* 2010). The quantities, quality, and timing of water flows required to sustain freshwater and estuarine ecosystems and the services they provide to people are termed "environmental flows" (Brisbane Declaration; www.eflownet.org).

Initially, the definition of environmental flows was based on the need for minimum low flows, since this is considered the limiting factor for maintaining a healthy river ecosystem (Acreman and Dunbar 2004). However, it is now widely recognized that all elements of the flow regime – including floods and low or zero flows – play a role in influencing the biodiversity and functions of freshwater ecosystems (Bunn and Arthington 2002), with too much flow at the wrong time of year or season being just as detrimental as too little flow. Early environmental flow methods focused on valued indicator species ("assets"), assuming that if conditions were appropriate

In a nutshell:

- The term "environmental flows" defines the water needed within managed rivers to support important ecological processes and the human well-being provided by the ecosystem
- The basis of many methods used to calculate environmental flow is to get as close as is practical to flow regimes that were present before river system regulation
- In heavily regulated river systems, there are lower expectations of a return to "naturalness", leading to flow regimes designed to maximize natural capital and to produce broader socioeconomic benefits
- In an altered climate and under intense river management, hydrological and ecological change is inevitable and future flow regimes should not be constrained to attempts to reinstate

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SPECIAL ISSUE

WILEY Freshwater Biology

Recent advances in environmental flows science and water management—Innovation in the Anthropocene

Angela H. Arthington[1] | Jonathan G. Kennen[2] | Eric D. Stein[3] | J. Angus Webb[4]

[1]Australian Rivers Institute, Griffith University, Nathan, Qld, Australia
[2]U.S. Geological Survey, Lawrenceville, NJ, U.S.A.
[3]Southern California Coastal Water Research Project, Costa Mesa, CA, U.S.A.
[4]Department of Infrastructure Engineering, The University of Melbourne, Parkville, Vic., Australia

Correspondence
Angela H. Arthington, Australian Rivers Institute, Griffith University, Brisbane, Qld, Australia.
Email: a.arthington@griffith.edu.au

Funding Information
Australian Rivers Institute; USGS National

Abstract

1. The implementation of environmental flow regimes offers a promising means to protect and restore riverine, wetland and estuarine ecosystems, their critical environmental services and cultural/societal values.
2. This Special Issue expands the scope of environmental flows and water science in theory and practice, offering 20 papers from academics, agency researchers and non-governmental organisations, each with fresh perspectives on the science and management of environmental water allocations.
3. Contributions confront the grand challenge for environmental flows and water management in the Anthropocene—the urgent need for innovations that will help to sustain the innate resilience of social-ecological systems under dynamic and uncertain environmental and societal futures.

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Ecological flow → sensu WFD

Freshwater Biology

Freshwater Biology (2010) **55**, 32–48 doi:10.1111/j.1365-2427.2009.02181.x

Environmental flows and the European Water Framework Directive

M. C. ACREMAN* AND A. J. D. FERGUSON†
*Centre for Ecology and Hydrology, Wallingford, U.K.
†Enviros Consulting Ltd, Shrewsbury U.K.

SUMMARY

1. Environmental flows is now a widely accepted term that covers the quantity, timing, duration, frequency and quality of water flows required to sustain freshwater, estuarine and near-shore ecosystems and the human livelihoods and well-being that depend on them.
2. The Water Framework Directive (WFD) of the European Union does not use the term environmental flows explicitly, but requires member states to achieve good ecological status (GES) in all waterbodies, which is assessed by reference to aquatic biology. Nevertheless, it is accepted that ecologically appropriate hydrological regimes are necessary to meet this status. Implementing environmental flows will be a key measure for restoring and managing river ecosystems.
3. The WFD explicitly requires stakeholder involvement, but this has been interpreted as largely a dissemination exercise by national government agencies. Stakeholders are no longer involved in negotiation over ecological objectives as these are pre-set in the WFD. However, stakeholders may be more involved in reviewing standards and agreeing to measures to restore river ecosystems to the status required by the WFD.

IRSA CNR

Gli invertebrati acquatici e le condizioni flusso

La sensibilità degli invertebrati alle condizioni di flusso è nota in letteratura

DOI: 10.1007/s00267-002-2737-0

Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity[1]

STUART E. BUNN*
ANGELA H. ARTHINGTON
Cooperative Research Centre for Freshwater Ecology
Centre for Catchment and In-Stream Research
Faculty of Environmental Sciences
Griffith University
Nathan, Queensland, Australia 4111

ABSTRACT / The flow regime is regarded by many aquatic ecologists to be the key driver of river and floodplain wetland ecosystems. We have focused this literature review around four key principles to highlight the important mechanisms that link hydrology and aquatic biodiversity and to illustrate the consequent impacts of altered flow regimes: Firstly, flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition; Secondly, aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes; Thirdly, maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species; Finally, the invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes. The impacts of flow change are manifest across broad taxonomic groups including riverine plants, invertebrates, and fish. Despite growing recognition of these relationships, ecologists still struggle to predict and quantify biotic responses to altered flow regimes. One obvious difficulty is the ability to distinguish the direct effects of modified flow regimes from impacts associated with land-use change that often accompanies water resource development. Currently, evidence about how rivers function in relation to flow regime and the flows that aquatic organisms need exists largely as a series of untested hypotheses. To overcome these problems, aquatic science needs to move quickly into a manipulative or experimental phase, preferably with the aims of restoration and measuring ecosystem response.

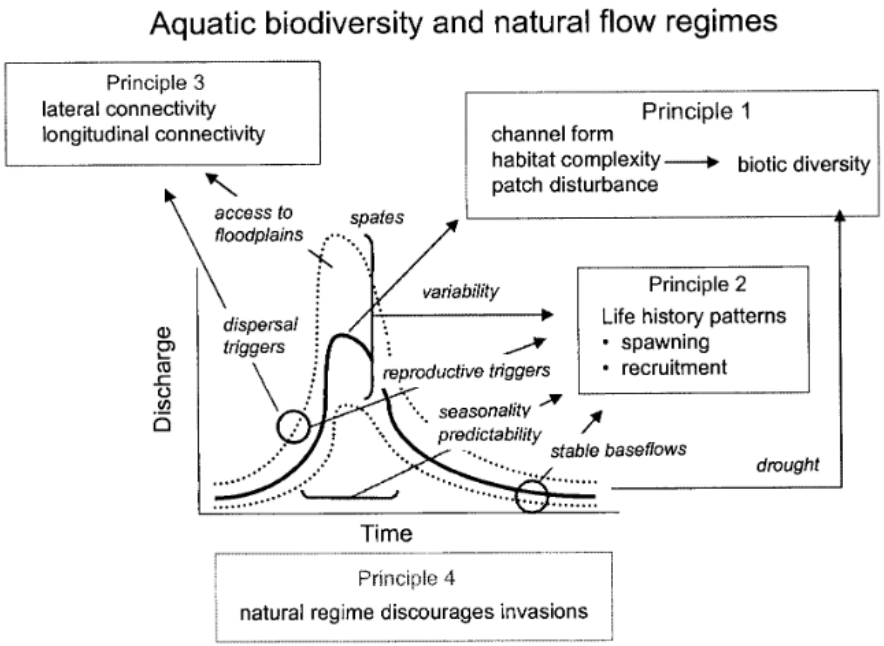

Figure 1. The natural flow regime of a river influences aquatic biodiversity via several interrelated mechanisms that operate over different spatial and temporal scales. The relationship between biodiversity and the physical nature of the aquatic habitat is likely to be driven primarily by large events that influence channel form and shape (principle 1). However, droughts and low-flow events are also likely to play a role by limiting overall habitat availability. Many features of the flow regime influence life history patterns, especially the seasonality and predictability of the overall pattern, but also the timing of particular flow events (principle 2). Some flow events trigger longitudinal dispersal of migratory aquatic organisms and other large events allow access to otherwise disconnected floodplain habitats (principle 3). The native biota have evolved in response to the overall flow regime. Catchment land-use change and associated water resource development inevitably lead to changes in one or more aspects of the flow regime resulting in declines in aquatic biodiversity via these mechanisms. Invasions by introduced or exotic species are more likely to succeed at the expense of native biota if the former are adapted to the modified flow regime (principle 4).

1. Flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition.

2. Aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes.

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ORIGINAL ARTICLE

WILEY Freshwater Biology

Habitat-specific invertebrate responses to hydrological variability, anthropogenic flow alterations, and hydraulic conditions

James C. White[1,2] | Hendrik J. Krajenbrink[1] | Matthew J. Hill[3] | David M. Hannah[4] | Andy House[5] | Paul J. Wood[1]

La quantificazione delle risposte ecologiche alla variabilità del regime idrologico è un tema centrale per impostare i ragionamenti sugli e-flow → La risposta degli invertebrati è mediata dagli habitat

Diversa composizione tassonomica tra habitat diversi →substrati grossolani *vs* substrati fini *vs Ranunnunculus spp.*

Le alterazioni idrologiche espresse attraverso indici idrologici sono significative per gli indici biologici (metriche di ricchezza, funzionalità ed abbondanza).

Il numero di Froude è il più importante per le comunità biologiche

È fondamentale tenere conto delle condizioni locali di habitat

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Gli invertebrati acquatici e le condizioni flusso

Freshwater Biology (2007) **52**, 145–164 doi:10.1111/j.1365-2427.2006.01663.x

APPLIED ISSUES

Modelling the hydraulic preferences of benthic macroinvertebrates in small European streams

SYLVAIN DOLÉDEC,* NICOLAS LAMOUROUX,† ULRIKE FUCHS‡ AND SYLVIE MÉRIGOUX*
*UMR CNRS 5023 Ecologie des Hydrosystèmes Fluviaux, Université Lyon 1, Villeurbanne, F-69622, France
†UR Biologie des Ecosystèmes Aquatiques, CEMAGREF, Lyon, France
‡Arbeitsgemeinschaft Landschaftsökologie (ALAND) Boeckhstr, Karlsruhe, Deutschland

Preferenze idrauliche degli invertebrati bentonici in un pool di fiumi europei
→ e.g. classificazione dei taxa in lentici o reofili

Received: 1 November 2019 | Revised: 18 June 2020 | Accepted: 25 June 2020
DOI: 10.1111/fwb.13596

ORIGINAL ARTICLE

Freshwater Biology WILEY

The lentic and lotic characteristics of habitats determine the distribution of benthic macroinvertebrates in Mediterranean rivers

Andrea Buffagni[1,2]

Preferenze dei taxa non solo per una o due variabili legate al flusso i (e.g. velocità di flusso; turbolenza)

ma anche per condizioni di habitat legate all'idrologia locale e che prevedono l'interazione tra diversi fattori (e.g. velocità, substrato, presenza di detrito, presenza di macrofite)

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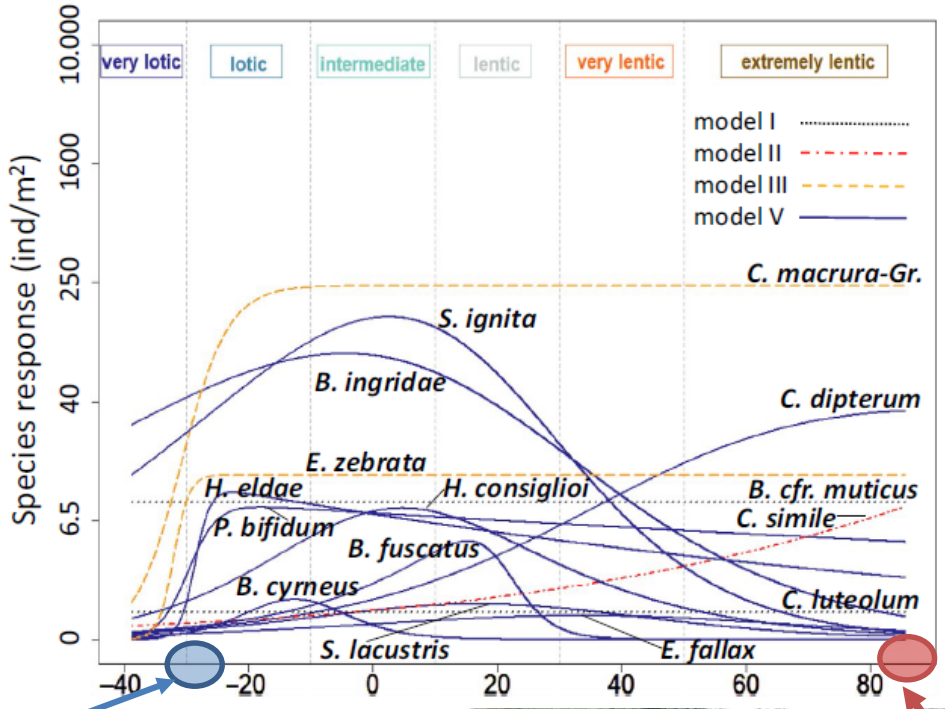
Gli invertebrati acquatici e le condizioni flusso

FIGURE 4 Response curves of Ephemeroptera species to the lentic–lotic gradient (lentic–lotic river descriptor, LRD) in Sardinian rivers. The *y*-axis displays the probability of occurrence on actual abundance range (logarithmic scale) observed in the samples for individual species, up to a maximum of *c*. 8,000 ind/m^2 (*Caenis macrura-Gr*). Species name is reported nearby the corresponding response curve. The LRD classes are indicated in the upper part of the chart (same colours as for ellipses in Figure 3) [Colour figure can be viewed at wileyonlinelibrary.com]



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Come tradurre queste informazioni in Deflusso ecologico

La risposta delle metriche biologiche alle variazioni di portata può non essere riconoscibile.

È sempre riconoscibile e quantificabile una riduzione nella disponibilità di habitat, che si può convertire in un fattore di correzione delle abbondanze di individui, soprattutto in assenza di variazioni della loticità degli habitat, e dei rapporti di abbondanza tra le specie.

Ci sono differenze tra habitat (riffle vs pool; comunità delle pool più sensibili alle variazioni di portata); differenze fra fiumi perenni e temporanei.

In generale però, le metriche biologiche in uso per la classificazione ai sensi della WFD si dimostrano sensibili alle condizioni di flusso osservate durante il campionamento.

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Ecological Indicators 117 (2020) 106563

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

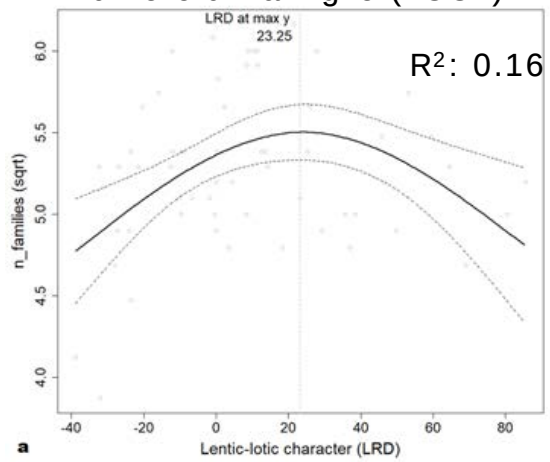
The ratio of lentic to lotic habitat features strongly affects macroinvertebrate metrics used in southern Europe for ecological status classification

Andrea Buffagni[a,b,*], Stefania Erba[a], Marcello Cazzola[a], Emanuele Barca[c], Carlo Belfiore[b]

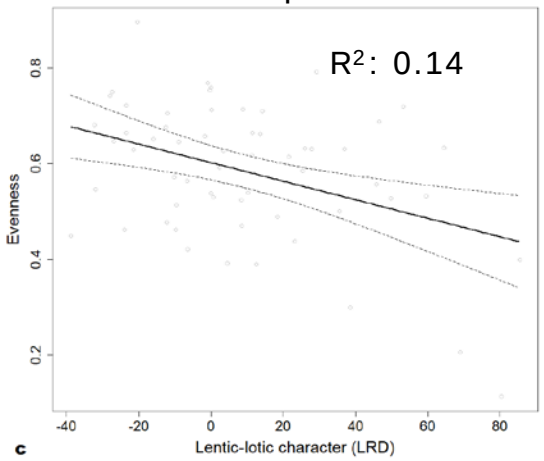
[a] Water Research Institute, National Research Council (CNR-IRSA), Brugherio MB, Italy
[b] Dipartimento di Scienze Ecologiche e Biologiche (DEB), Università della Tuscia, Viterbo, Italy
[c] Water Research Institute, National Research Council (CNR-IRSA), Bari, Italy

≈80% delle metriche testate (testate 19 metriche) e calcolate negli habitat di pool (inclusive di indici sintetici, metriche di abbondanza, etc.) hanno una associazione significativa con il gradiente lentico-lotico - LRD; **>70%** nei riffles

Numero di Famiglie (POOL)



Eveness – pool



La relazione è parabolica per la maggior parte delle metriche; **Lineare** per diversità (e poche altre metriche)

In taluni contesti può essere necessario sviluppare metriche dedicate:

- traits

Accepted: 29 August 2017
DOI: 10.1111/fwb.13030

SPECIAL ISSUE

WILEY Freshwater Biology

Flow velocity–ecology thresholds in Canadian rivers: A comparison of trait and taxonomy-based approaches

Wendy A. Monk[1,2] | Zacchaeus G. Compson[2] | David G. Armanini[3] | Jessica M. Orlofske[4] | Colin J. Curry[2] | Daniel L. Peters[5] | Jeffrey B. Crocker[6] | Donald J. Baird[2]

Global Change Biology (2007) **13,** 1658–1671, doi: 10.1111/j.1365-2486.2007.01375.x

Taxonomic and biological trait differences of stream macroinvertebrate communities between mediterranean and temperate regions: implications for future climatic scenarios

NÚRIA BONADA[1], SYLVAIN DOLÉDEC and BERNHARD STATZNER
CNRS-Ecologie des Hydrosystèmes Fluviaux, Université Lyon 1, F-69622 Villeurbanne Cedex, France

- e/o abbondanza di taxa selezionati (sulla base delle loro preferenze autoecologiche)

Metriche basate sulla presenza di taxa selezionati anche in funzione di preferenze ecologiche specifiche:

- 1-nOCH/nFAM (1- il rapporto tra numero di famiglie di Odonata, Coleoptera, Hemiptera e numero totale di famiglie),
- nEPT/nEPTOCH
- la metrica basata sull'abbondanza di taxa selezionati quale *AB*/BaSi ((*Acentrella*+*Baetis)* / (Baetidae+Siphlonuridae))

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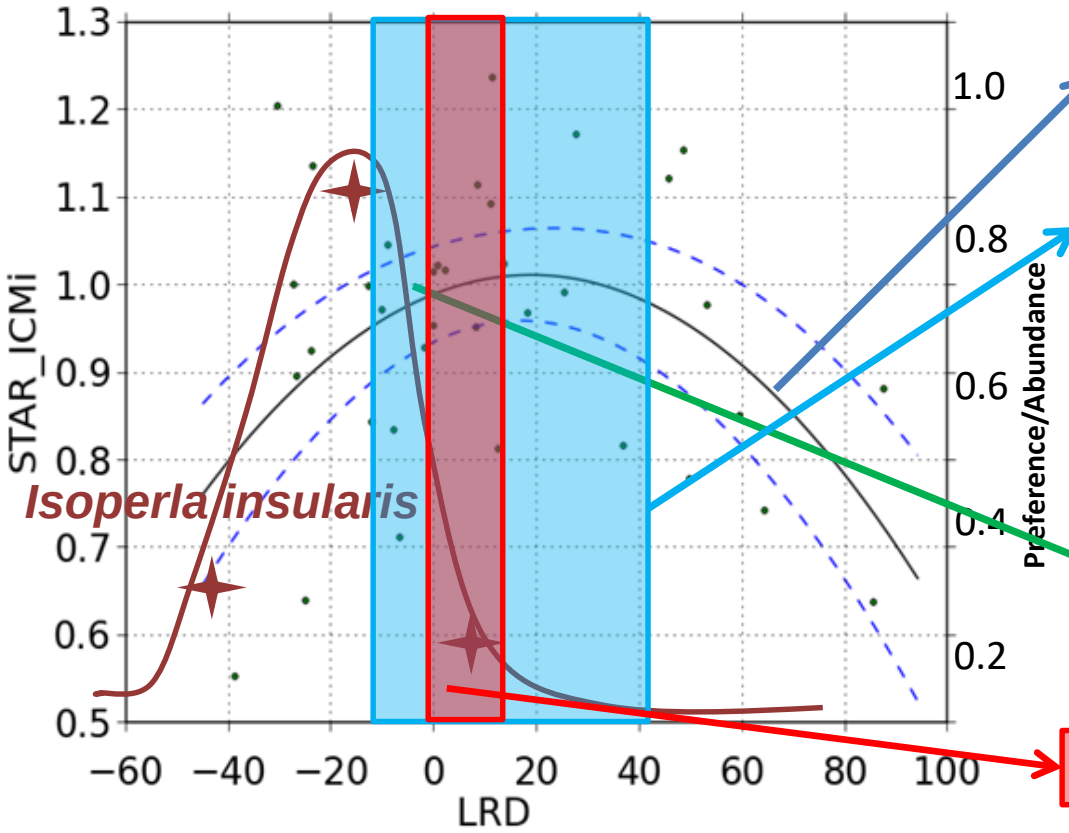
Tutela specie vs stato ecologico



STAR_ICMi → Stato ecologico

Optimal range for Ecological Status

e.g. minimum flow - LRD = f(Q) - in proper season at relevant sites/area

Both Directives implemented

Specie endemica

Valore critico per *I.insularis*

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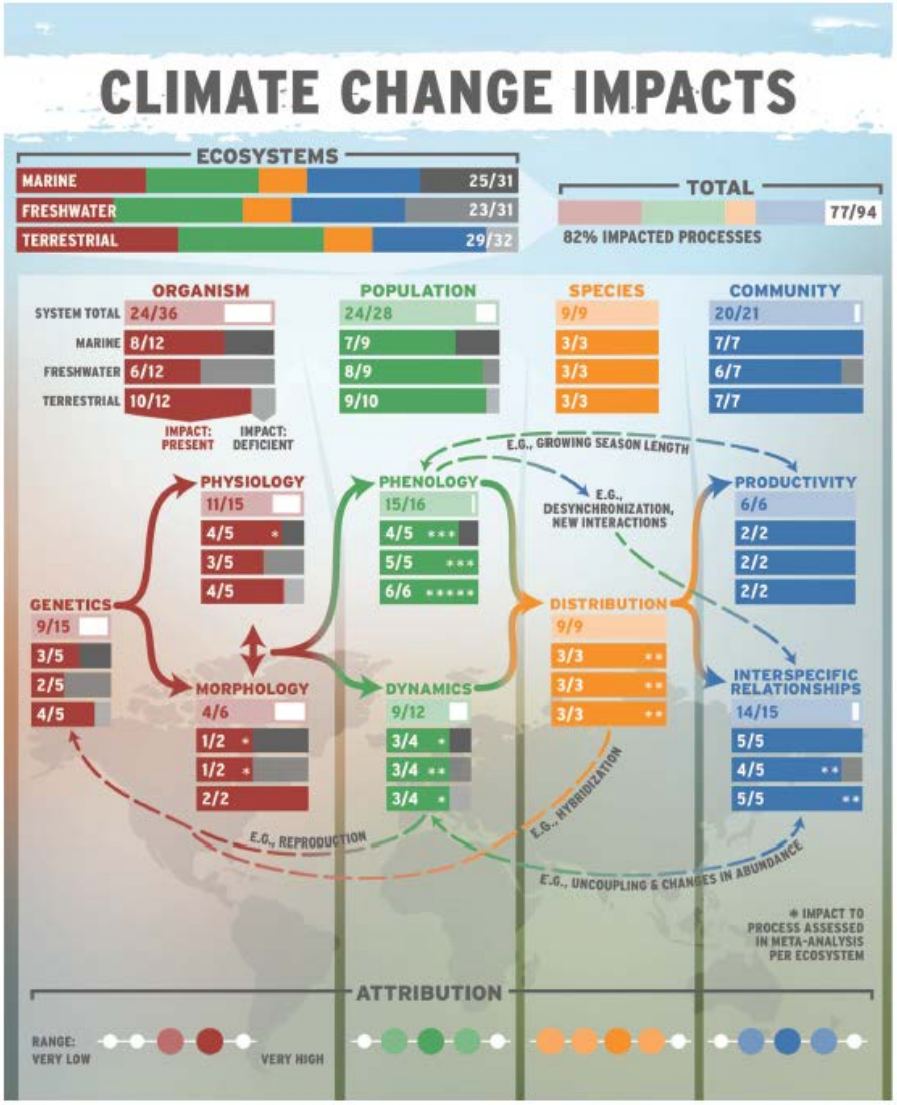

IMAGE CREDIT: STACEY JONES/MICHELE WOOD/PNAS

Fig. 1. Climate change impacts on Earth's marine, terrestrial, and freshwater systems. The presence of observed impacts on the different levels of biological organization and its inner components across the Earth's marine, terrestrial, and freshwater ecosystems. The denominator represents the total number of processes that we considered for each group, and the numerator is the number of these processes with evidence of impact (a complete list of processes is provided in fig. S1 and table S1). In total, 82% of all (n = 94) ecological processes that were considered have observed evidence of impact by climate change. Each process has at least one supporting case study. The asterisk indicates whether the affected process was assessed in a meta-analysis in addition to case studies. Thus, double-asterisk indicates that two processes were assessed in at least one meta-analysis. Confidence that the observed impact can be attributed to climate change was assigned for each level of organization and ranges from very low, low, medium, high, to very high; this assessment is based on tables 18-7, 18-8, and 18-11 in (*13*). The darkest circle indicates confidence level with the most literature support.

E-flow → problematica complessa e sfaccetata cui si sommano effetti del cambiamento climatico

82% of all (n = 94) ecological processes that were considered have observed evidence of impact by climate change

REVIEW

CLIMATE CHANGE

The broad footprint of climate change from genes to biomes to people

Brett R. Scheffers,[1]* Luc De Meester,[2] Tom C. L. Bridge,[3,4] Ary A. Hoffmann,[5] John M. Pandolfi,[6] Richard T. Corlett,[7] Stuart H. M. Butchart,[8,9] Paul Pearce-Kelly,[10] Kit M. Kovacs,[11] David Dudgeon,[12] Michela Pacifici,[13] Carlo Rondinini,[13] Wendy B. Foden,[14] Tara G. Martin,[15] Camilo Mora,[16] David Bickford,[17]† James E. M. Watson[18,19]

Climate change and the world's river basins: anticipating management options

Margaret A Palmer[1,2*], Catherine A Reidy Liermann[3], Christer Nilsson[3], Martina Flörke[4], Joseph Alcamo[4], P Sam Lake[5], and Nick Bond[5]

Major rivers worldwide have experienced dramatic changes in flow, reducing their natural ability to adjust to and absorb disturbances. Given expected changes in global climate and water needs, this may create serious problems, including loss of native biodiversity and risks to ecosystems and humans from increased flooding or water shortages. Here, we project river discharge under different climate and water withdrawal scenarios and combine this with data on the impact of dams on large river basins to create global maps illustrating potential changes in discharge and water stress for dam-impacted and free-flowing basins. The projections indicate that every populated basin in the world will experience changes in river discharge and many will experience water stress. The magnitude of these impacts is used to identify basins *likely* and *almost certain* to require proactive or reactive management intervention. Our analysis indicates that the area in need of management action to mitigate the impacts of climate change is much greater for basins impacted by dams than for basins with free-flowing rivers. Nearly one billion people live in areas likely to require action and approximately 365 million people live in basins *almost certain* to require action. Proactive management efforts will minimize risks to ecosystems and people and may be less costly than reactive efforts taken only once problems have arisen.

Front Ecol Environ 2008; 6(2): 81–89, doi:10.1890/060148

Alterazione regime idrologico → **Biodiversità** → modelli per identificare bacini più o meno sensibili a tali alterazioni

Global Change Biology

Global Change Biology (2013) **19**, 1085–1099, doi: 10.1111/gcb.12124

Global climate change in large European rivers: long-term effects on macroinvertebrate communities and potential local confounding factors

MATHIEU FLOURY*, PHILIPPE USSEGLIO-POLATERA†, MARTIAL FERREOL‡, CECILE DELATTRE* and YVES SOUCHON‡

*Laboratoire National Hydraulique et Environnement, EDF R&D, 6 Quai Watier, BP 49, Chatou 78401, France, †Laboratoire Interactions Ecotoxicité-Biodiversité-Ecosystèmes, CNRS UMR 7146, Université de Lorraine, Campus Bridoux, Rue du Général Delestraint, Metz 57070, France, ‡UR MALY, Milieux Aquatiques, Ecologie et Pollutions, Pôle hydroécologie Onema/Irstea, Irstea, 5 rue de la Doua, CS70077, Villeurbanne, Cedex 69626, France

Riscaldamento (+0.9 °C 1979–1988 e 1999–2008) → e **riduzione** di **portata**

Sparizione o **diminuzione** di taxa tipici di acque fredde e correnti (nel caso dei grandi fiumi e.g. Chloroperlidae e Potamanthidae).

Comparsa o aumento di taxa tipici di acque debolmente correnti e ferme, e caratteristiche di temperature più alte (a volte **specie invasive**, e.g. *Corbicula sp.* and *Atyaephyra desmarestii*).

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Journal of Hydrology: Regional Studies 41 (2022) 101061

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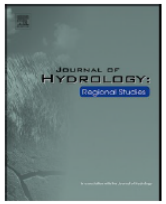
journal homepage: www.elsevier.com/locate/ejrh



Impact of long-term climate change on flow regime in a Mediterranean basin

A.M. De Girolamo [a,*], E. Barca [a], M. Leone [a,b], A. Lo Porto [a]

[a] Water Research Institute, National Research Council, 5 Viale F. De Blasio, Bari 70132, Italy
[b] Department of Agricultural and Environmental sciences, University of Bari Aldo Moro, Bari, Italy

Modelli idroclimatici regionali relativi al Sud Europa prevedono una riduzione fino a circa il 40% di portata media annua e una simultanea riduzione dei valori di portata massima annuale, congiuntamente ad un aumento della durata dei periodi di asciutta.

Combinare le informazioni di tipo idro-climatico, che includano elementi relativi alle condizioni locali di scarsità e assenza di flusso, a quelle relative alla comunità di invertebrati.

Grazie per l’attenzione

IRSA CNR

2 marzo 2023