



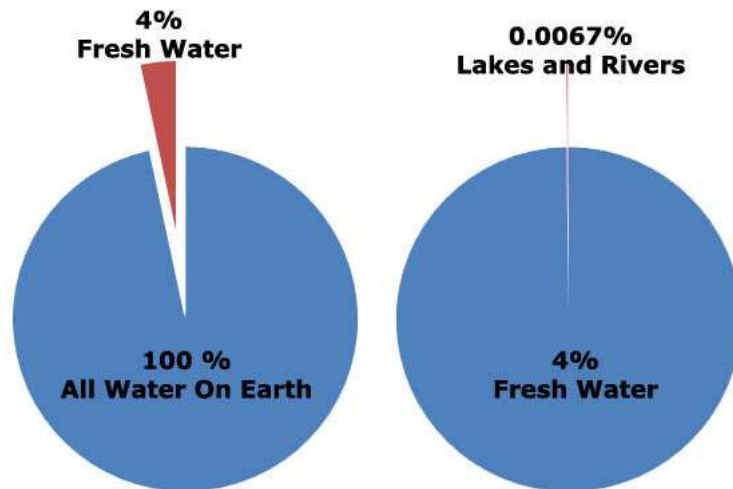
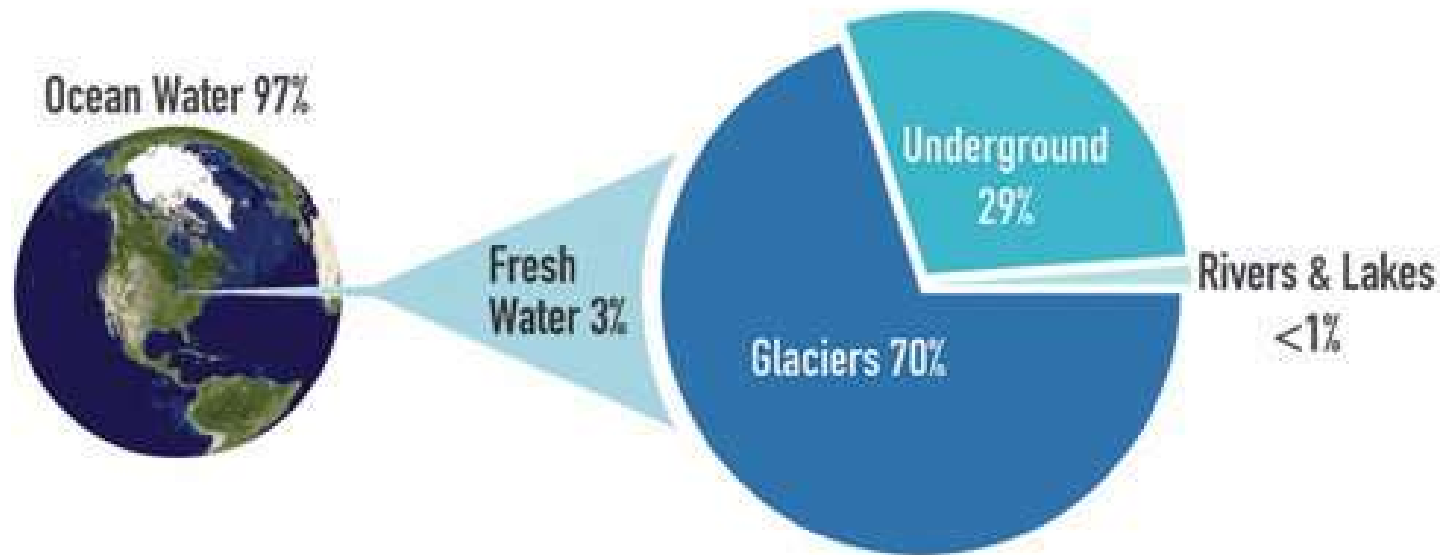
Lo stato della fauna ittica in Italia

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Water on Earth

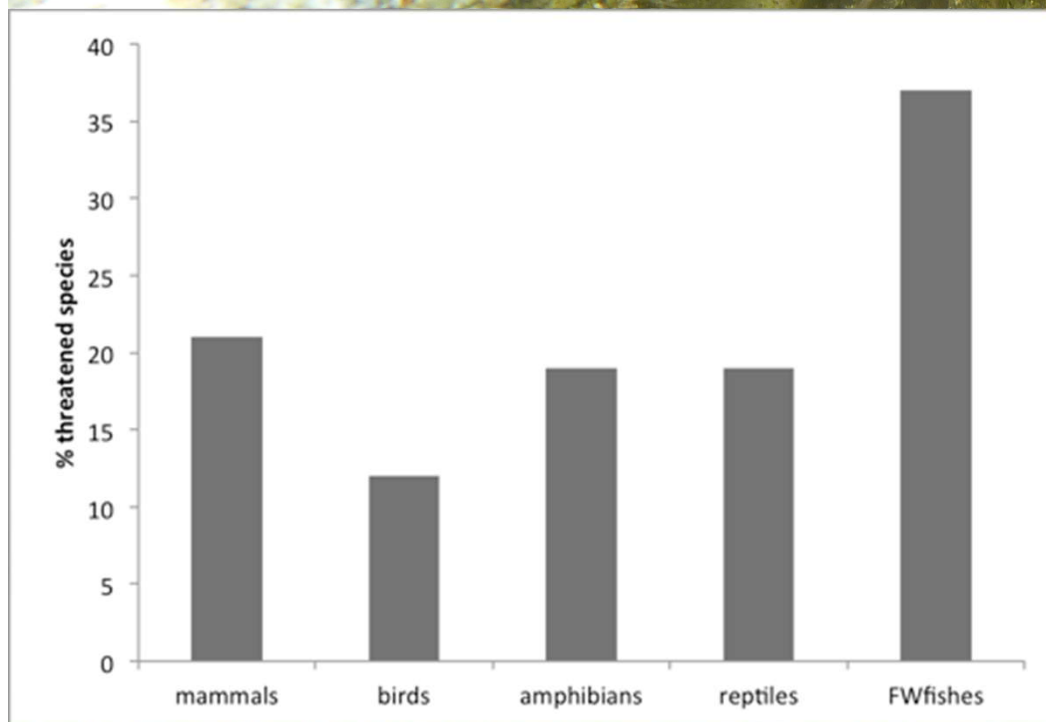


Modern Survival Blog
data source: USGS

Le acque dolci, nel loro insieme ovvero ghiacciai, falde sotterranee, laghi e fiumi, rappresentano meno del 1% dell'idrosfera,

Laghi e fiumi, che rappresentano meno del 0,01 % ospitano oltre al 10 % delle specie conosciute (Balian et al., 2008)

I pesci delle acque interne sono riconosciuti come il gruppo di animali maggiormente a rischio di estinzione di tutto il pianeta (IUCN, 2011)
Oltre il 37 % delle specie conosciute è a rischio



LIVING PLANET REPORT 2016

BIODIVERSITY

The Living Planet Index, which measures biodiversity abundance levels based on 14,152 monitored populations of 3,706 vertebrate species, shows a persistent downward trend.



ANTHROPOCENE

Scientists propose that, as a result of human activity, we have transitioned from the Holocene into a new geological epoch: the "Anthropocene".

RISKS

Our use of natural resources has grown dramatically, particularly since the mid-20th century, so that we are endangering the key environmental systems that we rely upon.

RESILIENCE

The 21st century presents humanity with a dual challenge to maintain nature in all of its many forms and functions and to create an equitable home for people on a finite planet.

100%
RECYCLED



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REPORT

INT

2016

THIS REPORT
HAS BEEN
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ZSL
LET'S WORK
FOR WILDLIFE

Global Footprint Network
Measuring the Impact of Humanity

Living Planet Report 2016

Risk and resilience in a new era



Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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CHAPTER 1: STATE OF THE NATURAL PLANET

MONITORING GLOBAL BIODIVERSITY

Biodiversity encompasses the genetic variation within species, the variety and population abundance of species in an ecosystem, and the habitats across a landscape. Monitoring of all these different aspects is imperative as it provides insight into trends in biodiversity and ecosystem health to make informed decisions on resource use and protection. Because biodiversity is so multifaceted, a variety of metrics are necessary; the use of any one in particular would depend upon the biodiversity component of interest and the ultimate use of the information. Contemporary examples of indices now in use include the Living Planet Index (LPI), the IUCN Red List of Threatened Species, and indicators that show us the state of specific habitats – such as forests – or the state of natural capital (Tittensor et al., 2014).

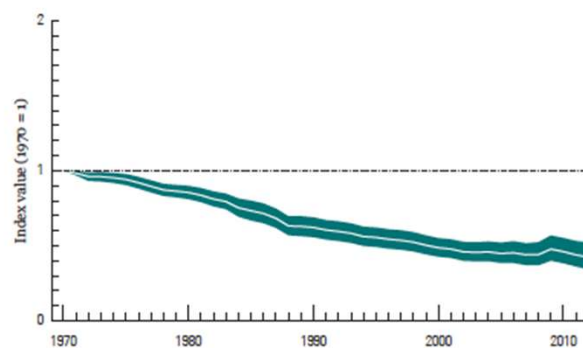
The Global Living Planet Index

The LPI measures biodiversity by gathering population data of various vertebrate species and calculating an average change in abundance over time. The LPI can be compared to the stock market index, except that, instead of monitoring the global economy, the LPI is an important indicator of the planet's ecological condition (Collen et al., 2009). The global LPI is based on scientific data from 14,152 monitored populations of 3,706 vertebrate species (mammals, birds, fishes, amphibians, reptiles) from around the world.

From 1970 to 2012 the LPI shows a 58 per cent overall decline in vertebrate population abundance (Figure 2). Population sizes of vertebrate species have, on average, dropped by more than half in little more than 40 years. The data shows an average annual decline of 2 per cent and there is no sign yet that this rate will decrease. The *Living Planet Report 2014* reported a 52 per cent decline from 1970 to 2010; although the marine and terrestrial datasets have been augmented with new data, it is the stronger decline in freshwater species that has had more influence on the global decline in this report.

FROM 1970 TO 2012
THE LPI SHOWS
A 58 PER CENT
OVERALL DECLINE
IN VERTEBRATE
POPULATION
ABUNDANCE

Figure 2: The Global Living Planet Index shows a decline of 58 per cent (range: -48 to -66 per cent) between 1970 and 2012. Trend in population abundance for 14,152 populations of 3,706 species monitored across the globe between 1970 and 2012. The white line shows the index values and the shaded areas represent the 95 per cent confidence limits surrounding the trend (WWF/ZSL, 2016).



Key

Global Living Planet Index
Confidence limits

OVER 3,000 DATA
SOURCES ARE
COMPILED WITHIN THE
LPI DATABASE

Monitoring species

Over 3,000 data sources are compiled within the LPI database. One requirement for including a data source is that the population in question has been consistently monitored using the same method over the entire length of the study time period. Some sources are long-term monitoring studies such as the breeding bird surveys in Europe (EBCC/RSPB/BirdLife/Statistics Netherlands, 2016) and North America (Sauer et al., 2014). Others are short-term projects that addressed a particular research question. The majority of these sources are derived from articles found in peer-reviewed scientific journals.

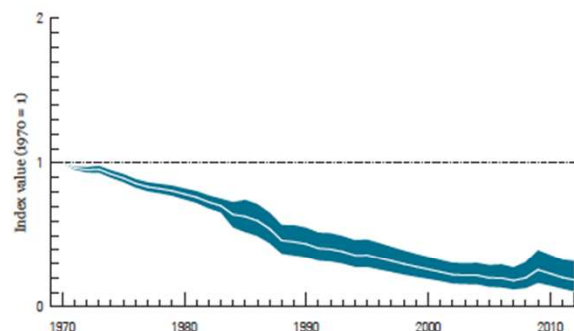
Combined into one dataset, the species census data provides an important tool for monitoring the state of nature. However, the distribution of locations represented by the data is uneven, lacking ideal coverage for all species groups and regions (Figure 3). By targeting data searches toward identified gaps in the dataset, researchers are trying to solve this problem. The LPI database is continually evolving and for each *Living Planet Report* a larger dataset is available to use for the analysis. As such, the percentages reported for LPIs often change from year to year as the dataset increases (see page 40-41 for more details). The new percentages stay within the same range (as measured by the confidence intervals) as previous results so there are similar overall trends even if the final percentage value is often different.

Freshwater Living Planet index

Freshwater habitats – such as lakes, rivers and wetlands – carry immense importance for life on Earth. Freshwater accounts for only 0.01 per cent of the world's water and covers approximately 0.8 per cent of the Earth's surface (Dudgeon et al., 2006) but provides a habitat for almost 10 per cent of the world's known species (Balian et al., 2008). Because humans and almost every living being require water, these habitats command high economic, cultural, aesthetic, recreational and educational value.

Freshwater habitats are challenging to conserve as they are strongly affected by the modification of their river basins as well as by direct impacts from dams, pollution, invasive aquatic species and unsustainable water extractions. Further, they often cross administrative and political boundaries so they require extra effort for collaborative forms of protection. Several studies have found that species living in freshwater habitats are faring worse than terrestrial species (Collen, et al., 2014; Cumberlidge et al., 2009).

The freshwater LPI substantiates this finding, showing that on average the abundance of populations monitored in the freshwater system has declined overall by 81 per cent between 1970 and 2012 (Figure 12), with an average annual decline of 3.9 per cent. These figures are based on data for 3,324 monitored populations of 881 freshwater species.



FRESHWATER HABITATS ARE CHALLENGING TO CONSERVE AS THEY ARE STRONGLY AFFECTED BY THE MODIFICATION OF THEIR RIVER BASINS AS WELL AS BY DIRECT IMPACTS FROM DAMS, POLLUTION, INVASIVE AQUATIC SPECIES AND UNSUSTAINABLE WATER EXTRACTIONS

Figure 12: The freshwater LPI shows a decline of 81 per cent (range: -68 to -89 per cent) between 1970 and 2012
Trend in population abundance for 3,324 populations of 881 freshwater species monitored across the globe between 1970 and 2012 (WWF/ZSL, 2016).

Key
Freshwater Living Planet Index
Confidence limits

THE MOST COMMON THREAT TO DECLINING FRESHWATER POPULATIONS IS HABITAT LOSS AND DEGRADATION

Figure 13: Threat type frequency for 449 declining freshwater populations in the LPI database showing 781 recorded threats
Each population has up to three threats recorded, so the total number of recorded threats exceeds the number of populations (WWF/ZSL, 2016).

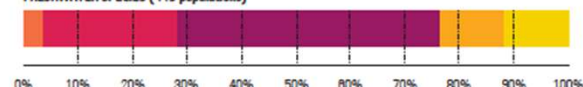
Key

Climate change
Overexploitation
Habitat loss / degradation
Invasive species and disease
Pollution

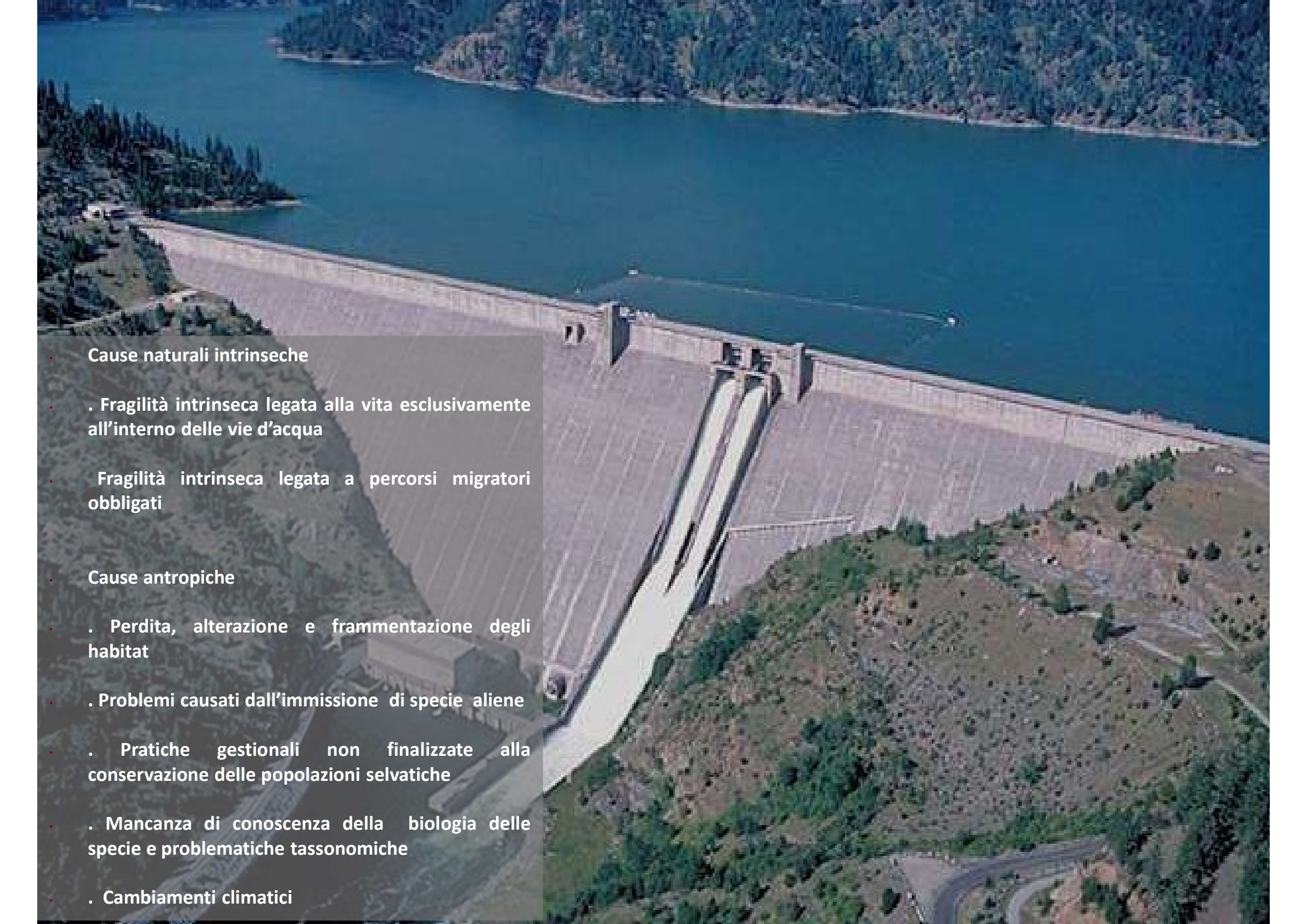


The LPI database contains threat information for 31 per cent of its declining freshwater populations (n=449). Based on this information, the most common threat to declining populations is habitat loss and degradation. This is mentioned in 48 per cent of threatened species cases (Figure 13). Freshwater habitat loss because of humans can occur through direct intervention, for example through excavation of river sand or interruption of a river's flow. But habitat loss and degradation can also occur through indirect effects. For example, deforestation can increase river sediment load, leading to more erosion of the river's bank (Dudgeon et al., 2006) with subsequent changes in the water quality and flow. Direct overexploitation – through unsustainable fishing or collection for subsistence or commercial purposes – is the second most frequent threat to freshwater populations (24 per cent), followed by invasive species and disease (12 per cent), pollution (12 per cent) and climate change (4 per cent).

FRESHWATER SPECIES (449 populations)



The frequency with which different threats are mentioned in the database varies according to taxonomic group (Figure 14). For amphibians, invasive species and disease represents the second most prevalent threat after habitat loss. It is cited as a threat in 25 per cent of cases, potentially reflecting the impact of *Batrachochytrium dendrobatidis*, a species of fungus responsible for chytridiomycosis, a disease of amphibians. This pathogen is implicated in the steep decline or extinction of more than 200 species of amphibians (Wake and Vredenburg, 2008) and threatens many more (Rödder et al., 2009). Furthermore, the rapid global spread of the disease has been linked to climate change (Pounds et al., 2006). The amphibian trade is likely to have contributed to the original spread of the pathogen (Weldon et al., 2004) and can still facilitate introduction into new regions (Schloegel et al., 2009).



• Cause naturali intrinseche

- . Fragilità intrinseca legata alla vita esclusivamente all'interno delle vie d'acqua

- . Fragilità intrinseca legata a percorsi migratori obbligati

• Cause antropiche

- . Perdita, alterazione e frammentazione degli habitat

- . Problemi causati dall'immissione di specie aliene

- . Pratiche gestionali non finalizzate alla conservazione delle popolazioni selvatiche

- . Mancanza di conoscenza della biologia delle specie e problematiche tassonomiche

- . Cambiamenti climatici



Nei vertebrati terrestri, anche in quelli con riproduzione e sviluppo acquatico (anfibi), la dispersione avviene sulla terra o attraverso vie aeree (uccelli e chiropteri)

Questo meccanismo permette agli individui in dispersione di superare le barriere geografiche, con tempi molto diversi a seconda dei gruppi zoologici, colonizzare nuovi territori e scambiare i geni con popolazioni diverse da quella di origine.

Questo permette di colonizzare nel tempo tutte le aree idonee per la specie, a 360 ° a partire dal punto in cui gli individui iniziano una nuova fase di dispersione



Dispersione dei giovanili in tritone crestato italiano
Triturus cristatus

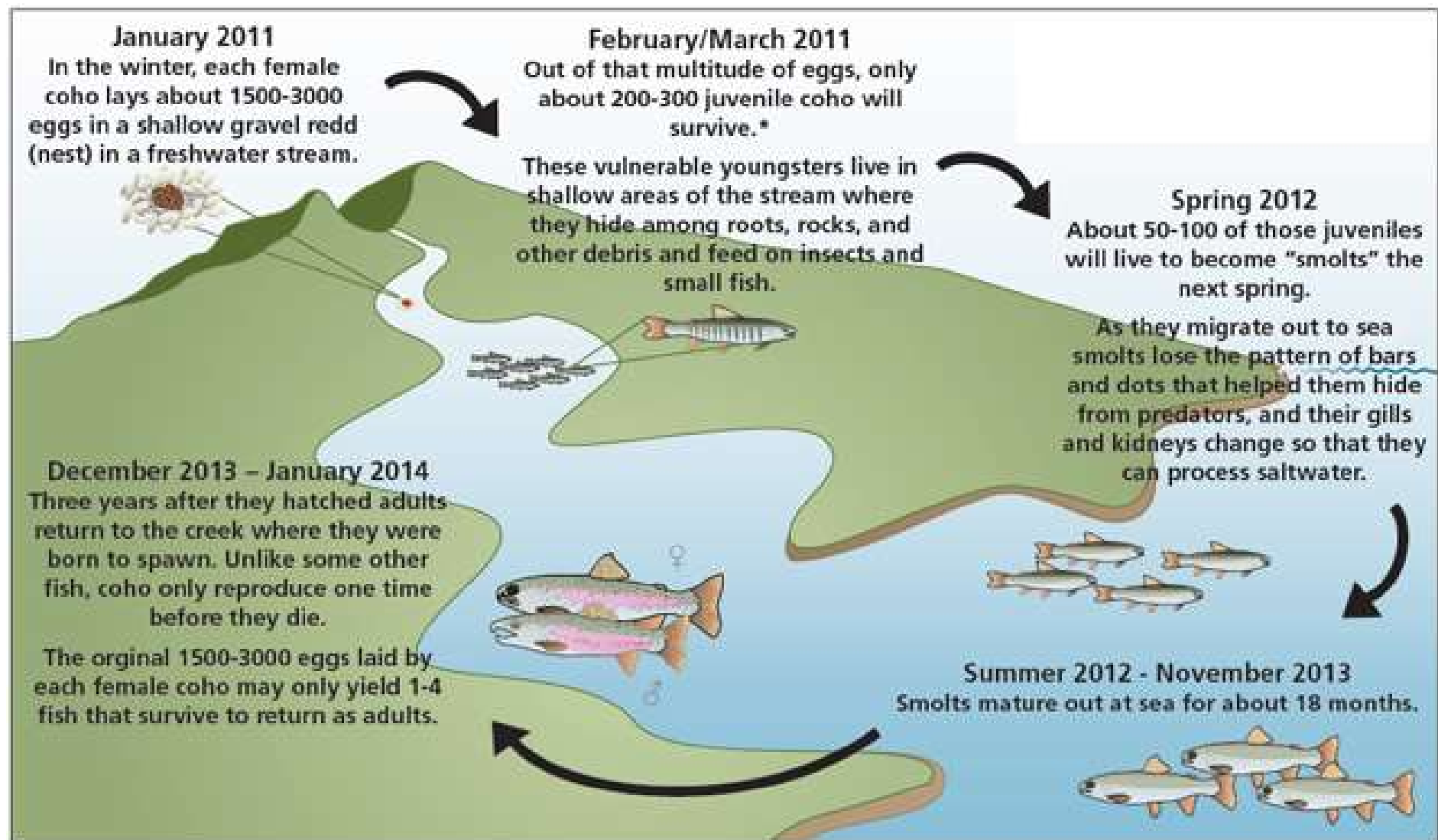


Nei pesci la dispersione avviene esclusivamente all'interno del reticolo idrografico in cui vive la popolazione.

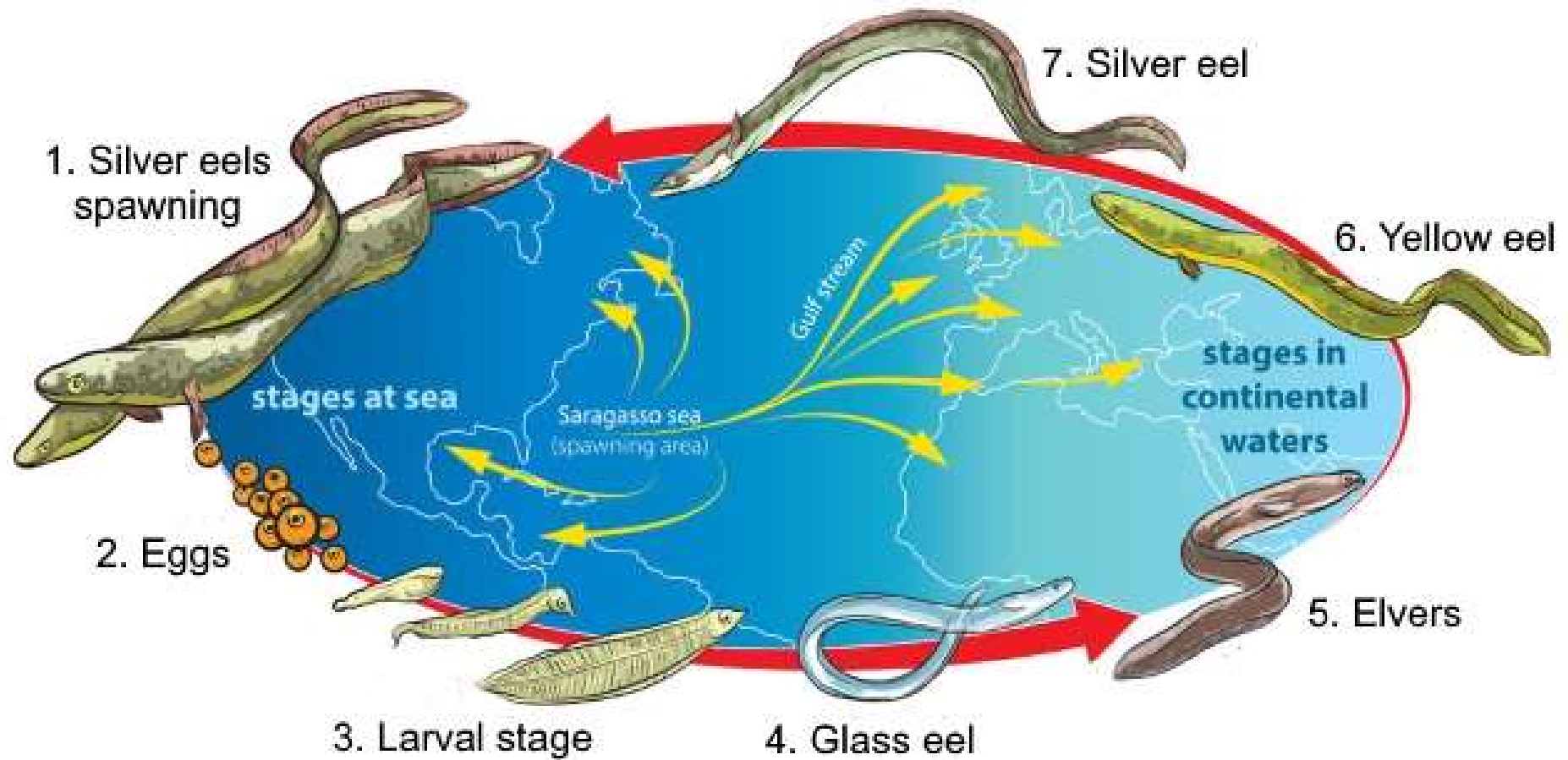
Alcune specie (note come potamodrome e/o ad alta vagilità) si spostano all'interno del bacino idrografico (es. salmonidi, ciprinidi reofili, luccio etc) per esigenze riproduttive e trofiche

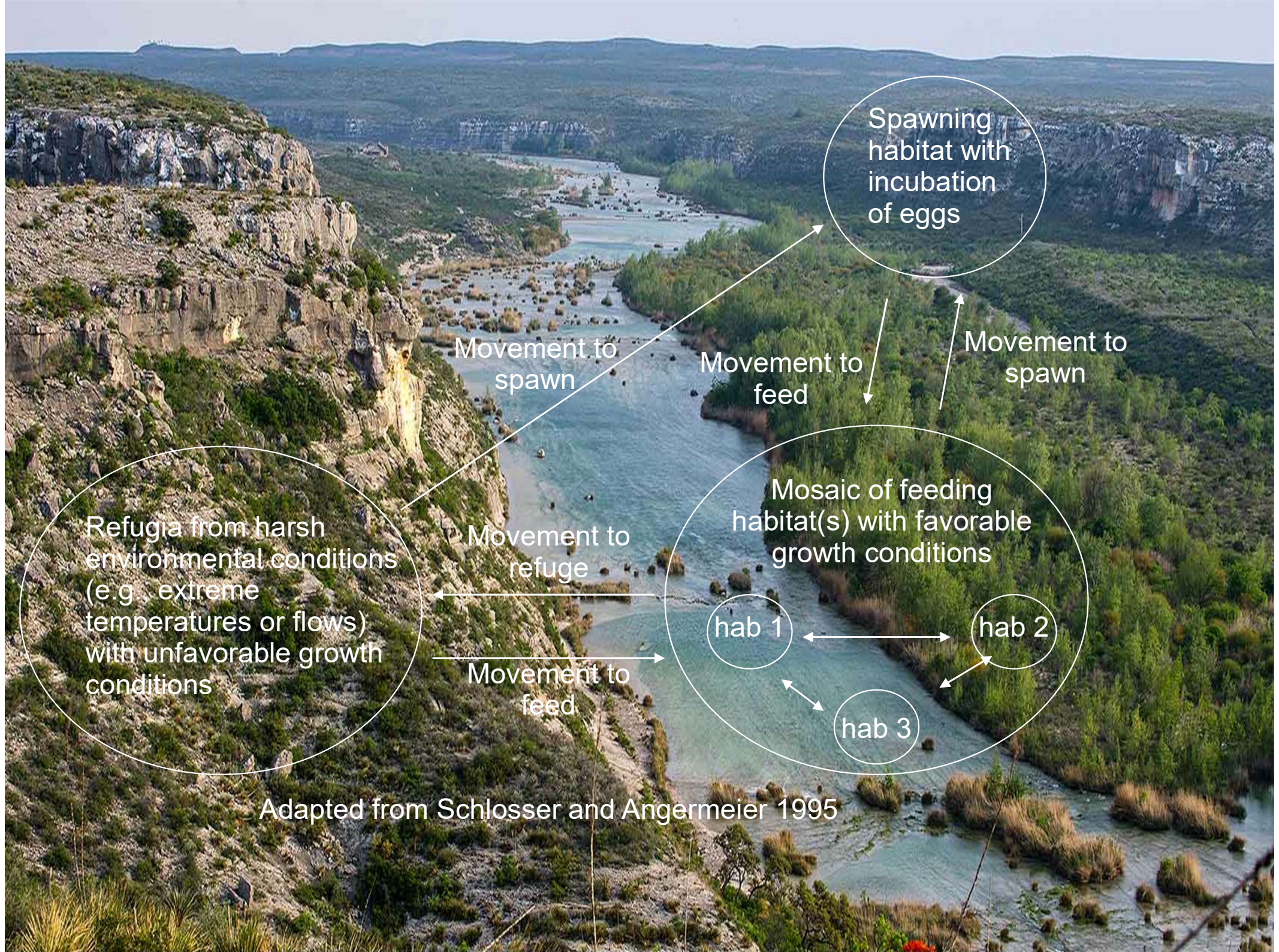
Altre specie sono sedentarie e tendono a non compiere spostamenti importanti nel corso della loro vita (specie non vagili o sedentarie) (es. ghiozzi, cobiti, scazzone, cagnetta etc). In questo caso gli scambi genetici tra le popolazioni viventi nello stesso bacino idrografico avvengono su tempi molto lunghi, soprattutto quello da valle verso monte.

Migratori anadromi: vita in mare – riproduzione in acqua dolce



Migratori catadromi: vita in acque dolci – riproduzione in mare





Spawning
habitat with
incubation
of eggs

Movement to
spawn

Movement to
feed

Movement to
spawn

Refugia from harsh
environmental conditions
(e.g., extreme
temperatures or flows)
with unfavorable growth
conditions

Movement to
refuge

Movement to
feed

Mosaic of feeding
habitat(s) with favorable
growth conditions

hab 1

hab 2

hab 3

Adapted from Schlosser and Angermeier 1995



Le alluvioni sono molto importanti per gli scambi genetici da monte verso valle

I bacini idrografici sono separati tra loro da diverse migliaia di anni, alcuni anche da più di 1 mya. Per questo motivo ogni bacino ha comunità ittiche esclusive (eccetto le specie migratrici)



• La situazione Italiana

- In Italia sono attualmente riconosciute 101 diverse specie, di cui il 50% alloctone (Bianco, 2013)
- La fauna ittica italiana è ricchissima di specie endemiche in gran parte differenziate per isolamento geografico durante le dinamiche glaciali pleistoceniche.
- Sono riconosciuti in Italia almeno tre diversi distretti ittio-geografici (Bianco 2013) caratterizzati da particolari specie endemiche: Padano – Veneto; Tosco –Laziale e Apulo –Campano

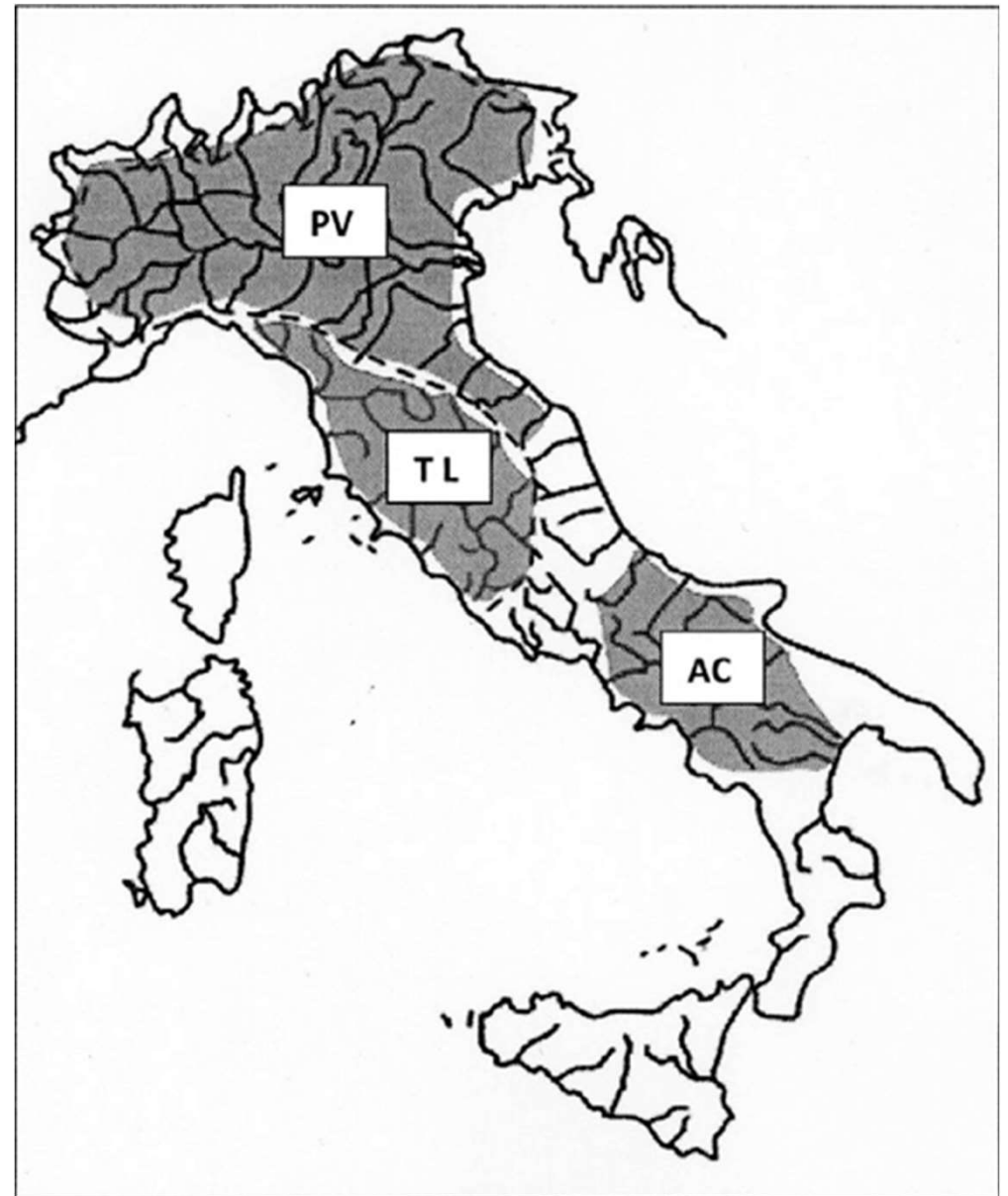


Fig. 3. Approximate delimitation of Italian ichthyogeographic districts: PV: Padany-Venetian; TA; Tuscany-Latium; AC; Apulia-Campania



Il distretto Padano - Veneto comprende l'intera Italia Settentrionale, la gran parte delle Marche, il versante adriatico della Slovenia e la maggior parte di quello adriatico della Croazia; quest'area corrisponde al bacino del Fiume Po durante l'ultimo periodo glaciale pleistocenico



Specie endemiche della Regione Padana (Distretto PV)

Lampreda padana *Lampetra zanandreae*



Savetta *Chondrostoma soetta*



Panzarolo *Knipowitschia punctatissima*



Cobite mascherato
Sabanejewia larvata



Triotto
Rutilus herythrophthalmus



Ghiozzo padano *Padogobius martensi*



Carpione del Garda
Salmo carpio



Ghiozzetto cenerino
Pomatoschistus canestrini



Specie subendemiche della Regione Padana (Distretto PV)

Sono taxa che hanno avuto origine evolutiva in questa regione ed hanno poi esteso il loro areale in distretti ittiogeografici vicini.



Storione cobice *Acipenser naccarii*



Trota marmorata *Salmo (trutta) marmoratus*



Lasca *Chondrostoma genei*



Alborella *Alburnus a. alborella*



Cobite *Cobitis taenia*



Barbo canino *Barbus meridionalis*



Barbo italiano *Barbus plebejus*



Vairone *Leuciscus souffia muticellus*
Knipowitschia panizzae



Ghiozzetto di laguna

Specie endemiche della Regione Italico-peninsulare (Distretto TL)



Barbo tiberino *Barbus tyberinus*.



Alborella meridionale *Alburnus albidus*



Rovella *Rutilus rubilo*



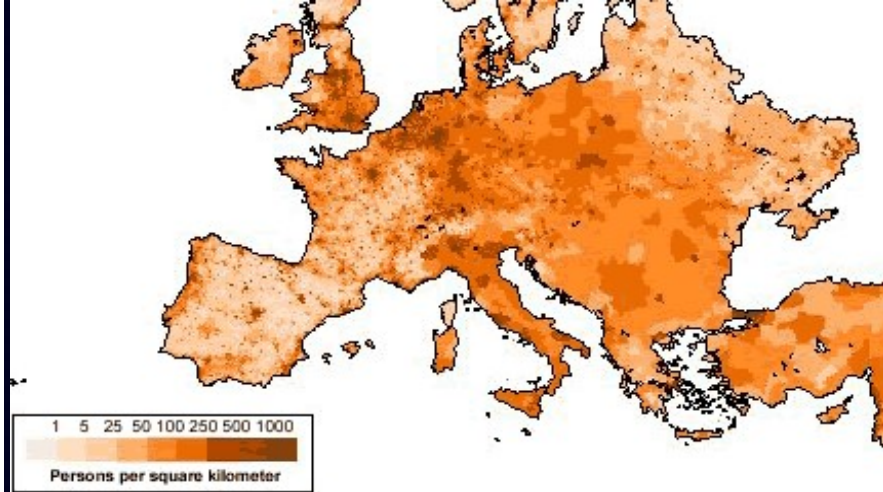
Cavedano do ruscello *Squalius lucumonis*



Carpione del Fibreno *Salmo fibreni*

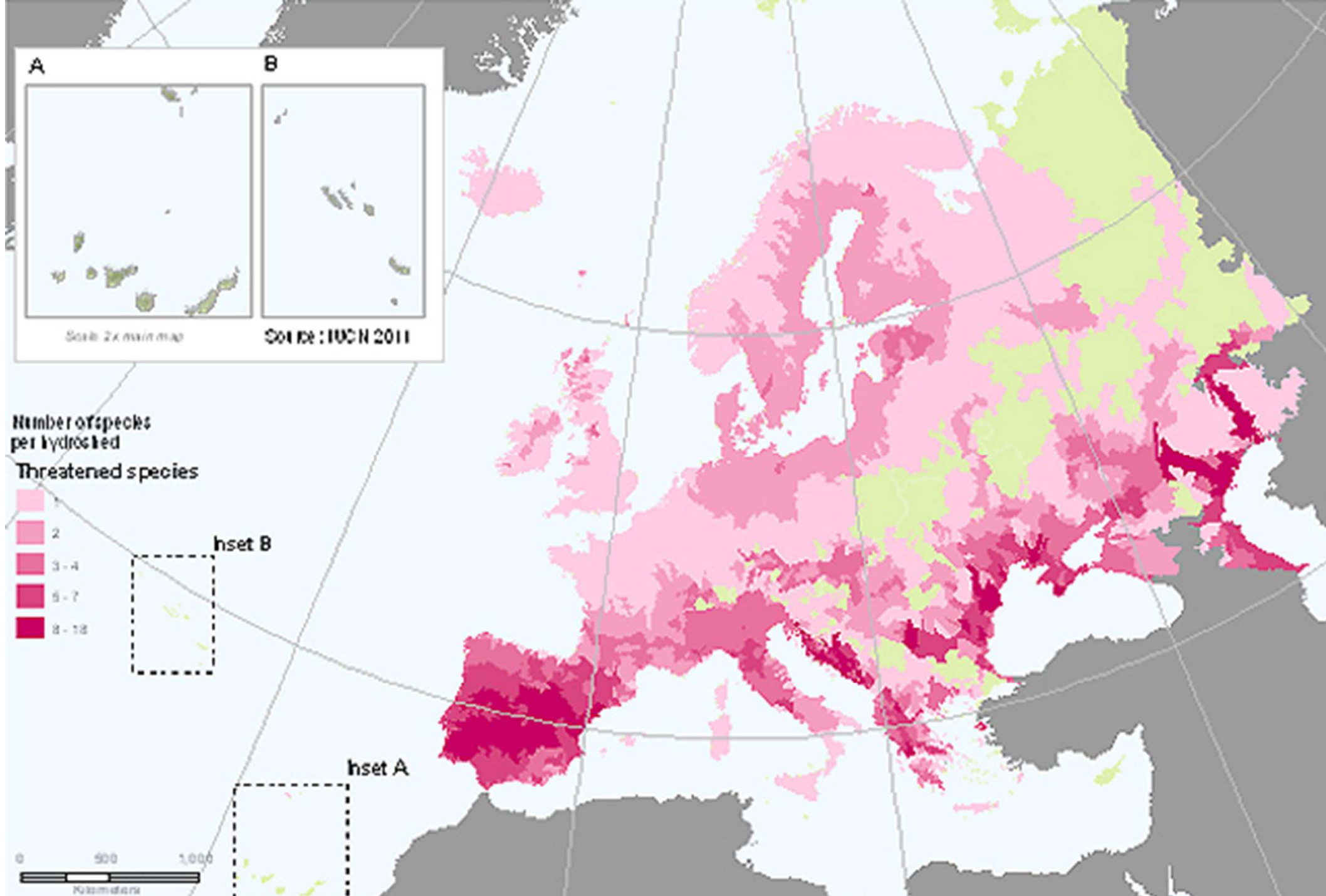


Ghiozzo di ruscello *Gobius nigricans*



Il distretto PV e il TL sono fortemente antropizzati e, di conseguenza, sono molto elevate anche le pressioni sulla fauna ittica





In Italia presenti oltre 18 specie endemiche e corrisponde a una delle aree di maggiore importanza ittiogeografica dell'intero Paleartico

La fauna ittica italiana è gravemente minacciata dalle attività umane che modificano gli habitat

- Banalizzazione del corso d'acqua che causa aumento della corrente, riduzione di *facies* diversificate e aree di rifugio. Riduzione dell'ombreggiatura. **Vengono meno le aree idonee alla frega e all'accrescimento**



Prelievi d' acqua per uso irriguo e/o domestico





Interruzione della connettività longitudinale



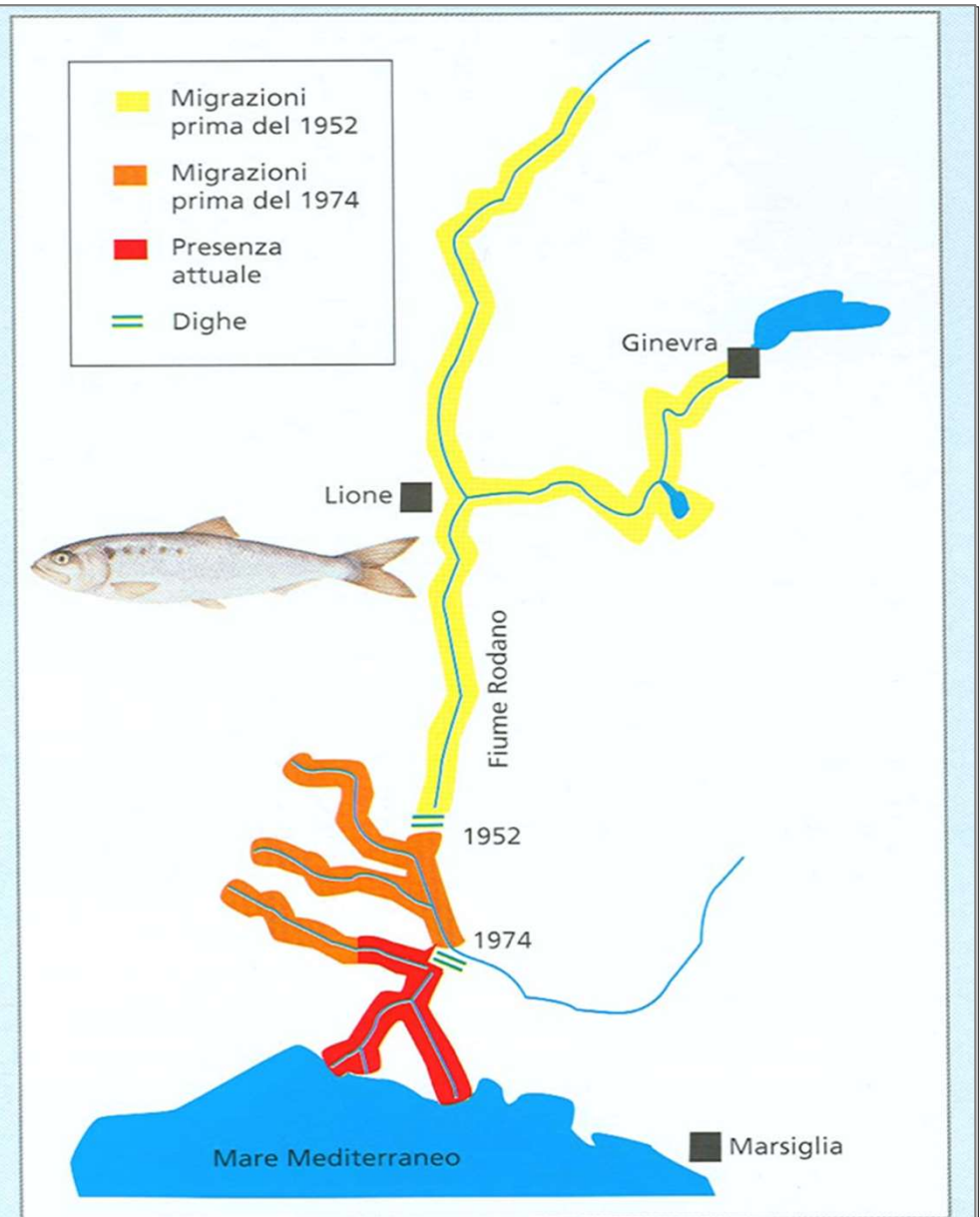


Fig. 3.12 - Progressiva scomparsa di *Alosa fallax rhodanensis* nel sistema idrografico del fiume Rodano (Francia sud-orientale), in seguito alla costruzione di dighe (da Maitland e Crivelli, 1996, ridisegnato).

Introduzione specie alloctone



Perche (Perca fluviatilis)
© Biopix.dk: JC Schou



La carpa (*Cyprinus carpio*) assieme al pesce persico reale (*Perca fluviatilis*) furono introdotti in epoca romana. La trota fario fu introdotta a partire dal Medio Evo.



I mostri venuti dall' Est

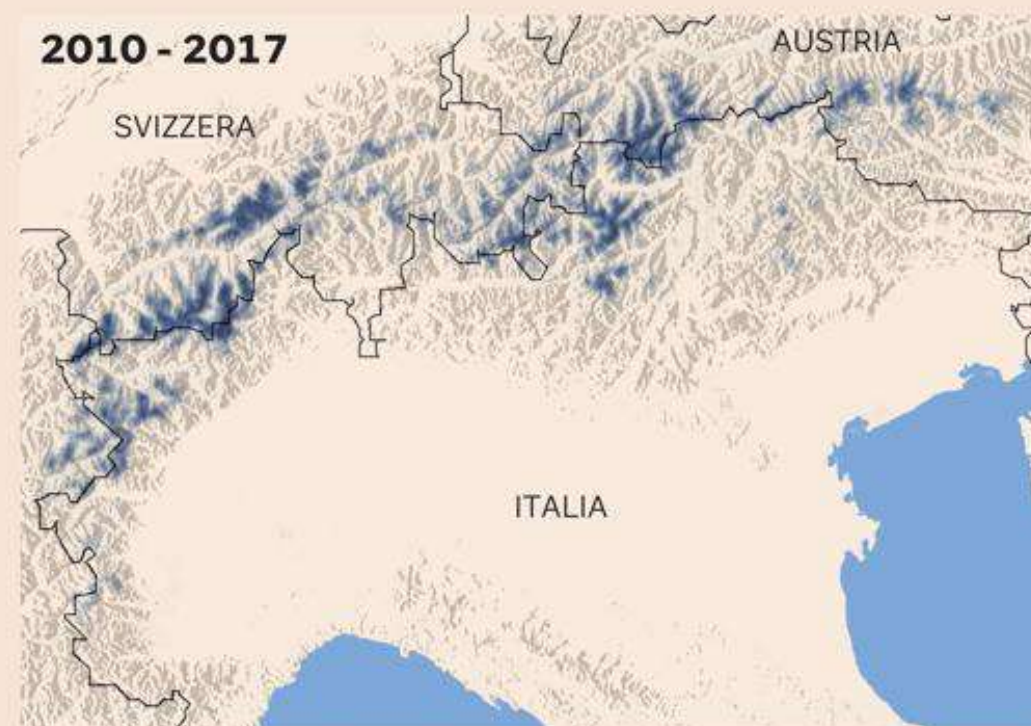
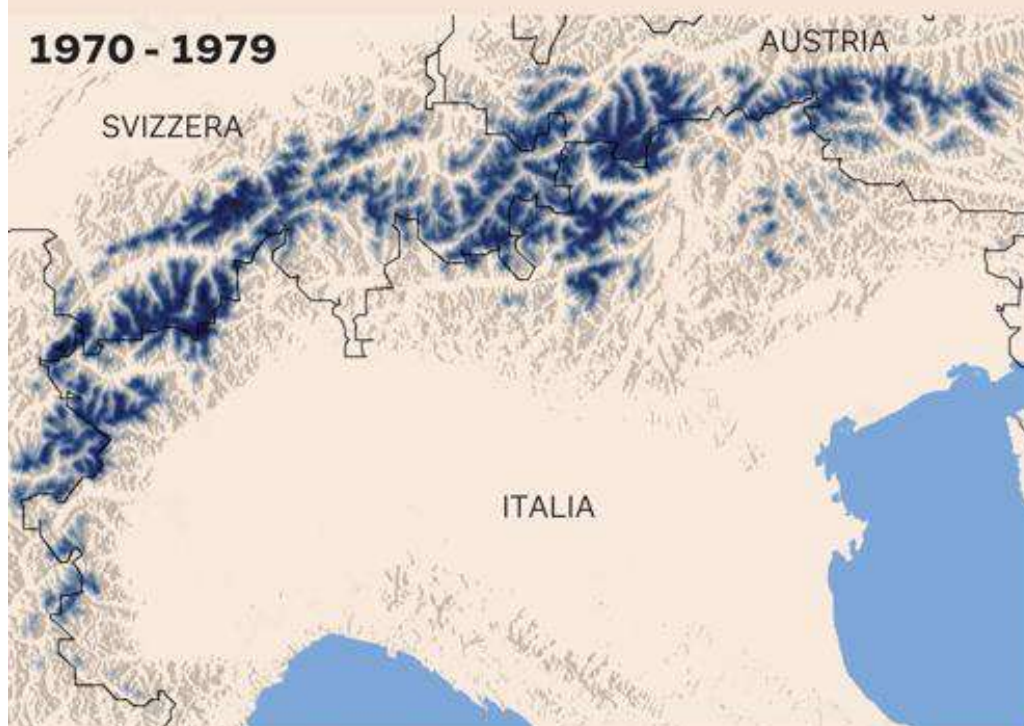
Tra le specie alloctone più pericolose per gli ecosistemi acquatici piemontesi, c'è il Siluro *Silurus glanis*.

Si tratta di un predatore formidabile e privo di nemici naturali

Cambiamenti climatici

ARCO ALPINO SEMPRE PIÙ CALDO

La mappa delle temperature medie inferiori a zero ° C tra il 1970 e il 1979 a confronto con quelle registrate tra il 2010 e il 2018 - Fonte: Isac-Cnr



In calo i giorni con temperatura minima inferiore a 0° C nelle località sopra i mille metri di altitudine (media registrata nelle località > 1000 m di altitudine)

Variazione annua

-0,2%

Variazione sul periodo 1971-2018

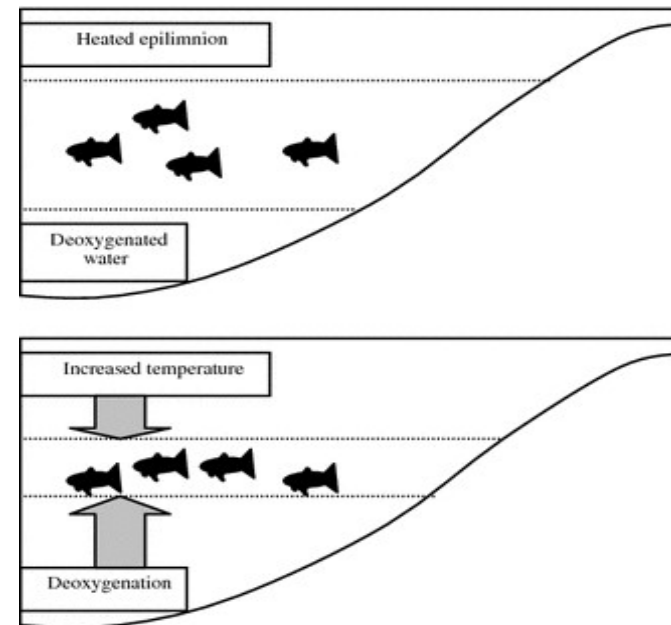
-10,1%

Numero di giorni sul periodo 1971-2018

-36,7

Sui pesci moltissima preoccupazione:

- Contrazione habitat per specie frigofile (alpine)
- Riduzione livello di ossigeno



- Tendenza delle popolazioni a risalire il verso ambienti ancora freddi ma limitati e subottimali

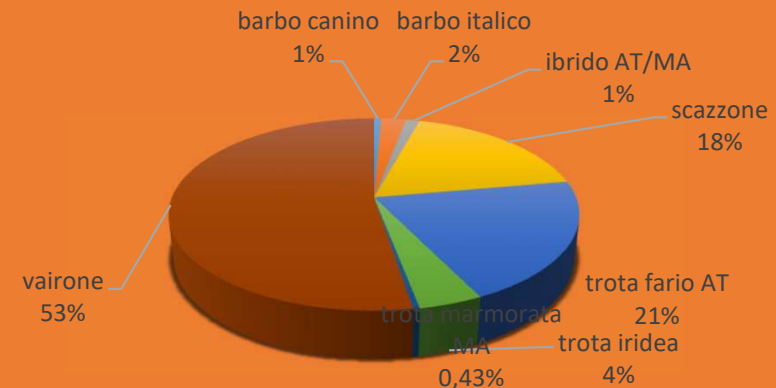
- Incremento di habitat per specie più termofile o più plastiche (specie alloctone e specie autoctone di altro contesto ambientale, es planiziale) che vengono a sottrarre risorse ambientali alle specie alpine



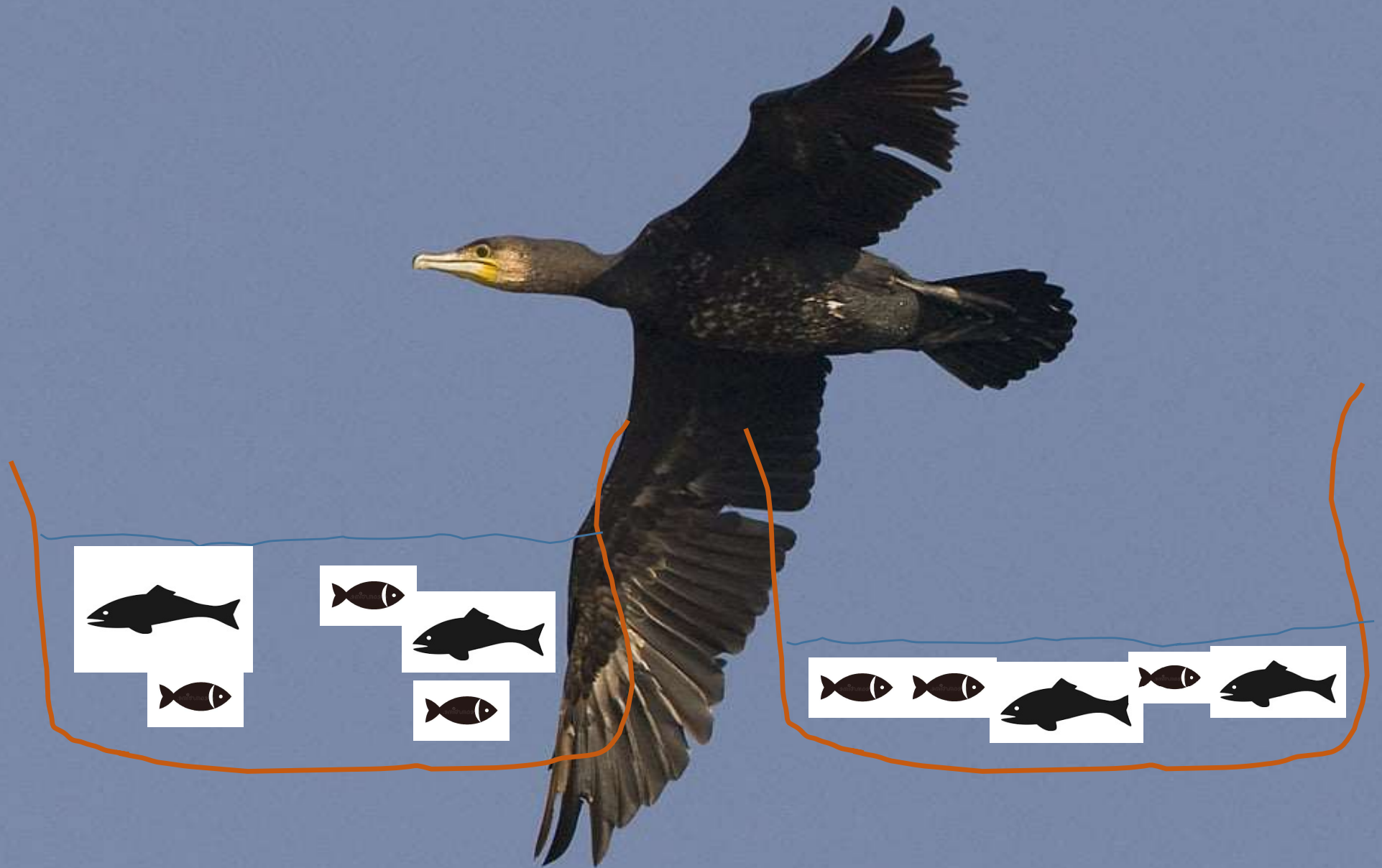
Mastallone Varallo
Sesia ottobre 2021

Popolazione
acclimatata di
Barbus plebejus,
specie
precedentemente
presente solo
molto più a valle

Comunità ittica 2021

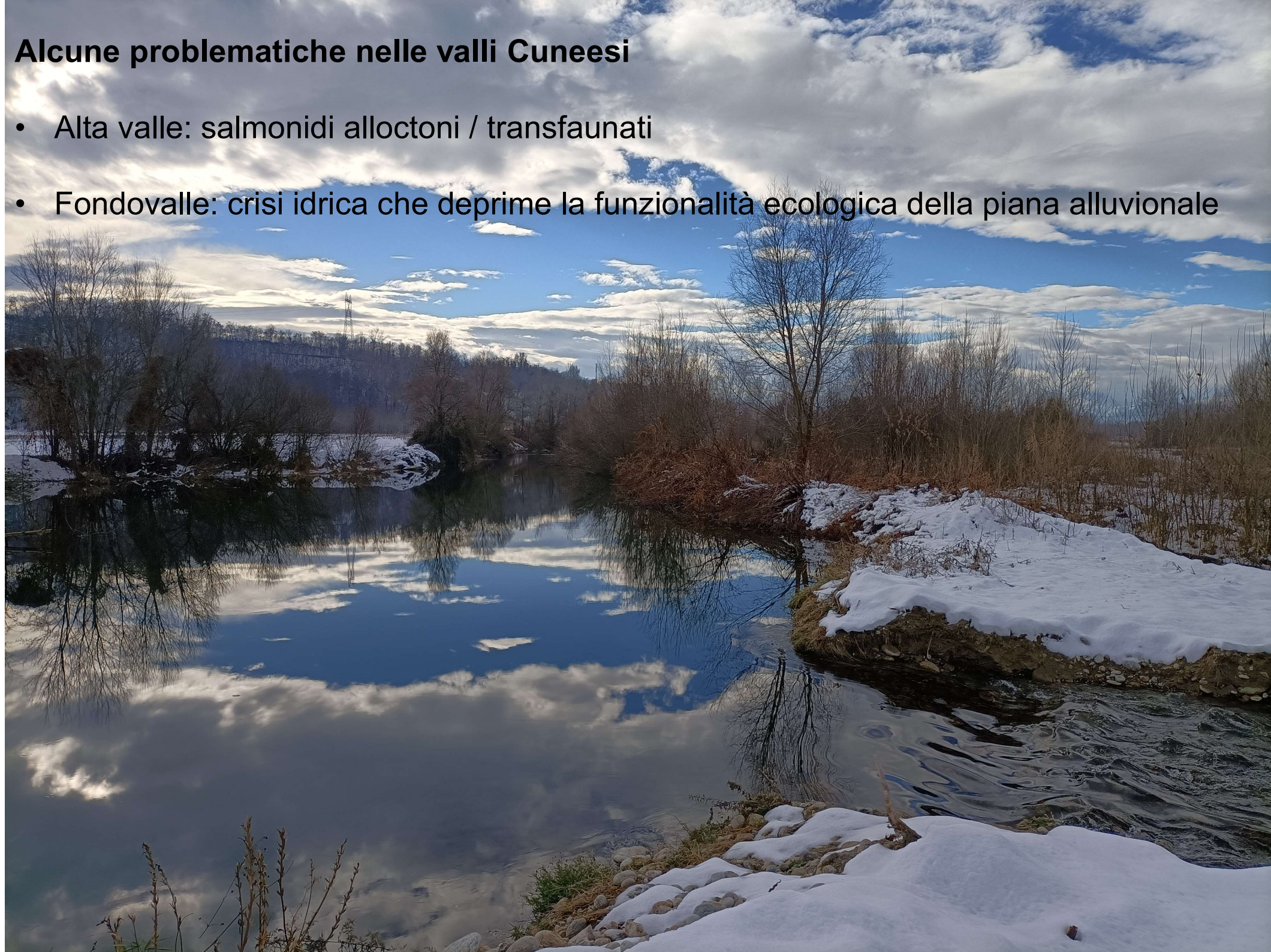


- Aumento della pressione predatoria per volume di acqua



Alcune problematiche nelle valli Cuneesi

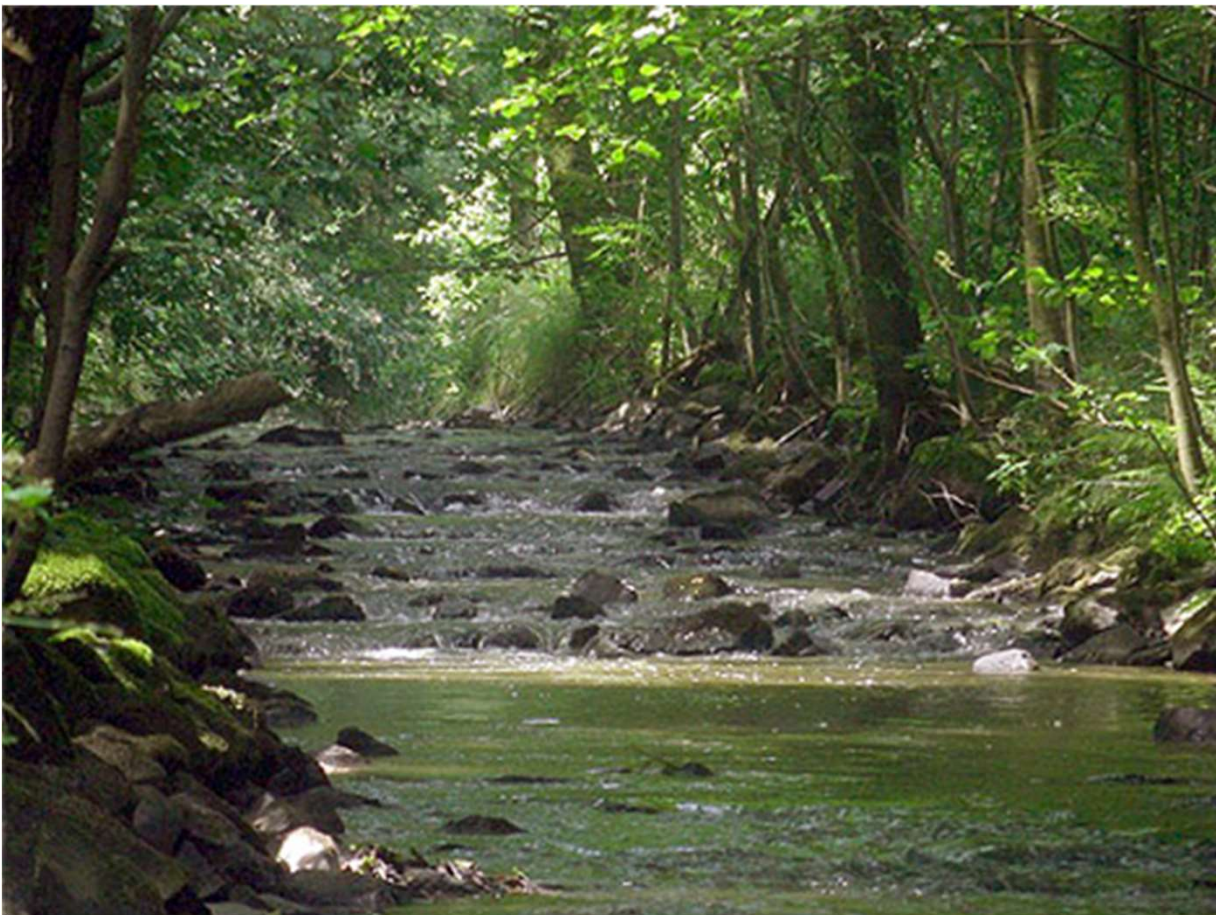
- Alta valle: salmonidi alloctoni / transfaunati
- Fondovalle: crisi idrica che deprime la funzionalità ecologica della piana alluvionale



Scazzone *Cottus gobio*
Allegato II Direttiva Habitat



Presenza di due pinne dorsali, appena separate tra loro, pinne pettorali separate, coda arrotondata



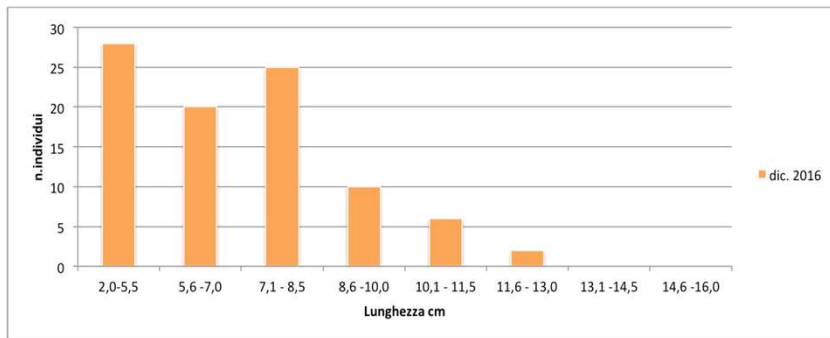
Cottus gobio è specie molto esigente
necessita di acque ossigenate e limpide,
comprese le risorgive dove può essere
associato alla lampreda e al gambero nostrano





Cottus gobio vs *Salmo* spp.

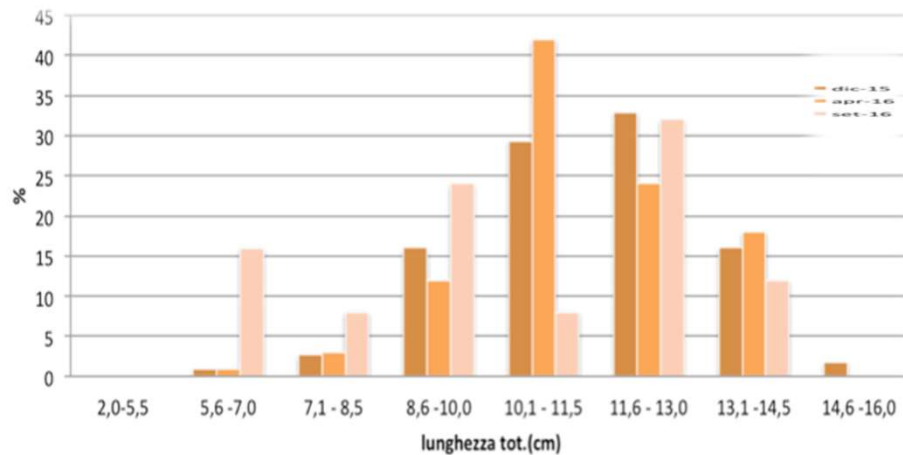
Fiume Po, Villafranca (TO): stazione con popolamento salmonicolo “naturale”



Nel dicembre 2016 un monitoraggio sul fiume Po, in una stazione in cui non vengono introdotti salmonidi, ha rilevato un popolamento di scazzone ben strutturato con buona presenza di classi giovanili



Torrente Pesio (CN): stazione con massicce introduzione di salmonidi



In base a uno studio effettuato sul Torrente Pesio in località Certosa tra il 2015 e il 2016 (Bovero, 2016) è stato evidenziato come la presenza di grandi quantitativi di salmonidi influisca negativamente sulla struttura delle popolazioni di scazzone a causa della pressione predatoria sugli stadi giovanili.



Salmo AT vs *Salmo* MA / AD.

Inquinamento genetico



Salmo marmoratus

X



Salmo trutta



Ibrido *Salmo trutta x marmoratus*



Salmo trutta

X

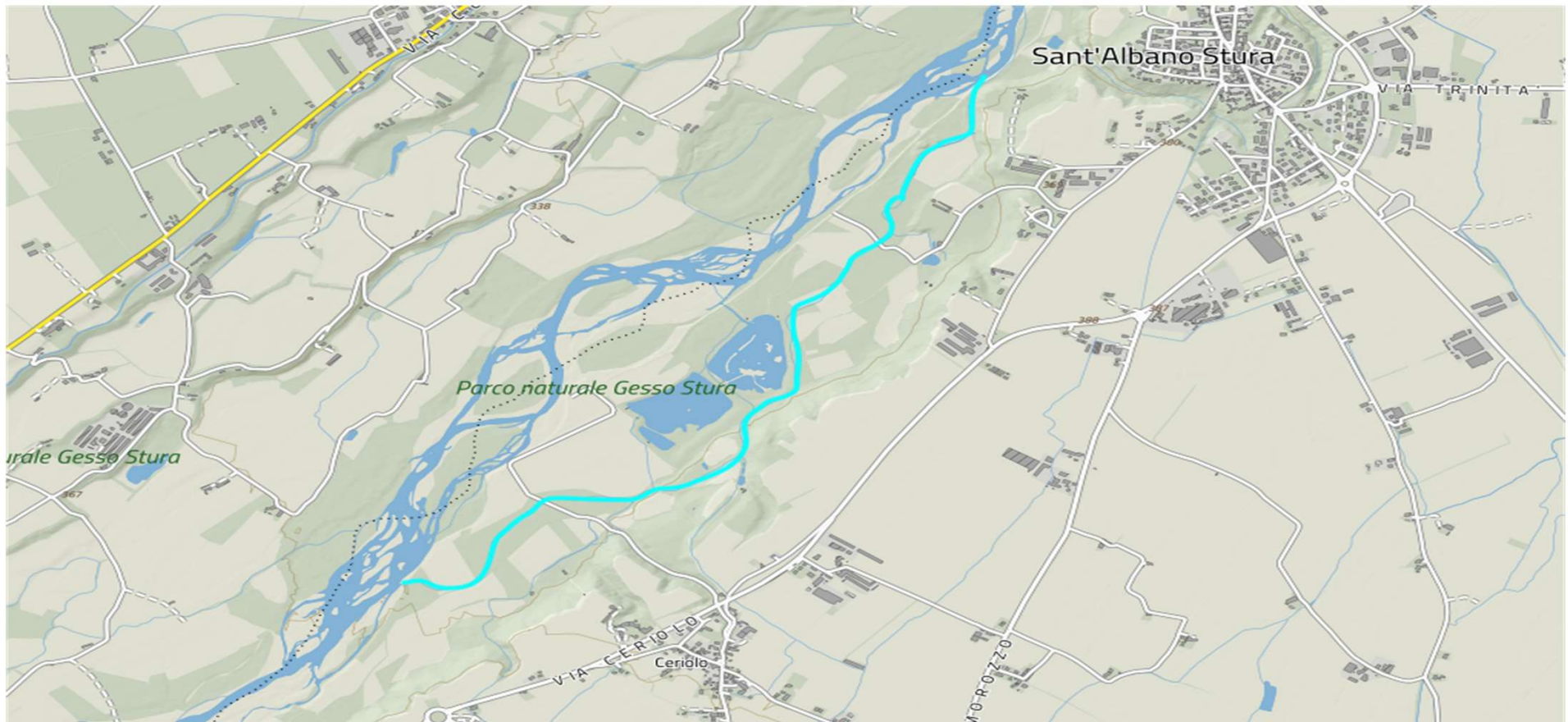


Salmo sp. AD



Ibrido *Salmo trutta* x *sp. AD*

La piana alluvionale dello Stura presso S. Albano



Il corso della Stura di Demonte in questo settore è sempre stato caratterizzato da un alveo plurimodale dove, in sponda orografica destra era associato un complesso reticolo secondario originato dai numerosi apporti delle risorgive che scaturivano dal terrazzo fluviale. Nel tempo questo sistema ha subito pesanti alterazioni dovute alle pratiche agricole e estrattive che, di fatto, ne hanno modificato profondamente l'originale assetto idrologico. Il ramo di destra dell'antico alveo (Fig. 1), noto ora come "Canale Consorzio Irriguo Tavolera-Savella" benché rimaneggiato e, a tratti, canalizzato, continua però ad avere un ruolo primario nel mantenimento della funzionalità ecologica di questo settore del bacino della Stura in quanto raccoglie gran parte degli apporti sorgivi, connette gli habitat fluviali con quelli del reticolo secondario e contribuisce a alimentare diverse aree umide su cui si basa il grande valore naturalistico della ZPS, tra le quali l'Oasi "La Madonnina".

Monitoraggio fauna ittica 2023



Stazioni di monitoraggio 2023 . In arancio quelle ricadenti nell'alveo della Stura, in verde quelle ricadenti nel reticolo secondario rappresentato dal canale Tavolera-Savella e altri corpi idrici sorgivi

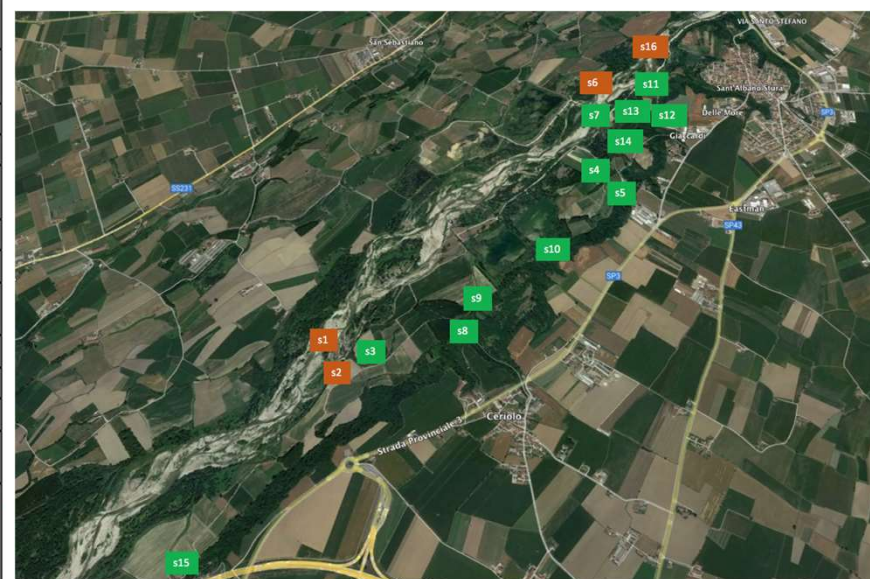
Specie	Nome comune	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16
Ittiofauna																	
<i>Lamprologus zanandrei</i>	Lampreda padana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	⊙ A
<i>Telestes muticellus</i>	Vairone italico	** S	** S	⊙ A-G	** S	* S	** S	** S	-	** S	** S	* S	** S	-	* S	* S	*** S
<i>Cottus gobio</i>	Scazzone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Barbus caninus</i>	Barbo canino	* G	* S	⊙ G	-	-	-	-	-	-	-	-	-	-	-	-	* S
<i>Barbus plebeius</i>	Barbo comune	⊙ G	* G	-	-	-	⊙ G	-	-	-	* G	-	-	-	⊙ G	-	** S
<i>Cobitis bilineata</i>	Cobite comune	-	** S	-	*** S	-	* S	-	-	-	* S	-	-	-	-	-	*** S
<i>Salmo marmoratus</i> ¹	Trota marmorata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	* G	-
<i>Phoxinus phoxinus</i>	Sanguinerola italiana	⊙ A	* S	⊙ A-G	*** S	-	-	-	-	* S	* S	** S	* S	-	* S	* S	* S
<i>Romano gobio benacensis</i> ²	Gobione italico	* S	* S	⊙ A-G	-	-	⊙ G	* S	-	-	-	-	-	-	-	-	* S
<i>Squalius squalus</i>	Cavedano italico	* S	* G	-	* S	-	* G	* S	-	-	* S	-	-	-	-	-	* G
<i>Leuciscus leuciscus</i>	Triotto	⊙ A-G	-	-	* G	-	-	-	-	-	-	-	-	-	-	-	* G
<i>Alburnus alburnus</i>	Alborella	** S	* S	-	** S	* S	* S	-	-	-	-	-	-	-	-	-	-
<i>Padogobius padanus</i>	Ghiozzo padano	** S	** S	-	*** S	* S	* S	* S	-	-	* S	* S	* S	-	* S	-	** S
<i>Tinca tinca</i>	Tinca	-	⊙ A	-	* G	-	-	⊙ G	-	-	-	-	-	-	-	-	* S
<i>Cyprinus carpio</i>	Carpa	-	-	-	* G	-	-	-	-	-	-	-	-	-	-	-	⊙ G
<i>Oncorhynchus mykiss</i>	Trota iridea	-	-	-	-	-	-	-	-	-	-	-	⊙ A	-	-	-	-
<i>Salmo trutta</i>	Trota fario	-	-	-	-	-	-	-	-	-	-	** S	⊙ G	* S	-	-	⊙ A
<i>Lepomis gibbosus</i>	Persico sole	-	⊙ A	-	* G	-	⊙ G	-	-	-	⊙ G	⊙ G	-	-	-	-	* S
Crostacei																	
<i>Austropotamobius pallipes</i>	Gambero di fiume	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	** S

¹: Questa specie è stata rilevata nella stazione s16 in forma ibrida con *Salmo trutta*. Altri esemplari sono stati rilevati nel canale Savella durante le fasi di recupero del 16 settembre 2022

²: Questa specie non compare nell'Allegato II della Direttiva 92/43/CEE Habitat ma è considerata "Endangered" ai sensi della Red List IUCN

Cottus gobio e *Austropotamobius pallipes* sono presenti esclusivamente nel reticolo secondario

Phoxinus phoxinus specie bandiera frigifila ha popolazioni abbondanti solo nel reticolo secondario



Le risorgive e i canali associati sono fondamentali per la funzionalità ecologica dell'intera piana alluvionale

Handbook of European Freshwater Fishes

Maurice Kottelat and Jörg Freyhof



Trout taxonomy: the shame of European ichthyology

Trouts are 'the' fish that most anglers prize throughout Europe. They are the main (if not the sole) concern of a number of fisheries agencies and associations. They have been the cause of most fisheries 'management plans' in many countries. They are produced in huge quantities. They have been the subject of innumerable studies. They have attracted the attention of hordes of geneticists. Nevertheless, all this 'interest' has resulted in very little data usable in a taxonomic framework. In 2007, trout taxonomy in most of Europe is still handled in a way that would be considered non-professional anywhere else and for any other group of animals.

In the cases when the data make sense, their usefulness is very limited (or even nullified) by the absence of voucher material on which the identity of the analysed material can be checked or confirmed. Some are accompanied by 'morphological' studies in which the authors merely counted red and black spots, which is a strange understanding of 'morphology'. To pretend to contribute anything towards solving taxonomic problems, a genetic study *must* be accompanied by information on the examined material, these individuals must be properly fixed (not dumped carelessly in a freezer or in a tiny vial with a few drops of ethanol), deposited in a natural history museum with facilities to make them available for future examination by other researchers, and access to this material must be permitted. If these minimum conditions are not satisfied, genetic, phylogenetic and phylogeographic studies represent little else than wasted money and effort, with the fish used for these researches having been sacrificed for no justifiable reason.

Bernatchez, 2001

Late Pleistocene
110 000 – 12 000 years ago

AT

ME

MA

DA

AD

Evolution, 55(2), 2001, pp. 351–379

THE EVOLUTIONARY HISTORY OF BROWN TROUT (*SALMO TRUTTA* L.) INFERRED FROM PHYLOGEOGRAPHIC, NESTED CLADE, AND MISMATCH ANALYSES OF MITOCHONDRIAL DNA VARIATION

LOUIS BERNATCHEZ

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Abstract.—Phylogeographic, nested clade, and mismatch analyses of mitochondrial DNA (mtDNA) variation were used to infer the temporal dynamics of distributional and demographic history of brown trout (*Salmo trutta*). Both new and previously published data were analyzed for 1794 trout from 174 populations. This combined analysis improved our knowledge of the complex evolutionary history of brown trout throughout its native Eurasian and North African range of distribution in many ways. It confirmed the existence of five major evolutionary lineages that evolved in geographic isolation during the Pleistocene and have remained largely allopatric since then. These should be recognized as the basic evolutionarily significant units within brown trout. Finer phylogeographic structuring was also resolved within major lineages. Contrasting temporal juxtaposition of different evolutionary factors and timing of major demographic expansions were observed among lineages. These unique evolutionary histories have been shaped both by the differential latitudinal impact of glaciations on habitat loss and potential for dispersal, as well as climatic impacts and landscape heterogeneity that translated in a longitudinal pattern of genetic diversity and population structuring at more southern latitudes. This study also provided evidence for the role of biological factors in addition to that of physical isolation in limiting introgressive hybridization among major trout lineages.

Key words.—Europe, fish, mismatch, mitochondrial DNA, nested clade, phylogeography, *Salmo*.

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Elucidating the evolutionary history of extant species is an important objective of any research program that seeks to understand population divergence and, ultimately, speciation. This history is also directly relevant to conservation biology because historical contingencies have been largely responsible for creating the most important genetic subdivisions in many, if not most extant taxa (e.g., Zink 1996; Avise et al. 1998; Hewitt 2000). The phylogeographic approach has been used to test the congruence between distributional histories against paleo-environmental settings and determining the chronology of evolutionary diversification (Avise 1998; Moritz and Berningham 1998). Comparative phylogeography has also emerged as a powerful method to address broader ecological and evolutionary issues.

In northern temperate freshwater fishes, comparative phylogeography revealed predictive trends in phylogeographic structure, genetic diversity, and speciation rates among species inhabiting formerly glaciated and unglaciated regions of North America (Bernatchez and Wilson 1998). Further generalizations of the effect of Pleistocene glaciations on freshwater fish fauna could be gained by comparing phylogeographic data from other regions. Contrasts between Eurasian and North American freshwater fish phylogeographic structure (e.g., Bernatchez et al. 1989) would be particularly informative, given the much less extensive glacial advances in Eurasia and its contrasting landscape with that of North America (Hewitt 2000). However, the phylogeographic structure of the Eurasian fish fauna is still largely unknown (Bernatchez and Dodson 1994; Durand et al. 1999a; Nesbo et al. 1999; Englbrecht et al. 2000).

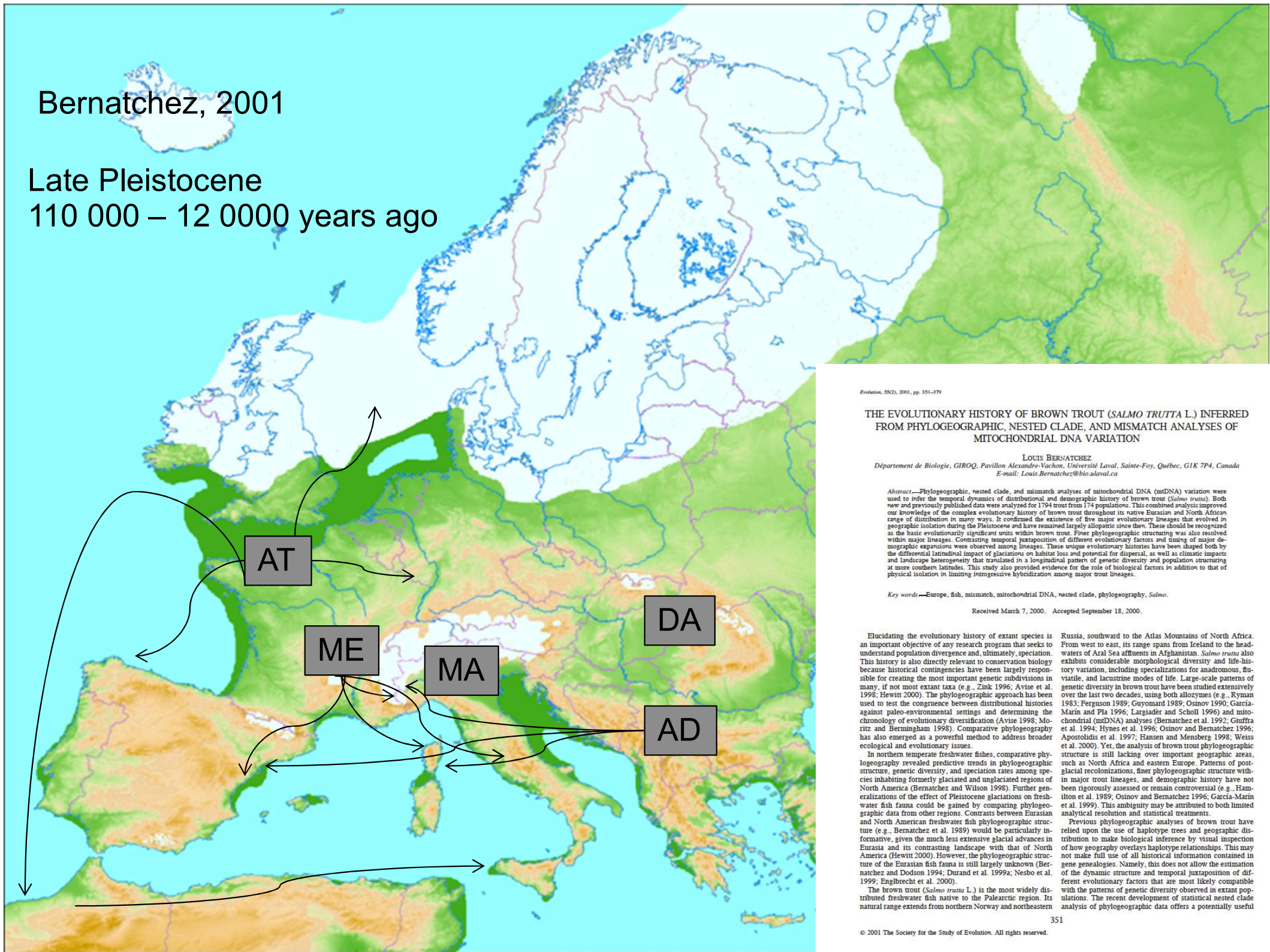
The brown trout (*Salmo trutta* L.) is the most widely distributed freshwater fish native to the Palearctic region. Its natural range extends from northern Norway and northeastern

Russia, southward to the Atlas Mountains of North Africa. From west to east, its range spans from Iceland to the headwaters of Aral Sea affluents in Afghanistan. *Salmo trutta* also exhibits considerable morphological diversity and life-history variation, including specializations for anadromous, fluvial, and lacustrine modes of life. Large-scale patterns of genetic diversity in brown trout have been studied extensively over the last two decades, using both allozymes (e.g., Ryman 1983; Ferguson 1989; Guyomard 1989; Osinov 1990; Garcia-Marín and Pla 1996; Lajardiér and Scholl 1996) and mitochondrial (mtDNA) analyses (Bernatchez et al. 1992; Giuffra et al. 1994; Hynes et al. 1996; Osinov and Bernatchez 1996; Apostolidis et al. 1997; Hansen and Mensberg 1998; Weiss et al. 2000). Yet, the analysis of brown trout phylogeographic structure is still lacking over important geographic areas, such as North Africa and eastern Europe. Patterns of post-glacial recolonizations, finer phylogeographic structure within major trout lineages, and demographic history have not been rigorously assessed or remain controversial (e.g., Hamblin et al. 1989; Osinov and Bernatchez 1996; Garcia-Marín et al. 1999). This ambiguity may be attributed to both limited analytical resolution and statistical treatments.

Previous phylogeographic analyses of brown trout have relied upon the use of haplotype trees and geographic distribution to make biological inference by visual inspection of how geography overlays haplotype relationships. This may not make full use of all historical information contained in gene genealogies. Namely, this does not allow the estimation of the dynamic structure and temporal juxtaposition of different evolutionary factors that are most likely compatible with the patterns of genetic diversity observed in extant populations. The recent development of statistical nested clade analysis of phylogeographic data offers a potentially useful

Bernatchez, 2001

Late Pleistocene
110 000 – 12 000 years ago



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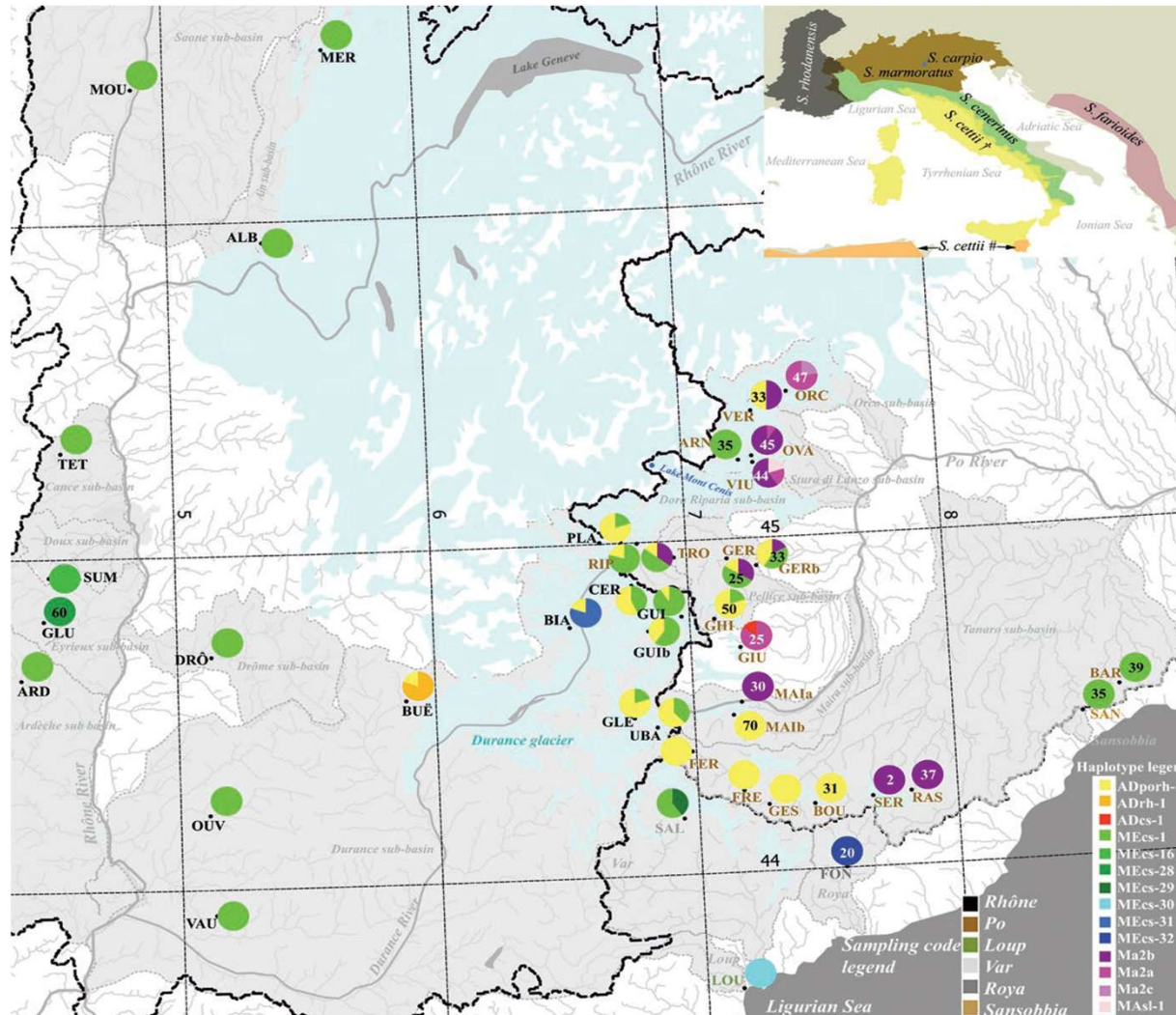
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Splendiani et al., 2020

The role of the south-western Alps as a unidirectional corridor for Mediterranean brown trout (*Salmo trutta* complex) lineages

Linee evolutive “marmoratus” MA, Mediterraneo ME e Adriatico AD



MA Torrente Pellice; Luserna S. Giovanni (TO)

ME: fiume Arc,
Savoia





AD: Stura di Demonte (CN)



ME o AD?: Torrente Ripa (TO)



AD: Monte Limbara (OT)

Trota di torrente *Salmo trutta* – AT



Inquinamento genetico



Salmo marmoratus

X



Salmo trutta



Ibrido *Salmo trutta x marmoratus*

Ibrido F1 salmo trutta x marmoratus



Ibrido F2

Puro x ibrido F1 o ibrido F1 x ibrido F1



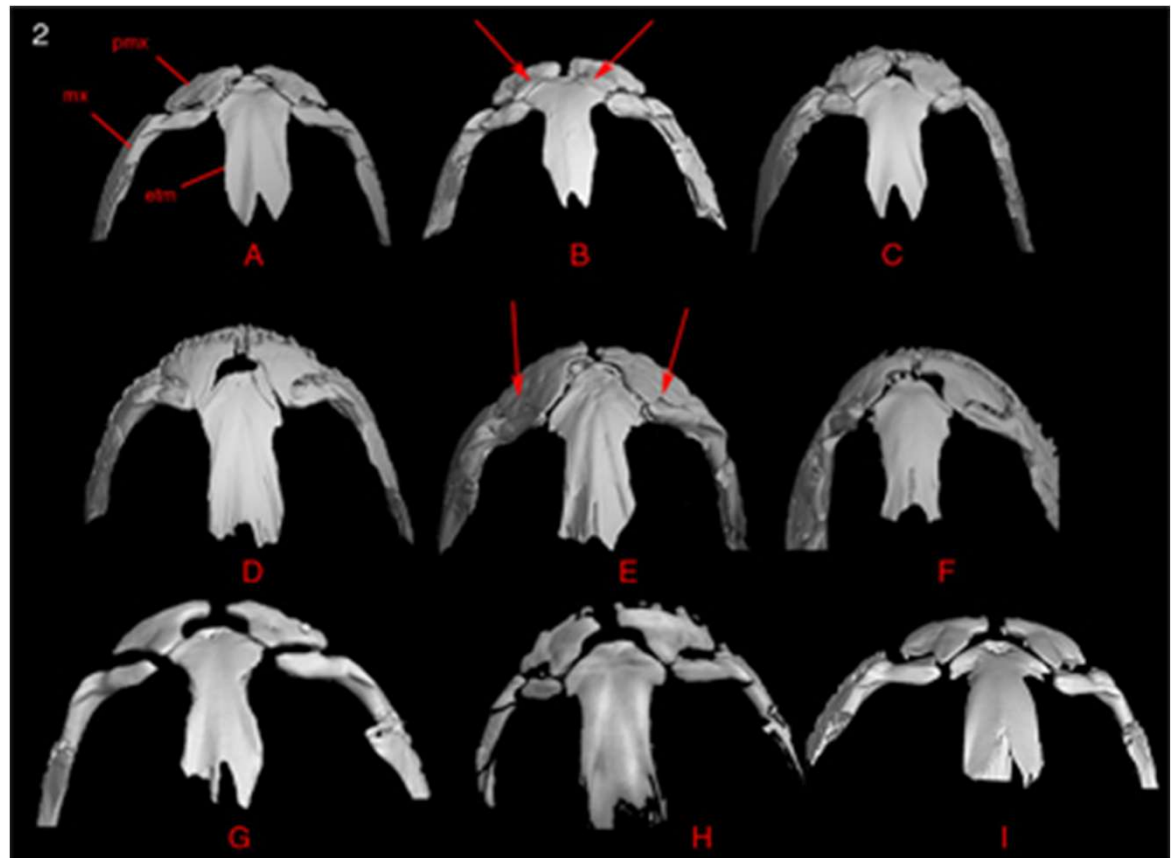
Ibrido Fn



AD Lineage species in Balkan peninsula



Lo studio approfondito
dei caratteri e le analisi
genetiche possono portare
al riconoscimento di nuove
specie



Trota sarda o trote sarde?



Rio Mannu Pattada



Rio Sa Eliana



Temo

Tuti individui puri di linea evolutiva AD ma le caratteristiche cromatiche e morfometriche sono diverse



Molti ittiologi italiani non sono filogenetisti e considerano le trote AD e ME come un'unica entità tassonomica *Salmo ghigi*

Anche se interfertili le popolazioni appartenenti a diverse linee evolutive possono mostrare segregazione ecologica e barriere riproduttive non complete ma, in alcuni contesti, funzionanti

parte delle acque provinciali (Fig. 37).

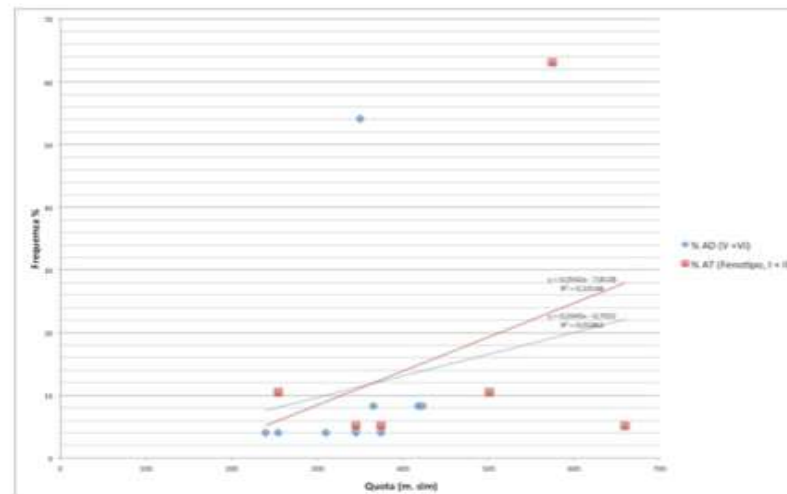
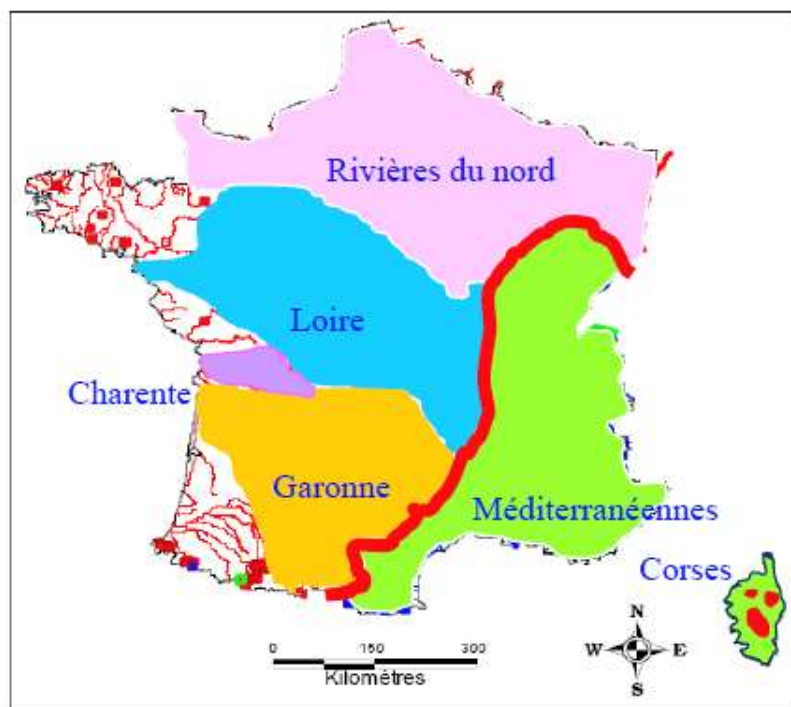


Fig. 37: popolamenti salmonicoli autoctoni e alloctoni rilevati in base alla quota

Il test del chi-quadrato eseguito confrontando i campioni con indice di ibridazione VI e V (AD puri e ibridi sbilanciato verso AD) contro quelli con indice I e II (AT puri e ibridi sbilanciato verso AT) su tre differenti fasce altimetriche da 240 a 345 m. s.l.m., da 350 a 423 m. s.l.m. e da 501 a 660 m. s.l.m., ha valore 15,75 con $p < 0,01$ ed è statisticamente significativo. I dati sono al momento ancora esigui ma consentono di ipotizzare che nelle acque della provincia di Sassari l'insediamento di popolazioni strutturate di trote alloctone è difficile e discontinuo in quanto, ad eccezione dei settori più alti, le condizioni climatiche e ambientali non sembrano essere adatte per questa entità. Già M. Pomini ⁽²⁵⁾ e, successivamente M. Cottiglia ⁽¹²⁾ avevano rilevato che solo la trota sarda è in grado di sopravvivere per periodi più o meno prolungati in acque con temperature superiori ai 25 °C e bassi livelli di ossigeno. La minore frequenza della sottospecie autoctona nelle posizioni più alte potrebbe essere invece spiegata sulla base di una preferenza ambientale della trota sarda per settori più bassi e meno oligotrofici oppure si può ipotizzare che i salmonidi alloctoni siano riusciti a sostituire l'entità indigena esclusivamente in questi contesti ambientali, in quanto simili a quelli loro originari.



Carte de synthèse de GENESALM

En 2009-2010, une aide de l'Observatoire des Sciences de l'Univers (OSU) OREME nous a permis de compléter les connaissances déjà acquises sur la génétique nucléaire par l'ajout d'un marqueur mitochondrial. Des centaines de nouvelles séquences ont déjà été obtenues, augmentant considérablement les connaissances.

C'est cette nouvelle avancée, intercalée entre les programmes GENESALM et GENETRUTTA, et impulsée par l'OSU OREME, qui fait l'objet de ce rapport.

STEFANO BOVERO* - ALESSANDRO CANDIOTTO** - LUIGI CEPPA*** - FEDERICO GIUNTOLI***
 MASSIMO PASCALE**** - GIAN CARLO PEROSINO*****

Stato dell'ittiofauna nei fiumi e torrenti in Piemonte

ABSTRACT - State of the riverine ichthyofauna in Piedmont.

Four major fish surveys were performed on the whole hydrographic network of Piedmont (NW Italy): 297 stations were monitored in 1988/1989, 202 in 2004, 428 in 2009 and 209 in 2017/2019. A considerable number of stations were common in all four monitoring campaigns and this allows us, by means of data comparison, to assess the evolution of the riverine fish fauna over the last thirty years. These are the main remarks:

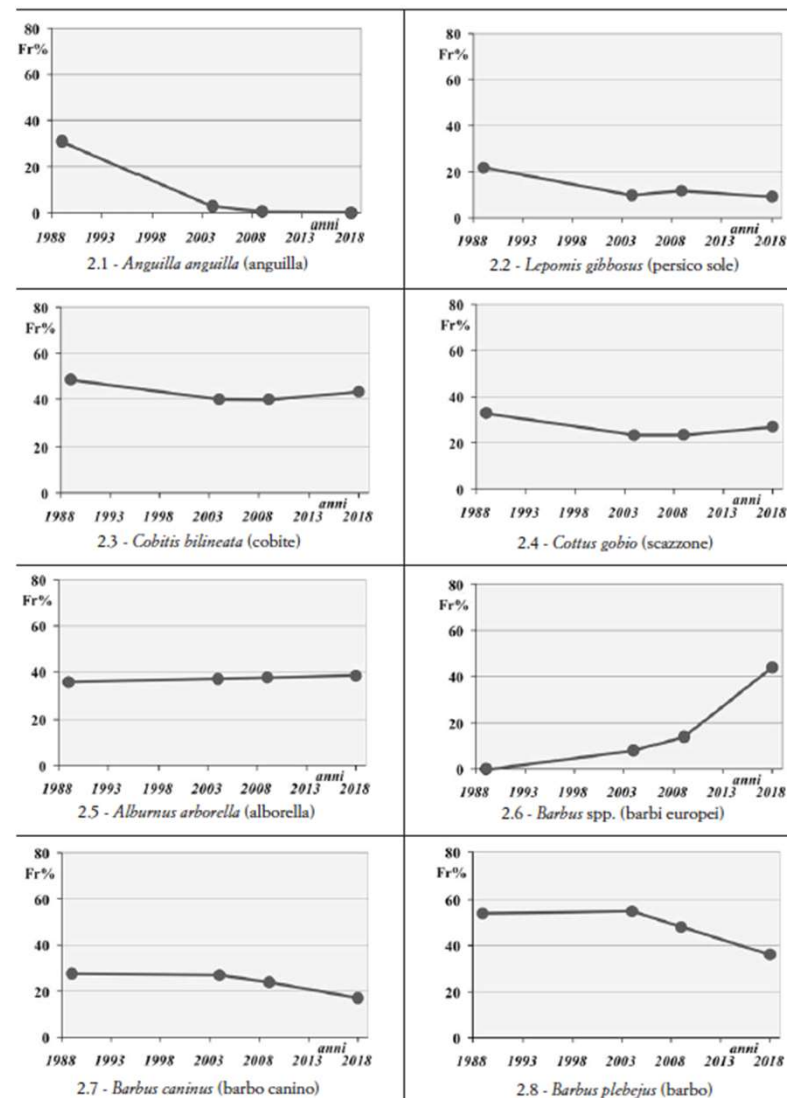
- The initial presence of twenty eight native species has been confirmed.
- Three diadromous species, the Atlantic sturgeon *Acipenser sturio*, the Eel *Anguilla anguilla* and the Twait shad *Alosa fallax*, are actually absent and further studies would be needed to confirm recent reports about the presence of the Adriatic sturgeon *Acipenser naccarii*.
- Eight species, the Italian golden loach *Sabanejewia larvata*, the Savetta *Chondrostoma soetta*, the Lasca *Protochondrostoma genei*, the Italian gudgeon *Gobio benacensis*, the Pigo *Rutilus pigus*, the Southern pike *Esox cisalpinus*, the Adriatic grayling *Thymallus aeliani* and Tenc *Tinca tinca* wild populations, are critically endangered and some of these appear to be almost extinct from the hydrographic network.
- Two species, the Italian barbel *Barbus plebejus* and the Italian rudd *Scardinius hesperidicus*, are vulnerable with decreasing populations in Piedmont.
- Twelve species are listed as least concern and their populations have remained stable or show only slight regression.
- Twenty three alien species are present. Among them two species, the Carp *Cyprinus carpio* and the Alpine charr *Salvelinus alpinus*, are considered "para-autochthonous" in Italy, twenty one are dangerous and five, allochthonous barbels *Barbus* spp., the Asp *Aspius aspius*, the Pseudorasbora *Pseudorasbora parva*, the Bitterling *Rhodeus amarus* and the European catfish *Silurus glanis* are very dangerous for native species.

Our study highlights that the conservation status of the ichthyofauna of rivers and streams in Piedmont is seriously compromised. Major threats to freshwater fishes include: habitat modification, fragmentation and destruction; excessive water withdrawals for agricultural purposes; lack or ineffectiveness of fish passes; invasive species; overfishing; environmental pollution; forestry practice; local increase of piscivorous birds; and climate change.

KEY WORDS - Monitoring, ichthyic communities, ichthyofauna evolution, Piedmont (NW Italy).

RIASSUNTO - In Piemonte sono stati effettuati quattro monitoraggi dell'ittiofauna nelle acque correnti del reticolo idrografico naturale: nel 1988/1989 su 297 stazioni di campionamento; nel 2004 su 202 stazioni; nel 2009 su 428 stazioni; nel 2017/2019 su 209 stazioni. Alcune stazioni delle diverse campagne di monitoraggio sono coincidenti. Pertanto si dispone di un significativo insieme di dati sullo stato delle popolazioni ittiche attuali con confronti con le situazioni pregresse degli ultimi trenta anni. Risulta quanto segue:

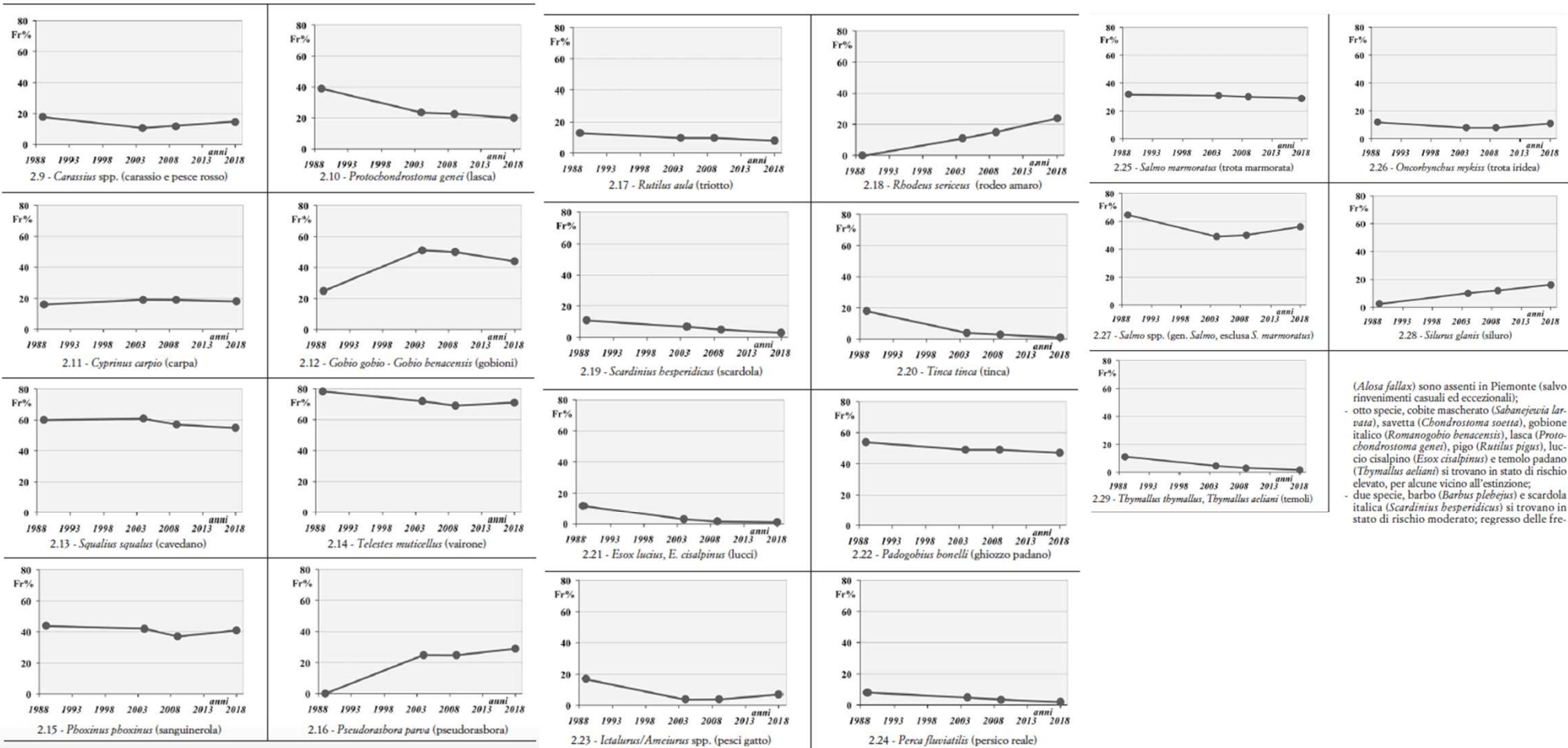
- Si conferma la presenza storica di almeno ventotto specie autoctone.
- Tre specie, storione comune (*Acipenser sturio*), anguilla (*Anguilla anguilla*) e cheppia/alosa (*Alosa fallax*) sono assenti in Piemonte; per quanto riguarda lo storione cobice (*Acipenser naccarii*) sono necessari ulteriori approfondimenti per confermare recenti segnalazioni.
- Otto specie, cobite mascherato (*Sabanejewia larvata*), savetta (*Chondrostoma soetta*), lasca (*Protochondrostoma genei*), gobione italico (*Romanogobio benacensis*), pigo (*Rutilus pigus*), luccio cisalpino (*Esox cisalpinus*), temolo padano (*Thymallus aeliani*) e le popolazioni selvatiche di tinca (*Tinca tinca*) sono in stato di rischio elevato, e alcune di esse sono vicine all'estinzione.
- Due specie, barbo (*Barbus plebejus*), scardola italica (*Scardinius hesperidicus*) sono in stato di rischio moderato, con regresso delle frequenze di campionamento.



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Gobione italico

(*Gobio benacensis*)

Famiglia: Ciprinidae

Endemico



Gobione europeo

(*Gobio gobio*)

Famiglia: Ciprinidae

Alloctono (Europa e Asia)

