Are we putting our fish  in hot water?

Global warming and the world's fisheries • Hot, hungry, and gasping for air • Shrinking fish and fewer babies? • Global warming puts fish on the run • Warm water beckons to unwelcome guests • Watery layers that refuse to budge • A warm welcome for diseases and toxins • How much are fish worth? • Which fish are feeling the heat? • How will fisheries change? • 2 °C is too much! • What needs to be done?

Global warming and the world's fisheries

■ Dashing through sparkling water, probing muddy depths, or weaving through a maze of corals, fish inhabit nearly every watery corner of the planet. With at least 27,000 known species living in oceans, lakes and rivers, fish are a cornerstone of global biodiversity, as well as an essential resource for humans – 132 million metric tons of fish are captured or raised each year, and more than 75% of this catch is eaten directly by people.

Worldwide, marine and freshwater fisheries generate over US$130 billion annually, employ at least 200 million people, and feed billions of people who rely on fish as their primary source of protein, particularly in some of the most populous and poorest countries on the planet.

But fish are increasingly threatened by global warming. Greenhouse gases released mainly by humans burning coal, oil, and natural gas have led to a sharp rise in mean global temperatures over the last 50 years. Temperatures are expected to rise 1.4-5.8°C more by the end of the century. As a result, the water in rivers and lakes is heating up, and even the oceans have warmed in the last 50 years.

Warmer waters, as well as changes in rainfall, currents, and sea level, are already affecting the world's fish and fisheries. As global warming continues, the pressure on populations already strained by overfishing, pollution, and habitat loss will increase. And while slightly warmer water may not sound so bad to many of us, its effect on fish and aquatic ecosystems, and ultimately on the global food supply and economic stability, could be severe.

Large image: Merja Zerga National Park, Morocco
Top: Cast net fishing in Ituqui Island, Para, Brazil
Below: Fish carvings in Angkor Wat, Cambodia

Hot, hungry, and gasping for air

■ Fish are more sensitive to temperature than many animals because they cannot maintain a constant body temperature like we do – in most cases, their body is exactly the same temperature as the water they are swimming in. Different species can live in very cold or very hot water, but each species has a range of temperatures that it prefers, and fish can't survive in temperatures too far out of this range.

When fish encounter water that is too cold for them, their metabolism – the chemical engine that drives their body – slows down and they become sluggish. As the surrounding water warms up, their metabolism speeds up – they digest food more rapidly, grow more quickly, and have more energy to reproduce.

But fish need more food and more oxygen to support this higher metabolism.

Some unlucky fish may be killed by even a slight rise in temperature.

If there is not enough food, all of a fish's available energy goes to fuelling its high metabolism, and less energy is available for growth and reproduction. Rainbow trout grow significantly more slowly when their water temperature is raised only 2°C and food is limited, and fish such as salmon, whitefish, and perch are all expected to grow more slowly if food supply does not increase as temperatures rise.

Even if there is more food to eat, it may no be enough to satisfy the ravenous appetites of warmed-up fish. Experiments in Toolik Lake, Alaska (US), suggest that a warming of 3°C will double the food supply for arctic trout, but their metabolism will increase so much that young trout are still expected to starve by the end of their first year. This lake has in fact warmed by several degrees during the last few decades, and young fish have begun to lose weight during August, the month when they normally grow the most – so arctic trout may already be suffering the effects of climate change.

To make matters worse, fish may not have enough oxygen to breathe as the water grows warmer. Fish filter oxygen from the water they are swimming in, but the amount of oxygen dissolved in water decreases as temperatures rise. So many fish will experience an "oxygen squeeze" as the climate warms – they will need more oxygen to support their elevated metabolisms, but may not be able to get it from the warmer, oxygen-poor water around them.

And some unlucky fish may be killed by even a slight rise in temperature. Many tropical species already suffer near-lethal temperatures during the hottest part of the day. An increase of 1-2°C could cause massive fish kills, especially in tropical aquaculture ponds or shallow pools of the Amazon and Mekong rivers. Ponds and lakes supporting lots of fish also experience critically low levels of oxygen overnight, when aquatic plants stop releasing oxygen through photosynthesis. As these waters warm, the combination of increased metabolic demand and reduced dissolved oxygen could lead to lethal oxygen shortages.

Top: Fisherman in Mekong River, Laos
Below: Giant Catfish, Mekong River, Thailand

Overfished and Overheated!

Overfishing is a massive threat to ocean-life and to the food and livelihoods of over a billion people. Over 76% of the world's fisheries are already fished to their limit or overfished, and as many as 90% of all the oceans' large fish have been fished out.

Global warming threatens to push already over-exploited and stressed fish poputions and habitats over the brink. To combat overfishing and global warming, responsible fisheries management and networks of Marine Protected Areas are urgently needed to help marine life and habitats survive the impacts of global warming.

From top:

Cod in the Atlantic is moving northwards

Amur sturgeon need low temperatures for spawning

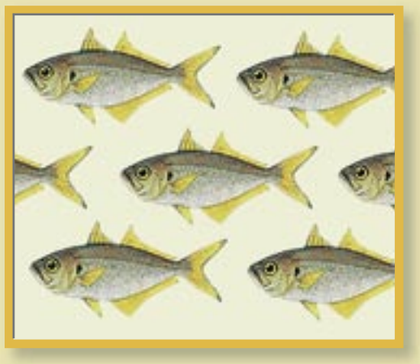
Butterfly fish live in corals which are threatened by global warming

Salmon harvests have gone down in unusually warm years

Shrinking fish and fewer babies?

■ Warmer fish tend to mature more quickly, but the cost of this speedy lifestyle is often a smaller body size. Ninety percent of aquatic animals like fish raised in warm water end up smaller than their peers raised at cooler temperatures. Southern calamari, for example, grow more quickly at higher temperatures, but they also hatch much earlier (and smaller), and reach sexual maturity earlier, so they can't catch up in size to squid who have more time to grow in cool water.

Many fish will also have less offspring as temperatures rise, and some may not be able to reproduce at all. Tropical fish like guppies produce smaller broods, and grass carp ovulate less frequently in warmer water. Temperate species like salmon, catfish, and sturgeon cannot spawn at all if winter temperatures do not drop below a certain level.



North-West Mediterranean Fisheries

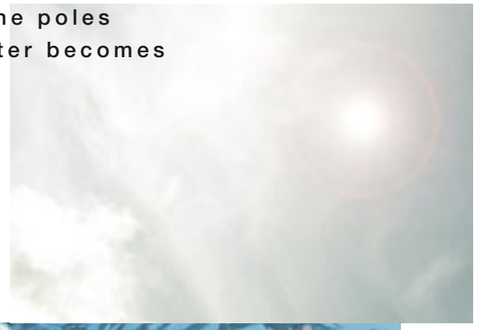
Climate change threatens the sustainability of north-western Mediterranean fisheries due to rising ocean temperature, sea-level rise, and reduced river flow. Declines in fisheries will have massive impacts on the region's commercial fishing, tourism, and biodiversity. For example, warmer water temperatures will likely cause cold water fish, e.g. economically important species such as hake and poor cod, to disperse and shift the range in which they live. They may be unable to survive in north-western Mediterranean waters.

Gulf of Mannar, India and the false trevally

False trevally is an economically and culturally important fish in India. It ranks as one of the most preferred, high-quality fish in the Gulf of Mannar region. But climate change has contributed to a drastic decline of the fishery over the last few years because of increased water temperatures and decreased rain (which flushes critical nutrients from the land into the Gulf of Mannar).

Global warming puts fish on the run

Many fish that cannot find a local solution are already heading towards the poles as the water becomes too warm.



School of big-eye trevally in the Indian Ocean

■ Naturally, when fish find themselves in hot water, they head out in search of cooler locales. As global temperatures rise, some fish may be able to shift locally – by moving deeper or by heading upriver towards cool headwaters. Fish in the Gulf of Alaska ride out unusually hot weather by shifting to deeper waters, but this can leave other animals with few options. When fish in the Gulf moved deep in 1993, 120,000 seabirds starved to death, most likely because they could not dive deep enough to catch their relocated prey.

Many fish that cannot find a local solution are already heading towards the poles as the water becomes too warm. Capelin – a cold water fish that marine mammals, seabirds, larger fish and humans rely on for food – will travel long distances to remain in water that is between minus 1 and 2°C. As the Bering Sea warmed in the 1970s, capelin shifted their range well north of seabird and marine mammal colonies on the Pribilof Islands, and essentially disappeared from the diets of these animals. Off the coast of south-west Britain, entire marine communities have shifted north by as much as 120 miles during periods of ocean warming over the last 70 years, and pilchard, the dominant fish in warm years, is less valuable for fishermen than the herring that they catch in cooler years.

Even a slight increase in global temperature is expected to shift the ranges of many economically valuable fish, including:

• Pacific and Atlantic salmon – unusually warm years have already led to poor Pacific salmon harvests in the southern part of their range.

• Cod, plaice, and halibut – these groundfish are expected to become scarce in US and southern Canadian waters, and cod are likely to disappear from the southern North Sea, one of their main spawning areas.

• Trout, whitefish, and bass – suitable habitat for these and more than 20 other cool and cold water fish in the US is expected to decline by as much as 50% due to the effects of global warming.

Warm water beckons unwelcome guests

■ As cool and cold water species decline or move poleward, fish that don't mind the heat will become much more common. Forty years of data from the Great Lakes (US and Canada) suggest that warm water species such as smallmouth bass will become 14 times more abundant than species like northern pike and lake trout if temperatures rise 2°C.

And the fish that stick around – and are already taxed by living in warmer water – will also have to deal with new species showing up on their doorstep. Many areas have been colonized by new species as water has warmed in the last few decades, and invasions are likely to increase, for example:

• In the north-western Mediterranean, which is traditionally cooler than nearby areas, new species such as the ornate wrasse, dusky grouper, and Senegalese sole have become common in recent decades, and tropical fish like the blunthead puffer have been spotted for the first time.

• In the temperate reefs of North Carolina (US), two new families and new species of tropical fish have moved in during the last two decades, while no new temperate species have been observed.

Tilapia from Africa competes with native species in Florida

• Twenty-seven fish species living in waterways south of the Great Lakes (US) are expected to invade the lakes as water temperatures rise.

Newly arrived species can wreak havoc in a number of ways. Introduced tropical fish in Florida (US) already harm native fish, and could move further north as water temperatures rise. Tilapia, a freshwater fish from Africa, competes with native fish for food and spawning habitat, and gobbles up eggs and juveniles, while larger predators like the jaguar guapote prey on native adults.

South Africa Anchovy fishery

Cape anchovy has dominated fish catches off of the South Africa Cape from the mid 1960s until fairly recently, generating revenues of about $50 million per year. However, climate change threatens to alter wind patterns in this region, affecting the anchovy fishery. It is projected that climatic changes over the western Agulhas Bank will decrease the frequency of Lasker events (periods of calm) by 20-27% and will likely be detrimental for anchovy spawning.

Watery layers that refuse to budge

■ Water may all look the same to us, but for fish, the world is made up of very distinct layers – each with its own temperature and supply of food and oxygen. In temperate lakes, as water near the surface heats up in the spring, it becomes lighter and floats on top of the cooler, denser layers below. More plants and animals live in the top layers, where nutrients are used up quickly, but oxygen diffuses in and is produced by aquatic plants. The cool bottom layers have less oxygen but lots of nutrients from decaying plant and animal matter, and they provide a thermal refuge for fish that find the summer surface waters too warm. As surface waters cool in the fall, they become heavy enough to drop down and mix with the bottom layers – this "turnover" moves nutrients up to the surface and sends oxygen below.

Water layers according to temperature – coral reefs and many lakes are susceptible even to small temperature changes.

Even the ocean cont ains layers that are affected by climate change.

As global temperatures rise, the top layers will become even warmer and lighter, making mixing harder. Earlier arrival of spring also increases the period of time when lakes remain layered, or stratified – lakes in Canada are now stratified for several weeks more each year.

Some lakes are even becoming permanently layered – Lake Ammersee (Germany), which has been well-mixed for the past 15,000 years, is expected to experience a dramatic and persistent lack of mixing, resulting from a predicted 1°C rise in European air temperatures.

When lakes remain layered, animals are starved of the nutrients and oxygen present in well-mixed lakes, and the fish that take refuge in cool bottom layers begin to suffer. As temperatures continue to climb, fishes like arctic char, lake trout and whitefish will have no choice but to crowd into bottom refuges that are smaller and have less oxygen, due to reduced mixing and their own increased metabolic needs. Competition for prey will intensify, and the stresses of low oxygen, low food supply, and crowding, combined with an increased chance of disease transmission, will make fish more susceptible to disease.

Not only temperate lakes are stuck with stubborn layering. Although temperatures in the tropics don't change much during the year, large, tropical lakes can become stratified because of their great depth, and lakes that remain stratified have less productive fisheries than those that are mixed by seasonal winds. Temperature increases over the last century have tripled the strength of stratification in Lake Tanganyika (Africa), and with less mixing the overall food supply has declined. Nearby Lake Victoria began experiencing decreased turnover in the 1980s, leading to low oxygen levels and huge fish kills. The stratification of this lake now appears permanent.

Even the ocean contains layers that are affected by climate change. Both temperature and salinity contribute to the density of seawater – cold, salty water is heavier than warm, fresh water. In the Gulf of Alaska, surface temperatures have risen and more freshwater is flowing into the sea from melting glaciers and increased precipitation. This lighter layer of warm, fresh water has reduced vertical mixing in the Gulf, and there are now less nutrients to feed the small organisms that fish depend upon.

A warm welcome for diseases and toxins

■ As water warms up, many parasites and microbes that cause fish diseases grow faster and become more virulent. Parasites in cooler climates are more likely to survive the winter and produce multiple generations of offspring each year, so more fish may become infected. And as harmful microbes and parasites become stronger and more numerous, fish whose immune systems are already stressed by warm water, low oxygen, and crowding, become even more susceptible to diseases and parasites.

Massive fish die-offs due to toxic algae and the risk of human illness from eating poisoned fish will also increase as temperatures climb. Lakes that remain stratified longer tend to have more blue-green algae, which produce toxins harmful to fish, their prey, and humans who consume the fish. Fish die-offs and human illness can also be caused by ciguatera fish poisoning, in which fish are poisoned by tiny organisms called dinoflagellates. A positive correlation has been found between sea-surface temperature and ciguatera fish poisoning in the South Pacific, and an increase in ciguatera poisoning in the Indian Ocean was linked to climate-related coral bleaching.

Warmer water increases the toxicity of pollutants, and as fish pump more water through their gills to meet increased metabolic needs, they also collect more pollutants. While warmer fish can flush out the extra load of some types of toxins, cadmium and lead levels remain higher in arctic char exposed to high temperatures, and fish in warmer water accumulate mercury more rapidly, even if only small amounts are present. Mercury poisoning is already a major economic problem for fisheries in Canada, Japan, and Scandinavia, and poses a significant public health risk. A recent study of 1700 American women of childbearing age found that blood mercury concentrations were seven times higher in women who ate fish more than twice a week, and because mercury is transferred directly to the fetus during pregnancy, 300,000 babies born each year in the US alone may be exposed to levels of mercury high enough to harm their neurological development.

Massive fish die-offs due to toxic algae and the risk of human illness from eating poisoned fish will increase as temperatures climb.

South-Eastern United States Rivers and Streams

Commercial and recreational fishing are big business in this part of the country. Catfish and trout are two of the biggest commercially cultured freshwater fisheries in the United States. Catfish alone are worth US$8 billion annually. High summer temperatures are already starting to limit their production in this region. A 2°C (3.6°F) rise in global average temperature is expected to shift many of the native species attractive to recreational anglers north out of this region as well. Invasive aquatic weeds (a US$13.2 million dollar problem in Florida already) are expected to spread throughout the region, as warmer winters allow for range expansions.

Tasmanian Calamary

Elevated temperatures accelerate the life histories of squid, increasing their growth rates and shortening their life-spans. The process of climate change will likely result in squids that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger and at a smaller size. Individual squid will require more food per unit body size, require more oxygen for faster metabolisms, and have a reduced capacity to cope without food. The southern calamary comprises about 8% of the total regional fishery but for the smaller coastal fishing towns on the east coast, it is considered very important.

How much are fish worth?

From left:
Trawler catch, Malaysia
Woman holds dried salmon, Russia
Pink salmon in Canada

Fish are food

■ Billions of people throughout the world rely on fish as a primary source of protein, particularly in developing countries with rapidly expanding populations. Worldwide, fish provide over 2.6 billion people with more than 20% of their animal protein, and are even more critical regionally; in Bangladesh, Congo, Equatorial Guinea, The Gambia, Ghana, Indonesia, Japan, Sierra Leone, and Sri Lanka, more than 50% of the population's annual animal protein comes from fish, while in Cambodia and Manaus (Brazil) this figure is as high as 70%. China, the most populous country on the planet, relies heavily on fish – it produces the world's largest supply of freshwater fish through aquaculture and consumes nearly one-third of the total fish eaten by humans worldwide.

Declining numbers of fish could have a devastating impact on human populations that rely on fish for protein, and may even endanger other wildlife. An 18-year study in Ghana revealed that during years when fish supply was low, sales of bushmeat (meat from a variety of wild animals) soared, poaching increased, and 41 species of wild, terrestrial mammals experienced sharp population declines.

Indigenous peoples in the arctic, where temperatures have risen dramatically, are already feeling the effects of global warming. Many communities have experienced recent changes in the distribution, abundance, and quality of fish they have historically relied upon. For example, decreases in arctic char and arctic cod have been reported in Hudson Bay, Canada. Residents of Baker Lake, Canada, have reported declines in the quality of local trout, and char-fish have less fat, smell different – "earthy" – and contain mushy meat.

Fisheries exports are especially important for developing countries, as these countries provide about 50% of the total fish that are traded internationally.

Fish are big business

■ The world's fisheries generate over US$130 billion annually, and contribute significantly to the economies of many countries. Fisheries products dominate the exports of Greenland, New Zealand, Iceland, and many small island nations, and make up a substantial fraction of exports for countries in Central and South America, Africa, and Southeast Asia. Fisheries exports are especially important for developing countries, as these countries provide about 50% of the total fish that are traded internationally. In many developing countries, fisheries now top other agricultural commodities like rice, cocoa, tobacco, and tea. Overall, fisheries trade tends to flow from less developed to more developed nations, with Japan, the US, and countries of the EU importing the most fish.

Even where fisheries are not important on a national level, they can be critical for regional employment, where entire communities of small-scale fishermen rely on fishing as their primary source of income. In the Tamil Nadu region of southeastern India, one third of the population depends on the sea for their livelihood, and average incomes declined by 50% when false trevally (the most valuable local fish) suffered a sharp decline blamed partly on climate change. Worldwide, over 38 million people earn an income by fishing or raising fish, and if activities associated with fisheries production are included, fisheries support over 200 million people.

In industrialized countries, recreational fishing also provides a large source of income. Forty-four million anglers in the US spent US$41.5 billion during 2001, producing over a million jobs in tourism and recreation, and providing nine times the overall economic input of commercial fishing. In the UK, recreational anglers spend approximately US$3.4 million per year, and in South Africa, recreational fishing provides over 80% of the income from all fishing activities.

Which fish are feeling the heat?

Polar marine fish

Polar species are uniquely adapted to narrow, cold temperature ranges and well-oxygenated water, making them vulnerable to even slight increases in temperature. Some species, such as the emerald rockcod and striped rockcod, are killed when temperatures climb only a few degrees above 0°C, and many Antarctic fish lack heat shock proteins – molecules that most animals have to repair cellular damage caused by heat. Arctic cod and other species associated with rich ice-edge communities already appear to be declining as polar ice melts and their habitats disappear.

Freshwater fish that are geographically isolated

Freshwater species that cannot migrate to cooler waters as temperatures rise may be stuck in hot water. Migration is impossible from many isolated lakes and wetlands, and many major river systems worldwide run from east to west, making poleward migration impossible. Nearly all major river systems in the southern Great Plains and southwestern US for instance run from east to west, and native fishes are already living near their thermal tolerance limits in some of the hottest free-flowing water on earth. Increased warming could lead to the extinction of up to 20 species that are found nowhere else in the world.

Coral reef fish

Coral reefs support a huge diversity of fish and contribute about one quarter of the total fish catch in developing countries. Climate warming leads to coral bleaching – the loss of symbiotic bacteria that corals depend upon. In 1998, mass coral bleaching destroyed 16% of the world's coral reefs. Significant changes in the abundance of some fish have been observed where intense bleaching has occurred, and fish that rely on live coral to survive have shown little recovery from these events.

Fisheries resources may become less predictable as extreme weather hits more often.

How will fisheries change?

■ Some of the most severe impacts of global warming (at least from a fish's perspective) may be related to changes in climatic variables other than temperature – changes in rainfall and evaporation that alter lake levels and river flow, changes in ocean and wind currents, and increases in mean sea level. But even based on the effects of temperature alone, it seems likely that fish will become smaller and harder to find, and valuable cool and cold water species will begin to be replaced by more adaptable (and often less valuable) warm water fish.

Aquaculture, which supplies over 30% of the fish consumed by humans, may suffer as certain areas lose the ability to culture species that they currently farm. A temperature increase of only 1°C could devastate the US$100 million catfish industry in the southern US by shifting the southern limit of viable catfish production 240km north, away from dependent local communities and established infrastructure.

Fisheries resources may become less predictable as extreme weather hits more often. Events like the 1972-73 El Niño that put 1500 boats, 200 processing plants, and 100,000 people out of work in the Peruvian anchoveta fishery are likely to increase in frequency and severity because of climate change.

And many fisheries resources will permanently shift location as water temperatures rise. Large, commercial fleets that can follow the fisheries may not be as strongly affected as local, small-scale fishermen, who will have to adapt their gear and methods, travel further, and fish longer to continue providing enough food for their families and local markets.

Large image: Rocky shore in the Bering Sea, Arctic

Top: Fisherman in Zanzibar Island, Tanzania

Below: Fishermen in Bazaruto Island, Mozambique

Right: Pacific Halibut on fishing boat in Alaska, USA

2°C is too much!

■ In order to preserve the diversity and abundance of fish – one of our most valuable biological, nutritional, and economic assets – we must keep global warming below dangerous levels. This is also crucial to help fish recover from threats like overfishing and the destruction of their habitats. WWF seeks to limit global warming of average global temperature to below 2°C (3.6°F) over pre-industrial levels.

Carbon dioxide (CO_2) is the main pollutant causing climate change. It rises through the atmosphere and captures heat, intensifying the effect of the greenhouse gases that keep the earth warm. This has dramatic consequences for the globe's climate system – more extreme weather like droughts, floods, and storms; rising sea levels and changes of large ocean currents, and changes of regional weather systems during events like El Niño.

Top left: Veranda with solar panels, NSW, Australia

Top right: Modern windmill in Castilla-La Mancha, Spain

Below: Solar power station in Chiang Mai, Thailand

What needs to be done?

• Industrialized countries need to cut their CO_2 emissions as obliged under the Kyoto Protocol, and all must agree to much more serious emission reductions in the next period, after 2012. To stay well below the 2°C danger threshold they must reduce their emissions by 60-80%. The rapidly industrializing countries also need to lower their emissions while meeting their development goals by 'leapfrogging' into clean and efficient technologies. This will only be possible when developed economies – governments as well as the business and financial communities – engage in this endeavor.

• The single largest source of man-made CO_2 is electricity generation, accounting for 37% of worldwide CO_2 emissions. The first step to move to a clean energy future is to clean up the power sector – the aim of WWF's PowerSwitch! campaign. The campaign challenges the coal-burning power sector to cut climate pollution and aims at sparking a major switch to clean power by 2006 in at least 12 countries.

• Governmental and private aid agencies are starting to take climate-related impacts and catastrophes seriously. Comprehensive strategies to build resistance and resilience to climate change impacts need to be developed – for threatened communities as well as for nature reserves. All this must happen while curbing CO_2 emissions rapidly, as resilience building can only buy some time and becomes an insurmountable challenge if global temperatures are allowed to rise too high.

Young Aleutian girl, Alaska, USA

Tuna fishing, Spain

Horned puffin, Alaska, USA

Climate change threatens fish and fisheries as temperatures rise in oceans, lakes and rivers.

WWF THANKS THE FOLLOWING PHOTOGRAPHERS:

Cover: Michel Roggo
Page 9: Steve Mason, Gettyimages

WWF-Canon:
Page 2/3: Michel Gunther, Edward Parker, Zeb Hogan; Page 4: Zeb Hogan, Michèle Depraz; Page 5: Ian Hudson, Thomas Neumann, Jürgen Freund, Michel Roggo (2), Isaac Vega, Internet; Page 6: Carlos Vallecillo, Jürgen Freund; Page 7: Edward Parker, Stefan Wassmer, Michel Gunther; Page 8,9: Jürgen Freund, Dr Gretta Pecl, Michel Roggo, Hartmut Jungius, J.C. del Olmo; Page 10,11: Jürgen Freund, Vladimir Filonov, Michel Roggo; Page 12,13: Kevin Schafer (2), Martin Harvey, Frederick J. Weyerhaeuser; Page 14,15: Adam Oswell (2), Carlos Vallecillo; Backcover: Kevin Schafer (2), Jorge Bartolome

WWF Climate Change Programme

Jennifer Morgan
Director
morgan@wwf.de

Martin Hiller
Communications manager
mhiller@wwfint.org

More information, the two scientific WWF reports and the case studies are available at www.panda.org/climate/fish

The list of references for this brochure can also be found on this website.

Take action at www.panda.org/powerswitch

Author: Stacey Combes
The text of this brochure includes contributions from Chris Myrick, Joe Cech, Michael Case and Lara Hansen.

Editor: Martin Hiller
Design: Wassmer Graphic Design Nyon
Printed by: RichArts Graphiques, Gland
Paper quality: Aconda FSC 170gm^2

Published in July 2005 by WWF, the global conservation organization, Gland, Switzerland.

Any reproduction in full or in part of this publication must mention the title and credit the above-mentioned publisher as the copyright owner.

© text (2005) WWF All rights reserved.

WWF

for a living planet®