Chapter 17

Cultural eutrophication: perspectives and prospects

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17.1 History of cultural eutrophication

Cultural eutrophication is old as *Homo sapiens*. In particular after the introduction of agriculture and larger settlements eutrophication has been mans faithful companion. During the pre-agricultural hunting and picking stage only probably a couple million humans inhabited the world and cultural eutrophication was negligible. The 3 orders of magnitude increase in population has changed this considerably. Human population growth and mans present existence is entirely based upon the development and efficiency of agriculture. Seafood delivers only a small percentage of human food word wide (see Chapter 15). A consequence of the increased population (based on agriculture) has been large-scale cultural eutrophication. This process has accompanied all major civilisations. Mesopotamia, the Golden Crescent, the Mediterranean cultures, central Europe, North America and China all have been affected/suffered from the effects of cultural eutrophication. Some of us may dream about the good old times of the Middle ages when man lived closer to nature, when the word appeared to be 'greener' than today and when life was more 'natural'. This view is based on a misunderstanding. The present eutrophication of the Baltic and North Sea was preceded by similar or even worse eutrophication periods caused by logging and the introduction of large-scale agriculture in Europe. Medieval cities were probably not only unsanitary, but contaminated by organic wastes, nutrients and heavy metals. The cultural eutrophication in major cities must have been immense, far beyond today's imagination. A good example of the ambience of Paris in medieval times is portrayed in Patrick Suesskinds novel 'Perfume'. Cultural eutrophication is thus not a recent phenomenon. It has continuously accompanied mans existence in variable degrees. Locally cultural eutrophication can have been far more significant than today.

The earth's recent development is characterised by accelerating population growth, human migration and immigration patterns (Figure 17.1), mod-

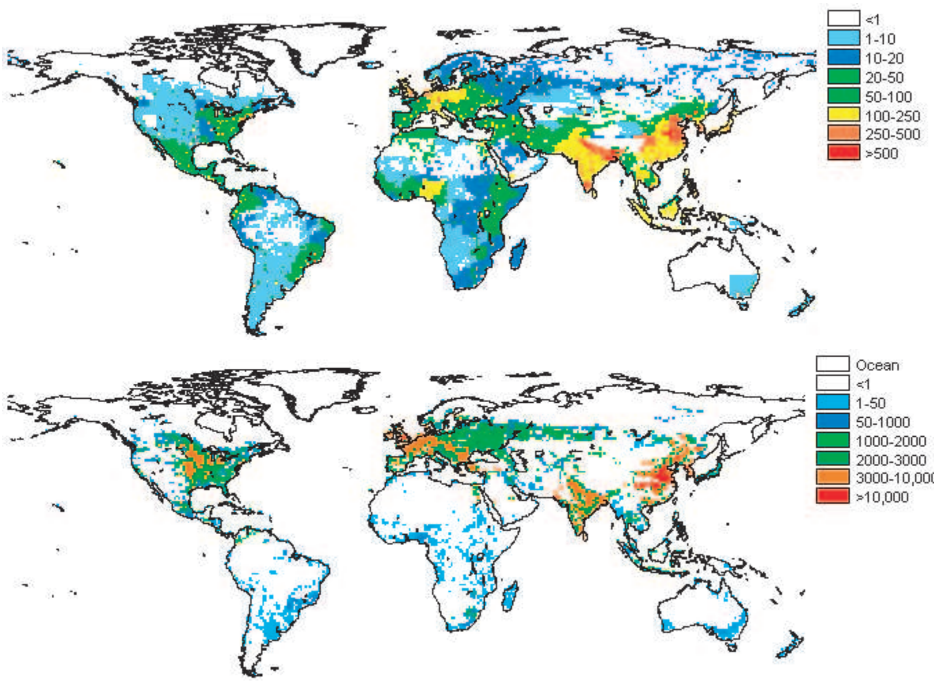

Figure 17.1: Upper panel. Population in 1990 (persons km^{-2}). Lerner et al. 1988; updated to 1990 by Bouwman, based on U.N. statistics. Lower panel. Nitrogen fertilizer use in 1990 (kg N km^{-2} y^{-1}). Bouwman et al. (1995) and FAO statistics. Remark the high fertilizer application in north-eastern North America and central Europe that is not accompanied by high population density. In the case of India and China the population density is high, but the fertilizer application is moderate. In Africa and South America the application of fertilizers is low relative to the population density.

ern agriculture and fundamental changes in nutrient and water cycles. Cultural eutrophication has become a global issue, in particular due to interference with the local and regional nutrient and water cycles. Substantial amounts of nutrients are discharged into rivers, lakes and estuaries. They reach the ocean more and more rapidly. Eutrophication is thus, in general, highest in the estuaries as nutrient concentration and population density increases along the rivers pathway from the interior to the coastal zone.

Many industrialised countries import not only fertilisers but also nutrients in the form of food. Often they even import the limited resource water in the form of food. For example, 1 kg of wheat demands 1 m^3 of water; 1 kg of rice needs 2 m^3 of water while 1 kg of beef requires 10 m^3 of water. Densely populated countries that have the financial means to buy food from outside, e.g. the Netherlands with plenty of water, is a large-scale importer of water. Thus not only nutrients and biomass are moved over long distances, connections between otherwise separated ecosystem, biogeochemical cycles and resource-limited societies are established. Many of the most developed countries are net-importers of nutrients, in particular nitrogen. The nitrogen supply can be several times greater than the natural standing stock, and that inevitably results in eutrophication. Resources from obviously resource-limited regions (food, water, and fertilisers) are deviated into resource-rich ones. However, here they can cause large-scale eutrophication.

The focal point of cultural eutrophication is the fundamental changes in cycling of carbon, nutrients and water. The recirculation inside small region that was characteristic for the ecological setting in earlier days when the means of transportation were limited, is changed and the nutrient and water circles are first *opened* (i.e. the natural space and times scales are exceeded) and subsequently *widened* to global scales. Due to this the biogeochemical cycles are significantly changed. Stored carbon (coal, oil, gas, wood, soil) are reassigned with the consequence that the atmospheric CO_2 concentration has increased from 240 to 380 ppm since the industrial revolution (Figure 17.2). We move phosphorus in the form of apatite from the Kola Peninsula to cover the worlds needs for phosphate. We fix nitrogen gas from the atmosphere in similar amounts than nitrogen fixers (Figure 17.2). We dam and channel rivers, change their discharge patterns and focus sewage into sewers. By fracturing existing biogeochemical and water cycles we change the original cycling, introducing a new, global cycling pattern that changes the overall functioning of the globe. Despite that nutrient discharge can be minimised by effective management in the drainage area, losses inevitably occur. Human population growth, altering global biogeochemical cycles, and increased eutrophication are therefore two aspects of the same cause.

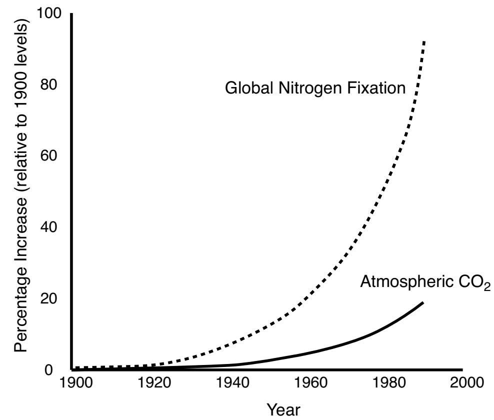

Figure 17.2: The relative change in nitrogen fixation caused by human activities globally compared to the relative increase in carbon dioxide in the atmosphere since 1900. Note that humans are having greater influence on nitrogen availability than they are on the production of carbon dioxide, an important greenhouse gas (modified from Vitousek *et al.* 1997).

17.2 Cultural eutrophication: regions, ecosystems, changes and organisms

An important concept for cultural eutrophication is the residence time of nutrients in the recipient. Low water exchange results in high residence times and that increases the effect of the supplied nutrients and vice versa. The volume of the recipient influences its flushing time that determines the nutrient residence time (Figure 17.3). In addition the supply rate by discharge from the drainage basin influences the degree of eutrophication. In concert these factor can give rise to a large range of eutrophication scenarios, both on an annual and seasonal scale. High residence times will be encountered in land locked ecosystems such as fjords with high sills, the Baltic Sea and the Black Sea, while shallow regions or enclosed regions with lower threshold such as the northern Adriatic, the North Sea, Kattegat and many Norwegian fjords take an intermediate position. The degree of eutrophication is determined by the supply rate of nutrients. If the supply is high, such as the Kattegat, Baltic Sea, southern North Sea and certain estuaries and fjords, the combination of highs supply and increased residence times create a scenario for extensive cultural eutrophication.

If the organic matter supply is greater than the degradation and oxygen reserves or its hydrodynamic supply seasonal or long-term hypoxia or anoxia will develop. This phenomenon has been encountered in increasing frequency and has been often been interpreted as a sign of eutrophication although changes in vertical mixing and stratification also can cause hypoxia or anoxia. Further, an increasing Harmful Algal Bloom (HAB) frequency have been interpreted as a consequence of eutrophication (Figure 17.4; see also Chapter 7). In the Seto Inland Sea, one of the most important aquaculture regions in Japan, a large-scale increase in HABs was encountered from the 60s and onwards. Increasing control of the effluents in the region in the 80s and onwards has resulted in a sharp decrease in HAB. However, it is not easy to indicate with confidence if the increased frequency of HABs all over the world is accelerated by eutrophication. For this we have too few reports from the days prior to aquaculture and to few long time series of phytoplankton. HABs have been observed throughout the times: The first HABs report can be found in the Old Testament (Exodus 7: 20-21). "...and all the waters that were in the river were

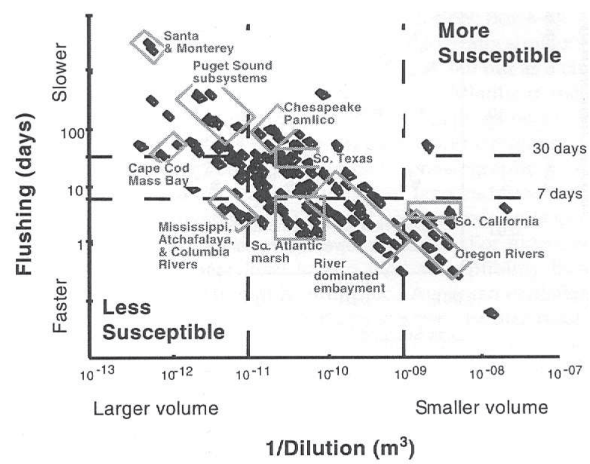

Figure 17.3: Coastal systems can be classified according to their dilution and mixing capabilities. Here 138 coastal systems of the U.S. are classified according to dilution (volume of estuarine water above the pycnocline) and flushing (based on time to replace estuarine volume by freshwater inflow or tidal prism volume). Coastal systems falling in the lower left region of the graph are those with extreme large dilution volumes and short flashing times. One can expect these systems to be least susceptible to eutrophication. Systems in the upper right region of the graph have the smallest dilution volumes and longest flushing times. One can expect these systems to be most susceptible to eutrophication. From Anonymous (2000).

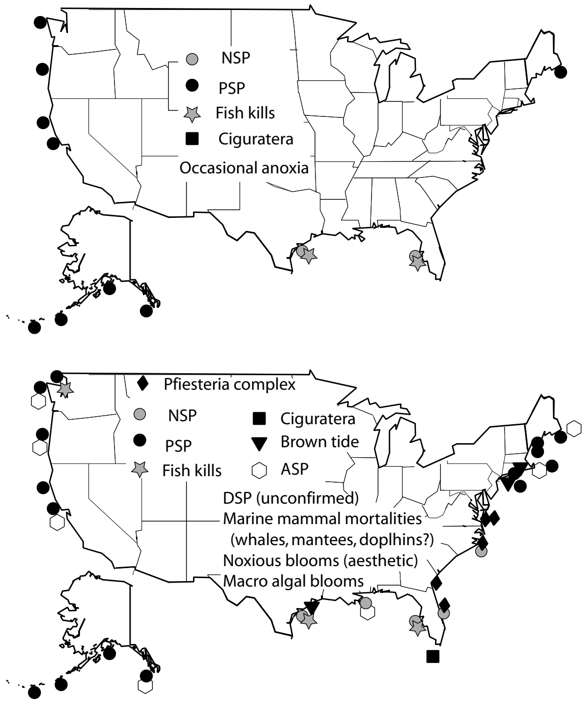

Figure 17.4: Expansion of harmful algae bloom (HAB) problems in the U.S.. These maps depict the HAB outbreaks known before and after 1972. This maps are rather indications of outbreaks than exhaustive compilations of all events. Remark the increasing frequency of HAB events along the coast with the highest population densities. There has been no increase in HAB event frequencies in low-populated regions such as Alaska and Hawaii. NSP = Neurotic shellfish poisoning; PSP = Paralytic shellfish poisoning; ASP = Amnesic shellfish poisoning. From Anderson 1996 and Anonymous 2000.

turned to blood. And the fish that was in the river died; and the river stank, and the Egyptians could not drink the water of the river ...". On the background of the extensive changes in ecosystem structure and composition increased HAB frequencies seem most likely.

Advent of opportunists and introduced species in eutrophicated regions is well known. For example, 3/4 of the benthic biomass of the Rhine River is comprised by inadvertently introduced species. There is great concern worldwide what happens to lacustrin and marine ecosystems under the impact of introduced and alien species. The number of alien species, often introduced by ballast waters, transport of aquaculture organisms, channels

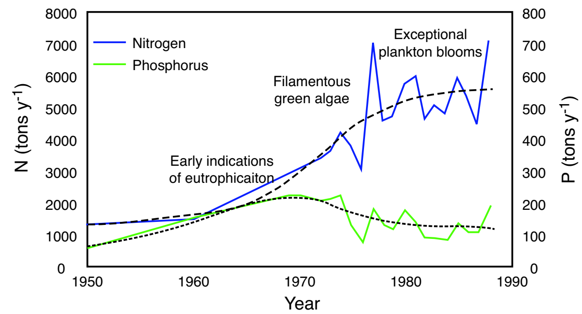

Figure 17.5: Emission of nutrients to Laholm Bay, Sweden. Note the increasing difference in P and N emission. Three phases of eutrophication are indicated: Early indications of eutrophication (colour, visibility), filamentous green algae and exceptional plankton blooms (accompanied by fish kills). From Rosenberg et al. (1990).

or voluntary introduction, is ever increasing. The long-term consequences are more or less unknown.

17.3 Phases of cultural eutrophication

We distinguish between three principle, consecutive phases: (A) enrichment phase, (B) initial and secondary effects and (C) extreme and ultimate effects (Figure 17.5). During the enrichment phase increases in pelagic and benthic biomass, fish and mussel yields are recorded. There are several lines of evidence that moderate eutrophication can result in increases in harvestable production and resources attractive to humans. Thus moderate eutrophication can be considered beneficial if increased harvest of fish and shellfish is the focus of our attention. In each ecosystem, there is a level of nutrient availability over which no increase in harvestable resources takes place. This is by definition the end of the enrichment phase. 'Points of no return' (beyond these the ecosystem does not return to its original state after a driver such as nutrient supply is reduced) lay somewhere between B and C.

When the enrichment phase comes to an end the initial and secondary effects of eutrophication become visible. There exists an entire range of phenomena and processes that are characteristic for the second phase of eutrophication. We can observe changes in species composition, e.g. certain benthic algae disappear or certain polychaets domiante. Similar processes can be observed for phytoplankton species. In the Southern North Sea extensive blooms of *Phaeocystis globosa* reflect eutrophication (see also Chapter 20). Further, the increase in relative contribution of flagellates to the phytoplankton biomass is interpreted as a sign of eutrophication, reflecting increased N and P supply while that of Si declines, mainly due to dam constructions (for Si decline see also Chapter 13). Reduction in light penetration caused by increased bloom density and turbidity decrease the depth of the euphotic zone and reduces the area where benthic algae prosper. The increasing frequency of hypoxic episodes belongs also to the initial and secondary effects of eutrophication.

The phase of extreme and ultimate effects is characterised by the large-scale disappearance of sensitive species and that opportunists take over. Mass proliferation of benthic algae such as *Ulva* and *Cladophora* are also characteristic for this stage. Mass mortality and anoxia are the ultimate stage of eutrophication.

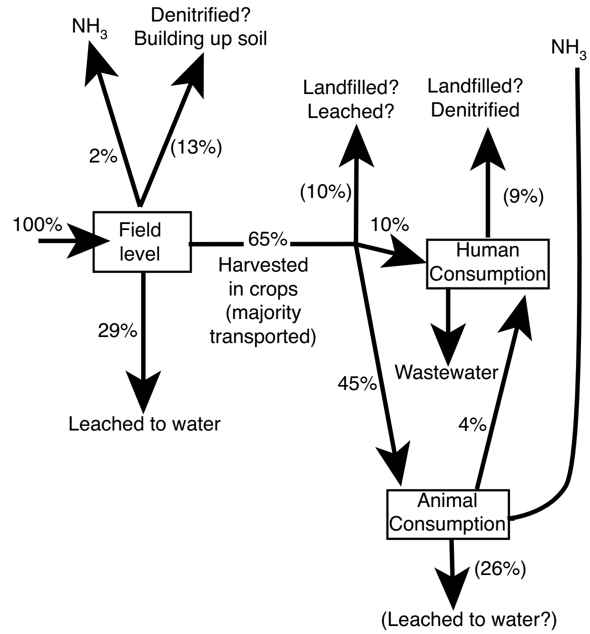

Figure 17.7: The average fate of nitrogen fertilizer applied to agricultural fields for North America. The numbers in parentheses are calculated by difference, and the other numbers are direct estimates. Remark that man only consumes 15% of the applied nitrogen fertilizer, that 46% is leaching into water, that 17% is emitted to the atmosphere. Note also that production on fields, husbandry and human consumption most often take place in separate region, connected by transport. From Anonymous (2000).

17.4 Evaluating the sources of cultural eutrophication

The natural sources of nutrients (streams, lakes, rivers) derived from natural (erosion) and human activity. Today the flux of nutrients from their sources to the coast is strongly influenced by anthropogenic activities. Human population growth does not cease in the near future and in all already high agricultural production regions (such as the U.S., central Europe, but in particular in India and China) the application of fertilizers will in crease (Figure 17.6). In addition, clear-cutting trees, drainage of wetlands, fertilising fields and meadows, intensive husbandry, building dams and towns, in essence all anthropogenic activities, contribute to the prevailing picture of cultural eutrophication (see Chapter). Only a small fraction of applied fertilizers ends up in human food while most is discharged to streams and the atmosphere (Figure 17.7; Chapter 2). The main nutrient sources are diffuse with agriculture as the contributor. Point sources such as towns play a moderate role in the complex scenario of nutrient discharge. The so far strong dedication to reduce eutrophication through point sources such as towns and factories implies that the most important sources for eutrophication have not been sufficiently focussed upon. Even in industrialised countries the main contribution of nutrients derives from agriculture, husbandry and forestry.

As an example we select intensive husbandry with Denmark as an example. Here are 13 million pigs that produce faeces and urine corresponding to 3 person equivalents. Pig farms alone produce probably 6 times more nutrients in Denmark then its population, which is connected to sewer

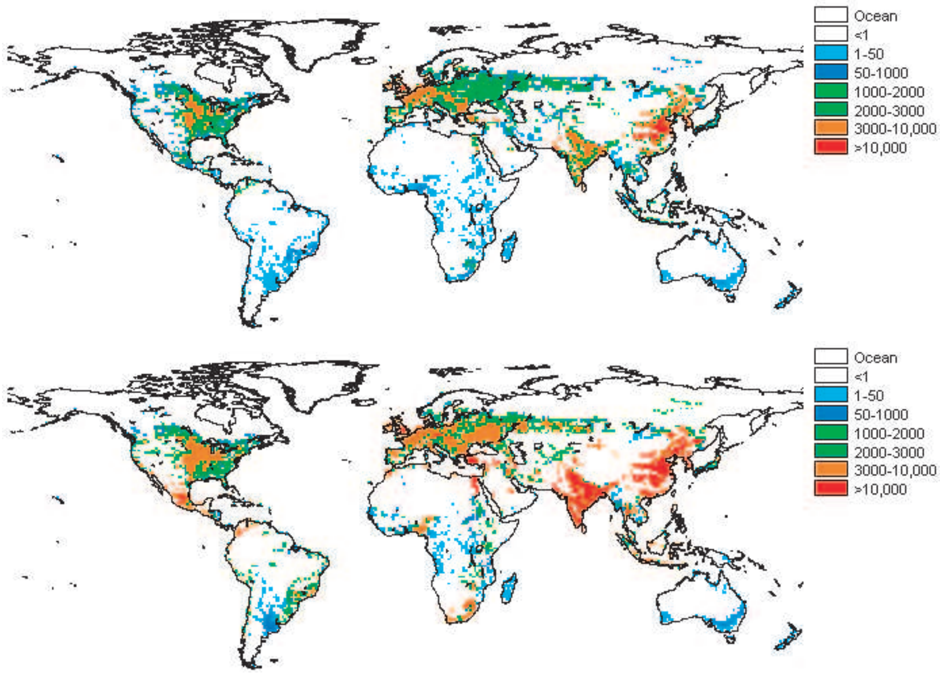

Figure 17.6: Nitrogen fertilizer use in 1990 (upper panel) and prediction for 2050 (lower panel) (kg N km^{-2} y^{-1}) Bouwman et al. 1995 and Bouwman 1997. Note the significant increase in future fertilizer consumption world wide, but particular in India, Eastern Europe, Turkey, Egypt, Mexico and South Africa.

systems. In addition there is the remaining husbandry and extensive agriculture production. In total, person equivalents of more than hundred million persons are discharged into the Danish aquifer and the coastal zone. Some of these millions are channelled through sewer systems, but the majority is discharged without significant limitation. Eutrophication of Danish coastal waters is thus not surprising. Locally towns and smaller settlements may cause it, but on a larger scale it is the agricultural practice, the intensity of crop growing and our choice of food (meat vs. vegetables and cereals) that determine most of cultural eutrophication. Sustainability in the coastal zone is thus, bye and large, a question of how we produce food, which food we prefer and what environmental constrains we select for the environment we live in.

Recent investigations indicate that 30% or more of the annual nitrogen supply can come from the atmosphere and burning of oil/gas and intensive husbandry are the reason. Everybody contributes to this large-scale eutrophication. Point sources of nitrogen are of minor significance (in the case of Denmark only 3%) while 66% derive from river discharge with agriculture as the main contributor. Should we attempt to reduce cultural eutrophication we must start where the gain is greatest. Thus we have to attempt to reduce the diffuse emission of nutrients and not focus mainly on the point sources that do only play a minor role in the total picture. This implies that the emissions from agriculture into aquifers and the atmosphere have to be reduced and regulated. There is no indication that this can take place in the near future. Little public debate about this matter exists and attempts to create such a debate in the media appear to result in no major public interest. We have to confront us with this debate if we wish to have an adequate opinion about sustainability.

17.5 An adequate understanding of cultural eutrophication

An adequate understanding of eutrophication is for the moment not effortlessly available. The main reason for that is the fragmentation of interest, education and responsibility. Despite of a basic understanding how nutrients flow through an aquifer and into the coastal zone, there exist few institutions and composite research groups that study the entire route and the involved processes simultaneously and from a superior perspective. Eutrophication of the coastal zone, freshwater, run-off from forests, agriculture, industry and sewage treatment are usually dealt with by different scientist and institutions that have few contacts. Education of students and scientists is separate too and we have at present not the adequate expertise and the will that binds the different sectors together.

While industry and citizens pay taxes for the damages of the environment to the costs for sewage treatment plants no such costs are imposed on the by far main contributor of cultural eutrophication, i.e. agriculture and in certain regions forestry. The public focus is directed to point sources that play only a minor role. While industry and cities give raise to environmental problems, the most significant contributors to cultural eutrophication are characterised as nature friendly. Sector thinking prevents holistic solutions or accomplishments that are proportional with the environmental damage. For an environmental impact that has probably a most important environmental effect (Gesamp, 1991) and occurs virtually worldwide, this inadequacy is surprising. A public debate that attempts to focus upon the most important global environmental effect, that is not characterised by sector interest, and that does not hesitate to focus upon the key problem, is indispensable. Emphasis has to be given to normal praxis regarding negative environmental impact — i.e. the polluter pays for the negative environmental effects. The greatest contributor to cultural eutrophication is exempted from this obligation, probably because the public is not aware of the full extent of the problem and is afraid to pay more for food. However, food has become a comparatively minor cost in our budget. In addition, all industrialised countries significantly subsidise agriculture. It must be puzzling that many societies subsidise activities that can cause anoxic bottom waters, reduced water quality, harmful algae blooms, reduced fisheries, prevent aquaculture etc. Obviously a holistic perspective is needed to solve this apparently invincible dilemma. At the end of the day we all pay for our approach to deal with cultural eutrophication, either through food costs, subsidies, environmental taxes or a negative development of the environment.

Assuming a connection between agriculture subsidies and increased production, taking notice of the lack of nutrient discharge appropriate limitations from agriculture and husbandry and considering the consequential eutrophication, a connection exists between subsidies, demands for inexpensive food, decreased environmental quality, reduced fisheries and increased HAB. Can removal of agricultural subsidies give rise to increased costal zone environmental quality and fisheries? It is timely to promote these type of questions and study the complete costs of food production and environmental losses.

17.6 Remediation of cultural eutrophication

An obvious mode to reduce the effects of cultural eutrophication is reduction of resource use in the drainage area. This could be achieved by a reduction of fertilisers use and limitations of husbandry. An obvious step would be to reduce nutrient discharge to the aquifer. This implies that steps are taken that effluents from fields, intensive husbandry towns and factories are strongly regulated. By regulating gullies and tiles in agricultural regions significant declines of nutrient discharge can be achieved (Figure 17.8; Chapter 2). With regard to point sources removal of nutrients by additional sewage plants could be an option. Low-price biological removal plants should be considered. Harvesting weeds in ponds and bringing them back to the fields or include them into compost is an option that is not adequately considered.

In marine environments growing blue mussels in river mouths can reduce eutrophication. By removing the rapidly growing mussels and transport them into the aquifer (compost, waste disposal sites etc.) the nutrient residence time can be significantly increased (see also Chapter 15). This is an efficient and low-cost manner to decrease the discharge of nutrients into coastal regions. One can also decrease the direct discharge of effluents to small rivers and streams by planting bushes and trees, which in recent decades have been removed by agricultural means to increase the farm area. To collect water from ditches that drain the tillage from fields into dams, is another manner to decrease direct and rapid losses of nutrients from agriculture (e.g. Figure 17.8). Taking fields out of production and destroying tillage is still another option that should be considered in times when overproduction of food is a predominant characteristic of agriculture in Europe.

A natural manner to get rid of nitrogen is denitrification. How can we increase denitrification in a drainage area? Denitrification is highest in waterlogged soils that are not efficient for agriculture. The height of water in ditches, the presence of dams and the amount of wetlands are important aspects of increasing denitrification. In many cases converting fields into wetland implies transferring them back into their original state. Often wetlands and waterlogged soils have been converted into farmlands previously. Wetland restoration is by far the most efficient and cheapest manner to reduce nitrogen supply to rivers and coastal zones, with ramifications for biodiversity and ecosystem variety.

The increasing imbalance between nutrients is of major concern. While nothing can be done with the decreasing discharge of Si unless dams are removed, the balance of the N and P discharge could be improved. So far the major goal has been to

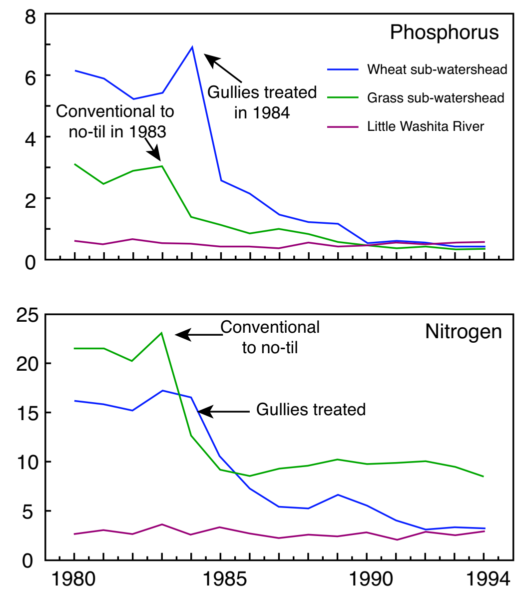

Figure 17.8: Annual nitrogen and phosphorous loss into the Little Washita River from a wheat- and grass-dominant sub-watershed. Note the reduction in both nutrients after the eroding of the gullies in the grass watershed were treated in 1984 and conventional tillage was replaced with no-till in 1983 in the watershed growing wheat (modified from Sharpley and Smith 1994; Sharpley et al. 1996, from Anonymous 2000)

reduce nutrient discharge *per se*. While this is a first, important step, the next must be to figure out if the discharge of N and P could be closer to the Redfield ratio to achieve a more environmental friendly composition.

The basic goal for reducing the eutrophication in streams, lakes and coastal waters is fist of all to increase their residence time on land and omit the present short-circuits in the nutrient cycles. This would decrease fertilizer use and result in a higher net-utilization of nutrients by man. Returning marine biomass back to the drainage area and spreading human and animal excrements efficiently in the drainage area is an option that has been previously applied and should be reconsidered. Decreased meat consumption (Figure 17.8) or more spread meat production are additional options that would decrease nutrient discharge.

17.7 Controlled cultural eutrophication and aquaculture

Agriculture has been the backbone of human existence that created the base for the 3 orders of magnitude increase in human population. While intensive agriculture often is considered negative for the productivity in adjacent aquatic environments (e.g. too high nutrient supply, major deviations in nutrient composition, large-scale modifications of water sheds and water supplies) the exploitation of aquatic ecosystems in Europe has until recently been dominated by various forms of fish and shellfish. Compared to agriculture, fishery is still based on the hunter and picker approach that agriculture left several thousand years ago: wild resources are exploited rather than cultivated. While various aquaculture techniques, often in combination with agriculture, have been widely applied in many countries (e.g. China and Japan), aquaculture in sea- or landbased enclosures first developed into a major economy in European countries in recent decades. Aquaculture can now be of similar or even greater significance than natural fish and shellfish catches. The majority of marine fish aquaculture depends on feed that derives from natural fish resources. The supply of nutrients that causes eutrophication in coastal regions may support a higher fishery, but this effect has not been quantified. One problem is that the nutrients are not added in close to Redfield ratio proportion and that pollutants such as heavy metals, pesticides and detergents are dumped in concert with the nutrients. For a general discussion of marine production and seafood; see Chapter 15.

Is it possible to leave the 'hunter and picker stage' of fisheries and introduce aquaculture in the meaning of agriculture, i.e. fertilising a region, manipulate the organisms and channel the nutrients into crops that are harvestable items of human food consumption? Can we control the fertilisation of aquatic recipients by using a limiting resource (i.e. nutrients), which at present is dumped into what we wish to be pristine regions or can we generate a controlled fertilisation of certain regions by adding fertilisers? Could we turn the waste of resources that result in eutrophication into a benefit, resources that benefit humans? The lack of knowledge how nutrients are channelled through manipulated food webs prevents extensive sustainable aquaculture in the foreseeable future. However, it is important to investigate the base for a future aquaculture (see Chapter 15), in parallel with the development of agriculture that took place several thousand years ago. There is no reason to assume that aquatic environments are in essence so different compared to terrestrial environments that significant aquaculture should be out of question. In particular not in a world that is short in food.

To build up a modern aquaculture know-how that would allow extensive aquaculture if the need arises would be a good investment in future prosperity of coastal populations. This knowledge would simultaneously contribute to a better understanding of eutrophication. Some attempts to obtain such knowledge have been already obtained by the MARICULT programme (see Chapter 15). To endeavor a controlled fertilization of coastal waters (in contradiction to our current uncontrolled experiment) to be subsequently utilized by fisheries or extensive aquaculture is an approach that has not found wide acceptance. On the contrary, the common attitude is rather to prevent eutrophication of coastal water or dump nutrients at depth. This attitude is opposed to use the already and in most poor regions of the world perpetuate eutrophied coastal waters for extensive aquaculture, in analogy to agriculture. There exists a conflict between the wish to (a) experience non-eutrophied coastal waters, (b) to use these waters eventually for aquaculture and fertilize them and (c) todays approach to dump nutrient at large-scale without considering (a) or (b). It can be questioned if option (b) is the best manner to cope favorably with the negative aspects of eutrophication. This in order to support the sustainability of the coastal zone that is rapidly decreasing in many regions (e.g. some estuaries and fjords, the southern North Sea or the 'death zone' in the Gulf of Mexico).

In Japan where aquaculture has played a vital role throughout the last thousand years examples exists showing that eutrophication and aquaculture can co-exist without destroying the long-term integrity of aquatic ecosystems. Edo, the capital of Japan during the Tukagawa regime (at present Tokyo), was densely populated and transported manure from the city to fields outside the town. Also, they harvested the undoubtedly eutrophicated bight outside the city through extensive aquaculture establishments (e.g. scallops, fish, seaweed etc.). The discharge and cycling of biomass and nutrients was so balanced that no negative episodes of eutrophication (e.g. HAB, anoxic bottom water) have been reported. The wisdom concealed in the case of Edo reflects a balanced solution, in a setting where resources (here nutrients/food) were strictly limited. The example shows that sustainable development is possible if appropriate techniques are applied. In many respects eutrophication functions like the waste of a limited resource, in this case nutrients. In a phase of our development characterised by excessive use of resources, phenomena such as eutrophication are difficult to omit. In times to come, when the negative consequences of our resource mismanagement will become difficult to cope, and resource and food shortage are difficult to deal with, the waste of nutrients and the accompanied negative effects have to be carefully evaluated. Extensive aquaculture combined with recycling of nutrients back to arable land may be one option to alleviate this conflict.

17.8 Epilogue

It is obvious that cultural eutrophication is tightly coupled to the development of man, his techniques, food production and dietary habits. Can cultural eutrophication be omitted as long as *Homo sapiens* exists? The answer to this question is frankly no. With few exceptions (the utmost outskirts of civilization) the surface of the earth has been transformed from nature into a cultural landscape. Not so visible for the human eye also the sea has been turned into a cultural landscape. We have various forms of marine pollution that can be encountered worldwide. We reduced the number of large mammals in *Homo sapiens* earliest days and recently also overfishing has taken place: Medium- and large-sized fish have declined to about 25% of what was found in the 50ties. The seafloor has become a deposition site for scrap, dredged material, constructions, ammunitions, chemical waste etc. Each m^2 of the North Sea or Kattegat is subjected to bottom trawls several times a year. What we in colloquial terms call *nature* is to a large extent actually *culture*, also in the ocean. And with regard to the latter the term culture reflects a rather uncultured attitude. We think highly about the ocean, but could not care less.

For obvious reasons, mankind is increasingly worried about the quality of its environment. What is a clean and healthy environment in times when most of the earth carries the signature of environmental change, habitat destruction and pollution? Given the strong increase in human populations over the last 1000 and particular the last 100 years, until when were our environments clean and healthy? When did the coastal regions where people live, stop to be clean or healthy? In 1900, 1500, 500 or 500 A.D.? There is no scientific definition for the terms clean and healthy. Clean and healthy have operational definitions that we have to generate. Most environmental standards are rather based on 'common sense' than scientific reasoning. Environmental standards must include the impact of humans, unless we wish to exterminate ourselves for the benefit of nature *per se*. Prior to a clean-up of our polluted coastal zones we have to decide *how clean* they should become and which point in time we wish to refer to that is *acceptably clean and healthy*.

Culture means alienation from nature. But culture is the very base of human existence; it is what makes us humans. We can thus not ignore alienation from nature. Even an environmentalist is alienated with regard to what he/she wishes to protect. This creates a basic problem for environmental protection that easily can result in sustainable development confrontations. Sustainable development implies that mans demands for natural resources such as food are covered inside the 'buffer capacity' of an ecosystem. Sustainability also implies that organic matter and energy harvesting from an ecosystem must not threaten the long-term integrity of ecosystems. In aquatic systems sustainable development is limited by new production, in other words the ecosystems carrying capacity, its maximum production capacity and harvestable production. Sustainability can only be maintained at harvest levels that are much lower than the carrying capacity. Where this limit is to be set is the great challenge that depends on our definition of sustainability which has not absolute, but an operational meaning.

Ecosystems changes are a direct consequence of our existence. There is no way to stop cultural eutrophication. Any attempt to target a clean environment without radically reducing human populations and thoroughly changing our life commodities, is utterly naïve. Technology (for the educated and wealthy) can only *help*, but does not fundamentally change the state of affairs. Thus we can only ask "What eutrophication, how much eutrophication and where should eutrophication preferentially take place"? The question is not cultural eutrophication or not, but *what type* of eutrophication, *how much* and at *what price* for nature and humans. Most aquatic ecosystems are thus a cultural 'landscape', which cannot be turned into nature or a sanctuary without removing humans from the entire watershed. And even this will not help as the atmosphere supplies nutrients from adjacent regions. We have to bear the responsibilities in a setting where we cannot run away from the consequences, but modify our management. We live in the environment that we deserve. And the recent growth in human population has probably resulted in that we have passed already the Earths point of no return. Most of the Earth has developed irreversibly into a cultural landscape. Cultural eutrophication is a facet of this process.

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