# Vulnerability assessment of ecosystem services for climate change impacts and adaptation (VACCIA)

# Action 10: Assessment of impacts and adaptation of fisheries production and wash off effects in Lake Päijänne

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**Report 1a and 1b**

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## Introduction

Lake Päijänne is one of the three lakes having a surface area larger than 1000 $km^2$ in Finland. It is also the deepest lake in Finland, maximum depth is 94 m. The lake water level was artificially lowered in 1832-1837 and it has been regulated since 1964 (Järvinen and Marttunen 1998). Currently it is recovering from pulp and paper mill wastewater loading. Lake water is used for source of tap water in Helsinki metropolitan area. Lake Päijänne is one site in the Finnish Long Term Socio-Ecological Research Network.

In this paper, the reports 1a (fisheries production) and 1b (wash-off and loading) are represented together. The aim of report 1a is to describe the present situation of fish stocks and fisheries in L. Päijänne. The aim of report 1b is to characterize the lake and drainage area in present situation. These will form a basis for the forthcoming annual reports.

# Report 1a: Fisheries production

## 1. Catch and fisheries system in Lake Päijänne

Catch and fishing effort in L. Päijänne in year 1996 were studied by Valkeajärvi and Salo (2000). About 35 000 people were fishing in L. Päijänne during that year and the number of professional fishermen was 15. The total catch was 925 tons.

In the northern part of L. Päijänne (Ristinselkä, subarea 1 in this study, 10 600 ha) the estimated total catch was 129 tons (Valkeajärvi & Salo 2000).The main species in catch were perch, pike and roach. This subarea is mesotrophic with average total phosphorus content of 17 $\mu g\ l^{-1}$ and average water colour of 37 $mg\ Pt\ l^{-1}$.

In the southern part of the lake (Asikkalanselkä, subarea 2 in this study, 7 900 ha) total catch on this area was 48 tons (Valkeajärvi & Salo 2000). The main species were vendace, whitefish and perch. This subarea is oligotrophic with average total phosphorus content of 9 $\mu g\ l^{-1}$ and average water colour of 30 $mg\ Pt\ l^{-1}$.

## 2. Fish species in Lake Päijänne

### 3.1. Species

There are 32 fish species and two crayfish species which have been observed in L. Päijänne (Table 1).

Table 1. Fish and crayfish species observed in L. Päijänne.

| Name | Latin name |
|---|---|
| Lamprey | *Lampetra fluviatilis* |
| Eel | *Anguilla anguilla* |
| Pike | *Esox lucius* |
| Salmon | *Salmo salar* |
| Brown trout | *Salmo trutta* |
| Rainbow trout | *Oncorhynchus mykiss* |
| Vendace | *Coregonus albula* |
| Whitefish | *Coregonus lavaretus* |
| Peled whitefish | *Coregonus peled* |
| Grayling | *Thymallus thymallus* |
| Arctic charr | *Salvelinus alpinus* |
| Smelt | *Osmerus eperlanus* |
| Roach | *Rutilus rutilus* |
| Dace | *Leuciscus leuciscus* |
| Minnow | *Phoxinus phoxinus* |
| Ide | *Leuciscus idus* |
| Rudd | *Scardinius erythrophthalmus* |
| Bleak | *Alburnus alburnus* |
| White bream | *Abramis bjoerkna* |
| Bream | *Abramis brama* |
| Blue bream | *Abramis ballerus* |
| Crucian carp | *Carassius carassius* |
| Carp | *Cyprinus carpio* |
| Stone loach | *Barbatula barbatula* |
| Burbot | *Lota lota* |
| Nine-spined stickleback | *Pungitius pungitius* |
| Bullhead | *Cottus gobio* |
| Alpine bullhead | *Cottus poecilopus* |
| Fourhorned sculpin | *Triglopsis quadricornis* |
| Perch | *Perca fluviatilis* |
| Pikeperch | *Stizostedion lucioperca* |
| Ruffe | *Gymnocephalus cernuus* |
| | |
| Noble crayfish | *Astacus astacus* |
| Signal crayfish | *Pacifastacus leniusculus* |

## 3.2. The most important species

The category of the most important species were selected for economical significance or for important role in lake ecosystem. The catch, stockings and importance of these species for recreational or professional fisheries are presented in Table 2. Optimum temperature for food consumption reflects the temperature ecology of each species. Roach, perch, pike and pikeperch are clearly species that in the present temperature conditions have to occupy suboptimal temperatures. The spawning time of these species occurs during spring or early summer.

Table 2. Catch (tons), stockings (yes/no), importance for recreational/professional fisheries (low/medium/high), spawning time/site and optimum temperature (°C) for food consumption of the most important species in L. Päijänne.

| **Species** | **Catch tons 1996** | **Stocked** | **Importance for recreational/profes sional** | **Spawning time/site** | **Optimum temperature for food consumption** |
|---|---|---|---|---|---|
| brown trout | 19 | yes | high/low | autumn/brooks | 17 |
| vendace | 150 | no | high/medium | autumn/depth 2-10 m | 13 |
| whitefish | 114 | yes | high/medium | autumn/depth < 2 m | 22 |
| smelt | 9 | no | low/low | spring/rivers | 12 |
| roach | 116 | no | low/low | spring/vegeta-tion zone | 30 |
| perch | 287 | no | high/low | spring/vegeta-tion zone | 28 |
| pikeperch | 18 | yes | high/medium | early summer/depth 1-3 m | 31 |
| pike | | yes | high/low | spring/vegeta-tion zone | 24 |
| signal crayfish | 0 | yes | medium/medium | copulation in autumn, hatching next summer | 20-25 |

### 3.3. Vendace (*Coregonus albula*)

Vendace is the most important target of the professional fishing in Finnish inland fisheries. Vendace stocks typically fluctuate a lot between years because total lifetime is only a few years and reproduction is not successful in every year. This fluctuation causes uncertainty in economical point of view for professional fishermen (Marjomäki et al. 1995).

Vendace spawns in autumn and eggs develop during winter under ice cover. Eggs hatch during spring, in the same time as ice melt. In Sweden, the timing of ice melts seems to affect to strength of forthcoming catch. In years with late ice melt the possibility of strong year-class is higher than in years with early ice melt (Nyberg et al. 2001). It has also noted that spawning time in autumn has changed later in recent years (Karjalainen et al., unpubl.). Overall, unfavorable weather conditions during early life stages can destroy strong year-class.

Gill nets, trap nets and trawl are the most important gears for vendace in L. Päijänne. The total vendace catch was 150 tons in year 1996.

### 3.4. Whitefish (*Coregonus lavaretus*)

Whitefish has the same kind of life cycle than vendace but longer lifetime and also less dramatic stock fluctuations. There are several whitefish forms in L. Päijänne which differs in growth rate and spawning areas. Some of these are reproducing naturally and some stocks are based on stockings.

The same factors attached to climate change that are affecting to vendace stocks are possible factors also for whitefish stocks.

The effect of water level regulation on whitefish reproduction has been investigated (Valkeajärvi et al. 2001). Because spawning depth is mainly < 2m, the decreasing water level during winter can destroy developing eggs. However, the effect of water level regulation was not very significant factor of whitefish stocks in L. Päijänne. Partly to compensate this possible effect average 960 000 yearling whitefish have been stocked annually to L. Päijänne. Whitefish catch was about 114 tons in year 1996 (Valkeajärvi & Salo 2000). Main gears are gill nets and trap nets.

## 3.5. Smelt (*Osmerus eperlanus*)

Smelt is not economically important species. However, it is important as a possible competitor for vendace and as a prey for large predatory fish.

Spawning time is during spring when smelt migrate to rivers to spawn. Smelt reach maturity in age of 2-3 years and oldest individuals are usually less than 5 years old (Kangur et al. 2007).

## 3.6. Pikeperch (*Stizostedion lucioperca*)

Pikeperch is a large percid predatory fish, which mainly consume smelt and perch (Keskinen & Marjomäki 2004). Pikeperch stocks have increased since the end of 1900's and it is now important predatory fish species for recreational fishery. Yearling pikeperch are stocked annually to L. Päijänne about 400 000 individuals but the role of natural reproduction is unknown. Total catch of pikeperch was 18 tn in year 1996 (Valkeajärvi & Salo 2000) and the main gears were gill nets. After that year catch has markedly increased.

Pikeperch prefer warm water with optimum temperature to growth being 27 °C (Hokanson 1977). Thus, in L. Päijänne temperature is always under optimum. Spawning time is when water temperature is about 8-16 °C (Lappalainen et al. 2003). Temperature in the first summer is important factor determining the strength of year-class (Lappalainen 2001).

## 3.7. Perch (*Perca fluviatilis*)

Perch is the most common fish species in L. Päijänne. Total catch was 287 in year 1996 and the most important gears were rod fishing and gill nets (Valkeajärvi & Salo 2000). The catch is almost totally from recreational fishing because volume of professional perch fishing is low.

Perch is flexible species in relation to habitat use and food selection (zooplankton, benthos and fish). Thus, it has a central role in fish community in L. Päijänne. Dense perch stock can prevent the recovery of vendace stock after collapse (Valkeajärvi & Marjomäki 2004). Perch prefer warm water with optimum temperature for growth being 26°C (Hokanson 1977). Spawning is usually in May, after ice smelt. The summer temperature in the first summer is important for the strength of year-class (Sarvala & Helminen 1996).

### 3.8. Brown trout (*Salmo trutta*)

Naturally reproducing brown trout is a threatened species in L. Päijänne. Brown trout stock is maintained by stockings. Annually about 26 000 2- or 3-year old brown trout have been stocked to L. Päijänne. Total catch of brown trout was 19 tons in year 1996 (Valkeajärvi & Salo 2000) and this catch is based totally on stocked individuals. Main gear is gill nets.

Brown trout reproduce in small rivers and brooks. The reason for endangered status is overfishing and impaired quality of spawning areas. High number of stocked brown trout can prevent the recovery of vendace stock after collapse. Thus, the management should be able to taken account the status of vendace stocks when planning the brown trout stockings.

### 3.9. Roach (*Rutilus rutilus*)

The economical value of roach as a catch is low. In eutrophicated lakes roach and other cyprinids can impair water quality by crazing zooplankton. In such lakes removal of cyprinids (mainly roach) has been used in the aim of improving water quality and decreasing the number of blue green algae's (Jeppesen et al. 2007).

In L. Päijänne the roach catch was 116 tons in year 1996 (Valkeajärvi & Salo 2000). This is almost totally bycatch.

### 3.10. Pike (*Esox lucius*)

Pike has been estimated suffering from water level regulation in L. Päijänne. This has been compensated by large stockings of YOY pike. In years 1989-2007 totally 830 000 pike (YOY) has been stocked to L. Päijänne.

### 3.11. Signal crayfish (*Pacifastacus leniusculus*)

Signal crayfish is alien species in L. Päijänne and introduced in the end of 1900's. It is expanding distribution both with stockings and natural way. Suitable areas of Southern part of L. Päijänne are colonized by this species but in the northern part distribution is patchy.

Signal crayfish is an omnivorous species and its potential effect on ecosystem in L. Päijänne is unknown. There is available new results which indicated that in the areas of high densities, signal crayfish cause large changes in the littoral communities of L. Päijänne (Hämäläinen et al. unpublished data). In the Southern L. Päijänne signal crayfish has raised economically important species also for professional fisheries.

## 4. Assessment of vulnerability of different species

### 4.1. Estimated effects of climate change

The preliminary assessment of vulnerability has done based on existing knowledge in literature. The possible vulnerable life stages of each important species are listed in Table 3. These factors are usually related to reproduction period or growth.

Table 3. The preliminary estimation of effect of climate change (+ or -) on reproduction and growth of the most important fish species in Lake Päijänne.

| Species | Effect | Vulnerable life stage | Possible causality |
|---|---|---|---|
| brown trout | - | reproduction | quality of spawning grounds, survival of eggs and larvae |
| vendace | - | reproduction | hatching time match/mismatch |
| | - | growth/survival | temperature/oxygen habitat during summer, predation |
| Whitefish | - | reproduction | hatching time match/mismatch |
| | - | growth | temperature/oxygen habitat during summer |
| smelt | - | growth/survival during summer | temperature/oxygen habitat during summer, predation |
| roach | + | reproduction | survival of larvae due faster growth |
| | + | growth | faster growth |
| perch | + | reproduction | survival of larvae due faster growth |
| | + | growth | faster growth |
| | + | ontogenetic shift | due faster growth earlier |
| Pikeperch | + | reproduction | survival of larvae due faster growth |
| | + | growth | faster growth |
| | + | ontogenetic shift | due faster growth earlier |
| pike | + | growth | faster growth |
| signal crayfish | + | growth | faster growth |
| | + | reproduction | long, mild autumn |

### 4.2. Other possible effects

The climate change can change species distributions. In generally, warm water species distribution will expand toward north and cold water species distribution will shrink from southern areas. In L. Päijänne this might mean disappearing or lessening of some cold water species (e.g. arctic charr, vendace) and warm water species coming more abundant (e.g. carp and other cyprinids, perch).

Fish spatial distribution is largely dependent on water temperature and oxygen consumption. Changes in temperature and oxygen stratification can change for example vertical migrations of vendace and smelt and thus affect growth rate and survival.

Changes in abundances and spatial distributions affect on interactions between species and whole ecosystem. Interactions between fish and other organism can determine for example water quality of lake. An accelerated growth due rising temperature increases the food consumption and has possible effects on these communities.

Many species, e.g. perch and pikeperch, undergo ontogenetic shift in their diet (from zooplankton via larger invertebrates to fish). Faster growth rate makes fish to shift to piscivorous phase possibly earlier. The increase in predation pressure on prey species may possibly affects their abundances. The changes in species proportions can cause large changes in ecosystem functioning in general.

## 3. Vulnerability of fisheries system

Because fisheries are based on different species on subareas 1 and 2, their vulnerability on climate change is different. Some large scale trends are however assessed in Table 4. Changes in fish community will affect all fisheries but effect is diverging depending on method and species. For example, increase of bream stocks can be harmful for gill net fishing of pikeperch due to large bycatch.

Table 4. Preliminary vulnerability assessment of different fishing methods in Lake Päijänne.

| Fishing method | effect | Possible causality |
|---|---|---|
| gill nets, open water | + | longer season |
| gill nets, winter | - | longer season |
| ice fishing | - | shorter season |
| | + | perch growth and abundance |
| rod fishing | + | longer season |
| trap net | + | longer season |
| seining, winter | - | shorter season |
| trawling | + | longer season |
| | + | more effective during summer |
| | - | changes in species composition |
| crayfishing | + | abundance |

## 4. Forthcoming reports

In forthcoming reports (4/2010) the response of fish community and fisheries to climate change will be assessed more detailed. In addition to direction of change also the magnitude and effect on interactions between species will be estimated and consequences to fisheries system will be analyzed.

## 5. References


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# Report 1b: Lake Päijänne and drainage area

## 1. Geology of Lake Päijänne and drainage area

After the last ice age, the lake basin was isolated from the ancient Ancylus Lake around 10 000 cal yr BP (Itkonen et al. 1999). At first the lake was transgressive due to the influence of glacioisostatic land uplift. After that a steady regression period began and continued until 1832-1837, when the water level was artificially lowered. The most typical soil type is moraine, and the bedrock consists of granite. Catchment topography is variable; highest hills are in the altitude of 130 m above sea level. The lake surface level is 78.5 m above sea.

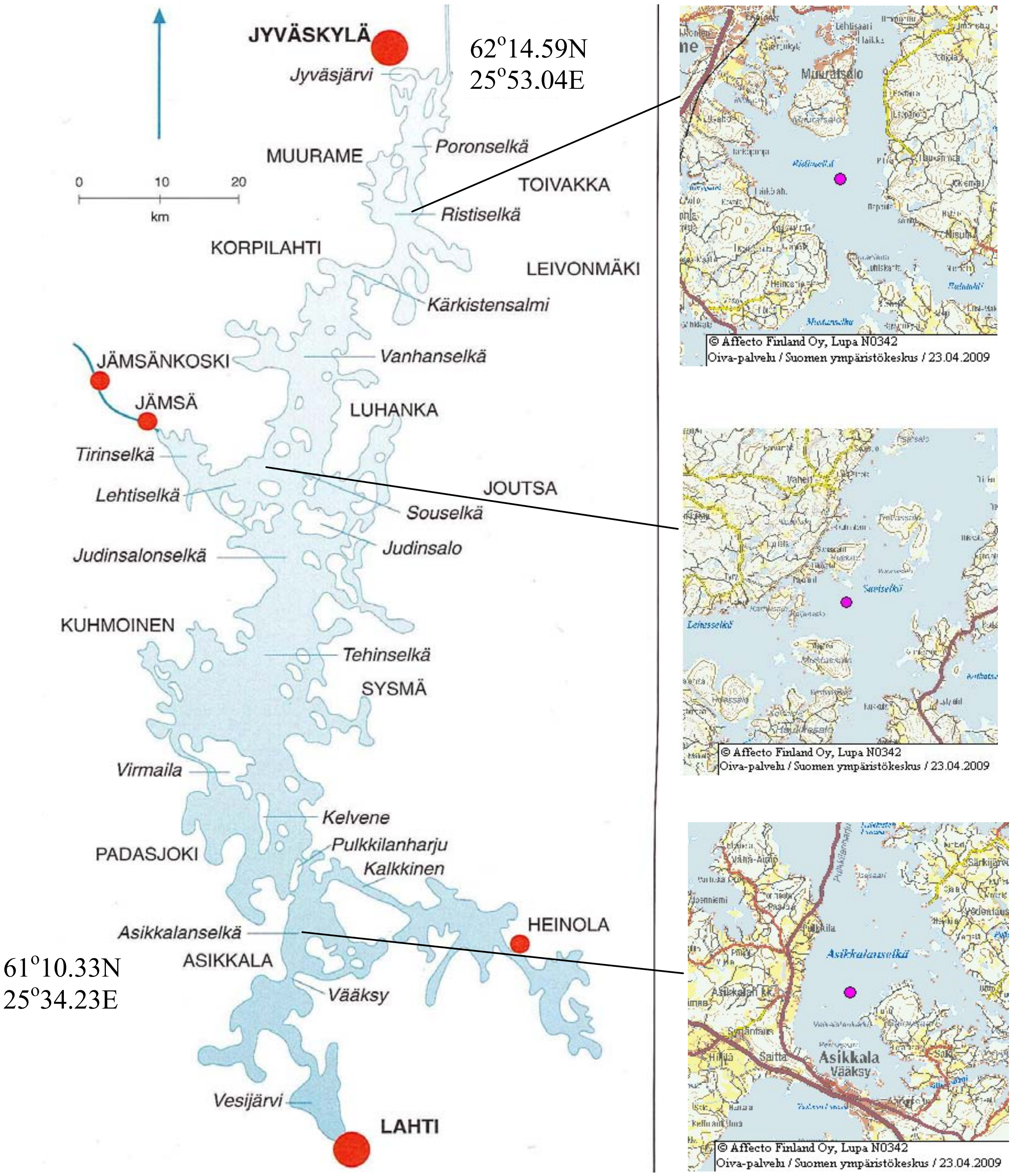


**Figure 1.** Map of Lake Päijänne. Right panel: maps showing the selected areas in L. Päijänne for basin morphometry and water quality. *Sources: Hakkari and Saukkonen 1998; FEI database.*

## 2. Morphology

The lake is oriented in North-South direction with a maximum length of 120 km and width of 28 km (Figure 1). Three basins were selected for detailed view on the basis of available long-term water quality data: Asikkalanselkä basin located in the southern, Saviselkä basin in the middle and Ristinselkä basin in the northern part of the lake system (Table 5, Figure 2).

**Table 5. Characteristics of the selected basins in Lake Päijänne.**

| | Northern Päijänne | Middle Päijänne | Southern Päijänne |
|---|---|---|---|
| Area, ha | 14066 | 86329 | 7667 |
| Mean depth, m | 16.2 | 15.2 | 13.1 |
| Max. depth, m | 94.5 | 91 | 79 |
| Volume, million $m^3$ | 228. 3 | 1314.5 | 100.4 |

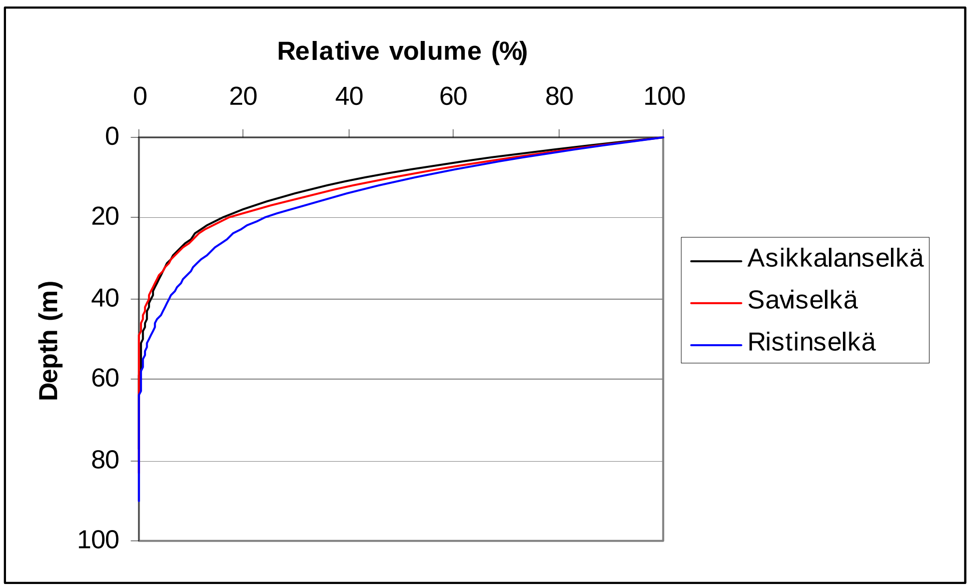


**Figure 2.** Relative volume curves (hypsographic curves) of the selected areas in Lake Päijänne. Source: FEI database

## 3. Meteorology

Meteorological observations are recorded by Finnish Meteorological Institute. Nearest stations are in Jyväskylä, Jämsä and Lahti. The coldest month of the year is January or February, and the warmest is July. In the L. Päijänne region the mean temperature in winter is -6 to -10 $^{o}$C and in summer 16-18 $^{o}$C (figure 3). Average annual rainfall (years 1991-2000) in the L. Päijänne region is 617 mm. University of Jyväskylä has also two weather station in Lake Northern Päijänne (www.paijanne.org).

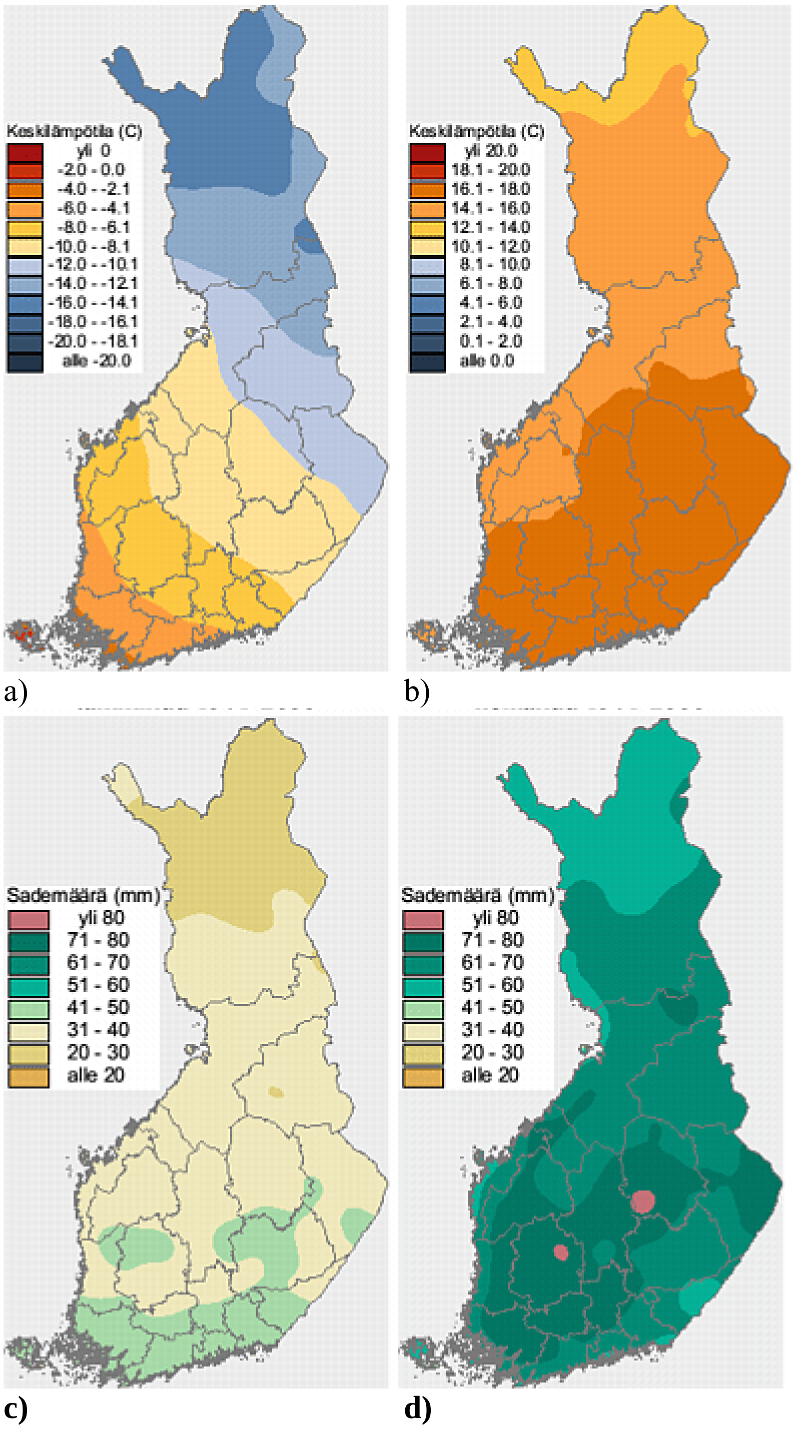


**Figure 3.** Mean temperature and rainfall in January (a,c) and in June (b,d) in Finland during the period 1971-2000. Source: FMI

## 4. Hydrology

Water level and discharge data are collected from several sites and archived in Finnish Environment Institute´s (FEI) database. The earliest recordings date from 1911. Currently there are two official water level recording sites; another in north Päijänne, Vaajakoski, and another in south, Kalkkinen. In addition there are three public water level measurement sites in Padasjoki, Sysmä and Korpilahti. The basic hydrological data is presented in table 6.

The annual rainfall in the region presented as discharge is 218 $m^3s^{-1}$. There are also rivers that drain into L. Päijänne. The largest inflow (63 % of total inflow) comes from North, Äänekoski water way, with an average of 148 $m^3s^{-1}$ (period 1991-2000) and also River Jämsänjoki ja Sysmä water way are significant (both comprise 6 % of the total inflow). L. Päijänne drains into the Gulf of Finland via river Kymijoki starting from southwestern part of L. Päijänne, and the mean discharge is 213 $m^3s^{-1}$ (period 1991-2000). The freezing and ice-out dates in Tehinselkä, middle area of L. Päijänne, have been monitored since winter 1955-1956. On the average, lake is ice –covered from early December until end of April (table 7).

In 1970´s and 1980´s intensive current measurements were conducted in Asikkalanselkä basin and in Middle Päijänne (e.g. Sarkkula 1997; Huttula and Sarkkula 1980). These studies were connected to Helsinki tap water intake and transportation of waste water and the environmental impact assessment.

**Table 6**. Hydrological data on Lake Päijänne.

| Parameter | Päijänne |
|---|---|
| Catchment area, $km^2$ | 26 480 |
| Retention time (d) | 804 |
| Mean discharge ($m^3s^{-1}$) | 230 |
| | |
| MHQ $_{1964\text{-}2004*}$ ($m^3s^{-1}$) | 350 |
| MNQ $_{1964\text{-}2004*}$ ($m^3s^{-1}$) | 133 |
| MHW$_{1970\text{-}2007}$ (m) | 78.64 |
| MNW (m) | 77.77 |

Source: FEI database
*From Korhonen 2007.

The water temperatures in the deepest sites of L. Päijänne were studied intensively in during the years 1950-1959 (Simojoki 1960). Although this data is over 50 years old, it can still be used to depict the thermal conditions of the lake, because these conditions have not been changed significantly according to Korhonen 2002. The surface water temperature in the most deepest site of the lake, is 7.1 $^oC$ in early June and it increases to

15.7 $^{o}C$ by the late June. In July the surface water warms up only few degrees, and reaches the maximum temperature, 18.5 $^{o}C$, in the end of July.

The nearest evaporation measurement site is located in the Jyväskylä airport in Tikkakoski. In May-October 1990-2000 the mean evaporation was 481 mm, corresponding 190 $m^3s^{-1}$.

**Table 7**. Date statistics (average, minimum and maximum) on the various phases of ice break-up and freezing, and the duration of ice cover in middle part of Lake Päijänne (Tehi). b1=open water on shore, b2= open water off shore, b3= ice in movement, b5= final break-up/ice disappeared even from areas out of the visible range. x1=ice on shore (finally),x3=ice cover in bays (permanent), x8=final freezing/freezing of areas out of the visible range.

| | | **b1** | **b2** | **b3** | **b5** | **x1r** | **x3** | **x8** | **Ice cover duration (d)** |
|---|---|---|---|---|---|---|---|---|---|
| **1961-2000** | | | | | | | | | |
| | Mean | 29.4. | 2.5. | 5.5. | 8.5. | 6.12. | 6.12. | 24.12. | 135 |
| | Min | 13.4. | 15.4. | 21.4. | 22.4. | 22.11. | 1.11. | 1.12. | 100 |
| | Max | 15.5. | 17.5. | 23.5. | 23.5. | 26.12. | 26.12. | 22.1. | 168 |

Redrawn from Korhonen (2005).

## 5. Water chemistry and hydrobiology

About forty years ago L. Päijänne was polluted by industrial wastewater load from pulp and paper mills of Jyväskylä, Äänekoski and Jämsänkoski as well as municipal wastewaters (Figure 4). Since the 1980´s L. Päijänne has been recovering from it. Nowadays Southern and middle areas of the lake are generally classified as oligotrophic (total P less than 15 $\mu g l^{-1}$ ; figures 5-6). Northern Päijänne is mesotrophic (Figure 7).

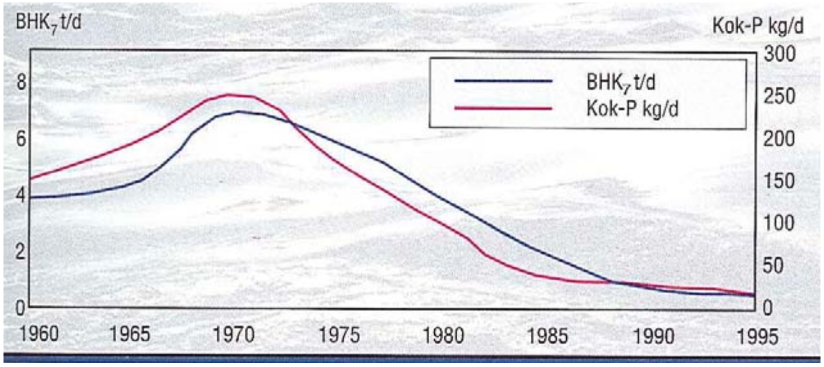


**Figure 4.** The development of loadings of the human effluents ($BOD_7$ tons/d; left, blue line) and the total phosphorus (kg/d, red line) during the years 1960-1995. *Source: Granberg 1998.*

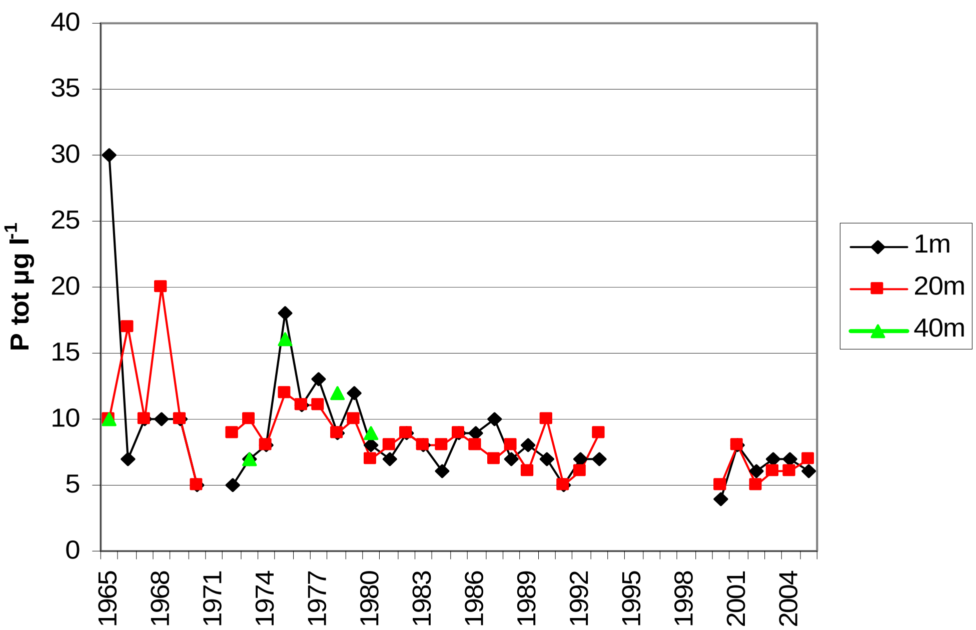


**Figure 5.** Total P in Southern Päijänne (Asikkalanselkä). *Source: FEI database*

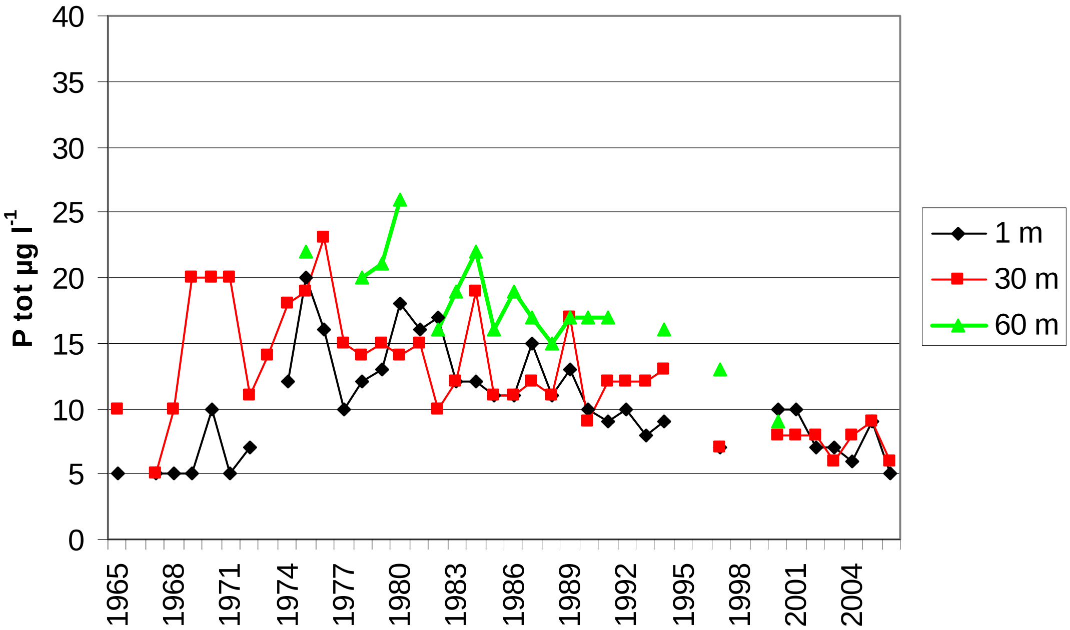


**Figure 6.** Total P in middle Päijänne (Saviselkä). *Source: FEI database*

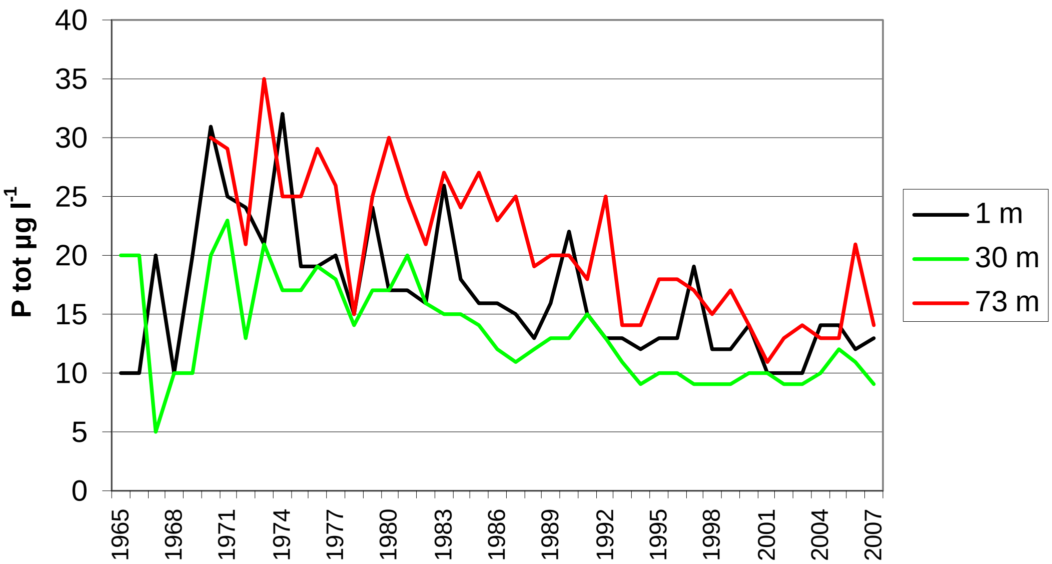


**Figure 7.** Total P in Northern Päijänne (Ristinselkä). *Source: FEI database*

## 6. Socio-economy

The catchment area of L. Päijänne consists mainly on coniferous and mixed forests on mineral land (Table 8). More built up areas can be found in the northern parts of the catchment, and agricultural areas in middle and southern parts of the catchment. About 300 000 inhabitants are living around the lake and the lake water is used as a raw water source of tap water in Helsinki metropolitan area for more than one million people. Recreational use of the lake (e.g. summer cottages and sailing) is also of great importance.

**Table 8.** Land use (in %) in the catchment areas of the southern, middle and northern parts of the Lake Päijänne. *Source:FEI*

| | **Coverage (%)** | | |
|---|---|---|---|
| **CORINE Land Cover classification** | south | middle | north |
| **Class 1: Built up area** | | | |
| Continuous urban fabric | 0.08 | 0.02 | 0.64 |
| Discontinuous urban fabric | 2.83 | 1.73 | 5.56 |
| Industrial or commercial units | 0.32 | 0.16 | 1.53 |
| Road and rail networks and associated land | 0.60 | 0.45 | 1.26 |
| Mineral extraction sites | 0.10 | 0.09 | 0.10 |
| Dump sites | 0.00 | 0.01 | 0.00 |
| Green urban areas | 0.03 | 0.00 | 0.01 |
| Summer cottages | 3.32 | 1.41 | 1.48 |
| Sport and leisure facilities | 0.08 | 0.04 | 0.42 |
| **Class 2: Agricultural area** | | | |
| Non-irrigated arable land | 4.65 | 5.20 | 2.78 |
| Pastures | 0.02 | 0.16 | 0.16 |
| Complex cultivation patterns | 0.50 | 0.80 | 0.59 |
| **Class 3: Forest and natural area** | | | |
| Broad-leaved forest on mineral land | 2.24 | 2.33 | 3.26 |
| Broad-leaved forest on peat land | 0.29 | 0.33 | 0.22 |
| Coniferous forest on mineral land | 14.24 | 19.05 | 20.96 |
| Coniferous forest on peat land | 0.13 | 0.86 | 0.32 |
| Coniferous forest on bare rock | 0.74 | 2.01 | 1.64 |
| Mixed forest on mineral land | 12.38 | 13.88 | 11.38 |
| Mixed forest on peat land | 0.34 | 1.09 | 0.38 |
| Mixed forest on bare rock | 0.13 | 0.29 | 0.19 |
| Sparse forests, cc <10 % | 3.70 | 5.26 | 5.48 |
| Sparse forests, cc 10-30 % mineral land | 3.57 | 4.03 | 3.73 |
| Sparse forests, cc 10-30 % peat land | 0.11 | 0.19 | 0.17 |
| Sparse forests, cc 10-30% bare rock | 0.11 | 0.37 | 0.49 |
| Sparse forests, under electrical power cable | 0.11 | 0.05 | 0.32 |
| Bare rock | 0.05 | 0.28 | 0.26 |
| **Class 4: Wetland** | | | |
| Inland marshes on land | 0.00 | 0.02 | 0.00 |
| Inland marshes in water | 0.02 | 0.23 | 0.03 |
| Peat bogs | 0.20 | 0.27 | 0.10 |
| Peat extraction site | 0.00 | 0.00 | 0.01 |
| **Class 5: Water** | | | |
| Rivers | 0.03 | 0.01 | 0.02 |
| Lakes | 49.09 | 39.36 | 36.54 |

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**Links**

FEI projects:
*http://www.paijanne.tkk.fi/index.htm*
*http://www.ymparisto.fi/download.asp?contentid=21564&lan=EN*
*http://www.ymparisto.fi/download.asp?contentid=55571&lan=EN*

Others:
*www.paijanne.org*
*www.kalapaikka.net/1id_28369__iid_11554__l_s.asp*
*www.fishing.fi/rbu.asp?id=28369&iid=11554&l=e*
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