Variations and patterns of fish yields in large reservoirs in Thailand

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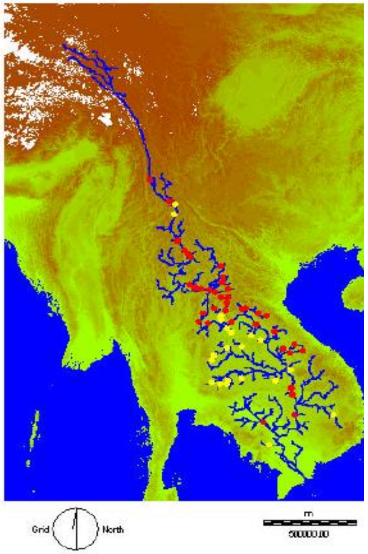
Damming the rivers



- In the Lower Mekong Basin, there are over 100 proposals for new dams that lies within Cambodia, Laos, Thailand and Vietnam. Of these, 11 are scheduled to be installed on the mainstream of the river
- These infrastructures create a new lentic- or semi lentic environments (i.e. large man-made lakes)
- Also alter the fish community, which could negatively impact to the fisheries productions
- **HOWEVER**, fisheries are considered a secondary benefit from the impoundments benefiting local populations in almost all proposals
- Yield estimate from large water bodies (including reservoirs), in the Basin, ranges between 100 – 300 $kg.ha^{-1}.yr^{-1}$.

According to the previous slide and variable yield of a fishery has direct consequences for the economics status of the fishers,

Therefore, the objectives of this presentation are

- To explore the variations (both long- and short-tems) of fish landings, which respected to individual species, in the selected reservoirs

- To patternize the compositions in fish landings, which implying changes in fish communities

- The results can be further applied to make an options for fisheries management

Limitations

- the data contained only the fish species recorded from the landing sites and lack of data on fish harvested for household consumptions and OAAs.

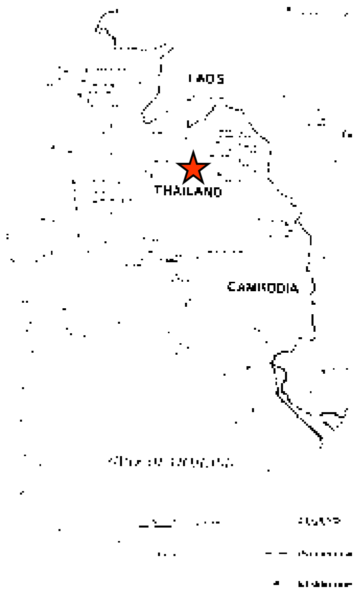
- Assumed that the fishing intensity and technologies has a minimal change and as a nature that Thai fishers catch all species regardless of size variation, the landings essentially represent actual spectrum of species composition.

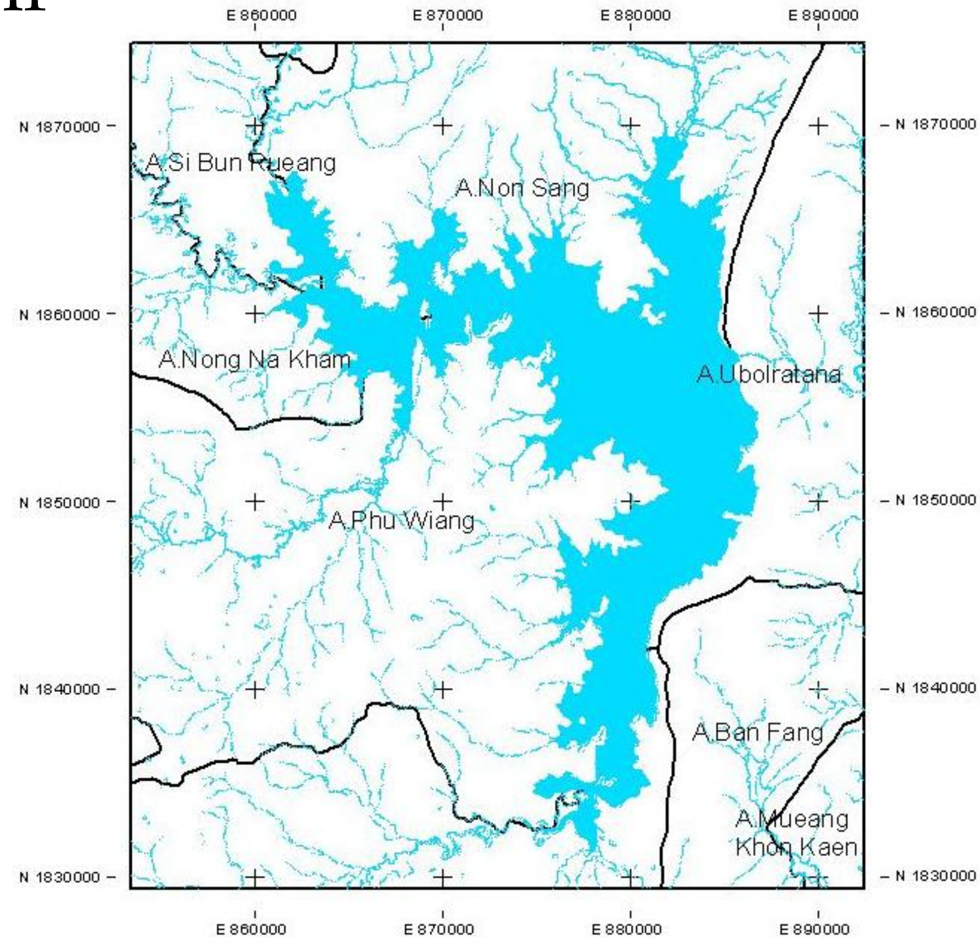
Choice of reservoirs

- Four large reservoirs were selected for the study, because the long time data series (i.e. $\geq$ 20 years) on fish landings are available for these. The statistical data on fish landings were available in the Department of Fisheries (DoF)

- Data were collected at the fish landing sites of the reservoir by the fishery staff of the fisheries patrol units. They were trained on data collection and procedure to compile the data. The catches were enumerated on collection forms, recording numbers and total weight by species.

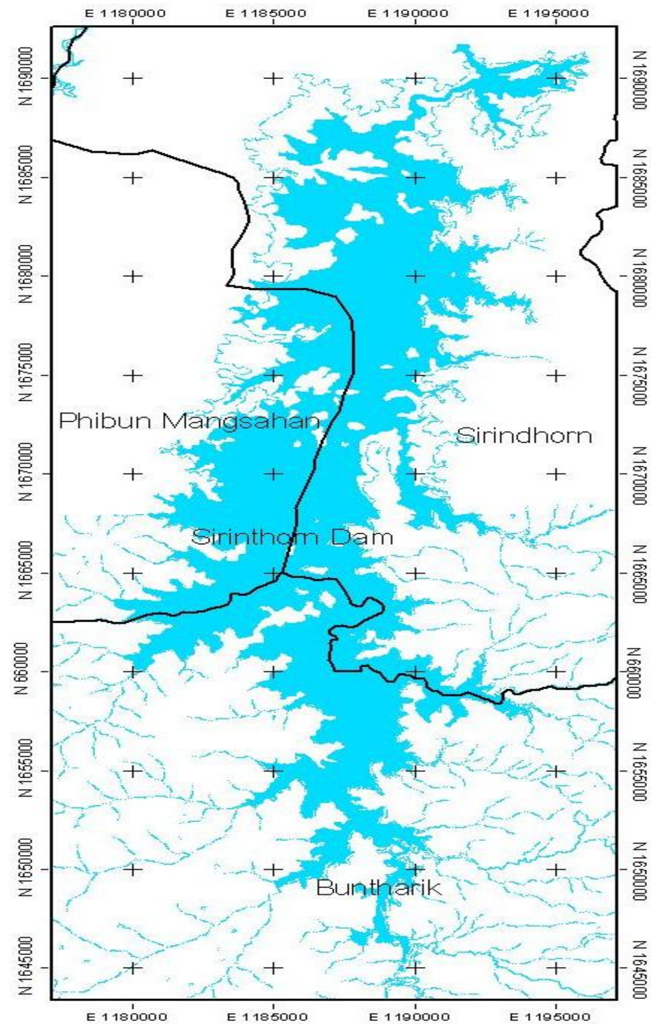
Ubolratana Reservoir





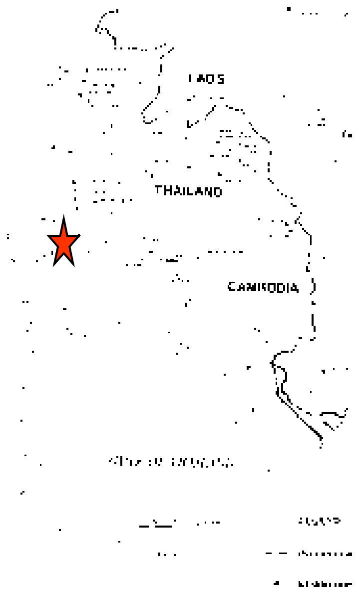
Surface area	Mean depth	Catchment area	Average annual yield	Year of impoundment
41,000 ha	15.8 m	12,160 km^2	2,274.0 MT	1965

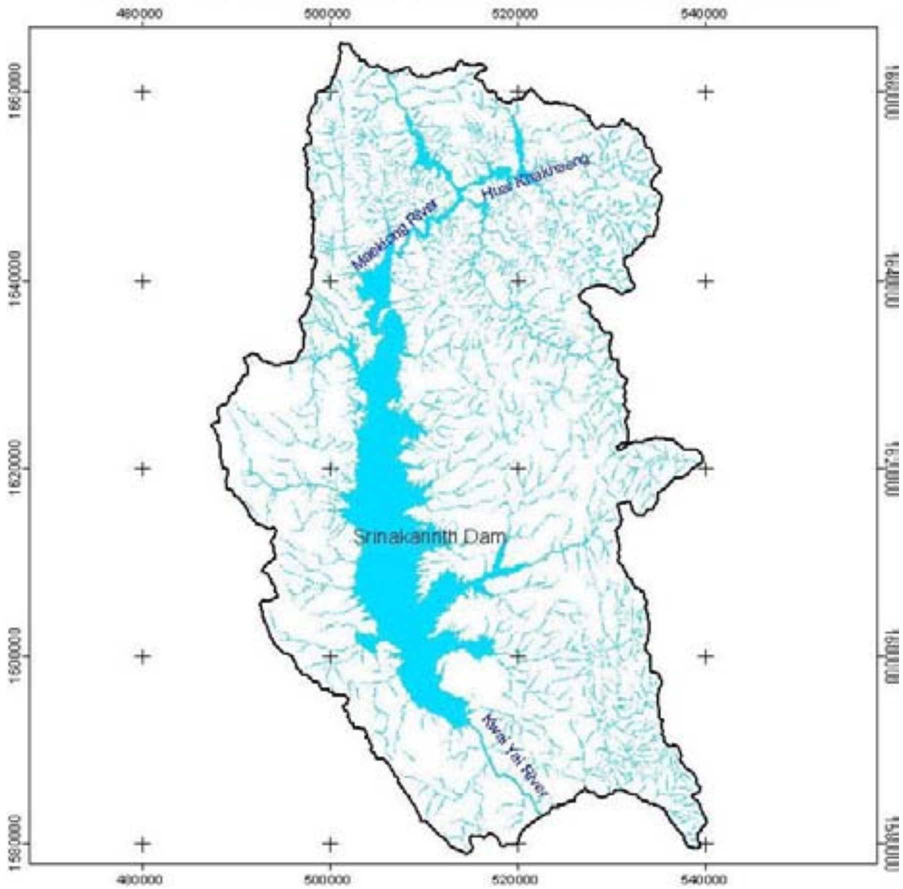
Sirindhorn Reservoir



Surface area	Mean depth	Catchment area	Average annual yield	Year of impoundment
29,200 ha	5.1 m	2,100 km^2	1,277.2 MT	1971

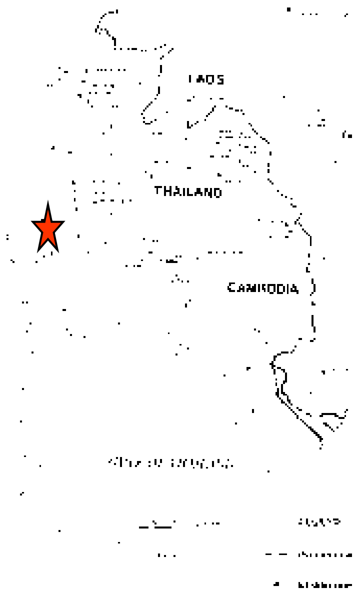
Srinakarin Reservoir

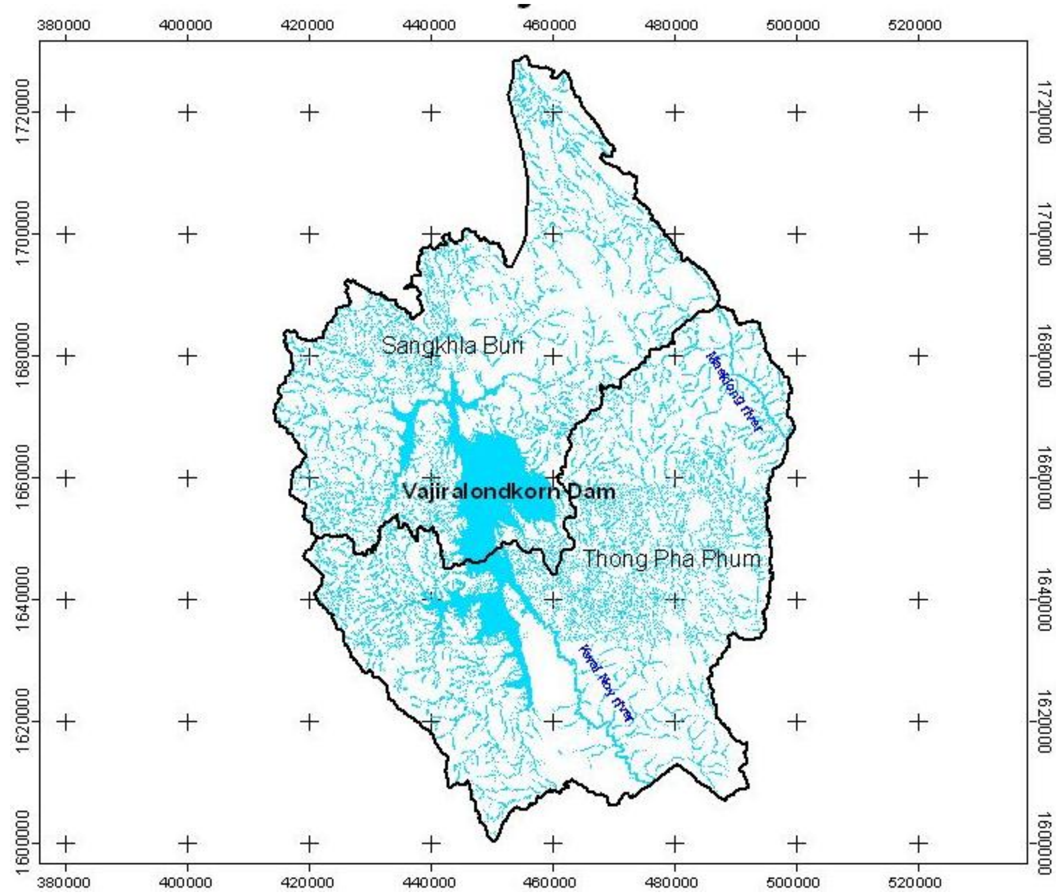




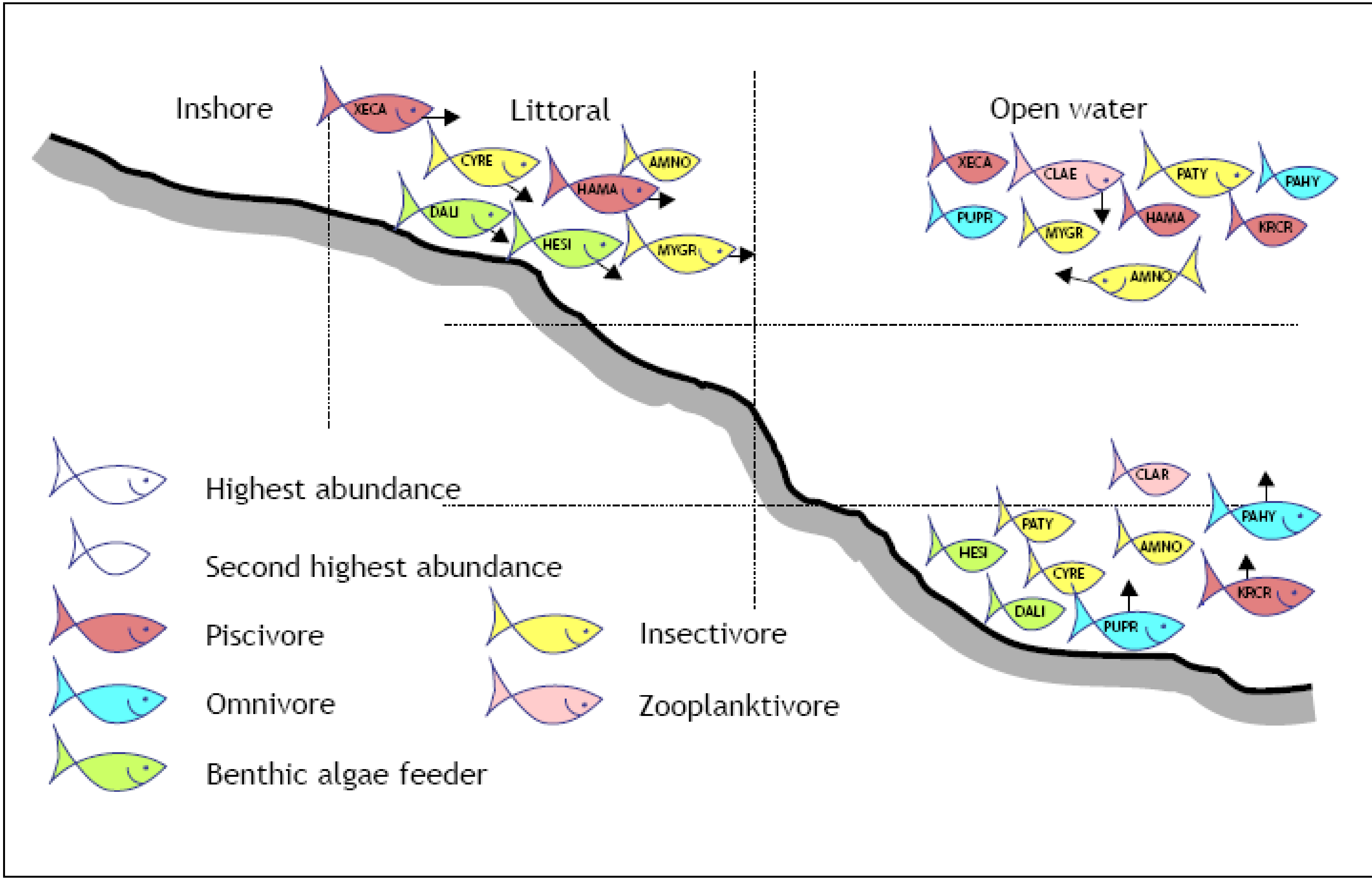
Surface area	Mean depth	Catchment area	Average annual yield	Year of impoundment
40,000 ha	44.6 m	10,880 km^2	371.0 MT	1977

Vajiralongkorn Reservoir





Surface area	**Mean depth**	**Catchment area**	**Average annual yield**	**Year of impoundment**
35,320 ha	24.0 m	3,720 km^2	520.0 MT	1984



Most of reservoir fisheries are intensified in the created littoral area.

Analysis of variations

- **Long-term variation:** The variation, of individual species, experienced by the fishers on a long-term basis, is expressed by coefficient of variation (CV0) in annual yield. Furthermore, to investigate the trends in the long term variation, the coefficient of variations of the 1st (linear trend, CV1) and 2nd order polynomials (CV2)

- **Short-term variation:** In the short-term the fishers relate their catches in a given year to that in the previous year and can be expressed as the index of absolute variation (U_a) and the relative variation (U_r), as for percentile change, were applied

Analysis of variations

- Short-term variation: the index of absolute variation (U_a) and the relative variation (U_r) were applied

$$U_a = \frac{|dy|}{y} = 100 \times \frac{mean|y_i - y_{i-1}|}{y} (\%)$$

$$U_r = 100 \times 2 \times \left(\left(1 - \frac{1}{10^r} \right) / \left(1 + \frac{1}{10^r} \right) \right) (\%)$$

where y = mean of long term fish landings data; y_i and y_{i+1} = fish landings in a given year and previous year, respectively, and r is the mean of absolute difference of log transferred catches calculated by

$$r = \sum_{i=2}^{n} \left| \log_{10} \left(y_i / y_{i-1} \right) \right| / (n-1)$$

Patternizing the fish landing data

- The log-transformation *ln (fish landing + 1)* was applied to reduce the skewness of the distributions of fish landing data

Formatted input data

Fish species

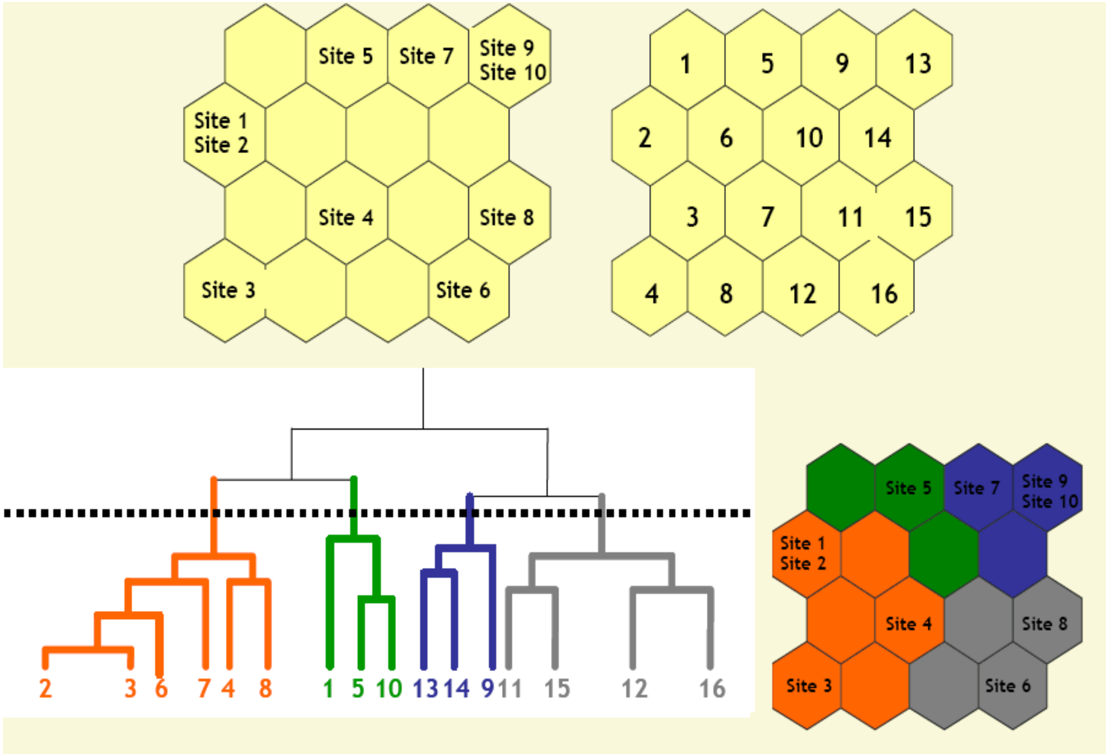
Year	HEMN	HEMW	OMPK	CLAB	PANH	KRYB	HAMS	MORC	BARG	BARS	PUNB	HENS	CYCA	OSTH	………
1985	3.36	0.00	2.04	1.39	0.00	0.00	3.78	2.88	2.34	0.00	0.00	3.76	0.00	0.00	………
1986	3.51	0.00	0.31	1.36	0.00	0.00	3.96	2.48	2.10	0.00	0.00	4.06	0.00	0.00	………
1987	3.29	0.00	1.30	1.33	0.00	0.00	4.24	2.86	2.21	0.23	1.21	1.38	2.58	2.75	………
1988	3.32	0.00	1.16	0.96	0.00	0.00	4.12	2.97	2.51	1.22	1.35	0.00	2.16	2.45	………
1989	2.79	0.00	1.21	1.31	0.00	0.00	3.08	2.66	2.72	0.00	2.16	0.00	2.03	2.20	………
1990	2.71	0.00	1.19	1.84	0.00	0.00	3.27	2.64	3.00	0.30	2.19	0.00	2.47	2.43	………
1991	2.69	0.00	0.76	1.13	0.00	0.00	3.29	2.26	3.15	0.00	2.57	0.00	1.74	2.17	………
1992	2.20	0.19	0.91	1.39	0.00	0.00	3.13	0.69	3.12	0.00	2.67	0.00	1.54	2.15	………
1993	2.67	0.00	0.00	0.00	0.00	0.00	0.01	1.65	2.43	0.00	0.00	0.00	1.15	0.00	………
1994	2.71	0.00	0.00	0.00	0.00	0.00	0.00	1.82	2.63	0.00	0.00	0.00	1.09	0.00	………
1997	2.94	0.14	1.00	0.00	0.00	0.00	2.10	1.27	3.61	1.22	0.00	0.00	0.96	0.61	………
1998	2.55	0.00	0.27	0.00	0.00	0.00	0.97	1.09	2.98	1.55	0.00	0.00	1.00	0.89	………
1999	0.28	0.00	0.00	0.00	0.00	0.00	0.83	0.59	2.46	0.73	0.00	0.17	0.60	0.00	………
2000	1.66	0.79	0.00	0.00	0.00	0.51	1.27	1.37	2.46	0.49	0.00	1.36	0.93	0.00	………
2001	2.46	1.26	0.00	1.20	0.00	1.99	2.11	1.63	3.29	2.05	0.00	3.42	0.00	0.00	………
2002	3.08	1.27	0.00	0.50	0.00	1.02	3.79	1.01	3.28	1.85	0.00	2.64	0.00	0.00	………
2003	3.57	1.82	0.00	1.72	0.00	2.41	3.20	1.90	3.78	2.47	0.00	2.56	0.00	0.00	………
2004	3.22	2.23	0.00	0.00	0.00	1.71	2.89	2.55	3.21	2.86	0.00	2.84	0.00	0.00	………
2005	3.30	2.63	0.00	0.00	0.00	2.36	3.18	2.72	3.48	3.18	0.00	3.51	0.00	0.00	………
2006	2.68	2.56	0.00	0.00	0.95	2.17	2.98	2.54	3.25	2.91	0.00	3.14	0.00	3.74	………
2007	2.75	2.15	0.00	0.00	0.67	2.02	2.76	2.33	2.96	2.65	0.00	3.35	0.00	3.36	………

Year

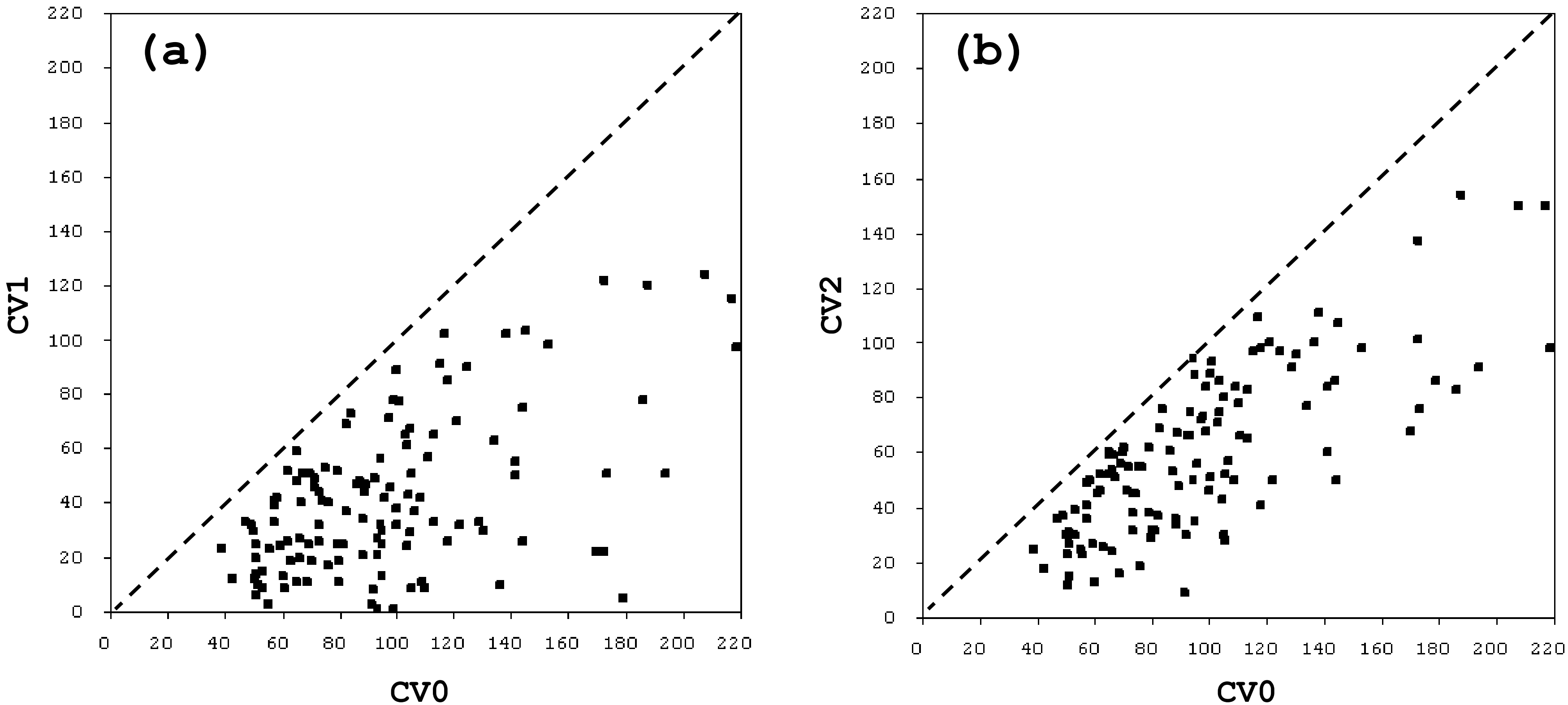
Patternizing the fish landing data

- The unsupervised Artificial Neural Networks (ANN) was used in the analyses the fish assemblage patterns in each period in form of Kohonen's self-organizing map (SOM)

- The ANN-SOM were computed on a PC using MATLAB software version 6.1.0 by using SOM-toolbox, developed by the Laboratory of Computer and Information Science (CIS), Helsinki University



Findings



- Plots between CV0 to CV1 and CV2 showed that all the co-ordinates below the bisectrix line indicated that there are significant trends on fish landings in all four reservoirs
- Lower value of CV1 compare to CV2 of most species indicated that long-term variation conformed the linear trend

Findings

- The species that had the low variation (i.e. stable in fish landings) were such as *Barbonymus schwanenfeldii, Barbonymus gonoinotus, Hampala* sp. *Notopterus notopterus* and *Oxyeleotris marmorata,* implying that these species can be able to adapt behaviourally to lacustrine conditions and thrive in high abundance.




Findings

- The species that had the high variation (i.e. highly fluctuated in fish landings) or non-consistency CV0 were found in the specialist species that require specific conditions such as connecting to river or upstream area during the early part of rainy season or "drawn-down" effect to increase high yields. *Henichorhynchus siamensis, Osteochilus melanopluera, Dangila lineata*, and *Cyclocheilichthys armatus*



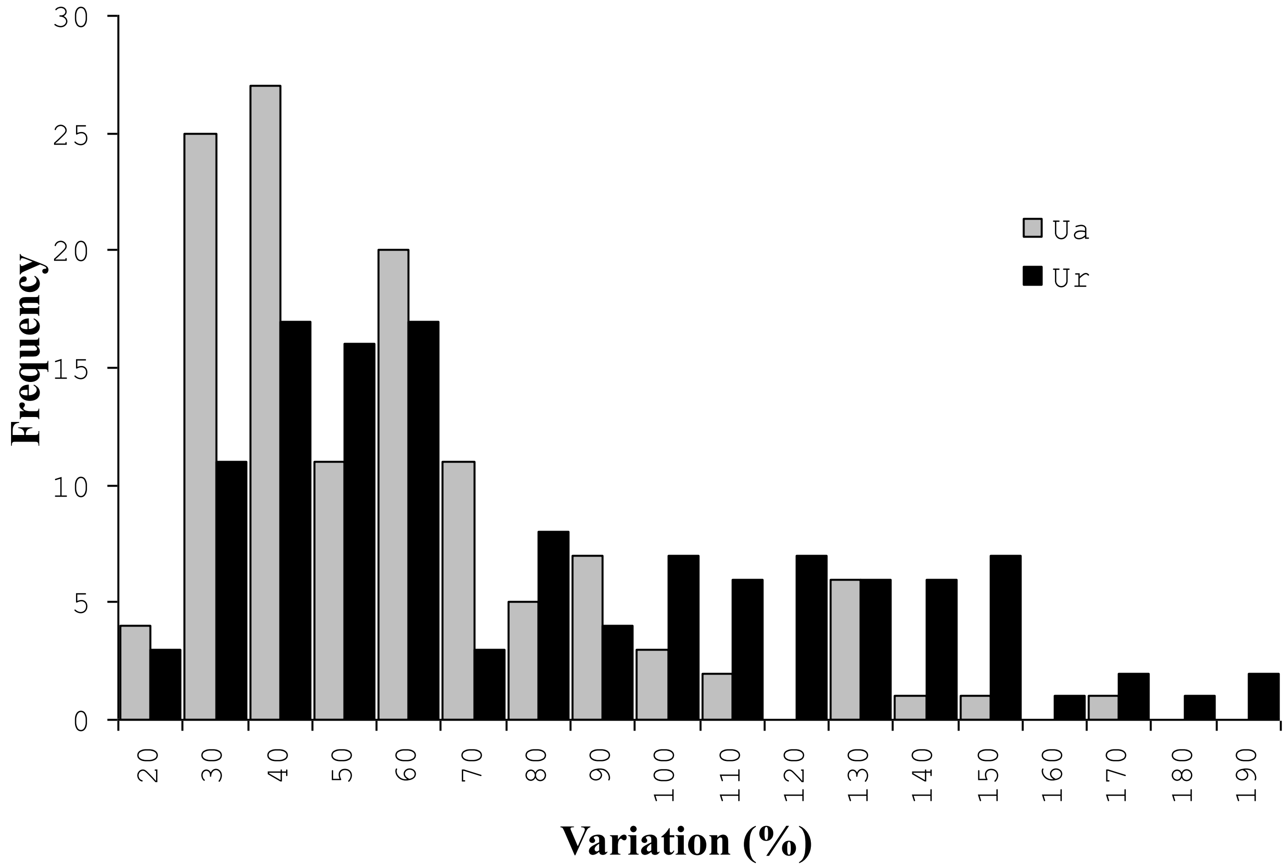

Findings

- Short-lived species such as the small clupeid, *Clupeicthys aesarnensis*, showed high production in catched, low CV0 and small inter-annual differences in the catches

- Except for *Oreochromis niloticus*, the exotic stocked species showed the highest variation in both the long-term and short-term variations and their contribution in catches of any given year related to the stocking density of the previous year.



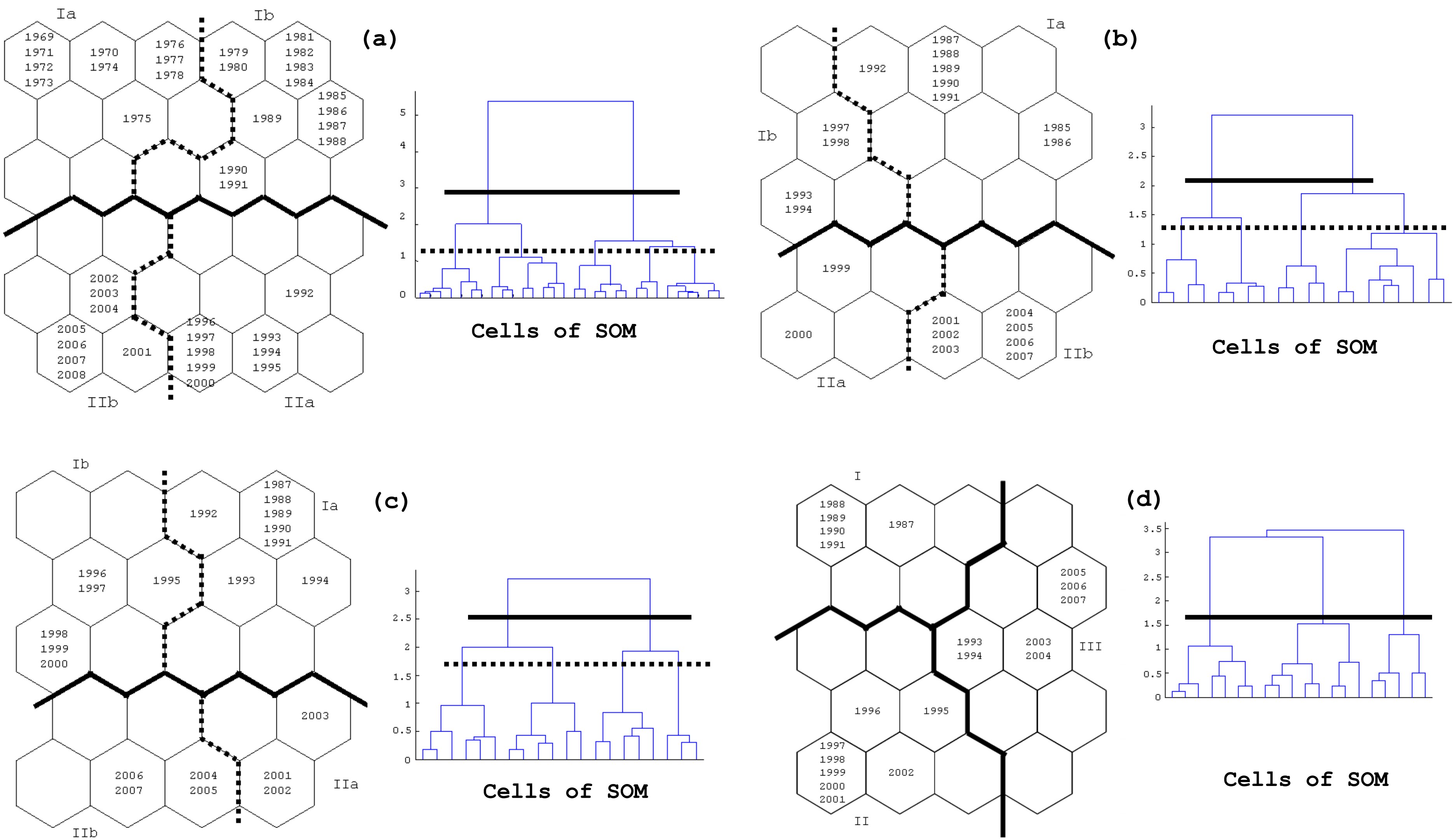
Findings

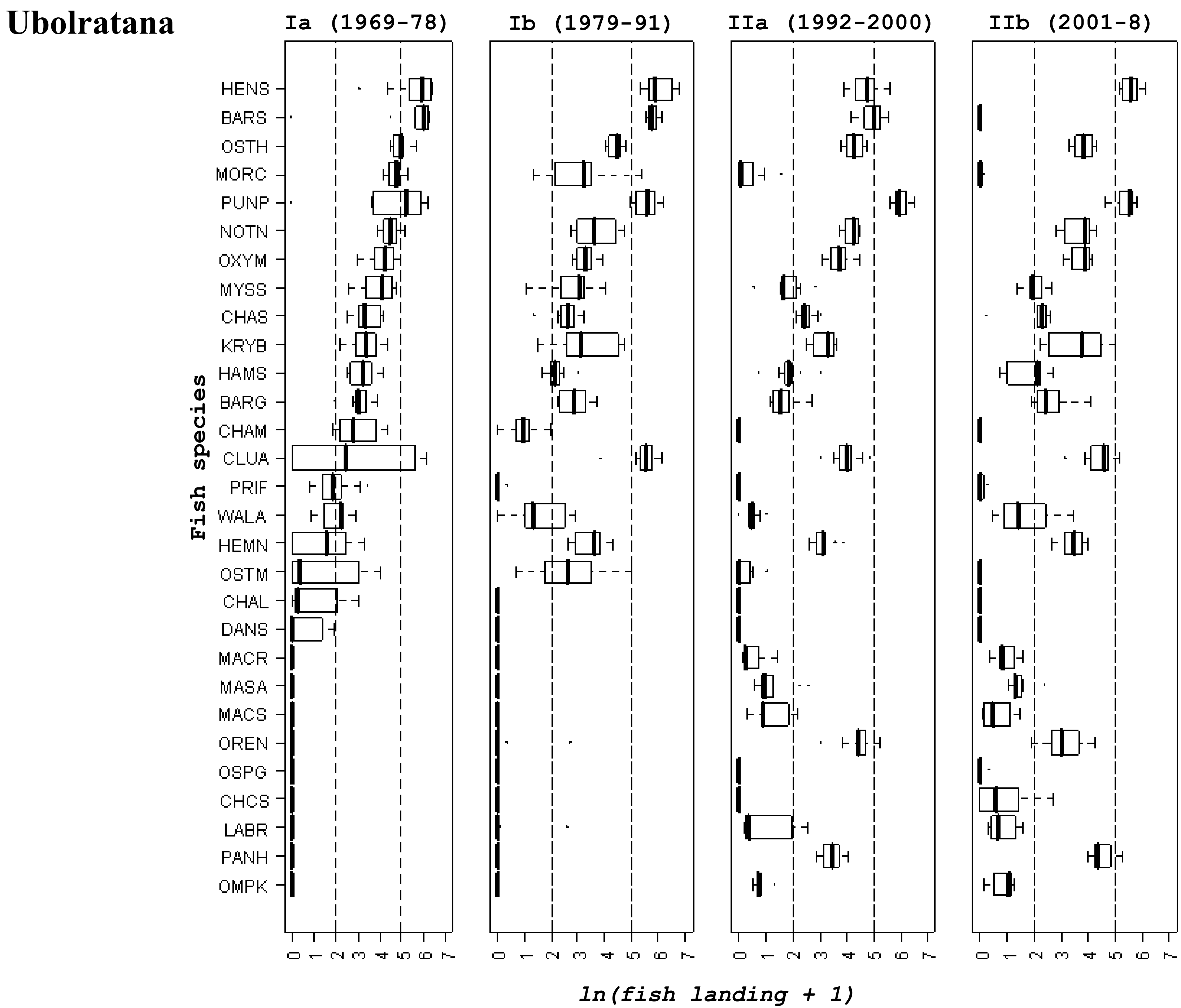


Ur was significantly larger than *Ua* (t-test; p-value < 0.001), which indicated that the short-term variation was inversely related to yield, resulting in a higher uncertainty when catches are low.

Findings

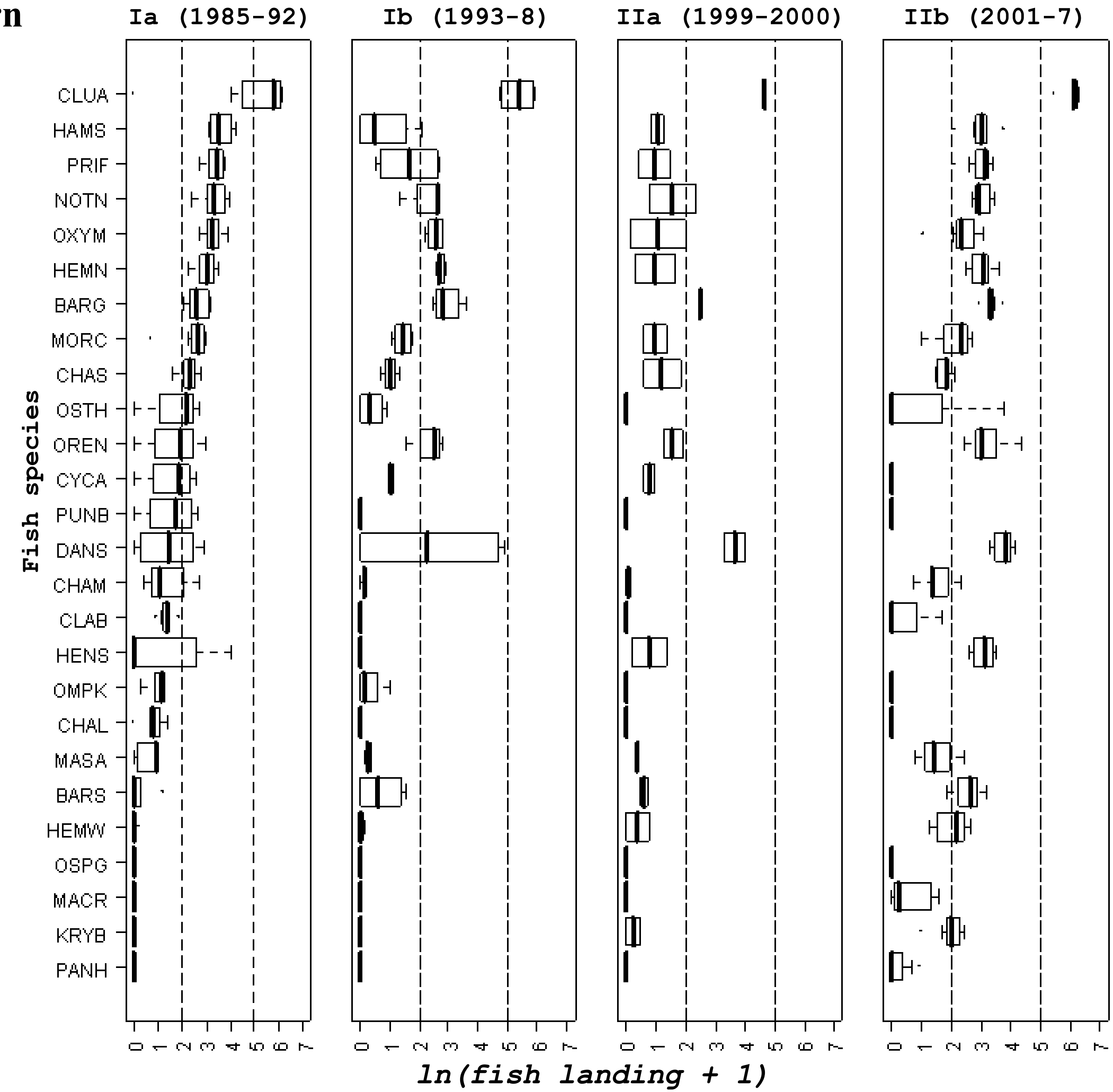
SOM map of each reservoir showed explicit temporal trends of chronological order to the annual fish landings

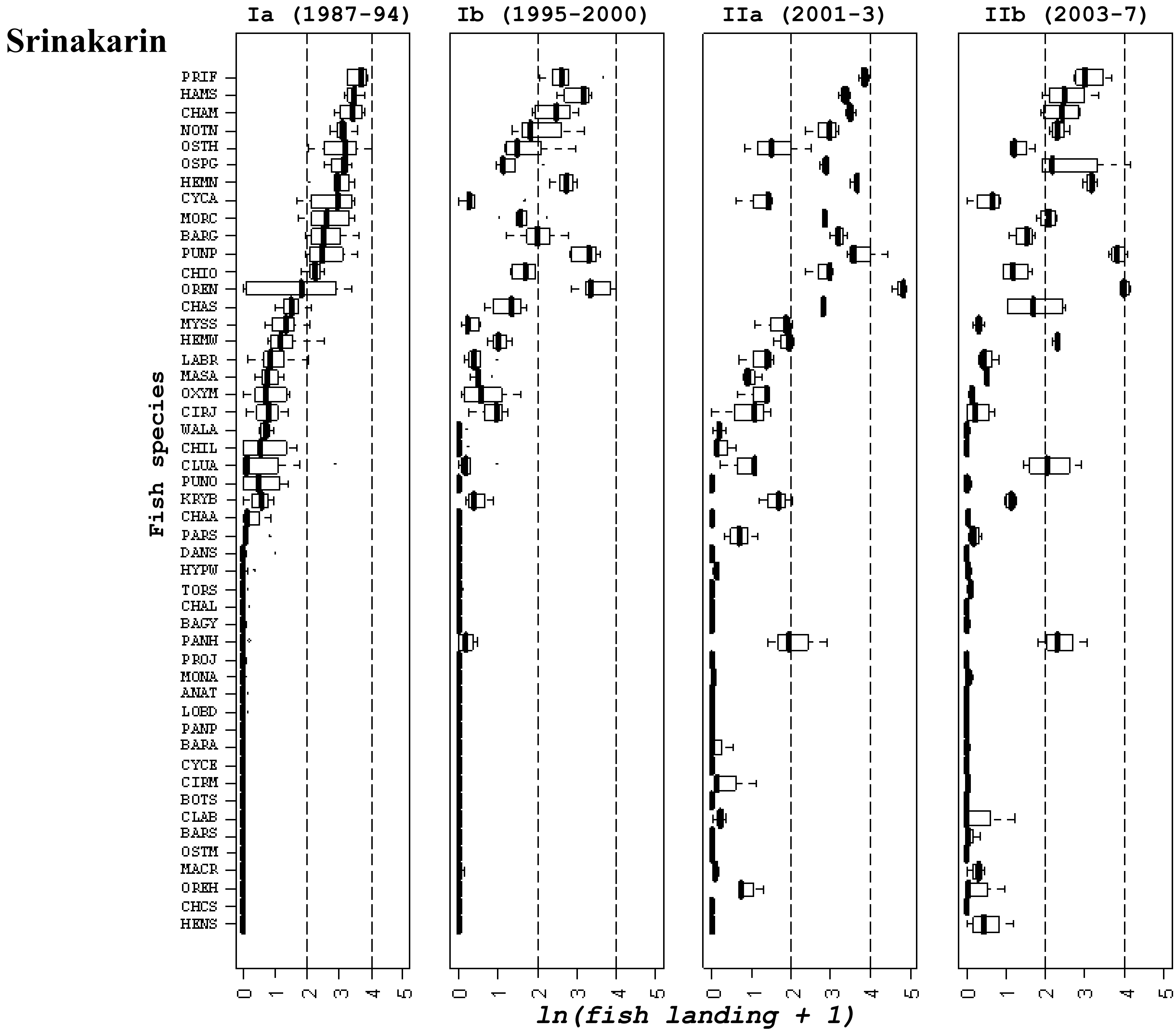




Ubolratana
Ia (1969-78)
Ib (1979-91)
IIa (1992-2000)
IIb (2001-8)
HENS
BARS
OSTH
MORC
PUNP
NOTN
OXYM
MYSS
CHAS
KRYB
HAMS
BARG
CHAM
CLUA
PRIF
WALA
HEMN
OSTM
CHAL
DANS
MACR
MASA
MACS
OREN
OSPG
CHCS
LABR
PANH
OMPK
Fish species
0 1 2 3 4 5 6 7
ln(fish landing + 1)

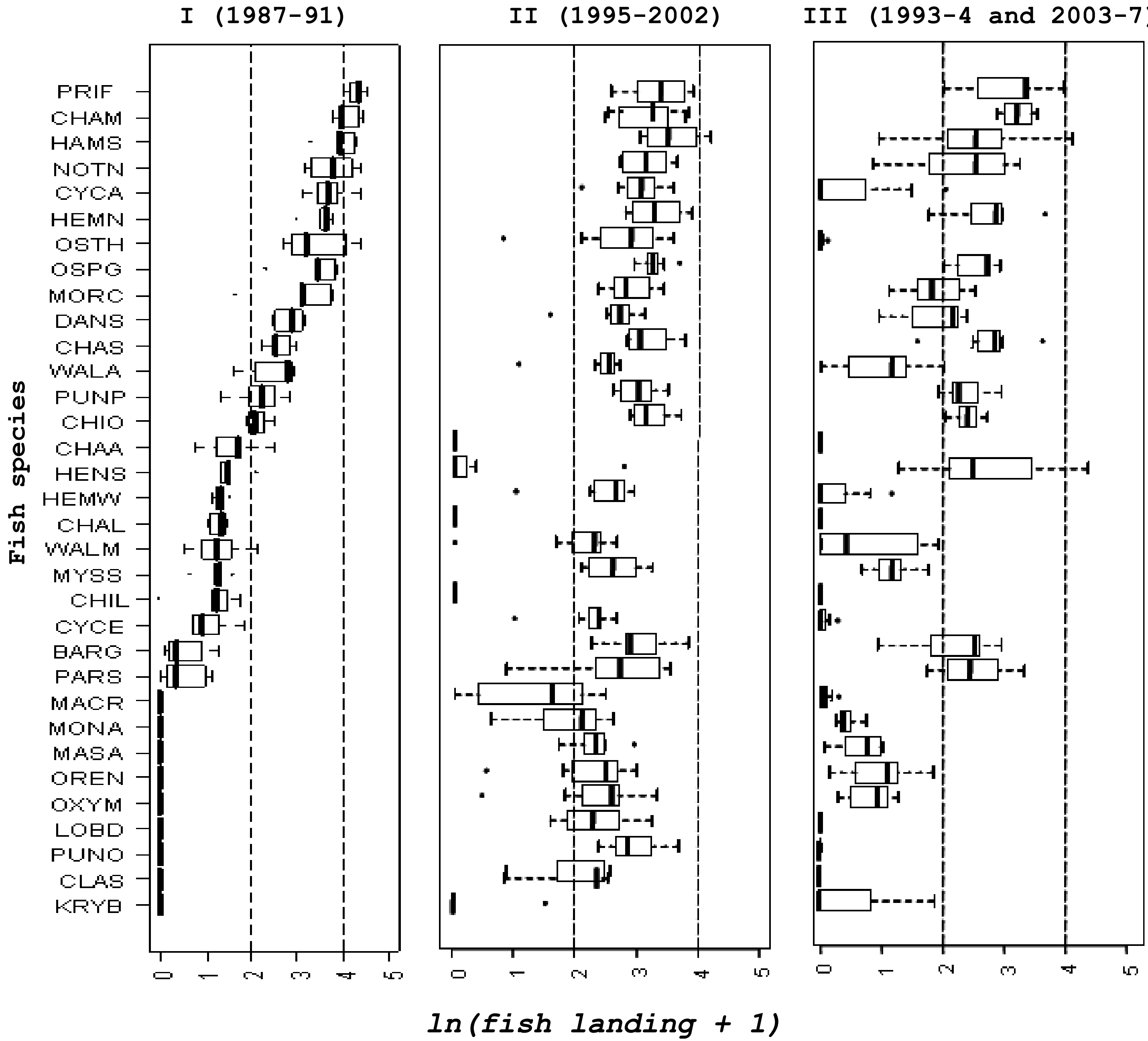
Sirindhorn


Ia (1985-92)
Ib (1993-8)
IIa (1999-2000)
IIb (2001-7)
Fish species
CLUA
HAMS
PRIF
NOTN
OXYM
HEMN
BARG
MORC
CHAS
OSTH
OREN
CYCA
PUNB
DANS
CHAM
CLAB
HENS
OMPK
CHAL
MASA
BARS
HEMW
OSPG
MACR
KRYB
PANH
0 1 2 3 4 5 6 7
ln(fish landing + 1)



Srinakarin
Ia (1987-94)
Ib (1995-2000)
IIa (2001-3)
IIb (2003-7)
Fish species
PRIF
HAMS
CHAM
NOTN
OSTH
OSPG
HEMN
CYCA
MORC
BARG
PUNP
CHIO
OREN
CHAS
MYSS
HEMW
LABR
MASA
OXYM
CIRJ
WALA
CHIL
CLUA
PUNO
KRYB
CHAA
PARS
DANS
HYPW
TORS
CHAL
BAGY
PANH
PROJ
MONA
ANAT
LOBD
PANP
BARA
CYCE
CIRM
BOTS
CLAB
BARS
OSTM
MACR
OREH
CHCS
HENS
0 1 2 3 4 5
ln(fish landing + 1)

Vajiralongkorn

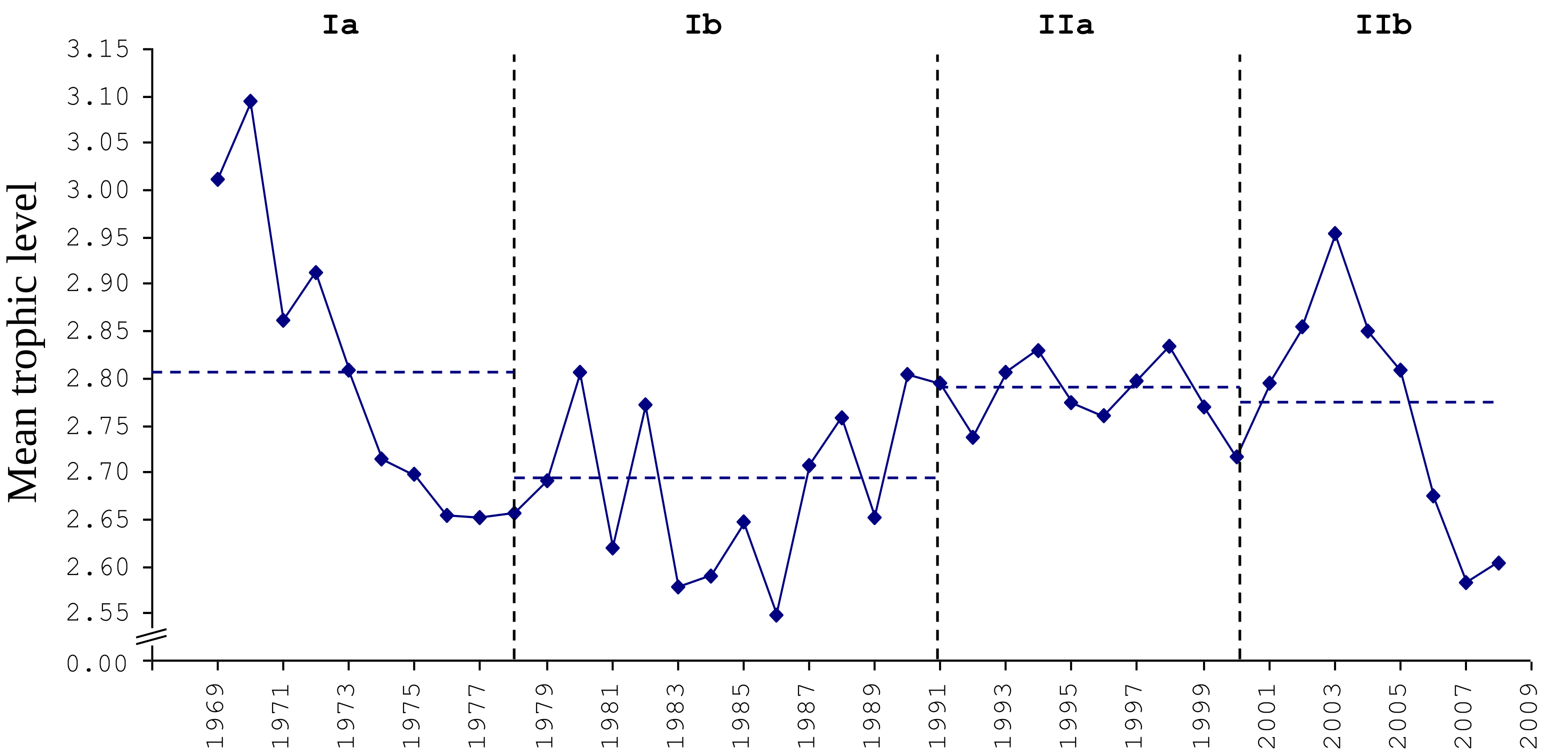


Findings

The obtained pattern was caused by

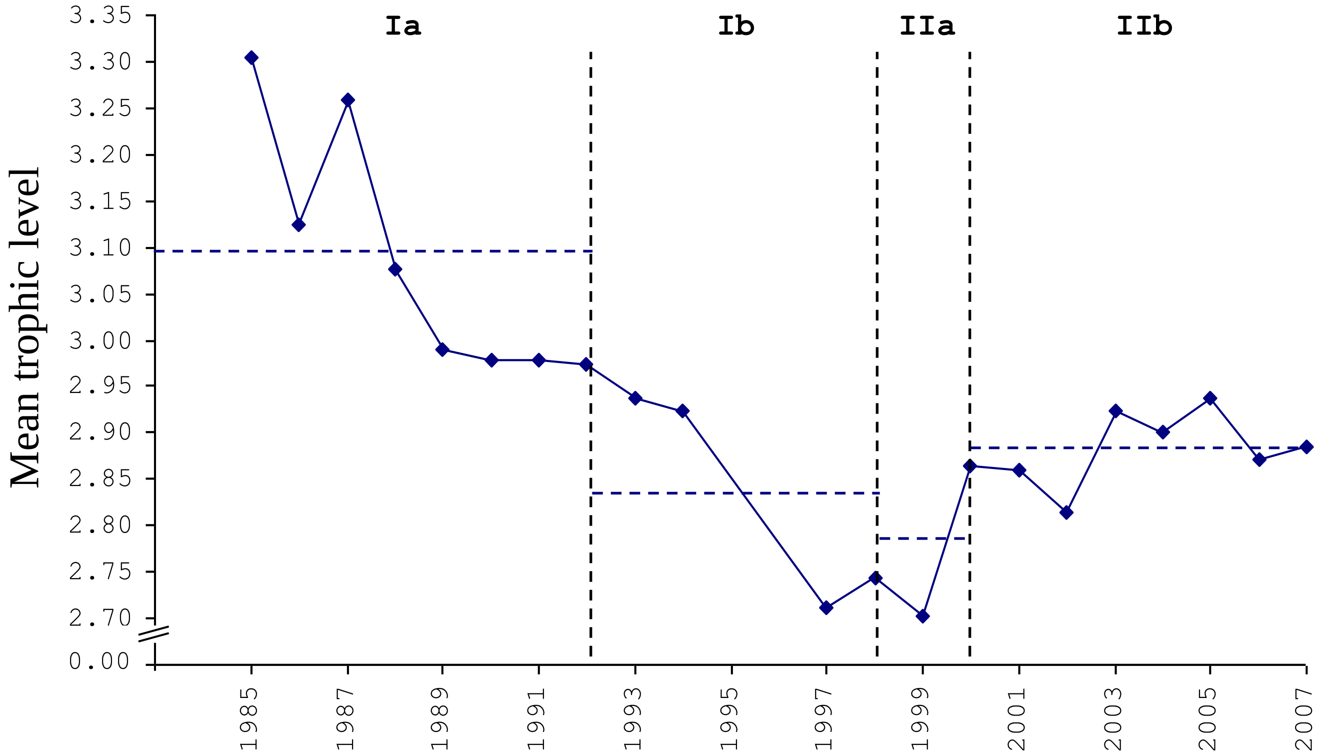
- Declining of riverine species such as of Pangasiid- and some Silurid- fishes.
- Declining of large predatory species.
- Increasing of the species that adapt behaviourally to lacustrine conditions such as many herbivorous cyprinids.
- Fluctuation of the specialist species.
- Contributions of the stocked species, both exotic and indigenous.
- and these causes also reflect changes in mean trophic level in each reservoir

Ubolratana



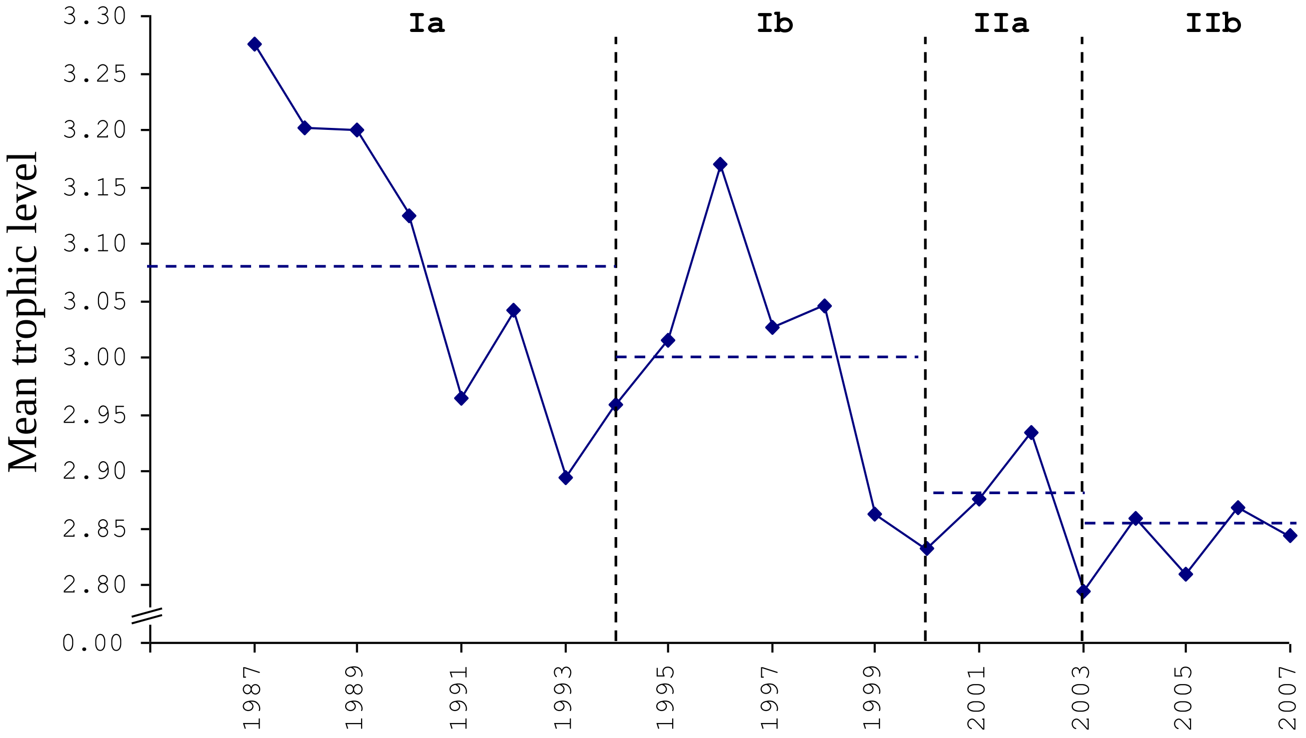
Ia
Ib
IIa
IIb
Mean trophic level
3.15
3.10
3.05
3.00
2.95
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
0.00
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

Sirindhorn

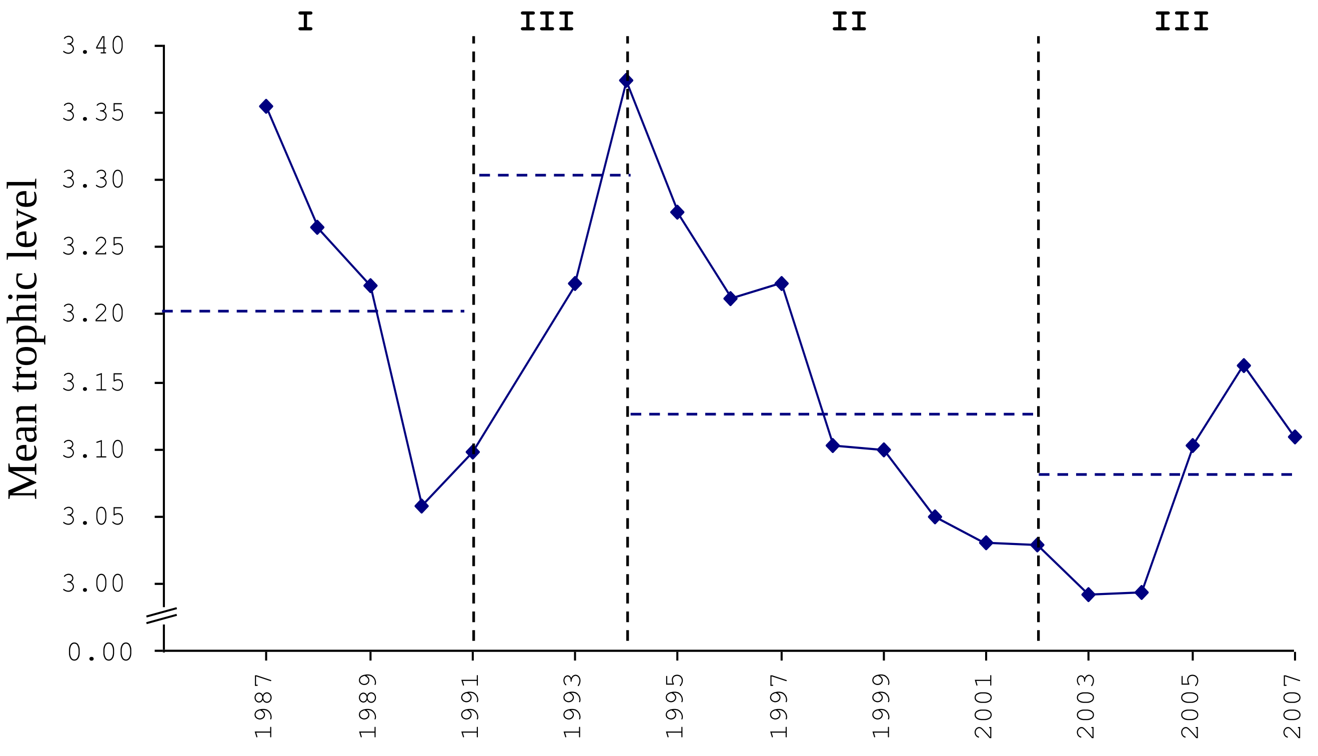


Mean trophic level
Ia
Ib
IIa
IIb
3.35
3.30
3.25
3.20
3.15
3.10
3.05
3.00
2.95
2.90
2.85
2.80
2.75
2.70
0.00
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007

Srinakarind



Vajiralongkorn



Implications for management

- Treating the littoral zones is particularly important.
- Conservation program to the species that impacts by the impoundment, i.e. true riverine species.
- Conservation of the “drawn-down” area.
- Fish stocking program on the low variation and self-recruit indigenous species
- Stocking on the short-lived species such as C. *aesarnensis* as the prey for predatory species to avoid “fishing down the food-web” maybe an option.
- The last two options are possible due to The low value (i.e. < 0.0015) of gross efficiency transfer of primary production through the catches in Thai reservoirs.

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THANK YOU

- Thank [illegible], C[illegible]P-MRC, for his [illegible]s a[illegible]d [illegible]on of the first version of this work

- Details will be published in *Lake & Reservoir: Research & Management*