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어류를 이용한 다양한 평가

2023년 11월 29일

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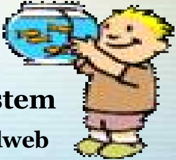
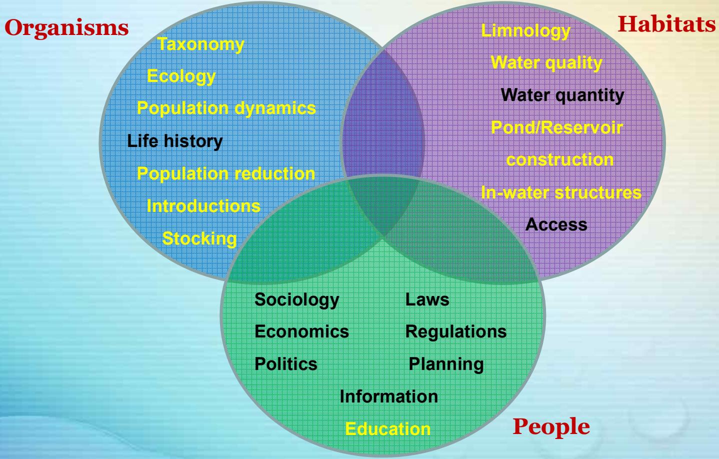
Why Fish ?



- Belong to vertebrate same as human
- Top consumers in many aquatic ecosystem
  ⇒ rely on other organisms to balance the foodweb (phyto-/ zooplankton, macroinvertebrate)
- Excellent bioindicator
  ⇒ influenced by physical, chemical, & biological factors
  ⇒ representing condition of an aquatic environment

Fisheries Management



Fisheries management depicted as three overlapping circles (from Kohler and Hubert 1993)

Multilevel appoaches

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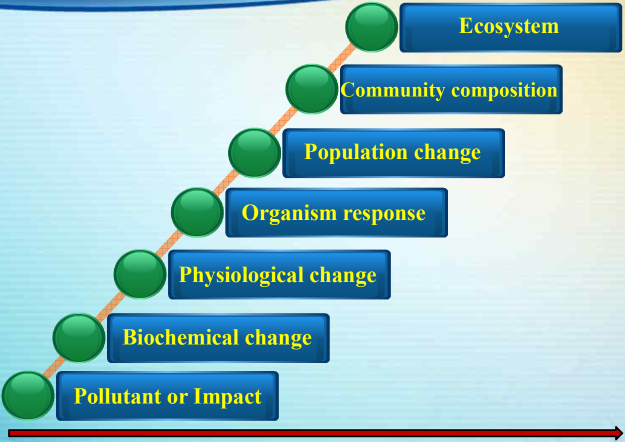


Increasing response time
Increasing difficulty of linkage to specific chemicals(impact)
Increasing importance

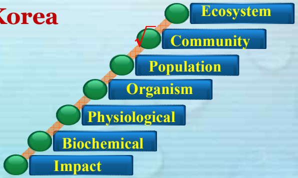
1 Community-level Approaches

Case 1. Comparison of fish communities in Ledbetter Creek and Ledbetter Embayment, Kentucky Lake

Case 2. Determination of ecological change in fish for sustainable development in Geum River, Korea

Case 3. Environmental impact assessment on Hwabuk Dam construction, Korea

Case 4. Fishway Monitoring



Fish community analysis

Murray
MURRAY STATE UNIVERSITY

- Fish density, biomass, species richness
- Relative abundance
- Species diversity
- Dominant family and species

General characteristics

Zone	Channel width (m)	Zone Description	Shading effect	Nutrient (TN, TP)
Stream	4	Well-developed pools and riffles	High	Low
Ecotone	7	Non-measurable water flow, No pool or riffle development	Medium	Medium
Littoral	Wide-open area	Lentic water, bottom gently sloping region 0 ~ 1.5 m	Low	High

815 fish representing 27 species and 9 families

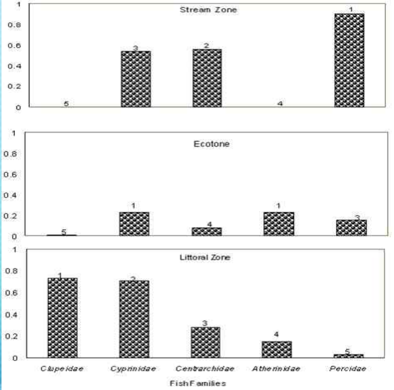
Zone	Stream	Ecotone	Littoral
Families	6	6	7
Species	17	18	19

Mean number/biomass of fish per trap

Zone	Stream	Ecotone	Littoral
Number	2.2	0.9	1.9
Biomass	6.2 g	1.3 g	2.1 g

Habitat selection

Spatial distribution of abundant families of fish



- **Family rankings in the stream appeared to be the opposite of the littoral zone.**

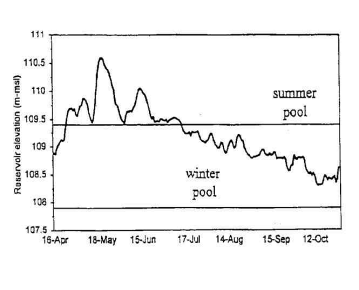
Five of the most abundant species

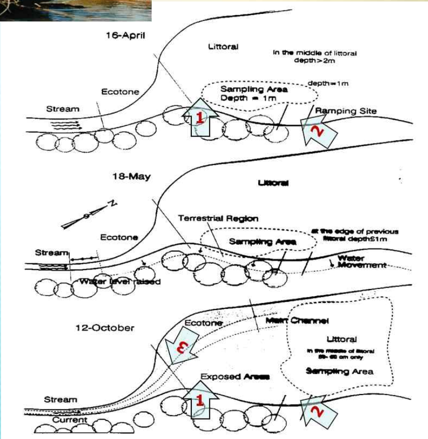
Species	Stream zone	Ecotone	Littoral zone	P value
Guardian darter	0.72 (0.33 – 1.95)	0 (0)	0 (0)	< 0.001
Longear sunfish	0.285 (0.1 – 1.36)	0 (0 – 0.09)	0 (0 – 0.65)	< 0.001
Central stoneroller	0.13 (0 – 2.23)	0 (0 – 0.2)	0 (0)	< 0.001
Threadfin shad	0 (0)	0 (0 – 0.05)	0.025 (0 – 3.17)	= 0.001
Bullhead minnow	0 (0)	0 (0 – 0.08)	0.165 (0 – 1.33)	< 0.001

Values represent median of mean fish density over months / trap.
Numbers in parentheses indicate its range

- **The five most abundant species seemed to have habitat selection.**

Habitat shift

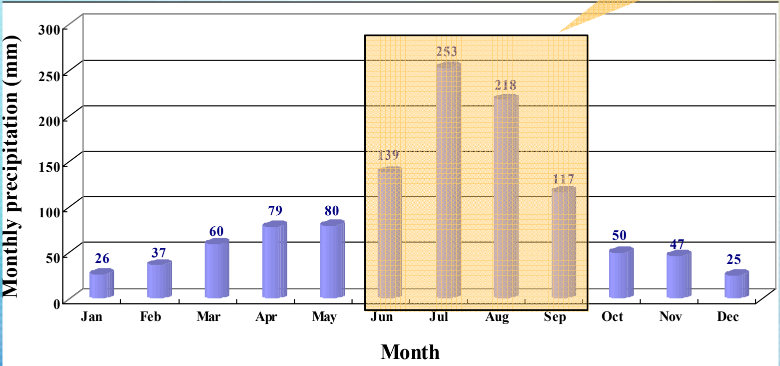




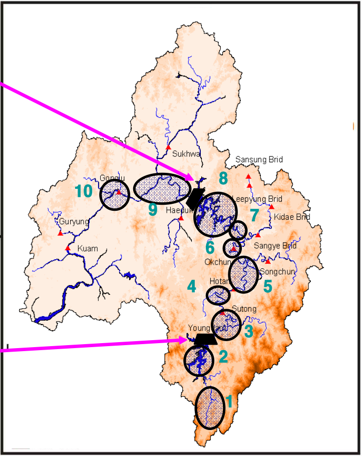
Precipitation (1966-1996)

- Annual mean precipitation: 1,130.7mm (44.5 inches)
- Its fluctuation is wide.

64% of annual precipitation



Study Area



Zonation of investigation sites

Materials and Methods

Field Investigation

- Backpack electrofishers are normally used for quantitative sampling in developed countries such as America, Europe, and Australia, and etc.

Analysis

- **Fish fauna and community**
  - **Ecologically valuable**
  - **Economically valuable**
  - **e.g.. Number of species**
    Relative abundance
- **Relations to flow regime**
  - **Positive/negative effect on** certain species
- **Further investigation**
  - **Examine physical preferences** such as water current, depth, and substrate type when fishes are collected

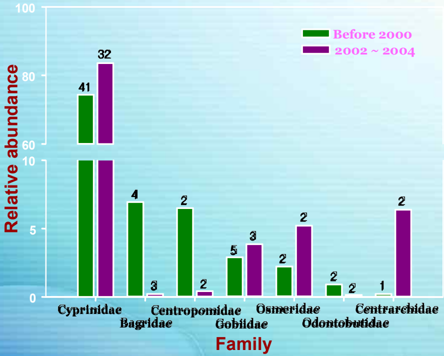
Fish Assemblage

- Total fish fauna in Geum River
  - 20 families 82 species
  - Before 2000 : 20 families 78 species
  - 2002~2004 : 12 families 58 species
    (5 additional introduced species)

	Up- and Downstream of Yongdam Dam		Up- and Downstream of Daecheong Dam	
	Before 2000	2002~2004	Before 2000	2002~2004
Fauna	**11 family 49 species**	**11 families 42 species**	**20 families 76 species**	**11 families 52 species**
Natural monument species	**1**	**0**	**0**	**0**
Endangered species	**5**	**4**	**7**	**1**
Korean endemic species	**22**	**20**	**28**	**16**
Exotic species	**0**	**3**	**1**	**6**

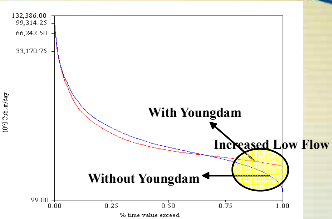
Daecheong Dam (completed in 1980)

- Before 2000 - Total 20 families 76 species
- 2002 ~ 2004 - Total 12 families 52 species



Flow Duration Curve

- **Scenario : Before/After Yongdam Dam construction**
- **Increased low flow after Yongdam Dam construction**



(Unit: $10^3 m^3$/Day)

Whole Period	Abbreviation	With Youngdam Dam	Without Youngdam Dam
Minimum	Min	369	99
Maximum	Max	132,386	121,661
Percentile 10	P 10	3,793.8	4,897.7
Percentile 90	P 90	441	313.7
Mean	MDF	2,498.1	2,705.5
Median	Med	694	780.5
CV	CV	3.05	2.88
Standard Deviation	STD	7,619.2	7,797.7
Skweness	Skw	3.6	3.5

Relation between change of flow regime and ecological characteristics

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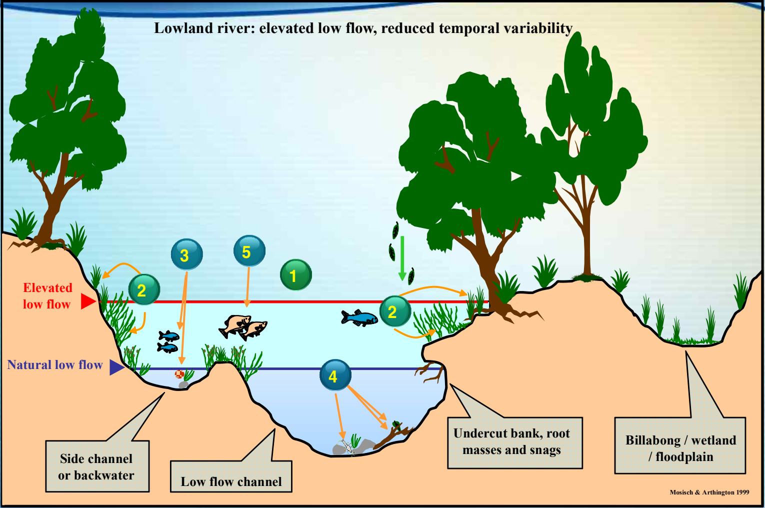
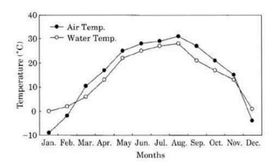
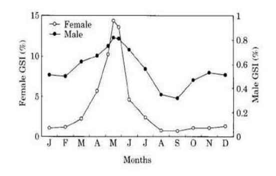


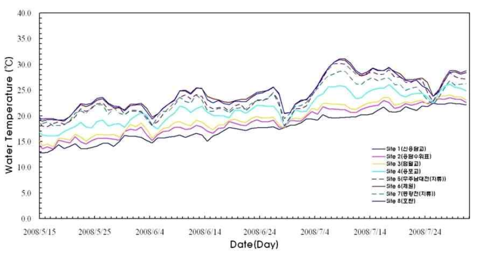
Effect of dam discharge



Monthly variation of air/water temperature

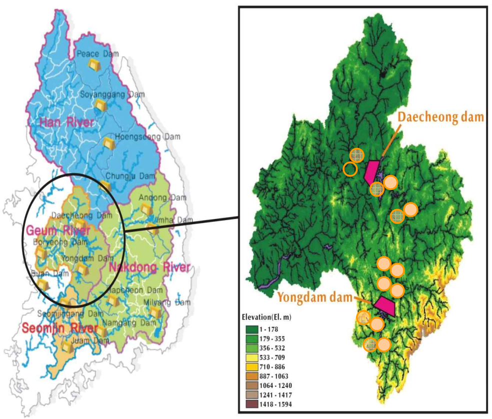


Reproduction of freshwater goby

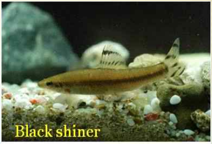


Selection of key species

- "Select key species", and compare their distribution between before and after dam construction

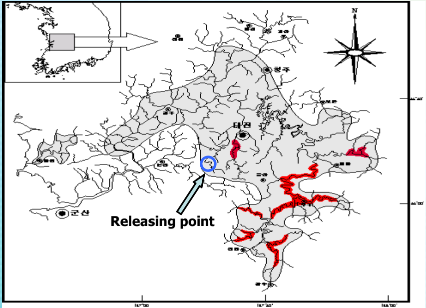


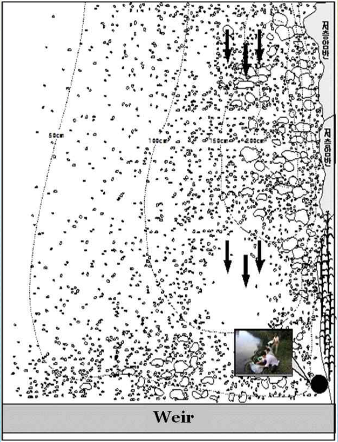
Endangered species



Korean endemic species

Habitat for restoration





Habitat investigation for key species

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Korean J. Limnol. 42 (4): 495~501 (2009)

Preference of Physical Microhabitat on the 1st-class Endangered Species, *Gobiobotia naktongensis* inhabiting the Gam Stream, Tributary of the Nakdong River

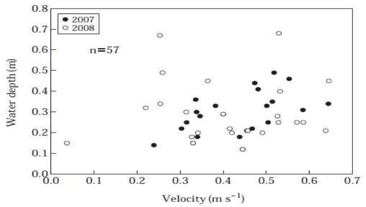
Seo, Jinwon*, Heesung Kim, Hye Suk Yi and Sun A Jeong

- Sieve analysis of substrate where the endangered species, *Gobiobotia naktongensis* was found

Unit: %

May	gravel	coarse sand	fine sand	silt	clay
St. 3	0.08	90.96	8.16	0	0
St. 5	0	89.60	10.40	0	0
St. 6	0.16	87.04	12.64	0	0
St. 8	0.24	70.20	29.20	0	0
August					
St. 3	2.36	76.60	20.60	0	0
St. 8	0.68	85.92	13.00	0	0

- Velocity : 0.239 ~ 0.585 m/sec
- Depth : 0.14 ~ 0.46 m
- Substrate : Mostly coarse sand (> 0.425mm)
- They prefer shallow run in sandy bottom



Artificial propagation

- Collect brood fish from the same watersheds
- Induce artificial sex maturation with manipulation of photoperiod and water temperature
- Embryo development and hatching (9 days in black shiner w/ 20 ℃)
- Food source for juvenile : Artemia, daphnids
- keep and maintain good water quality

1 hour after fertilization

Hatch

2^{nd}- day after hatching

Juvenile

감돌고기

다시 볼 수 있을까

생태복원 위해 水公 지난주 금강 방류

청주 미호천까지 올라올지 여부도 관심

근래들어 개체수 급감-멸종위기 직면

Interview on TV

(YTN, 2005.10.7)

Monitoring of restored fish

Investigation

	2005		2006			
	Before release	After release	1st	2nd	3rd	4th
Black shinner	–	12	1	10	8	–
Korean aucha perch	–	6	–	1		1
Family	4	5	3	5	4	6
Species	15	15	9	16	15	16

- Total 7 families 20 species including 11 species (55%) of Korean endemic species

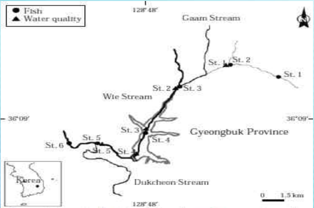
Underwater camera

Interview on TV (TJB, 2006.8.3)

Environmental Impact Assessment

Korean J. Limnol. 42 (2) : 260~269 (2009)

A Study of Fish Community on Up and Downstream of Hwabuk Dam Under Construction in the Upper Wie Stream. *Seo, Jinwon* and Heesung Kim (Korea Institute of Water and Environment (KIWE), Korea Water Resources Corporation, Daejeon 305-730, Korea)*



Map of the study sites. Dam is under construction and the grey line indicates expected area submerged.

A list of fish species and number of individuals caught from the sampling sites from 2004 to 2008.

Species	English name	2004	2005	2006	2007	2008	Total	RA	Re.
Cyprinidae									
Carassius auratus	Crusian carp	13	3	32	12	5	65	0.63	
Pungtungia herzi	Striped shinner	52	49	44	20	56	221	2.15	
Coreoleuciscus splendidus	Korean shinner	24	81	37	132	142	416	4.05	K
Squalidus gracilis majimae	Korean slender gudgeon	52	112	64	93	173	494	4.81	K
Hemibarbus longirostris	Long nose barbel		27	21	6	7	61	0.59	
Pseudogobio esocinus	Goby minnow				13		13	0.13	
Microphysogobio yaluensis	–	70	76	17		17	180	1.75	K
Rhynchocypris oxycephalus	Chinese minnow	335	280	142	127	204	1,088	10.60	
Zacco koreanus	Korean chub	1,002	1,716	986	1,343	1,370	6,417	62.53	K
Zacco platypus	Pale chub	1	80	83	93	81	338	3.29	
Cobitidae									
Misgurnus anguillicaudatus	Muddy loach		7	3		6	16	0.16	
Koreocobitis naktongensis	Naktong nose loach		1	3	1		5	0.05	E, K
Cobitis sinensis	Spine loach	5	24	44	37	31	141	1.37	
Niwaella multifasciata	Eastern spine loach	14	47	87	36	51	235	2.29	K
Siluridae									
Silurus microdorsalis	Slender catfish		1			1	2	0.02	K
Amblycipitidae									
Liobagrus mediadiposalis	South torrent catfish	30	8	13	5	3	59	0.57	K
Odontobutidae									
Odontobutis platycephala	Korean dark sleeper	75	45	90	94	127	431	4.20	K
Gobiidae									
Rhinogobius brunneus	Common freshwater goby	45	5	15	5	10	80	0.78	
Belontiidae									
Macropodus ocellatus	Roundtailed paradise fish		1				1	0.01	
Number of family		7	5	5	6	7	7		
Number of species		13	18	16	15	16	19		
Number of individuals		1,718	2,563	1,681	2,017	2,284	10,263		

K: Korean endemic species, E: Endangered species, RA: Relative abundance, Re.: Remark

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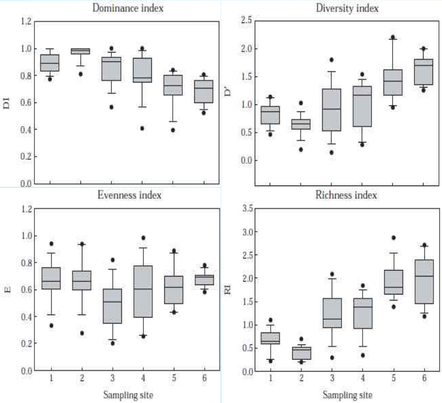
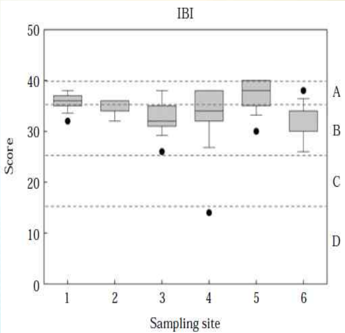
Community analysis



Dominance index decreased toward lower site, but diversity and richness indices increased toward lower site

Stream health assessment



Stream health assessment with index of biotic integrity (IBI). A: Excellent (36～40), B: Good (26～35), C: Fair (16～25), D: Poor (≤15).

Index of biotic integrity (IBI) using eight metrics resulted mostly in good and excellent condition in all sites.

Ice harbor type fishway

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- Pool type ice-harbor
- 1:20(height : length) slope
- about 1.0 m/s water current
- divided into six spillways

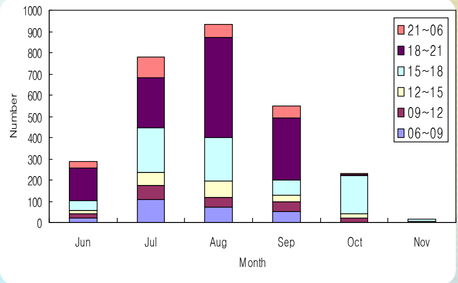
  - Total 9 families 36 species
  (2004: 24 sp. ⇒ 2008: 12 sp.)

- Various size distribution between 21 mm (black bullhead) and 550 mm (far eastern catfish)

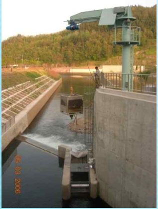
- Study and acquire fundamental data on swimming ability by species and size

- Maximum of fish movement in 18~21 o'clock (47.8%)

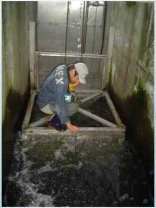
- Related amount of fish movement with water temperature



Crane-truck fishway



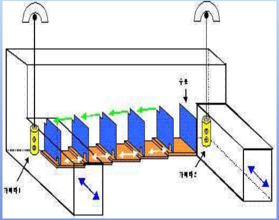
- found total 7 families 22 species:
  Anguillidae(1), Cyprinidae(15), Cobitidae(2), Osmeridae(1), Gobiidae(1) Centropomidae(1), Odontobutidae(1),
- *Z. platypus* is dominant(90% in number)
- found a fish as small as 30 mm TL
- found movement of lentic & benthic sp.
- studied swimming ability by species and size with velocity measurement



Fishway of Estuary barrage

- Operate fishway and Navigation lock for fish migration

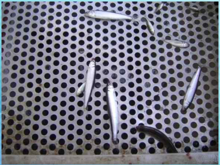
Fishway



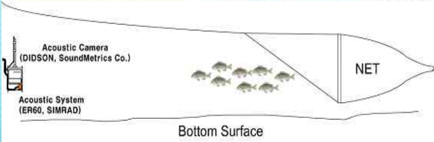
※ FISH LOCKING ?

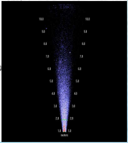
Fish movement program(6~8 times per day)

Monitoring method



Fishway monitoring



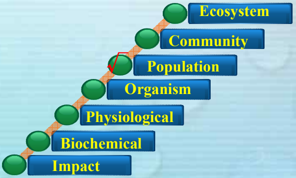


Fish locking monitoring(Top: netting, bottom: Acoustic camera)

2 Population-level Approaches

Case 1. Monitoring of a fluvial bull trout in Arrowrock Reservoir, Idaho, USA

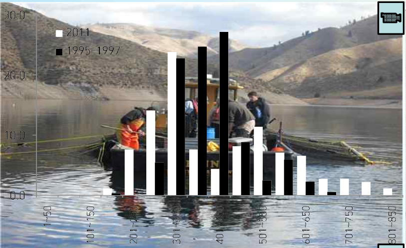
Case 2. Investigation of largemouth bass with a sport-fishing tournament in Andong Reservoir, Korea

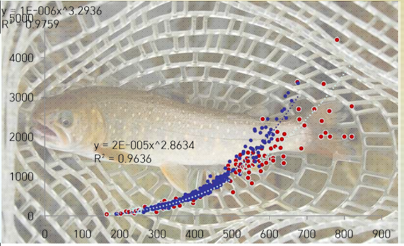


Common indicators

Survival related	
• age-specific survival rates • year-class strength • age structure • catch per unit effort	• density or abundance • mean age • maximum age • recruitment indices
Growth related	
• mean weight-at-age • allometric relationships • size structure • condition factor • proximate body composition	• mean length-at-age • specific growth rate • liver somatic index • incidence of parasites
Reproduction related	
• age-at-maturity • reproductive life span • gonad somatic index • incidence of atresia	• fecundity • sex ratio • egg size • spawning frequency

Bull trout as a threatened species





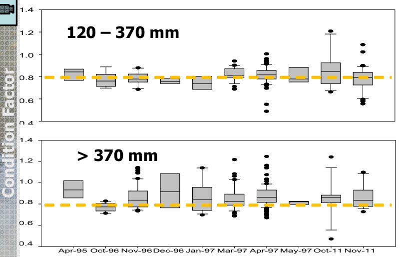
Telemetry

- Mark fish at weirs and in reservoir.
- Radio tags, acoustic tags, Pit tags, archival temperature tags

Tags deployed in reservoir (fall 2011):

Archival tags n=18

Radio tags n=32



Others in Arrowrock Reservoir

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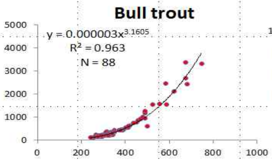
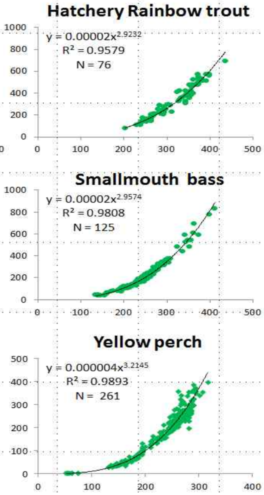
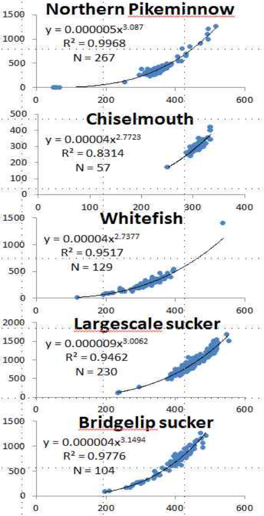






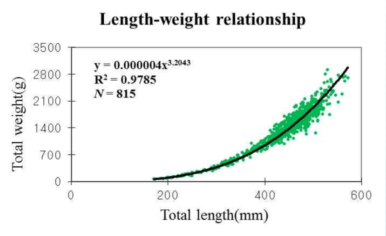
Length-weight relations by endangered, sporting, and undesirable fish species

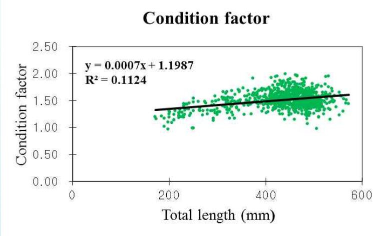
Largemouth bass (introduced species)

- Purpose : Investigation of introduced species, largemouth bass in Andong Resevoir
- Supported by Korean Sportfishing Association(KSA)
- Examination: growth states (growth rate and condition factor)
  reproduction states (gonad somatic index, fecundity)

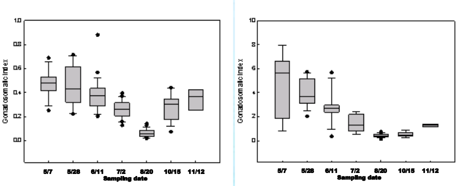
Index of well-being : Condition factor (CF)

$K = (TW / TL^3) \times 10^5$



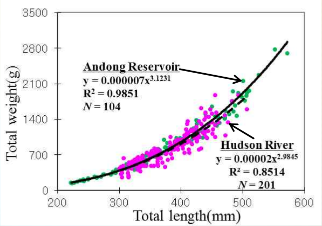


Change of gonad somatic index(GSI) by time and sex



GSI = Gonad weight/Total weight × 100

Comparison of length-weight relationship



Fecundity of female largemouth bass

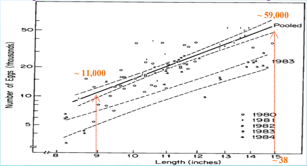
<7 May 2006>

Total length	Total weight	Gonad weight	Estimated eggs
318	525	30	25,077
319	475	4	6,820
328	515	7	5,409
353	760	49	40,157
430	1,100	70	47,308
467	1,770	74	59,239
492	2,005	137	116,134

<11 June 2006>

Total length	Total weight	Gonad weight	Estimated eggs
385	820	46.5	16,740
411	1,090	29.1	13,367
429	1,150	29.3	17,114
475	1,400	40	61,677
505	1,985	46	26,279
536	2,270	67	44,859
555	2,710	113.8	59,440

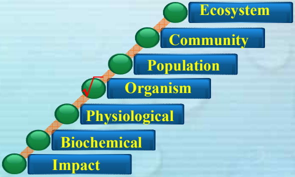
Fecundity of Michigan largemouth bass (Laarman and Schneider 1985)



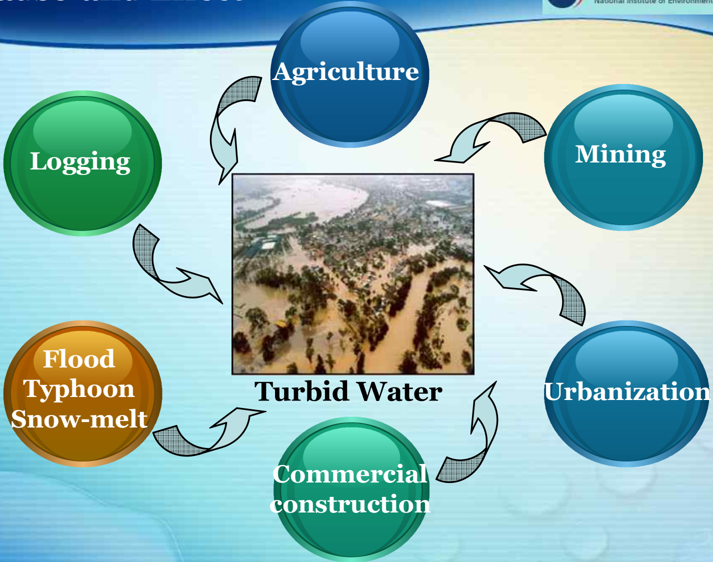
$Log_{10}\ egg = 0.4254 + 3.2857\ log_{10}\ (length\ in\ cm)$

3 Organism-level Approaches

Case 1. Effect of turbid water on fish ecology in streams and reservoirs in Korea



Cause-and Effect



Typical human activity

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National Institute of Environmental Research

Bank revetment

Stream rehabilitation

Dredging

Eco-park construction

회색으로 멍든 강물이 힘겹게 흐른다

지자체마다 앞다퉈 골재채취 … 하천부지 농약 · 비료에 가축분뇨까지 뿌려

4/대/강/집/중/탐/사

낙동강 ⑥ 밀양을 거쳐 부산 하구둑까지

General point of view

Impact on aquatic ecosystem due to dredging

Respiration Difficulty in fish due to turbid water

Sediment particle can clog fish gill.

Reduction of species diversity by habitat degradation

Continuous dredging in particular area causes avoidance and even less population of some sensitive fish

Effects of turbidity on fish

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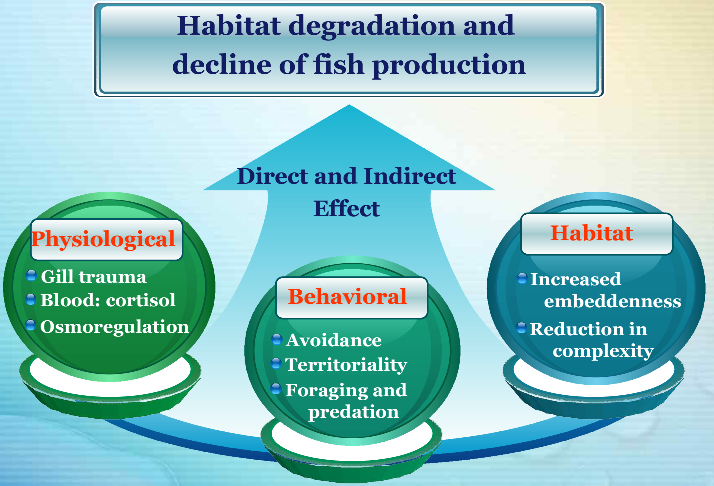

Relation with other factors

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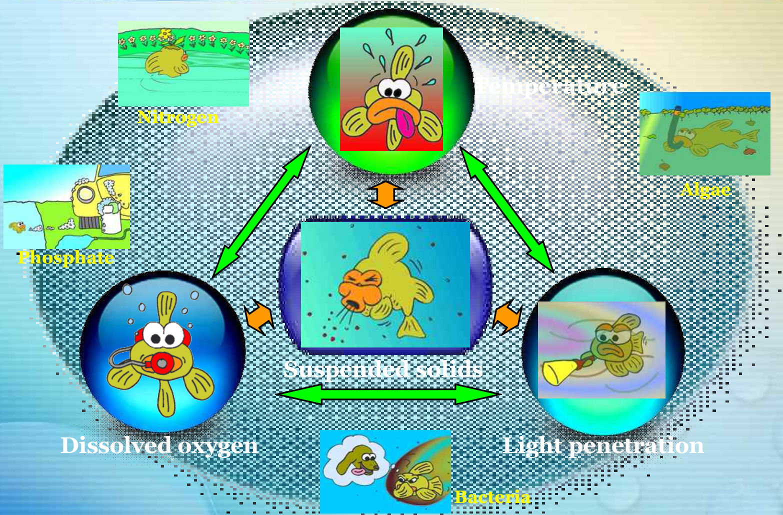
National Institute of Environmental Research



Histopathological analysis

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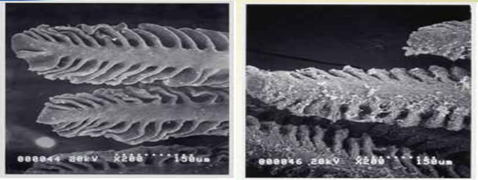
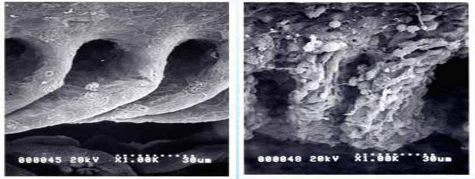
Tracheal gills of *Siphlonurus chankae* (Ephemeroptera) in control (top) and turbid (bottom) sites



Gill of goldfish *(Carassius auratus)* in control (left) and turbid (right) sites (×200, SEM)



2nd gill lamella of goldfish *(Carassius auratus)* in control (left) and turbid (right) sites (×1000, SEM)

Korean J. Limnol. 41 (4): 431~440 (2008)

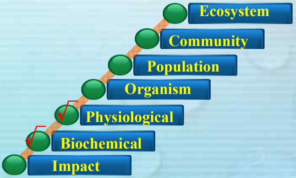
Effects of Turbid Water on Fish Ecology in Streams and Dam Reservoirs

Seo, Jinwon and Jong Eun Lee[1]

4 Lower-level Approaches

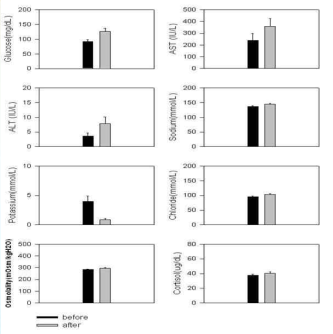
Case 1. Study on effect(s) to fish by burning reeds in constructed wetland, Korea

Case 2. Ecological risk assessment of abandoned mine drainages for managing water quality in streams, Korea



Physiological indicator

catching fish⇒collecting blood⇒performing analysis



- **Cortisol, Glucose : related to stress**
  - little increased but not significantly

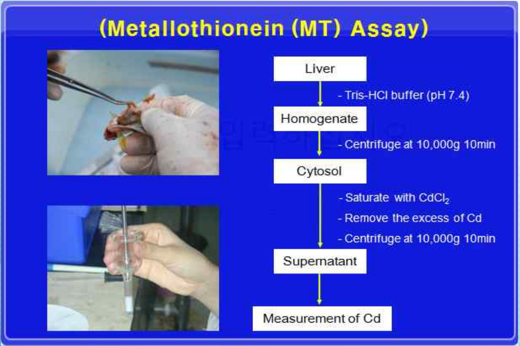
AST, ALT : related to enzyme activity in liver
- little increased but not significantly

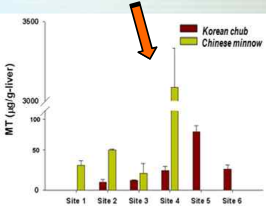
Na^+, K^+, Cl^- : related to cytosol
- little increased except for K^+ but not significantly

Biochemical indicator

Abandoned mine & Smelting factory drainage

- low pH (high acidity)
- high metal concentration (mostly Fe, Al, Mn)
- Increased sulfate level, suspended solids, & siltation





5 Effects of water quality

Case 1. Influences of seasonal rainfall on water quality near the intake tower of Daechung Reservoir, Korea

Case 2. Best management practices for improving water quality in inland fisheries, USA

Case 3. Characteristics of water quality and fish presence and distribution in streams/rivers, Korea

Case 4. Use of Chinese bleak in embryo and sac-fry stages toxicity test with zinc

Case 5. Ecological risk assessment of abandoned mine drainages for management of water quality in streams

Water quality in Limnology

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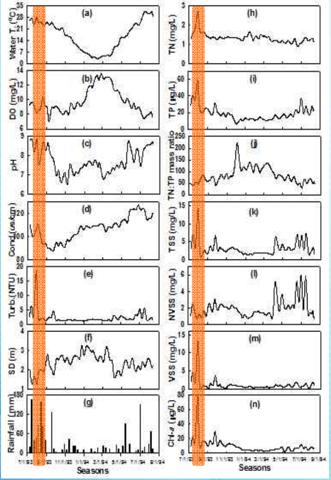


Temporal variation of water quality parameters

Korean J. Limnol. 34 (4): 327~336 (2001)

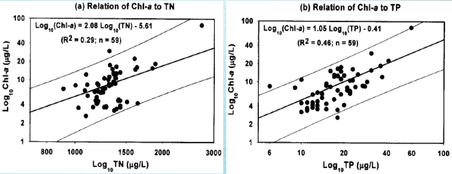
Influences of Seasonal Rainfall on Physical, Chemical and Biological Conditions Near the Intake Tower of Taechung Reservoir

An, Kwang-Guk*, Jinwon Seo and Seok Soon Park

	Prec.	TN	TP	TN/TP	Chl-*a*	TSS	NVSS	VSS	Temp	pH	DO	Cond.	Turb.
TN	0.61												
TP	0.76	0.58											
TN/TP	−0.58	−0.05	−0.80										
Chl-*a*	0.71	0.77	0.86	−0.52									
TSS	0.47	0.33	0.81	−0.69	0.76								
NVSS	−0.11	−0.53	0.05	−0.44	−0.09	0.44							
VSS	0.59	0.68	0.86	−0.50	0.89	0.84	−0.12						
Temp	0.60	0.08	0.79	−0.90	0.53	0.58	0.33	0.44					
pH	0.64	0.22	0.79	−0.76	0.46	0.54	0.04	0.58	0.74				
DO	−0.38	0.03	−0.55	0.66	−0.44	−0.44	−0.32	−0.28	−0.87	−0.48			
Cond.	−0.17	−0.48	−0.02	−0.17	−0.45	0.07	0.28	−0.09	0.09	0.36	0.08		
Turb.	0.64	0.65	0.90	−0.58	0.85	0.89	0.06	0.95	0.50	0.65	−0.27	0.02	
SD	−0.72	−0.32	−0.80	0.79	−0.67	−0.78	−0.28	−0.69	−0.65	−0.66	0.37	−0.04	−0.74

*Prec. = Precipitation, Temp = Water temperature, Cond. = Conductivity, Turb. = Turbidity, SD = Secchi depth

Correlation coefficients among the water quality parameters



Regression analyses of chlorophyll-a against TN and TP

Water quality in Aquaculture

국립환경과학원 +Pride
National Institute of Environmental Research





1. **Channel catfish industry**
2. **Current management practices**
3. **Environmental concerns**
4. **Best management practices (BMPs)**

JOURNAL OF THE WORLD AQUACULTURE SOCIETY
Vol. 32, No. 3 September, 2001

Dry-Tilling of Pond Bottoms and Calcium Sulfate Treatment for Water Quality Improvement

JINWON SEO AND CLAUDE E. BOYD[1]
Department of Fisheries and Allied Aquacultures, Auburn University, Alabama 36849 USA

ELSEVIER
Aquacultural Engineering 25 (2001) 83–97
aquacultural engineering
www.elsevier.nl/locate/aqua-online

Effects of bottom soil management practices on water quality improvement in channel catfish *Ictalurus punctatus* ponds

Jinwon Seo, Claude E. Boyd *
Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL 36849-5419, USA

Mechanism of water quality improvement with physical and chemical management practices

Oxidation of Bottom Soil by Drying and Tilling → Increased Adsorption of phosphorus

Gypsum ($CaSO_4$) Application → Precipitation of Calcium Phosphate

→ Reduced Phosphorus Availability → Less Phytoplankton → Water Quality Improvement → Better Effluent Quality / Better Fisheries Production

Water quality criteria

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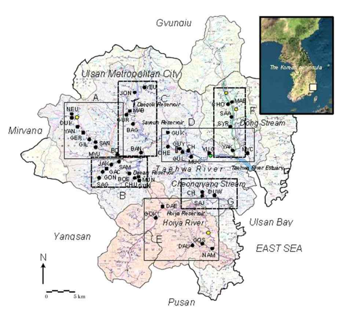
National Institute of Environmental Research

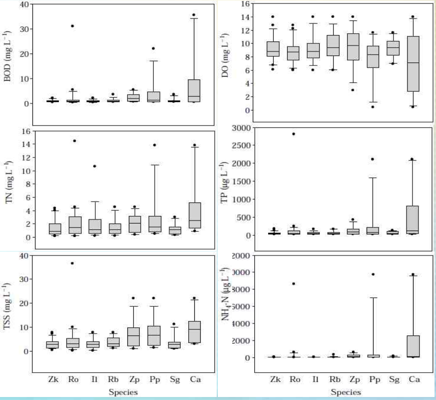
Korean J. Limnol. 41 (3) : 283~293 (2008)

Status of Fish Inhabitation and Distribution of Eight Abundant Species in Relation with Water Quality in Streams and Rivers, Ulsan City

Seo, Jinwon, In-Soo Lim, Hojoon Kim and Hye Keun Lee (Korea Institute of Water and Environment, Korea Water Resources Corporation, Daejeon 305-730, Korea)



1. Total 44 sampling sites
2. Water sampling and analysis
- Period : Mar, May, Aug, & Oct 2006
3. Fish collection
- Period : Aug 2006
- Gears : cast net and kick net



Range of fish presence vs. water quality with vertical box plot

Water quality criteria

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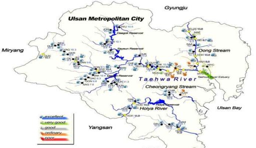
Class	State	pH	DO (mg/L)	BOD (mg/L)	SS (mg/L)	TP (mg/L)
Very Good		6.5~8.5	≥ 7.5	≤ 1	≤ 25	≤ 0.01
Good		6.5~8.5	≥ 5.0	≤ 2	≤ 25	≤ 0.02
Fairly Good		6.5~8.5	≥ 5.0	≤ 3	≤ 25	≤ 0.03
Fair		6.5~8.5	≥ 5.0	≤ 5	≤ 25	≤ 0.05
Fairly Poor		6.0~8.5	≥ 2.0	≤ 8	≤ 100	≤ 0.1
Poor		6.0~8.5	≥ 2.0	≤ 10		≤ 0.15
Very Poor			< 2.0	> 10		> 0.15



DO

BOD

Total phosphorus

Zinc toxicity test

J. ENVIRON. TOXICOL.
Vol. 20, No. 4, 359∼363 (2005)

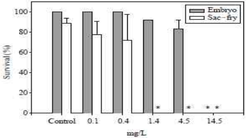
Use of Chinese Bleak, *Aphyocypris chinensis*, in Embryo and Sac−Fry Stages Toxicity Test

Dong Hyuk Yeom*, Jinwon Seo[1] and Sung Kyu Lee

Continuous flow-through system supplying test solution

Embryo vessels suspended in control and test aquaria

A. chinensis(***Aphyocypris chinensis***)



O. latipes(***Oryzias latipes***)

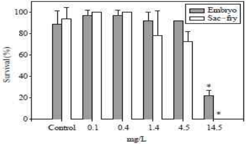


Fig. 1. Embryo and sac−fry survival of *A. chinensis* and *O. latipes* exposed to zinc. Data are given as mean± SD; n = 3. *Significantly different from the control (p≤0.05).

Table 1. Body length and weight of *A. chinensis* exposed to zinc

Concentration (mg/L)	Sac−fry survival (%)	Length (mm/individual)	Weight (mg/individual)
Control	88.9±4.9	4.46±0.20	0.15±0.05
0.1	77.8±12.7	4.33±0.17*	0.18±0.06
0.4	72.2±25.5	4.26±0.18*	0.19±0.06
1.4	0*	−	−
4.5	0*	−	−
14.5	0*	−	−

Data are expressed as mean± SD; n≥3
*Significantly different from the control (p≤0.05)

Table 2. Body length and weight of *O. latipes* exposed to zinc

Concentration (mg/L)	Sac−fry survival (%)	Length (mm/individual)	Weight (mg/individual)
Control	93.9±10.5	4.54±0.23	0.30±0.07
0.1	100±0	4.62±0.17	0.29±0.11
0.4	100±0	4.57±0.22	0.29±0.09
1.4	78.2±22.8	4.57±0.22	0.26±0.09
4.5	72.7±9.1	4.56±0.21	0.25±0.08
14.5	0*	−	−

Data are expressed as mean± SD; n≥3
*Significantly different from the control (p≤0.05)

Table 3. Comparison of the sensitivity to zinc (mg/L) in embryo−sac fry toxicity tests of *A. chinensis* and *O. latipes*

Species	LC_{50} (95% confidence limits)	Effect concentration		MATC
		NOEC	LOEC	
A. chinensis	0.7 (0.5∼0.8)	<0.1	0.1	<0.1
O. latipes	4.8 (3.8∼6.1)	4.5	14.5	8.1

Environmental hormone test

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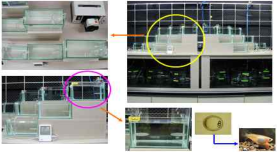
- **Test species**
  Japanese ricefish
  (*Oryzias Latipes*)

- **Test substance**
  Bisphenol A (BPA), Nonylphenol (NP)

- **Exposure design (Partial life-cycle test)**

Parameter	Test conditons
Test type	Continuous flow-through system
Duration	Embryos(24-hr post-fertilization) to 60-days post-hatch
Test concentration (ppb)	Control Positive control (E_2, 0.5 ppb) BPA(1.2 ppb) + NP(1.0 ppb) BPA(80 ppb) + NP(6.0 ppb) BPA(400 ppb) + NP(12 ppb) BPA(2000 ppb) + NP(24 ppb)
Temperature	22~26℃
DO	> 60%
pH	7.0 ± 0.5
Photoperiod	16 h light : 8 h dark regime
No. of exposed egg	20 / 3 replicates
Diet	brine shrimp, Tetramin flake

- **Continuous flow-through system**



J. ENVIRON. TOXICOL.
Vol. 22, No. 3, 203 ~ 209 (2007)

Combination Effect of Bisphenol A and Nonylphenol to Japanese Medaka (*Oryzias latipes*)

Jinwon Seo, Woo-Keun Kim[1,*] and Sung-Kyu Lee[1]

Effect on Embryo

Table 1. Effects of exposure to combination of bisphenol A and nonylphenol on mortality, hatchability, and time to hatch of fertilized eggs of Japanese medaka (*Oryzia latipes*)

Treatment (μg/L)	Mortality (%)	Hatching rate (%)	Time to hatch (day)
Control	11.6±1.4	84.1±3.8	8.7±0.2
BPA (1.2)+NP (1)	11.6±2.9	87.0±2.5	8.2±0.2
BPA (80)+NP (6)	13.0±5.0	82.6±6.7	8.0±0.1
BPA (400)+NP (12)	13.0±5.0	87.0±5.0	8.3±0.1
BPA (2,000)+NP (24)	5.9±1.4	92.6±2.8	8.5±0.3
E_2 (0.5)	10.1±5.8	88.4±5.2	8.9±0.2
P value	0.815	0.710	0.083

Data expressed as mean±standard error (n=3)

※ **Control should have greater than 80% of survival rate and hatching rate.**

Effect on Juvenile

Table 2. Effect of exposure to combination of bisphenol A and nonylphenol on growth of medaka (*Oryzia latipes*) at 60-day post-hatch

Treatment (μg/L)	Total length (mm)	Total weight (mg)
Control	21.0±0.5	87.7±6.2
BPA (1.2)+NP (1)	20.8±0.4	81.5±4.5
BPA (80)+NP (6)	21.2±0.4	84.8±4.8
BPA (400)+NP (12)	21.1±0.3	80.1±3.6
BPA (2,000)+NP (24)	20.1±0.3	69.4±2.7
E_2 (0.5)	15.9±0.5*	42.3±4.0*
P value	≤0.001	≤0.001

Vitellogenin concentration

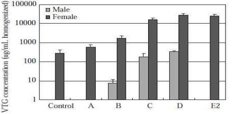


Fig. 1. The effects of different mixture concentrations of bisphenol A and nonylphenol on homogenized vitellogenin levels in medaka (*Oryzia latipes*) exposed for 60-day post-hatch.

➢ **Concentration-dependent increase**

➢ **Exposure to combination groups induced VTG concentrations of male except for the lowest combination.**

※ **What is Vitellogenin (VTG)?**
- egg yolk precursor protein expressed in the females of nearly oviparous species

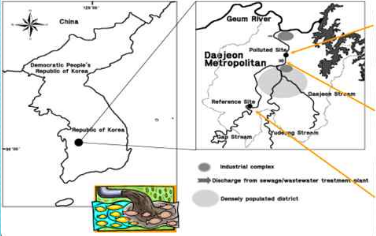
Vitellogenin test kit

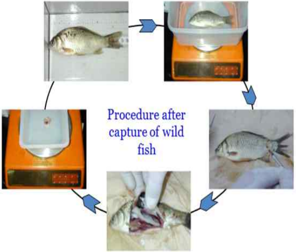
Case Study of Multilevel Approaches

Available online at www.sciencedirect.com
ScienceDirect
Chemosphere 67 (2007) 2282–2292
CHEMOSPHERE
www.elsevier.com/locate/chemosphere
ELSEVIER

Stressor identification and health assessment of fish exposed to wastewater effluents in Miho Stream, South Korea

Dong-Hyuk Yeom [a,*], Soon-Ae Lee [a], Gi Soo Kang [b], Jinwon Seo [c], Sung-Kyu Lee [a]





Whole effluent toxicity(WET) test

- Test species

Site	Discharge (m^3/day)	*Oryzias latipes*		*Daphnia magna*		*Lemna gibba*	
		1st	2nd	1st	2nd	1st	2nd
STP	521,755~907,927	N/E	N/E	N/E	N/E	< 6	12
WTP	52,930~60,710	N/E	N/E	N/E	N/E	< 6	< 6

Unit : %

Multimetric Biological Health Assessments Using Fish Assemblage

IBI	Integrity Class	Characteristics
53-55	Excellent	Comparable to pristine conditions, exceptional assemblage of species.
43-47	Good	Decreased species richness, intolerant species in particular; Sensitive species present
35-39	Fair	Intolerant and sensitive species absent; skewed trophic structure
23-29	Poor	Top carnivores and many expected species are absent or rare; omnivore and tolerant species are general.
8-17	Very Poor	Few species and individuals present; tolerant species dominated; diseased fish frequently

Upstream IBI = 47 (Good)

Downstream IBI = 17 (Very poor)

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National Institute of Environmental Research

Biological parameters from the fish collected

M: Male, F: Female

Site (water T ℃)	M:F	Total Length (TL, cm)	Total Weight (TW, g)	Condition factor (CF)	Gonadosomatic Index (GSI, %)	Hepatosomatic Index (HSI, %)
April Non-polluted (15) Polluted (15)	12:6 3:5	M:16.1 F:17.6 M:17.3 F:20.8	M:63.7 F:93.8 M:93.9 F:204.0	M:1.52 F:1.67 M:1.71 F:1.96	3.62 8.93 2.06 15.71	N/A N/A 2.64 2.51
May Non-polluted (22) Polluted (23)	3:10 1:9	M:14.7 F:15.1 (18.7) M:28.5 F:24.6	M:48.3 F:68.5 (111) M:334.4 F:270.3	M:1.50 F:1.63 (1.57) M:1.44 F:1.74	M:3.99 F:5.69 (10.01) M:3.92 F:13.19	M:1.59 F:2.14 (2.20) M:1.93 F:3.00
June Non-polluted (22) Polluted (24)	3:13 4:17	M:16.0 F:15.5 M:16.6 F:16.4	M:69.1 F:61.4 M:80.4 F:84.8	M:1.63 F:1.59 M:1.73 F:1.75	1.91 3.72 1.18 1.29	2.22 1.75 3.35 3.06

Necropsy-Based Fish Population Health Assessment

Comet Parameter Method

- Head DNA(%), Tail DNA(%), Tail Length(μM), Tail Extent Moment

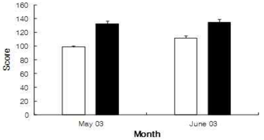
Parameter	May 2003 Upstream (N=12)	May 2003 Downstream (N=7)	June 2003 Upstream (N=10)	June 2003 Downstream (N=10)
Head DNA (%)	94.10+0.42	84.0+82.11*	91.31+0.90	84.15+1.27*
Tail DNA (%)	5.90+0.42	15.92+2.11*	8.69+0.90	15.85+1.27*
Tail extent moment	0.25+0.02	2.05+0.86*	0.56+0.08	1.34+0.15*

Empirical Score Method

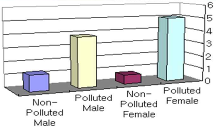
Tail DNA(%)

Approximate percentage DNA in tail	Damage category allocated	Score allocated
0	No	0
1-20	Low	1
21-50	Med	2
51-99	High	3
100	complete	4

Reference: Wilson *et al.*, (1998)



Enzyme activity by EROD - from fish liver



Conclusion

1 Conservation and restoration of fish ecology

- Determination of declined fish species and population

2 Prevention of factors causing fish decline

- Restriction of unnecessary in-stream constructions : Physical
- Reduction of point & nonpoint pollution sources : Chemical
- Elimination of illegal fish releases : Biological

3 Periodic- and systematic monitoring of fish

- High-level : Population- and community-level approaches
- Low-level : Molecular-, biochemical-, organism-level approaches