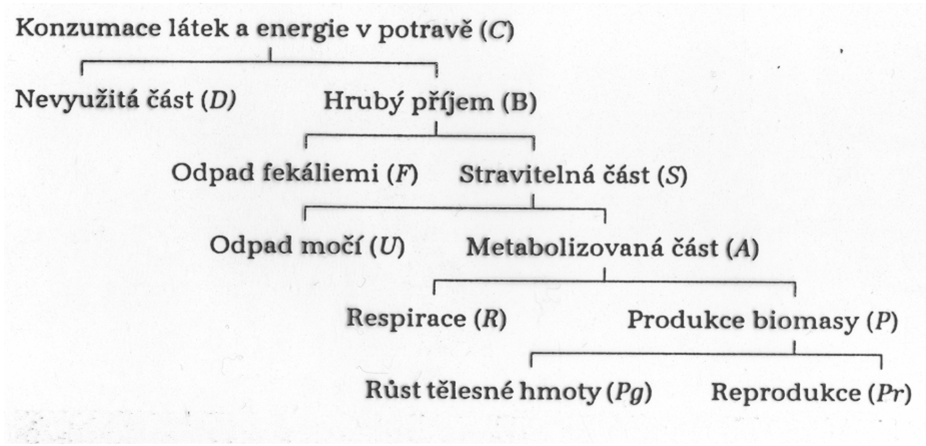
Akvatická ekotoxikologie

Ekosystémová ekotoxikologie

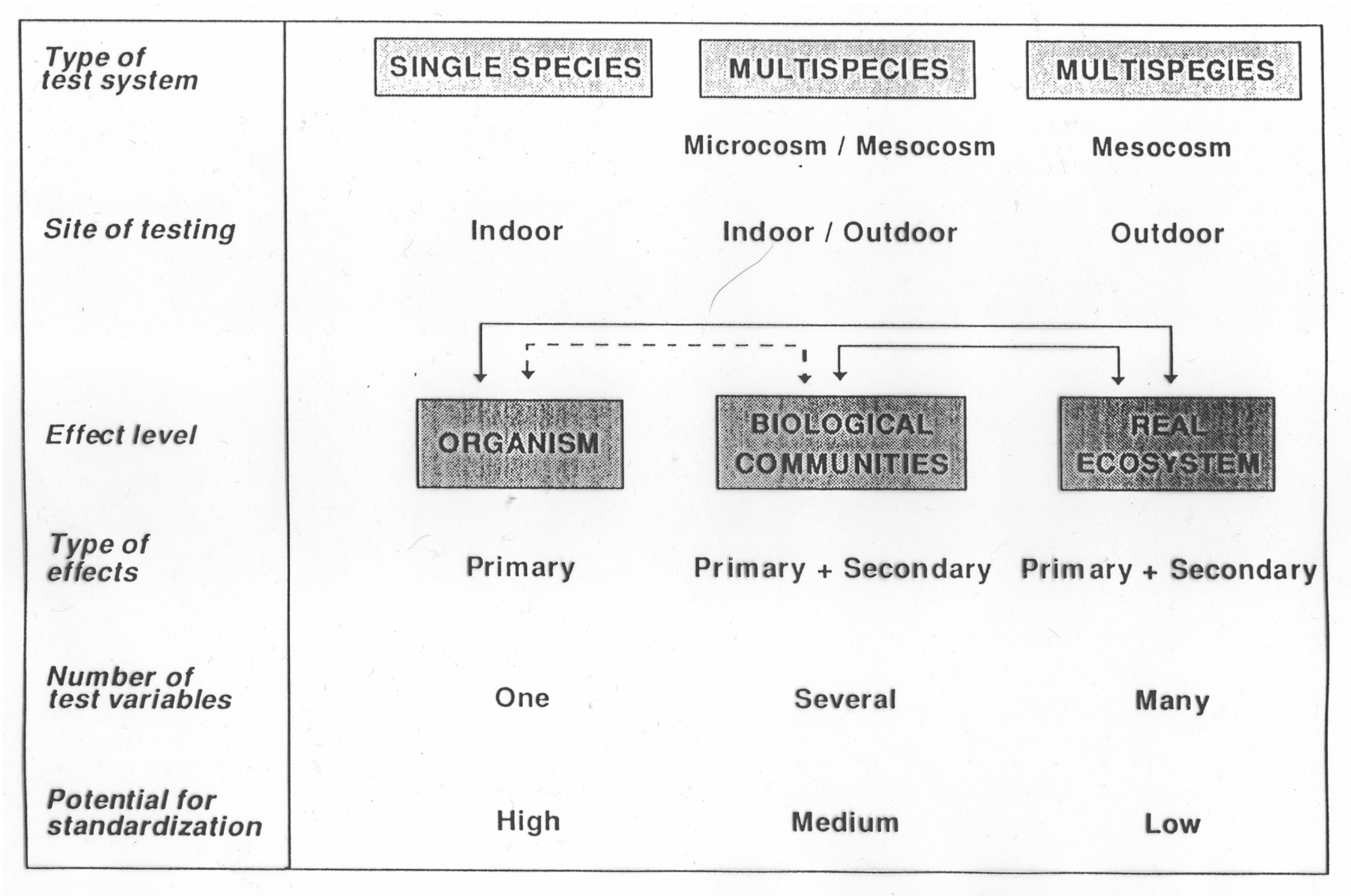
Druh	C
Asplanchna priodonta	0,5
Brachionus rubens	1,5
Linmodrilus neuneruis	0,01-0,04
Daphnia pulex	0,21-0,45
Daphnia longispina	0,12
Moina brachiata	0,25
Bosmina longirosrris	0,15
Cyclops sp.	0,12
Unio tumidus	0,00035
Sphaerium corneum	0,0044
Chironomus phanasus	0,007-0,024
Chaoborus crystallinus	0,033



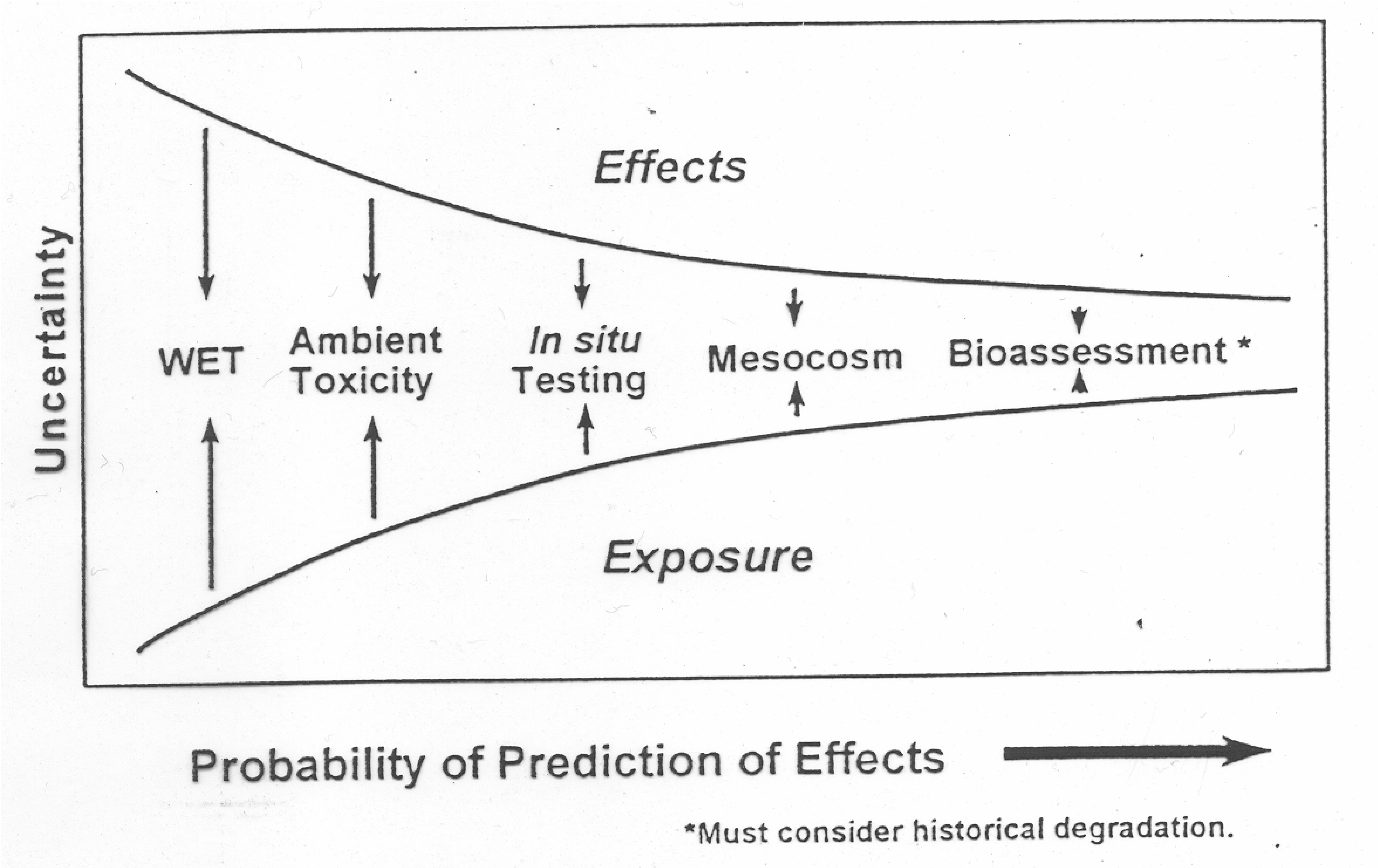
Produkce/ hrubý příjem jako ekologický parametr toku energie

Průměrné hodnoty a rozpětí P/B koeficientů v různých trofických skupinách organismů sladkovodních ekosystémů (podle různých autorů sestavil Wetzel, 1963)

	Průměmá hodnota	Rozpětí hodnot
baktérie	141,0	73 -237
fytoplankton	113,0	9 -359
herbivorní zooplankton	15,9	0,5- 44,0
karnivomí zooplankton	11,6	1,5- 30,4
herbivorní bentičtí bezobratlí	3,7	0,6- 12,6
karnivorní bentičtí bezobratlí	4,6	1,0- 25,0



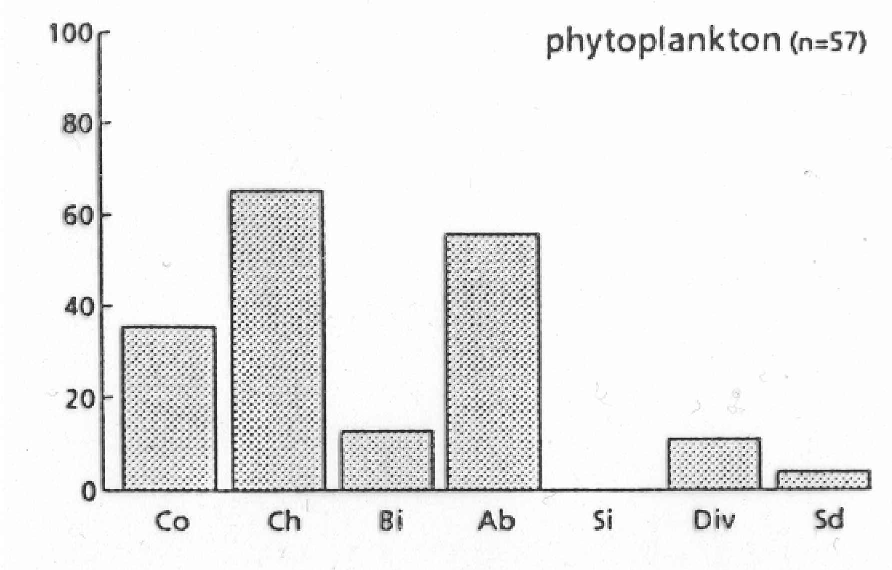
Schematic presence of the major characteristics of the three main types of toxicity tests; the arrows indicate the extrapolation/validation steps

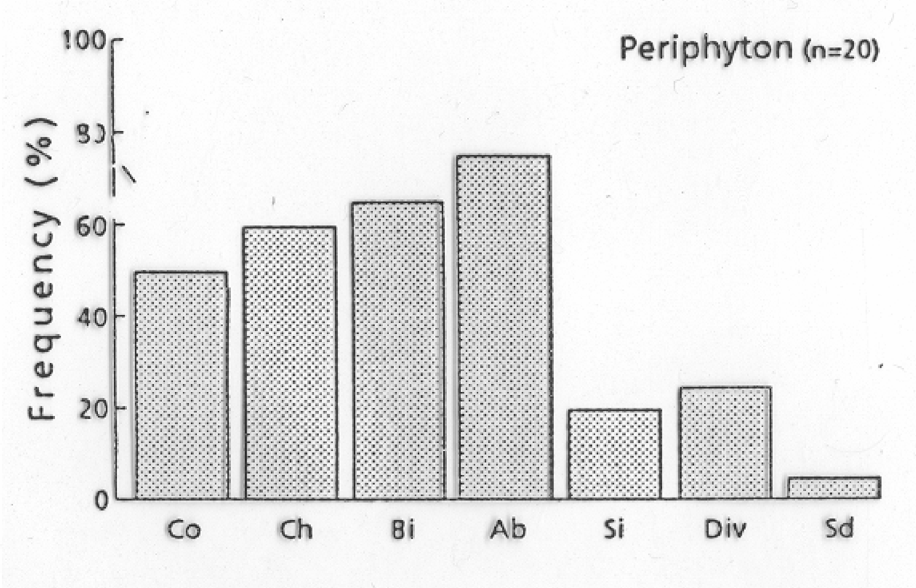


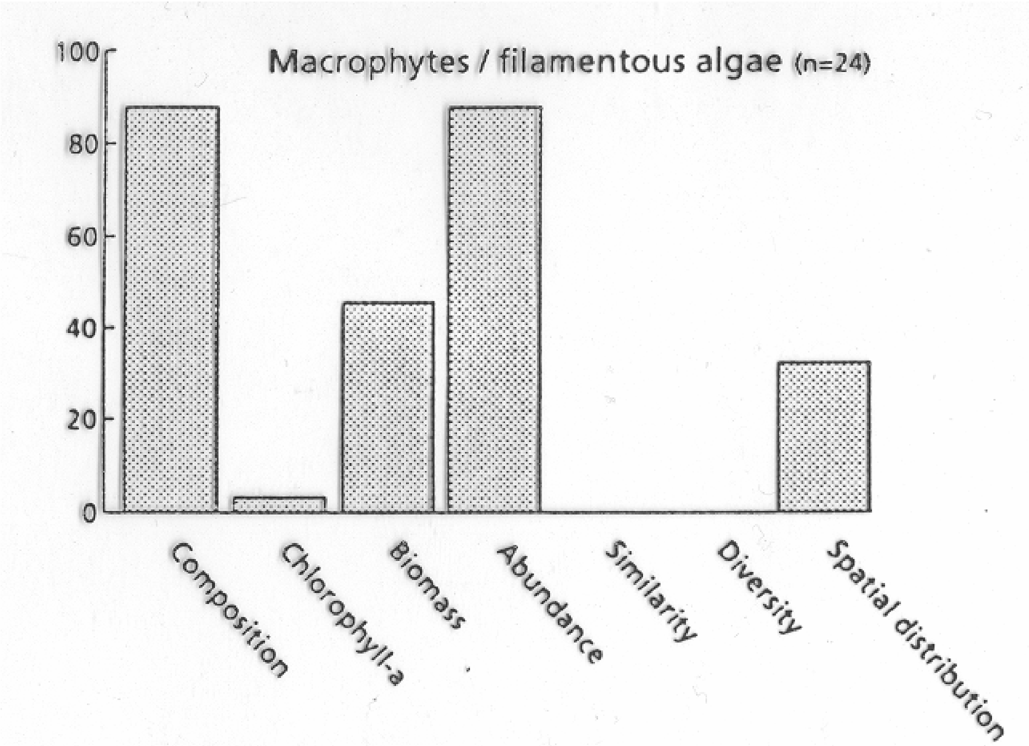
Predicting receiving system impacts from effluent discharge (adapted from Cairns *et al*. 1978)

Table 4. List of recommended structural parameters in pesticide testing in lentic systems, after three guidance documents.

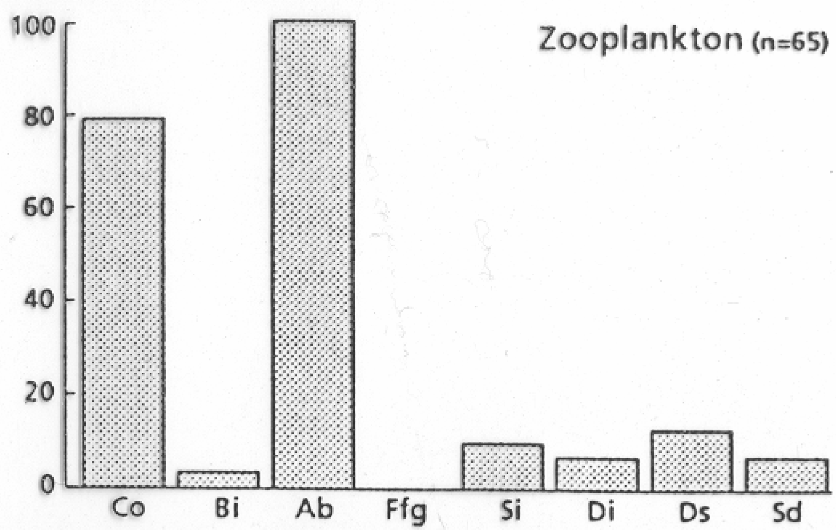
	Aquatic mesocosms, guidance document (Touart 1988)	Aquatic microcosms, guidance document (SETAC 1991)	Freshwater mesocosms, guidance document (SETAC-Europe 1991)
Phytoplankton sample frequency parameters	biweekly • chlorophyll-a/phaeophytin • identification dom. taxa	biweekly • chlorophyll-a • total density • density dom. taxa • taxonomic composition	logarithmic time series (6–10 times post-treatment) • chlorophyll-a • taxonomic composition • abundance (at least dom. taxa)
Periphyton (art. substrate) sample frequency parameters	biweekly • chlorophyll-a • ash free weight	biweekly • chlorophyll-a • ash free dry weight • total periphyton density • density dom. taxa • taxonomic composition	logarithmic time series (6–10 times post-treatment) • chlorophyll-a • biomass
Macrophytes sample frequency parameters	at least at end of test • species composition • % cover • dry weight	at least at end of test • species composition • % cover • wet and dry weight	logarithmic time series (6–10 times post-treatment), at least at end of test • % cover • biomass
Zooplankton sample frequency parameters	weekly collection, biweekly counts • abundance of dom. taxa (species/genus level) • length of muon of cladocerans	weekly • total density • densities of Cladocera, Rotifera and Copepoda • density of dominant genera • taxonomic composition	logarithmic time series (6–10 times post-treatment) • abundance (at least of dom. taxa) • taxonomic composition
Macro-invertebrates sample frequency parameters	biweekly • abundance of emergent insects (lowest practical taxon) • abundance of epifauna on artificial substrates (lowest practical taxon)	weekly • total abundance emergent insects • total abundance Chironomidae and dom. chironomid subtaxa • total density benthic macro-invertebrates • density dom. benthic taxa • taxonomic composition	logarithmic time series (6–10 times post-treatment) • abundance (at least of dom. taxa) • taxonomic composition
Fish (caged fish excl.) sample frequency parameters	beginning and end of test • abundance (per taxon) • length • wet weight • pathologic condition	beginning and end of test • abundance (per taxon) • length • weight	logarithmic time series (6–10 times post-treatment) • abundance (per taxon) • length • weight • sex

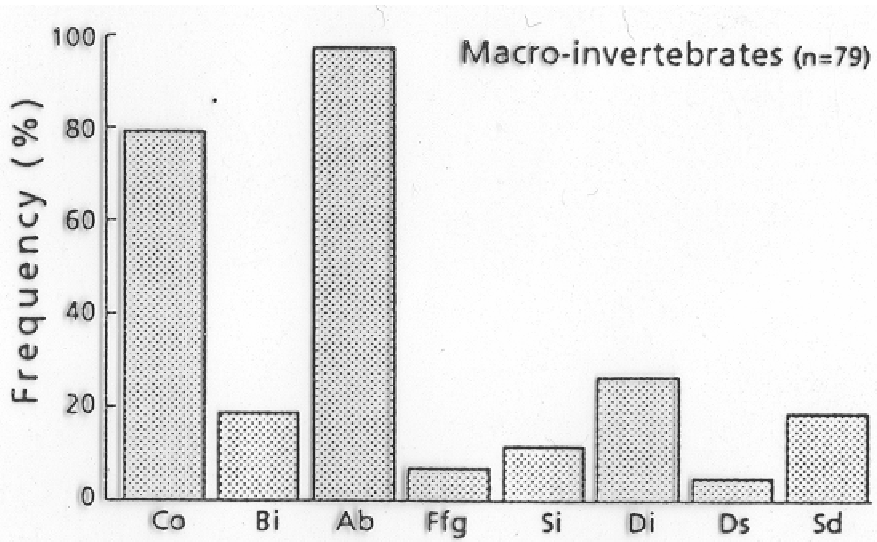


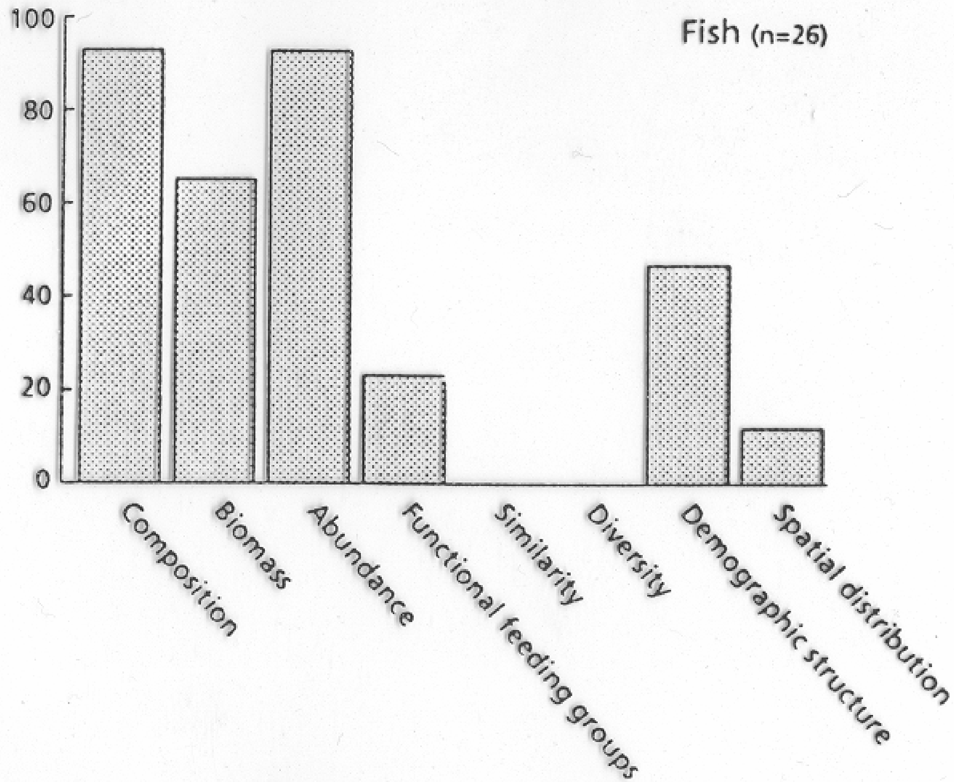




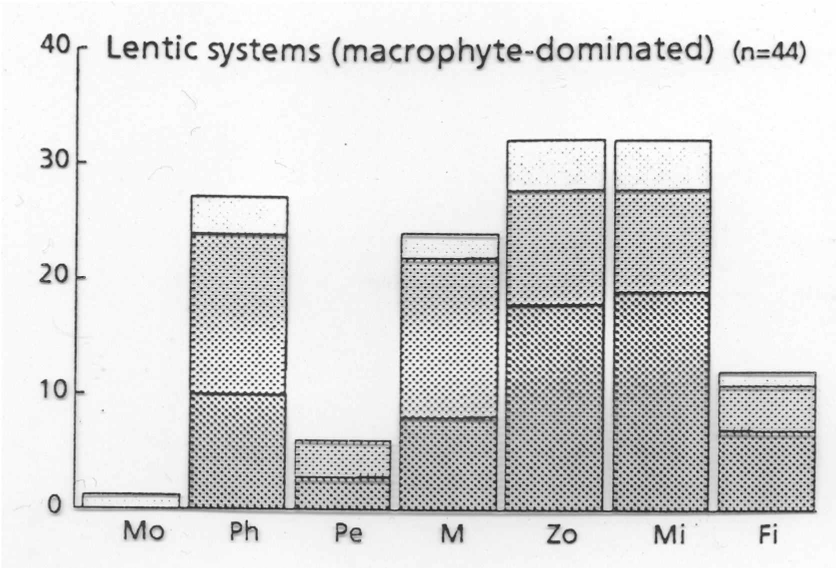
Relative frequency of the use of specific structural parameters to characterize the responses of phytoplankton, periphyton, and macrophytes, respectively (Co=Composition of lowest practical taxon; Ch=Chlorophyll-a; Bi=Biomass; Ab=Abundance; Si=Similarity index; Div=Diversity index; Sd=Spatial distribution.

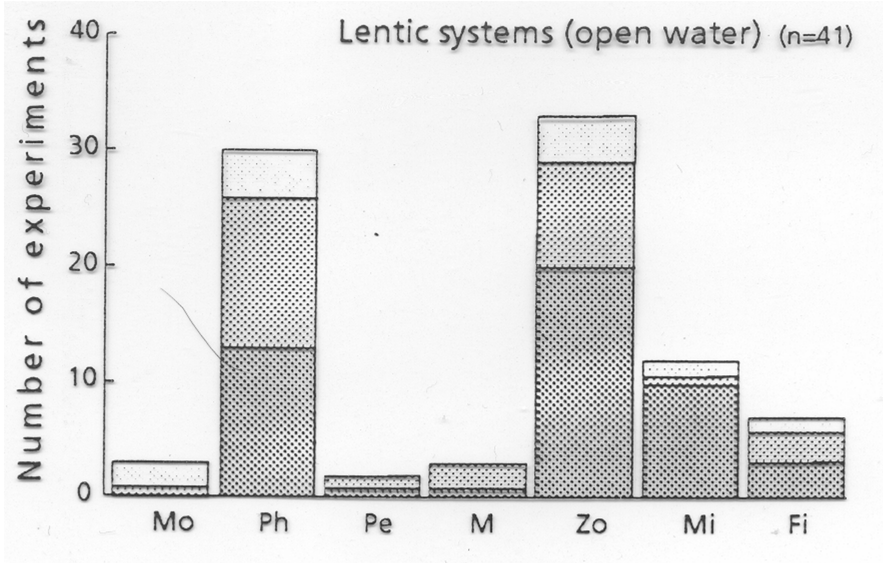


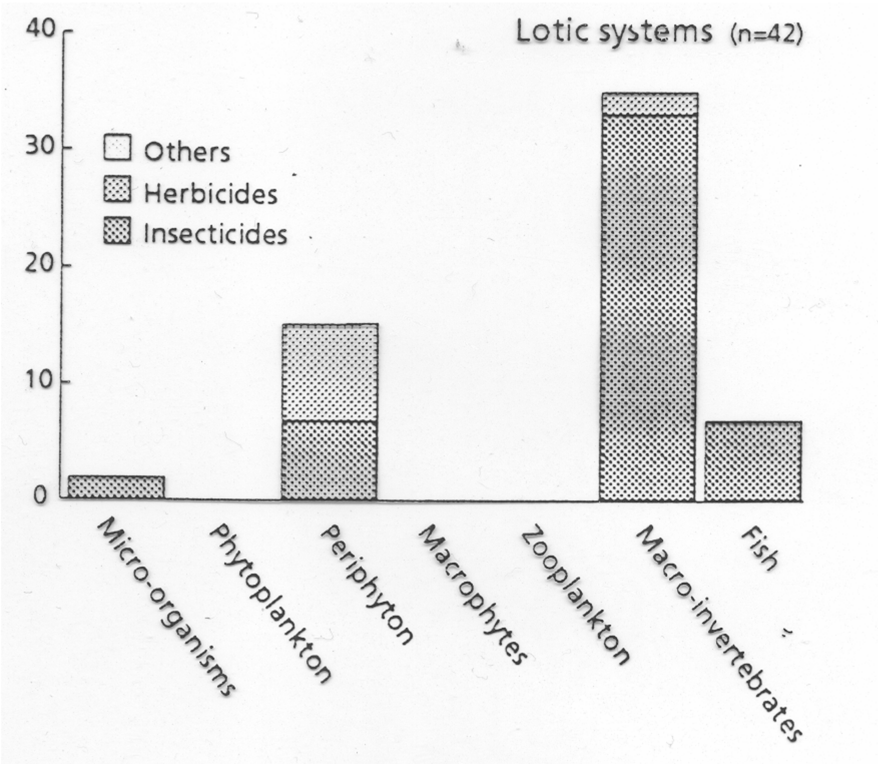




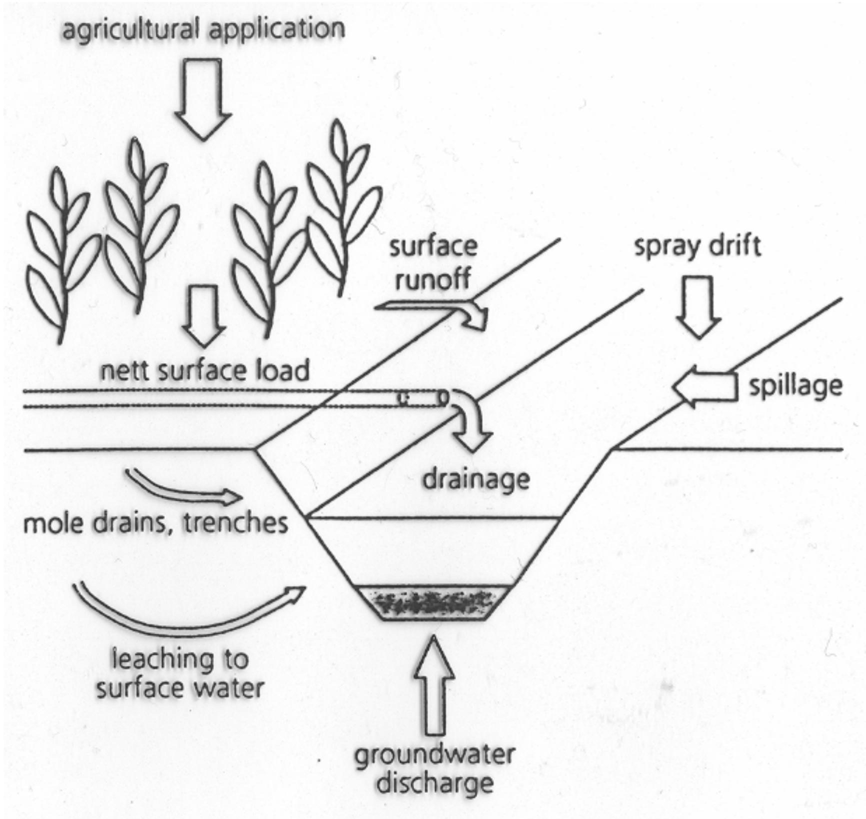
Relative frequency of the use of specific structural parameters to characterize the responses of zooplankton, macro-invertebrates and fish, respectively (Co=Composition at lowest practical taxon; Bi=Biomass; Ab=Abundance; Flg=Functional feeding groups, food choice and diet; Si=Similarity index; Di=Diversity index; Ds=Demographic characteristics; Sd=Spatial distribution).

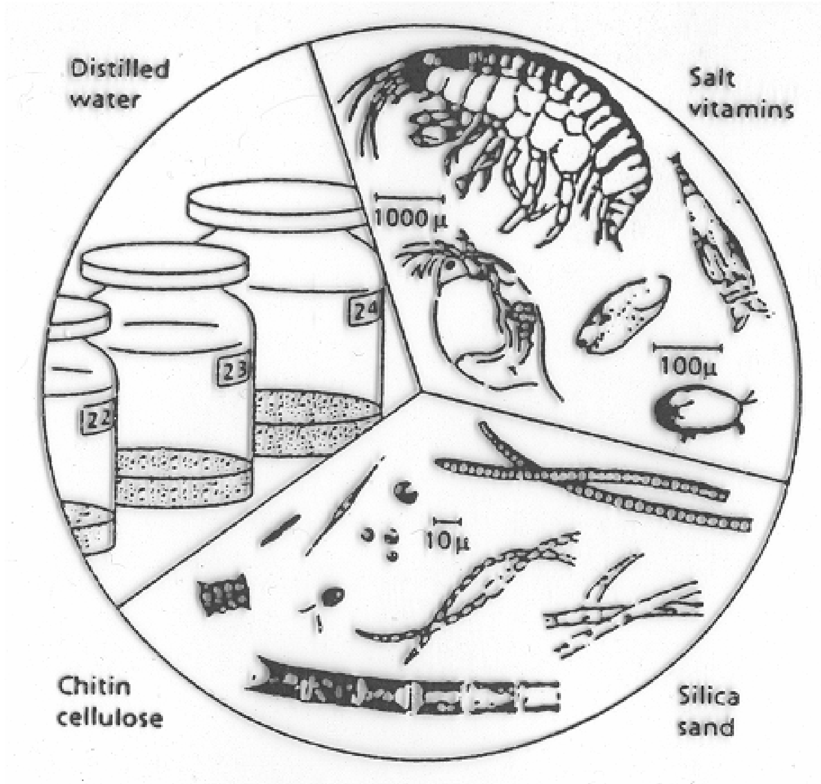






Numbers of experiments in which structural aspects of different (sub)communities have been studied, in the three types of aquatic (model) ecosystem discerned. (Mo=Microorganisms; Ph=Phytoplankton; Pe=Perinhyton; M=Macrophytos; Zo=Zooplankton; Mi=Macro-invertebrates, Fi=fish)





Design experimentu ovlivní spektrum sledovaných organismů

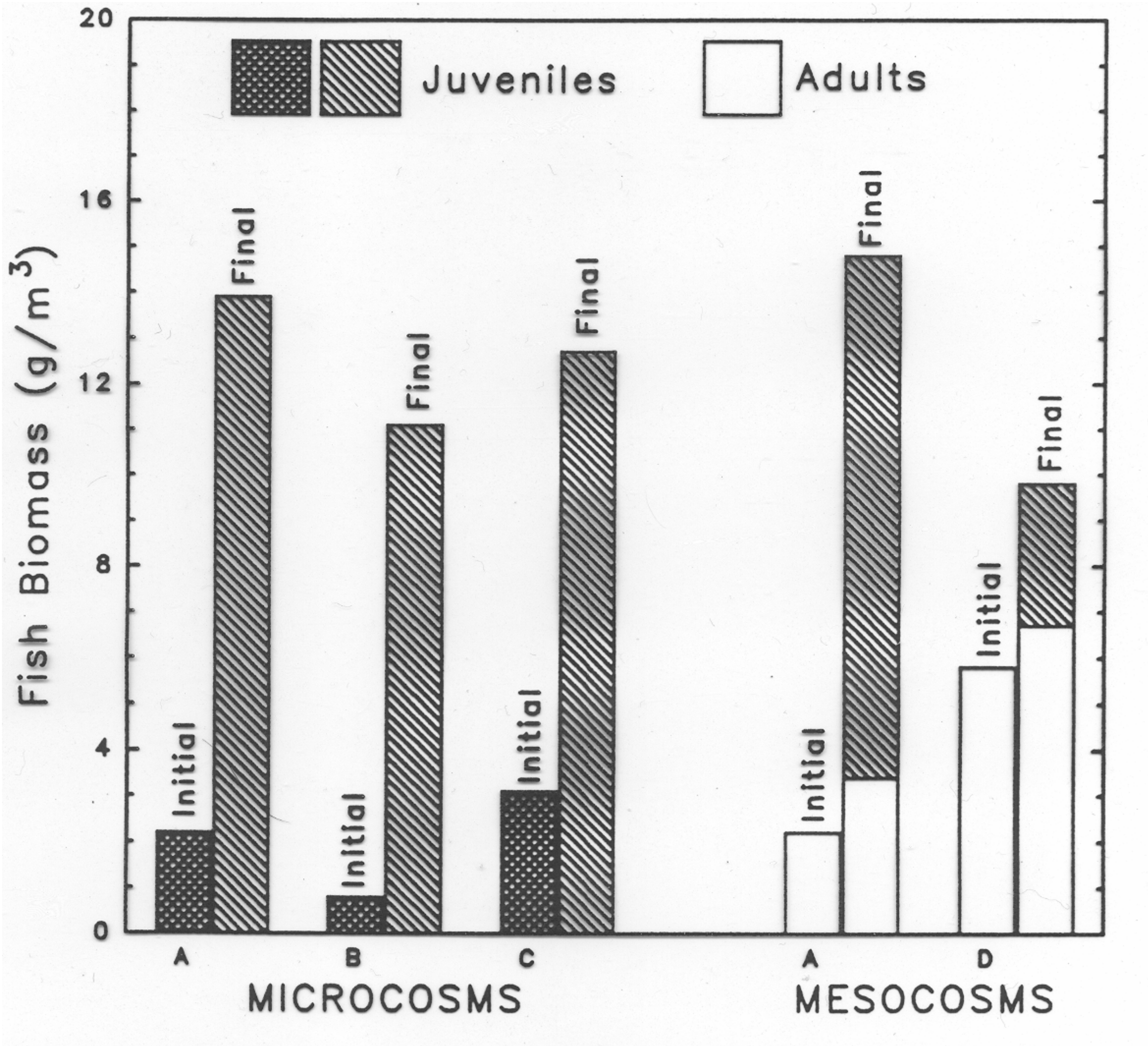
Komponenty standardního akvatického mikrokosmu

Taxa, volumes and endpoints appropriate for tests of circa three to six month duration in aquatic experimental ecosystem used in testing the fate and effects of agricultural chemicals. Taxa richness may be supplemented by indices or diversity, dominance and similarity. Chl a is chlorophyll a. From SETAC•Europe, "Testing Procedures tor Pesticides in Freshwater Static Mesocosms," Monks Wood Experimental Station, July 1991.

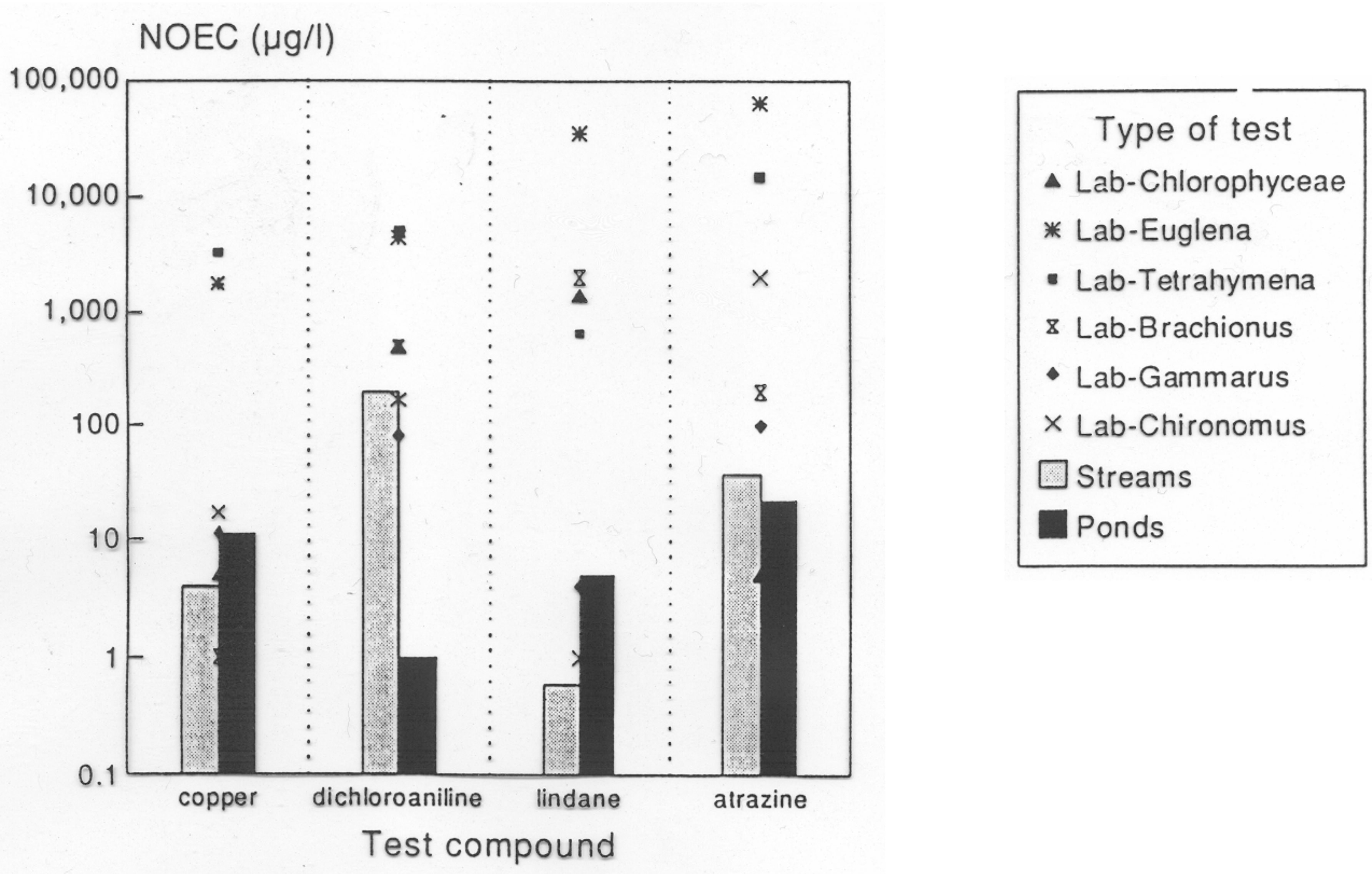
Taxon	System size	Endpoint
Fish	$\geq 25\ m^3$	Growth; condition
Zooplankton	$\geq 25\ m^3$	Taxa richness; recovery
Macroinvertebrates	$\geq 25\ m^3$	Taxa richness; recovery
Phytoplankton	$1 - 5\ m^3$	Chl *a*; taxa richness; recovery
Periphyton	$1 - 5\ m^3$	Chl *a*; taxa richness; recovery; biomass
Macrophytes	$\geq 25\ m^3$	Biomass; % cover

Taxa, volume and endpoints appropriate for tests of circa one-month duration in aquatic experimental ecosystems used in testing the fate and effects of agricultural chemical. LC50 is the lethal concentration for a 50% reduction in test organisms. EC50 is an effective concentration, typically used for behavioral endpoint

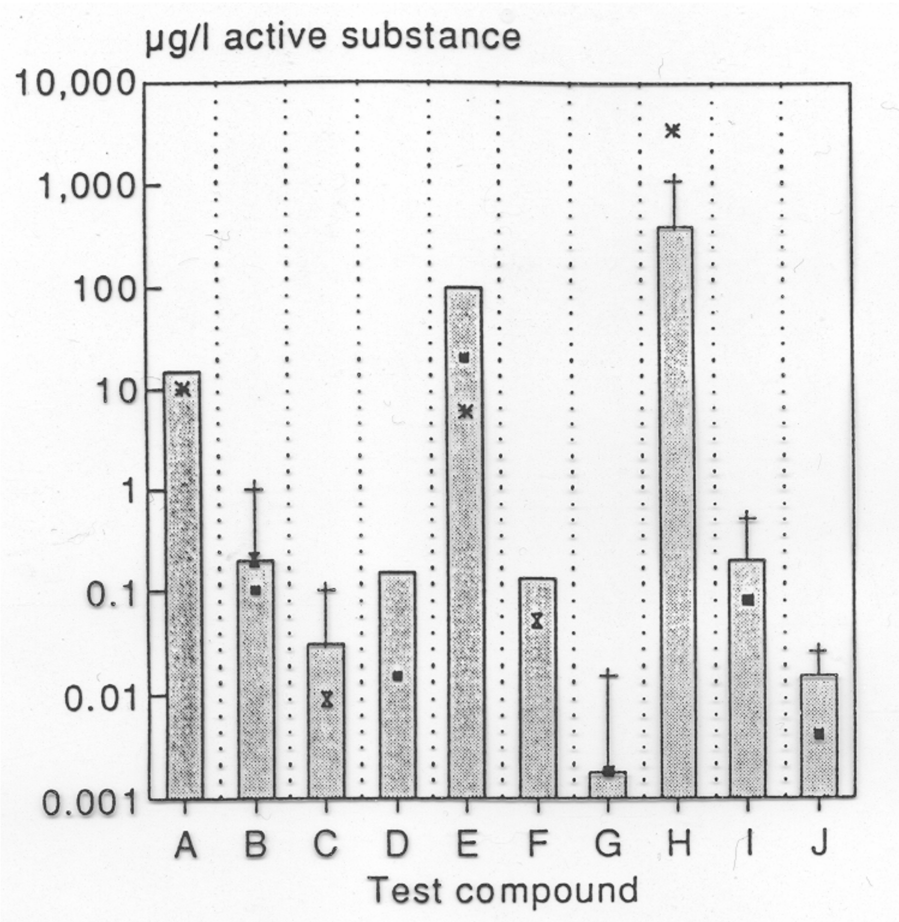
Taxon	System size	Endpoint
Fish	$1 - 5\ m^3$	LC_{50}; EC_{50}; % Mortality
Zooplankton	$1 - 5\ m^3$	Taxa abundance
Macroinvertebrates	$1 - 25\ m^3$	Taxa abundance
Phytoplankton	$1 - 5\ m^3$	Chlorophyll *a*

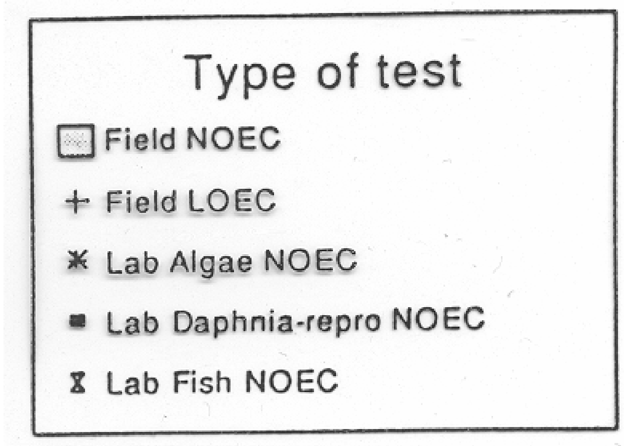


Increase in fish biomass (g/m3) during microcosm and mesocosm studies. A, B, C and D represent the four compounds tested. Data are averages for control microcosms and mesocosms. There were two or three replicates in each study.



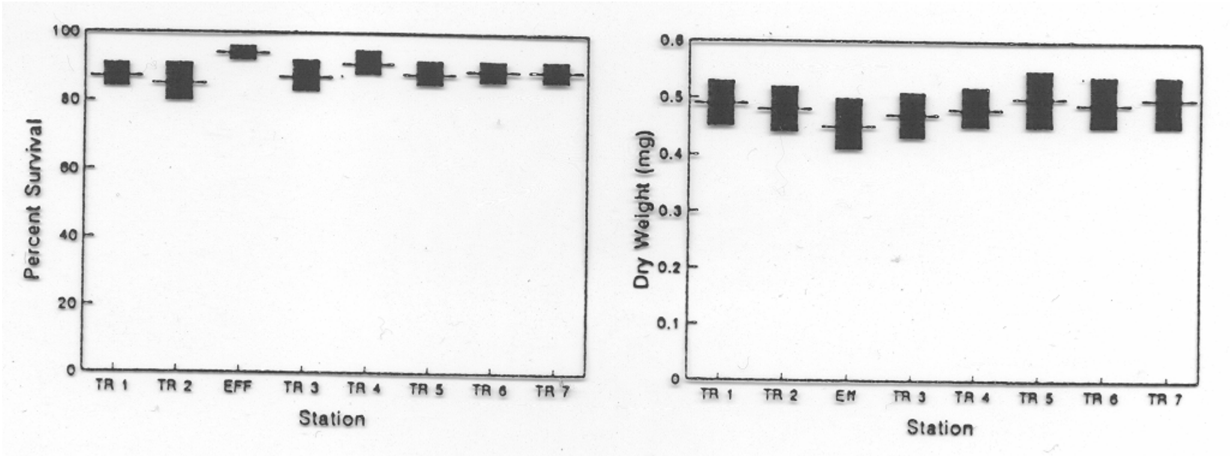
Comparison of the NOEC's of SS tests with microalgae, protozoans, rotifers, crustaceans and insect larvae and the NOEC's of lotic and lentic outdoor microcosm tests (CEC project, 1988-1992)



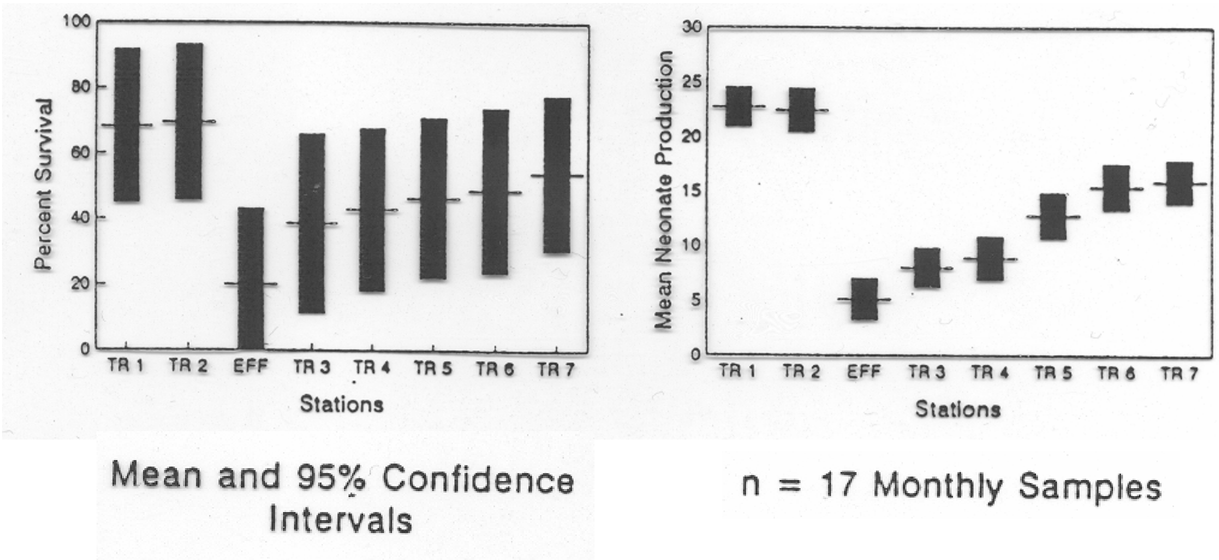


Comparison of the LOEC's and NOEC's obtained in SS laboratory and MS field tests for 10 pesticide. A: atrazine, B: azinphosmethyl: C cyflurin, D: cypermethrin, E: diquat, F: endosulfan, G: lambda-cyhalothrin, H: matamitron, I: parathion, J: tralomethrin

A



B



Fathead minnow survival and growth (A) and *Ceriodaphnia dubia* survival and reproduction (B) (mean and 95% confidence intervals) during the dechlorination period

Table 6. Effects of Cyfluthrin in a "Side-by-side" Microcosm and Large Mesocosm Study (Johnson *et al.*, 1994; Kennedy *et al.*, 1992; Morris *et al.*, 1994)[a]

Organism	2 m^2 microcosm L[b]	2 m^2 microcosm M	2 m^2 microcosm H	2 m^2 microcosm VH	480 m^2 mesocosm L	480 m^2 mesocosm M	480 m^2 mesocosm H	480 m^2 mesocosm VH
Zooplankton								
Rotifera	no effect	increase 50–95%	increase 50–95%	increase >95	no effect	no effect	no effect	no effect
Copepoda	no effect	no effect	no effect	⬇ decrease	decrease 50–95%	decrease 50–95%	decrease 50–95%	decrease >95%
Macroinvertebrates								
Oligochaeta	no effect	no effect	no effect	no effect	no effect	no effect	no effect	no effect
Ephemeroptera - Baetidae	decrease 50–95%	decrease 50–95%	decrease >95%	decrease >95%	⬇ decrease	⬇ decrease	⬇ decrease	⬇ decrease
Ephemeroptera - Caenidae	decrease <50%	decrease >95%	decrease >95%	⬇ decrease	decrease >95%	decrease >95%	decrease >95%	decrease >95%
Odonata	no effect	no effect	no effect	decrease <50%	no effect	no effect	no effect	no effect
Diptera - Chaoboridae	decrease >95%	decrease >95%	decrease >95%	decrease >95%	decrease >95%	decrease >95%	decrease >95%	decrease >95%
Diptera - Chironominae	no effect	no effect	increase >95	increase <50%	no effect	no effect	no effect	no effect
Diptera - Tanypodinae	no effect	no effect	decrease <50%	decrease 50–95%	decrease <50%	decrease 50–95%	decrease 50–95%	decrease >95%
Fish - survival[c]	no effect	no effect	no effect	no effect	no effect	no effect	no effect	no effect
Fish - growth[d]	no effect	decrease <50%	decrease 50–95%	decrease <50%	no effect	no effect	no effect	no effect
Fish - reproduction					no effect	no effect	no effect	no effect

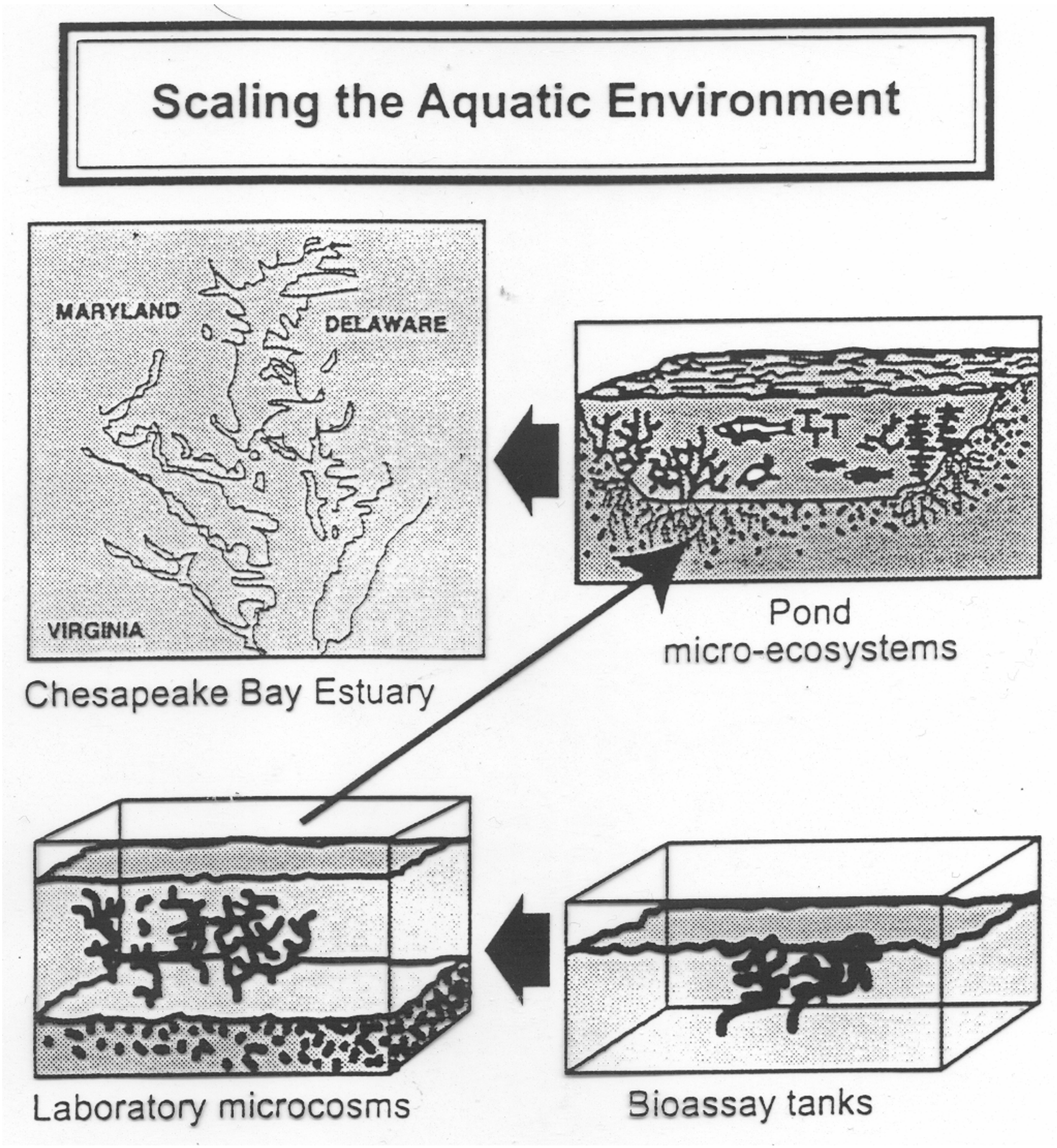
a □ = no effect (quantitative or qualitative)
quantitative decrease [symbol] = <50%, [symbol] = 50–95%, [symbol] = >95%
quantitative increase [symbol] = <50%, [symbol] = 50–95%, [symbol] = >95;
qualitative data ⬇ = decrease, ⇧ = increase.

b Treated with 10 drift (D) and 5 run-off (R) applications; each application as % of USA maximum label cotton rate:

	microcosm	mesocosm
Low	D 0.7% + R 4.2%	D 0.8% + R 5.1%
Mid	D 1.8% + R 4.2%	D 2.1% + R 5.1%
High	D 3.5% + R 4.2%	D 4.2% + R 5.1%
Very High	D 3.5% + R 21%	D 4.2% + R 25%

c Survival of juveniles (microcosms) and adults (mesocosms) added prior to pyrethroid treatments.

d Biomass of juveniles (microcosms) and adults/young-of-year juveniles (mesocosms).


Scaling the Aquatic Environment
MARYLAND
DELAWARE
VIRGINIA
Chesapeake Bay Estuary
Pond
micro-ecosystems
Laboratory microcosms
Bioassay tanks

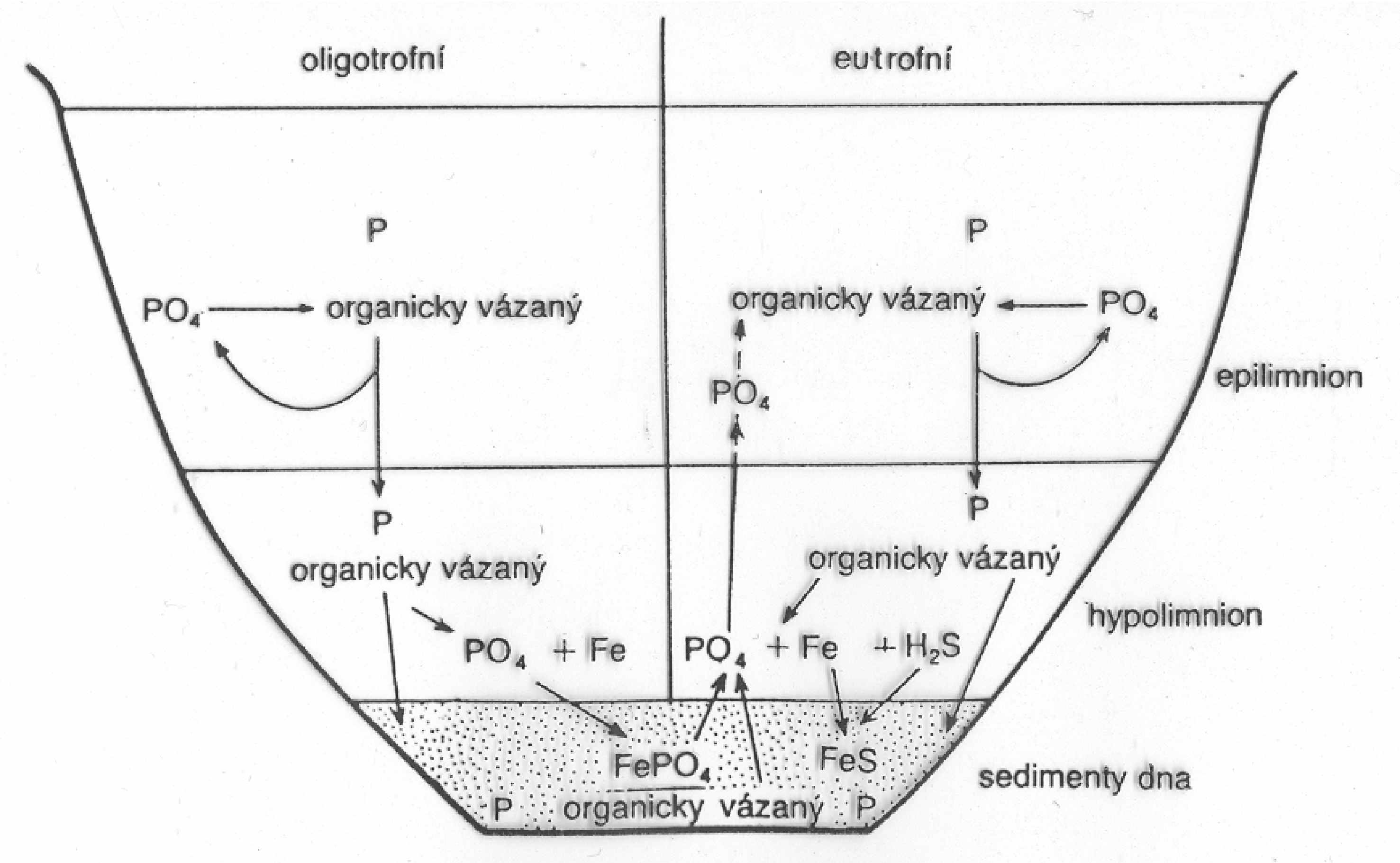
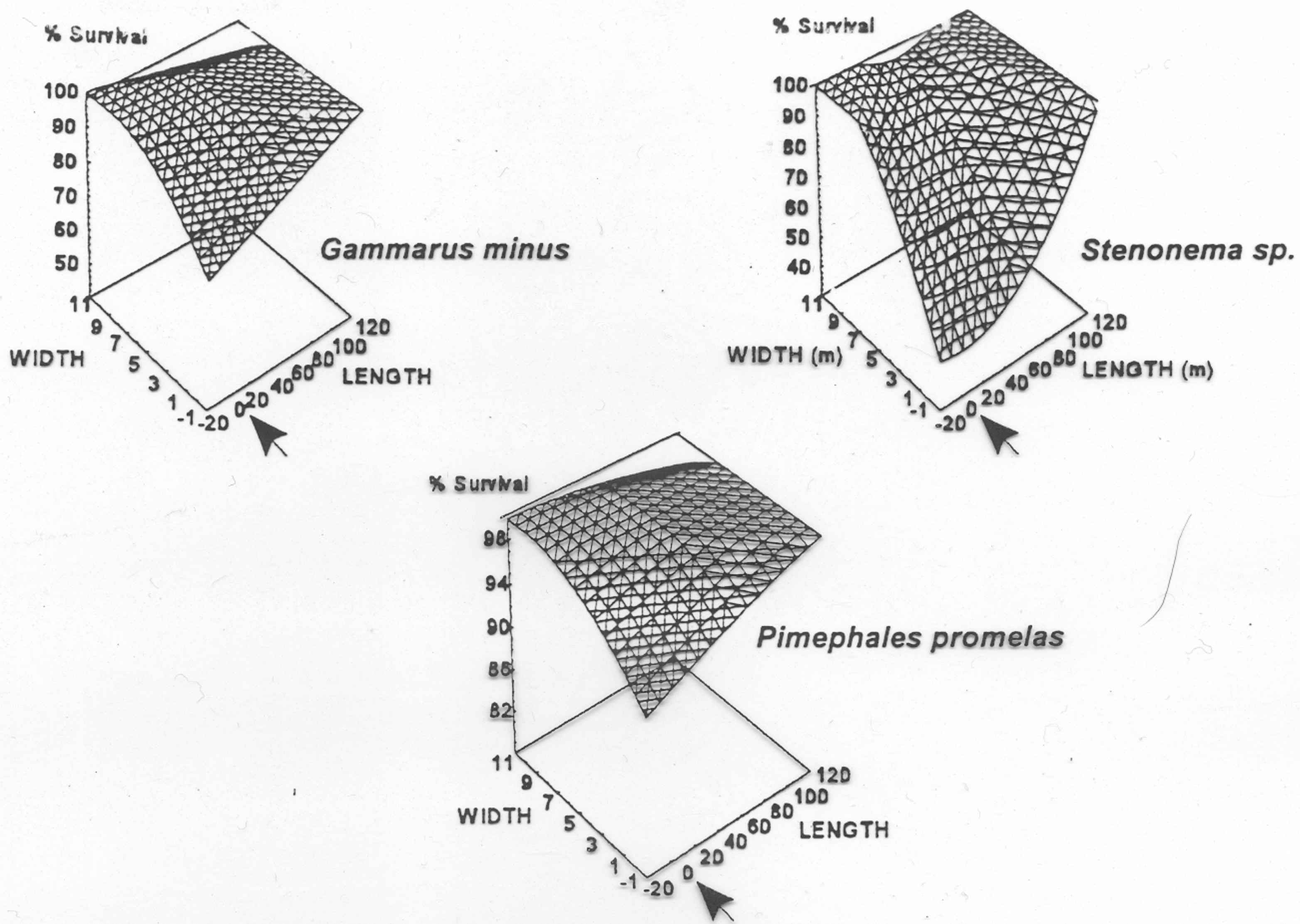
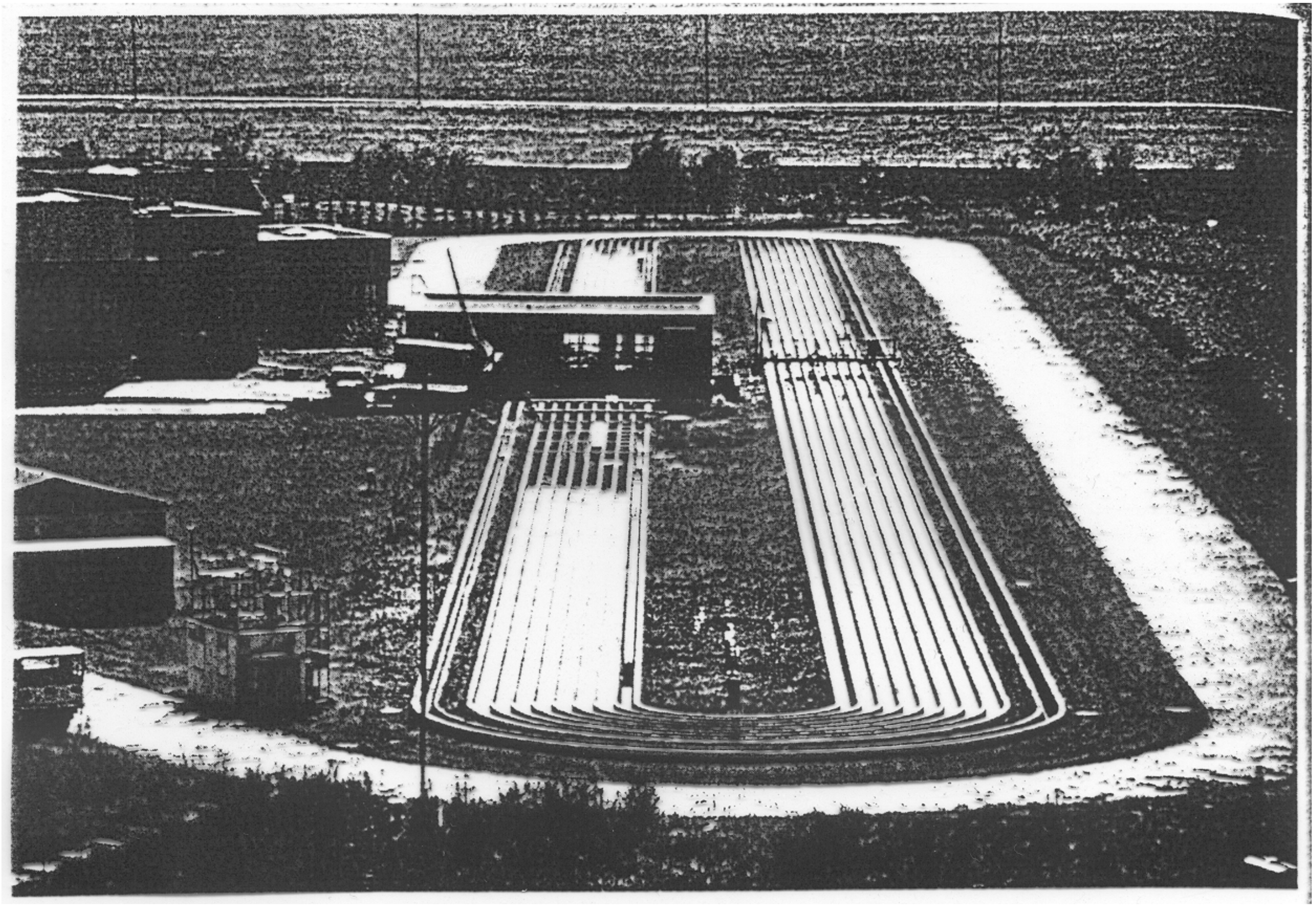


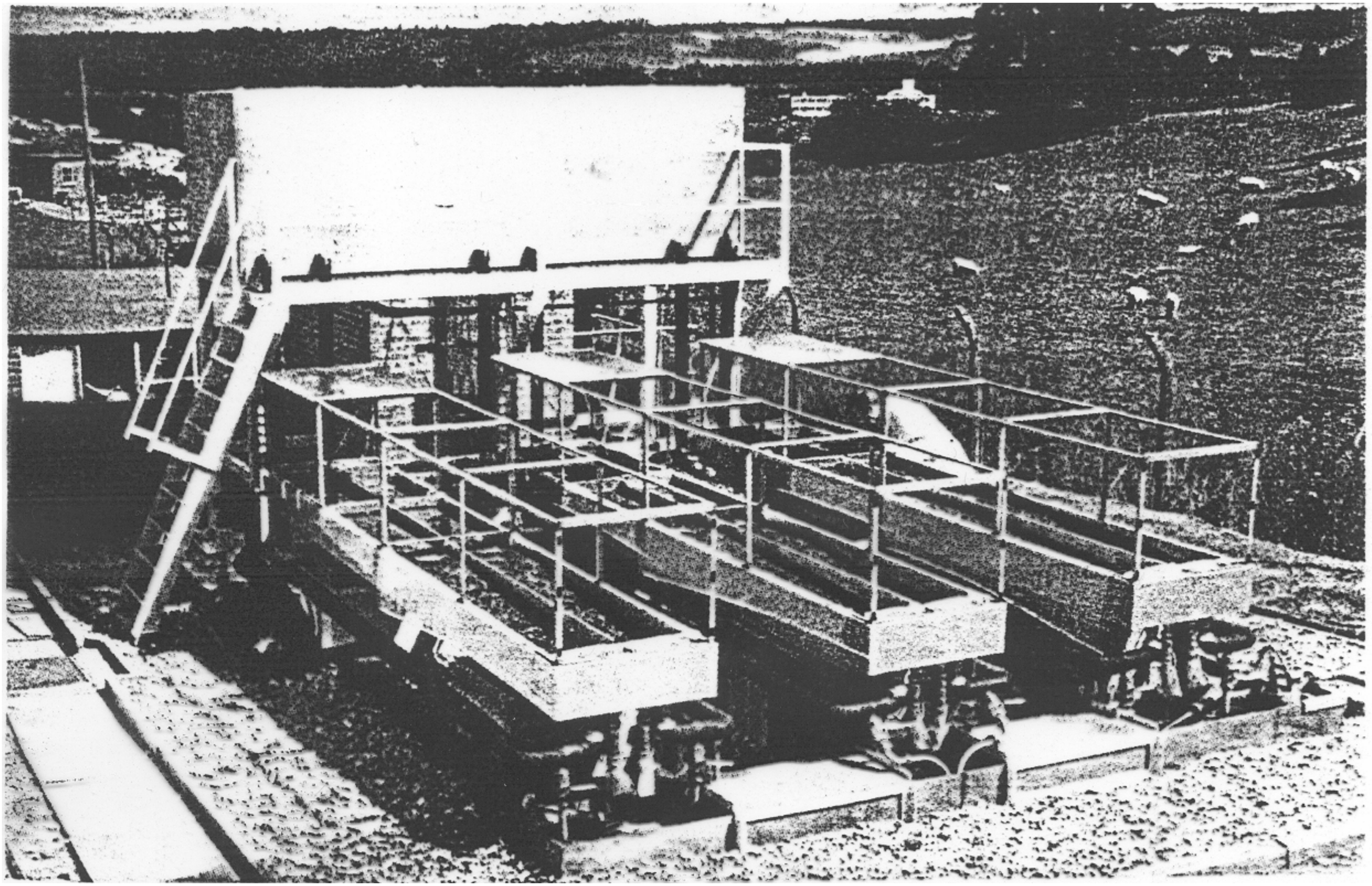
Schéma koloběhu fosforu ve vodním ekosystému v interakci se železem a sírou. Vlevo situace za aerobních podmínek u dna, vpravo za anaerobních podmínek a za vzniku H_2S v hypolimnionu. Znázorněn je rovněž koloběh fosforu v epilimnionu. Bakteriální a chemické uvolňování PO_4 v hypolimnionu nádrže za přítomnosti H_2S může pokračovat po podzimní cirkulaci a zrušení termální stratifikace rovněž ve svrchních vrstvách vodního sloupce (čárkované šipky) (podle Barthelmesa, 1981)



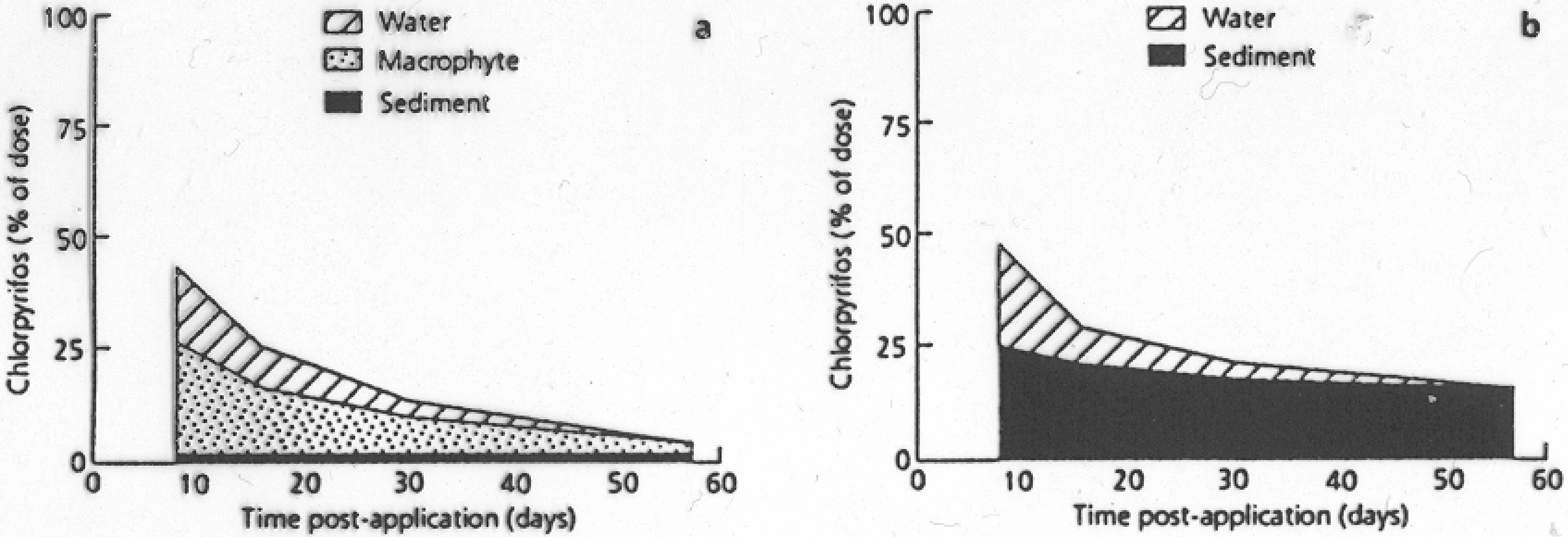
Survival of organisms after 96 hours of exposure in in situ testing. The arrow signifies the point of effluent discharge into the river.

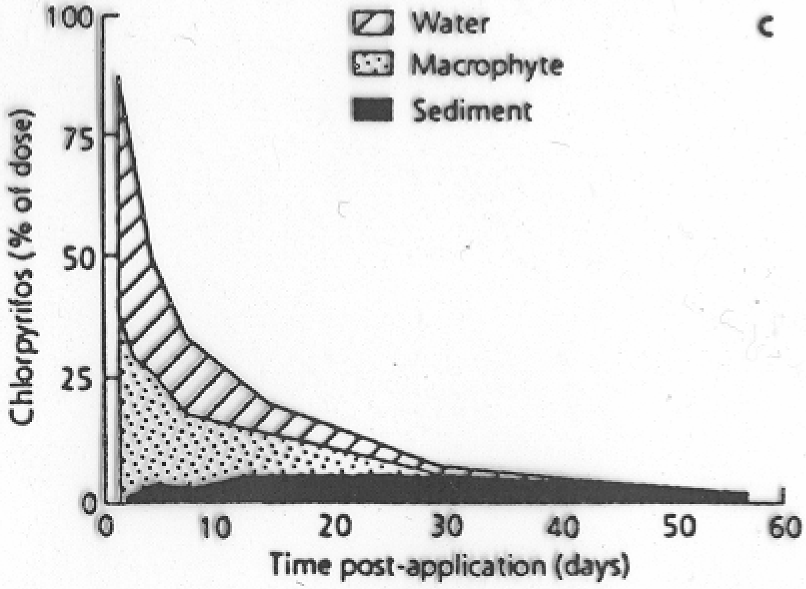


Artificial stream system of the Water, Soil and Air Hygiene Office, Marienfelde, Germany. Facility has been used to study the effects ot sewage, nutrients, and detergents on stream ecosystem. Large building in the center is a pilot sewage treatment plant which contains automated sampling equipment. (Photo by P. D. Hansen.)

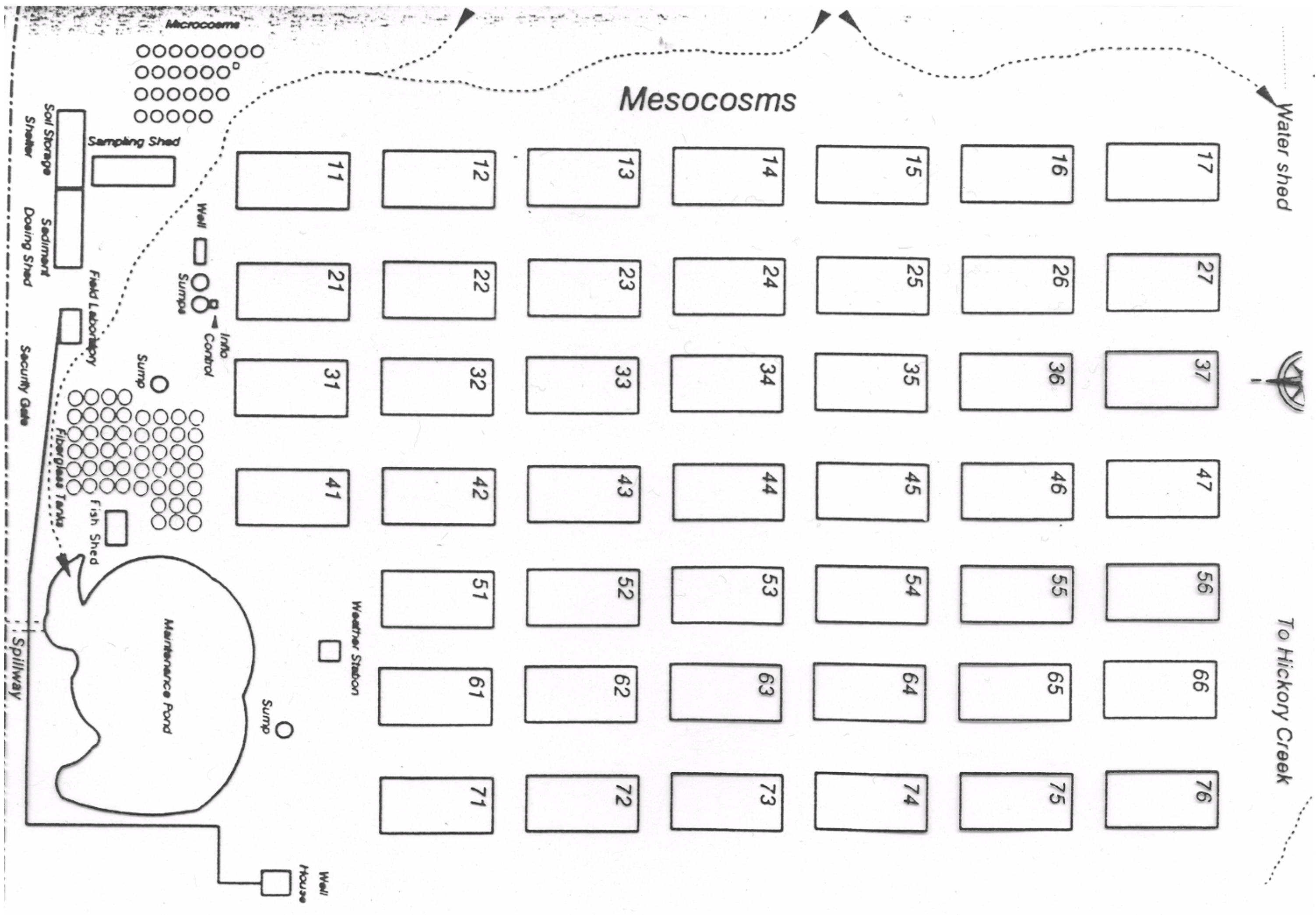


Photograph of recirculation artificial system developed by Shell Research (England)

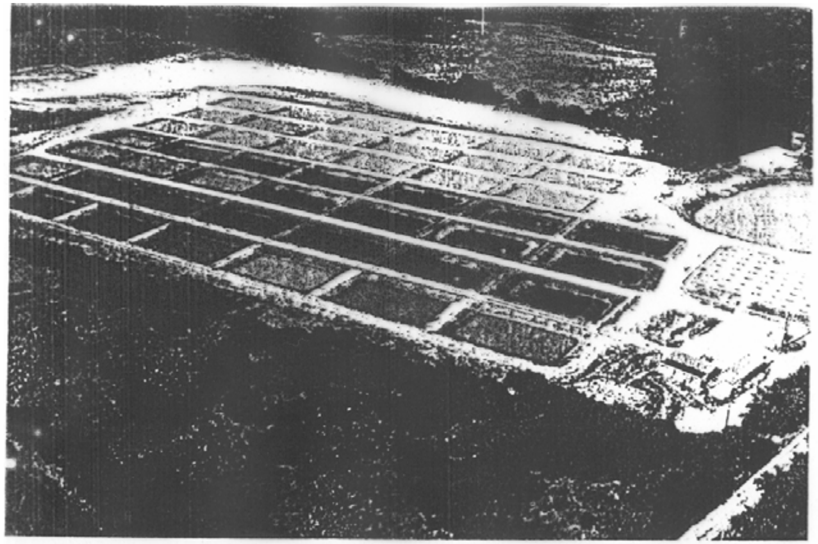
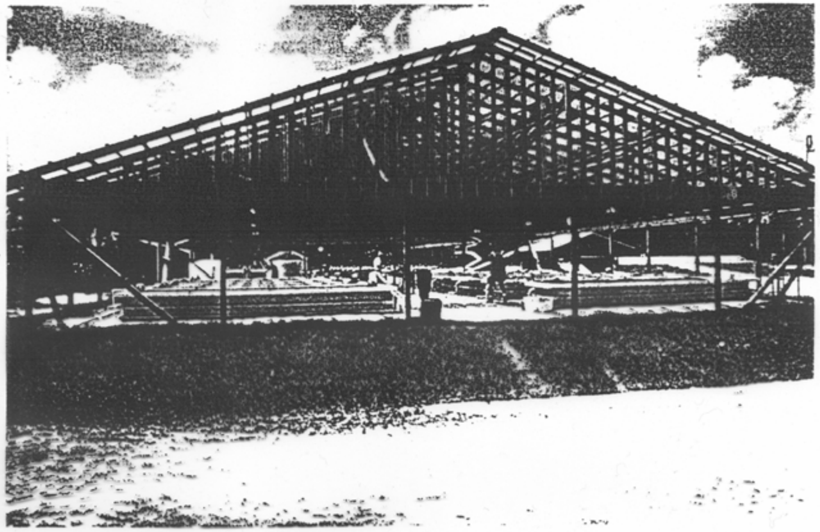
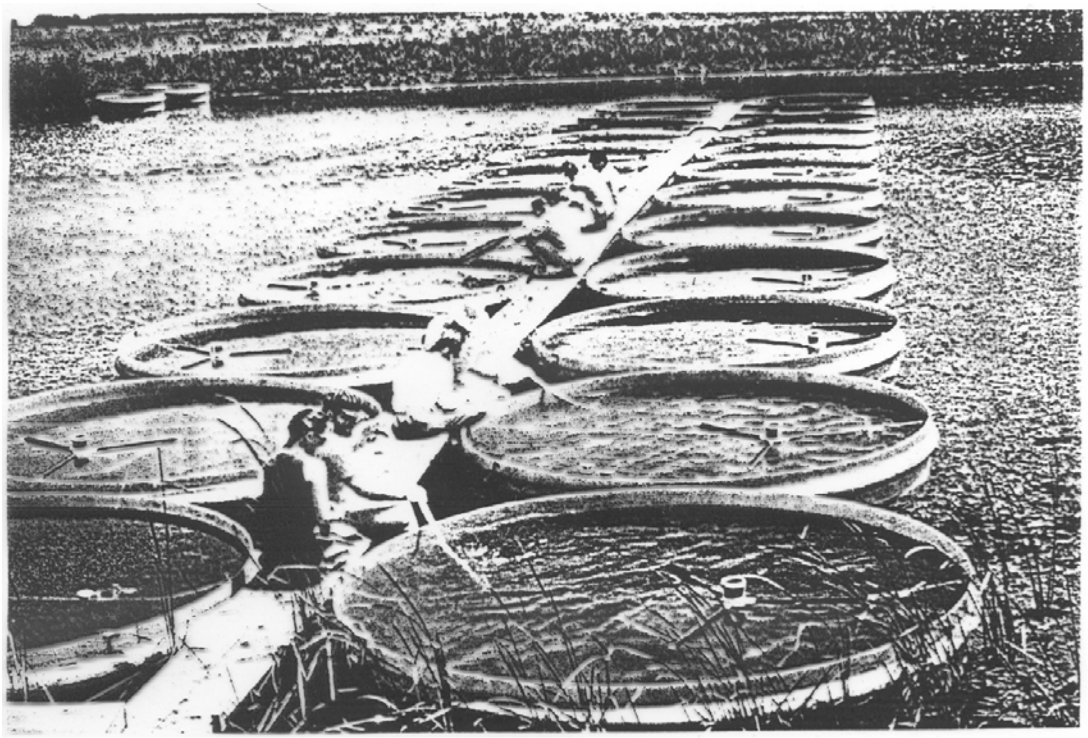


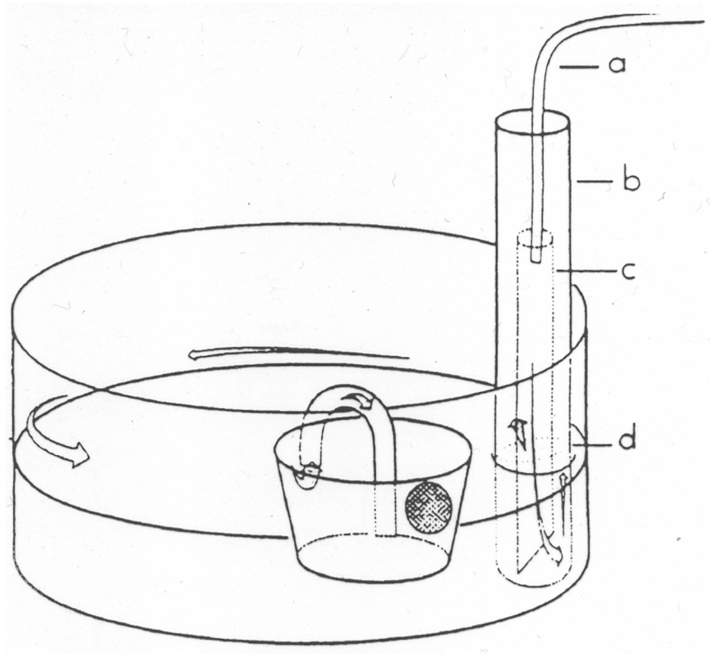


Chlorpyritos, as a percentage of the dose applied, in the water, sediment and vegetation compartments of microcosms with (a) and without (b) macrophytes and macrophyte dominated ditches (c). During the first week post-application sediment and macrophytes were not sampled in the microcosms.



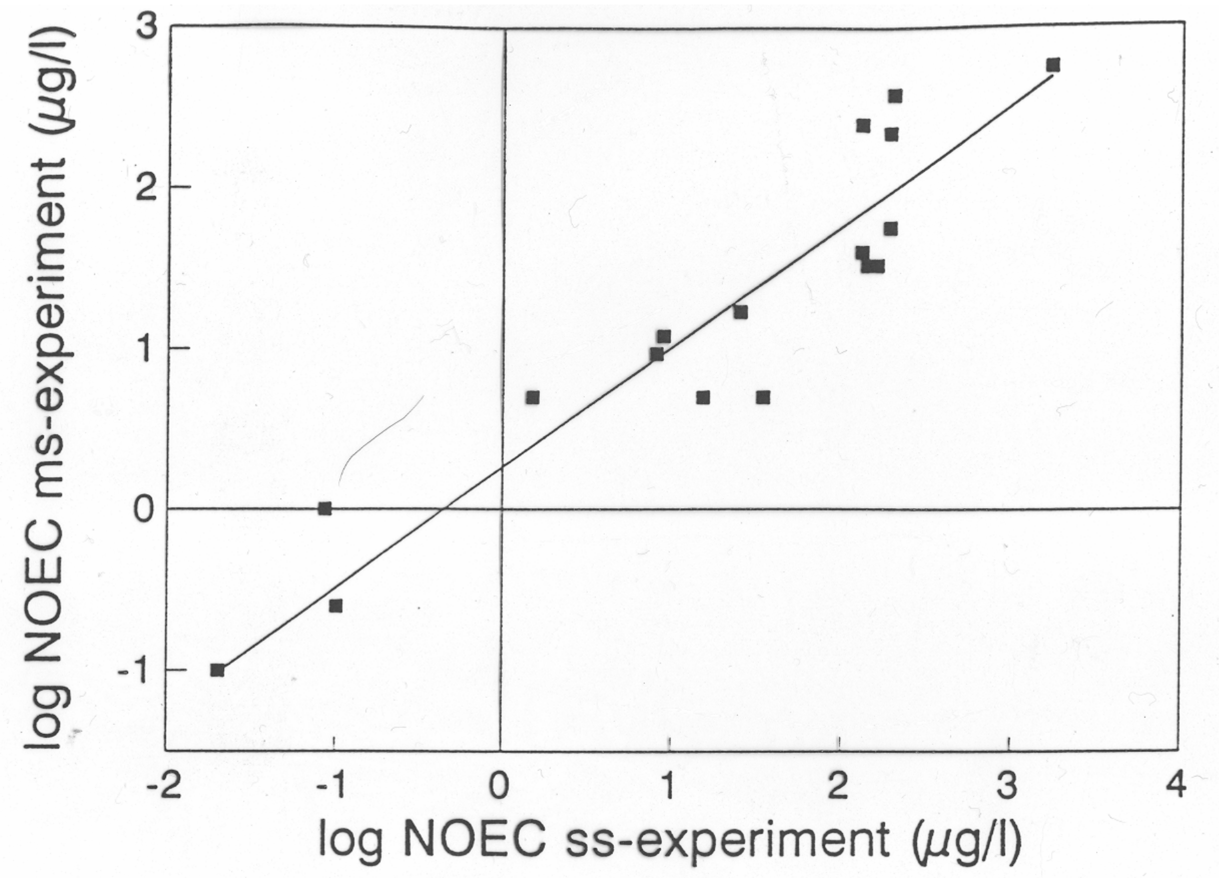
Schematic diagram of the lentic mesocosm ponds at the Water Research Field Station of the University of North Texas. Smaller circles represent the location of fiberglass microcosm test systems



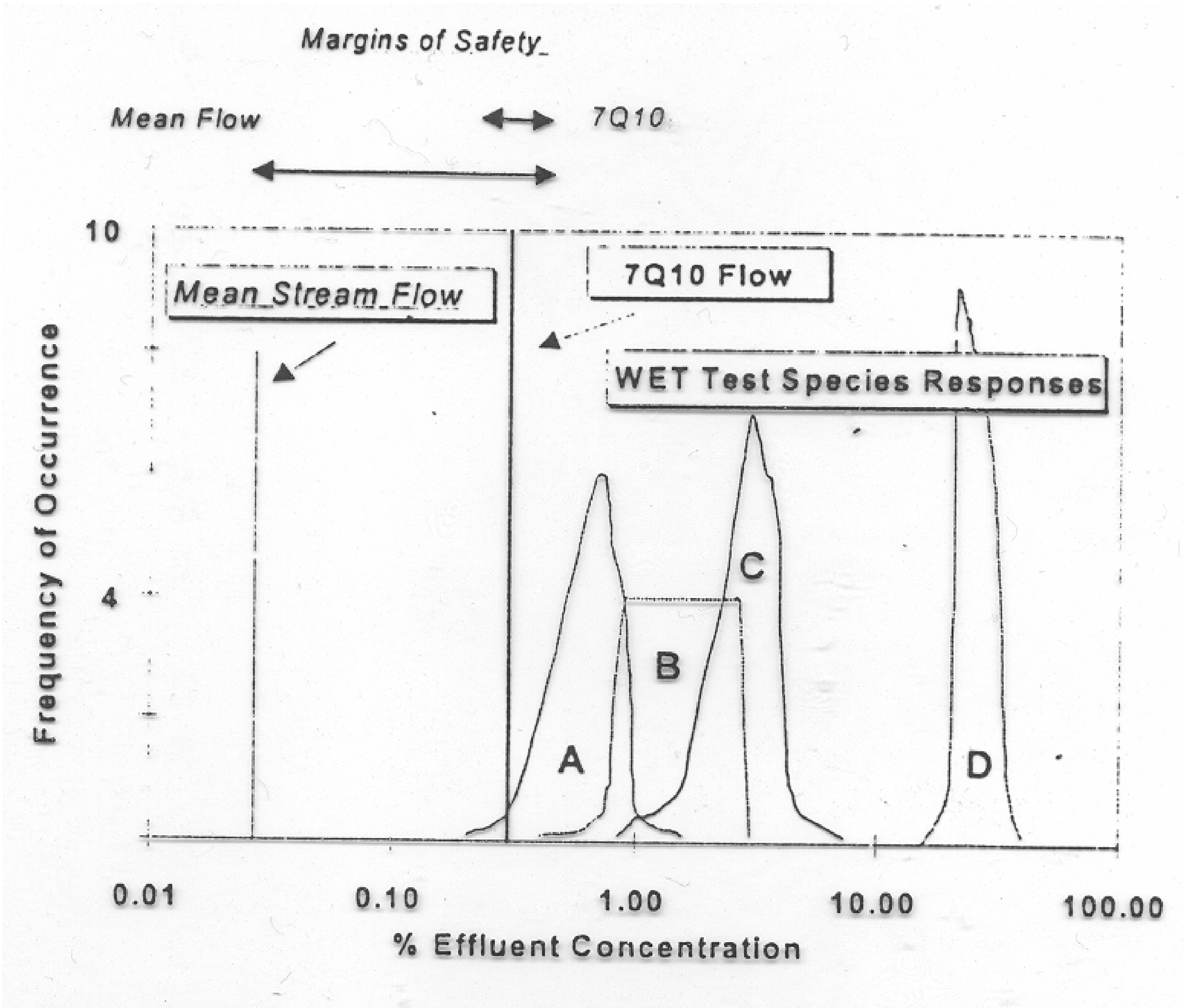
Flow-through exposure chamber for flow-through tests with polychaetes.

The exposure chamber is a glass crystallizing ditch with an inflow of water over the sediment surface. Arrows show flow of water into the test tube (b) through silicone tubing (a), which has a piece of glass tubing (c) attached at the bottom then through an elliptical opening; (d) cut in the side of the test tube and into the dish just above the sediment surface. Water circulates around the dish and leaves through a siphon and catch cup. (Reprinted with permission from Pesch, C. E.. Munns, W. R. Jr., Gutjahr-Gobell R.: Effects of a contaminated sediment on life history traits and population growth rate of Nennthes arenoceodénmra (Polychaeta: Nereidae) in the laboratory. Environmental Toxicology and Chemistry 70(6):805-875. Copyright 1991. SETAC)

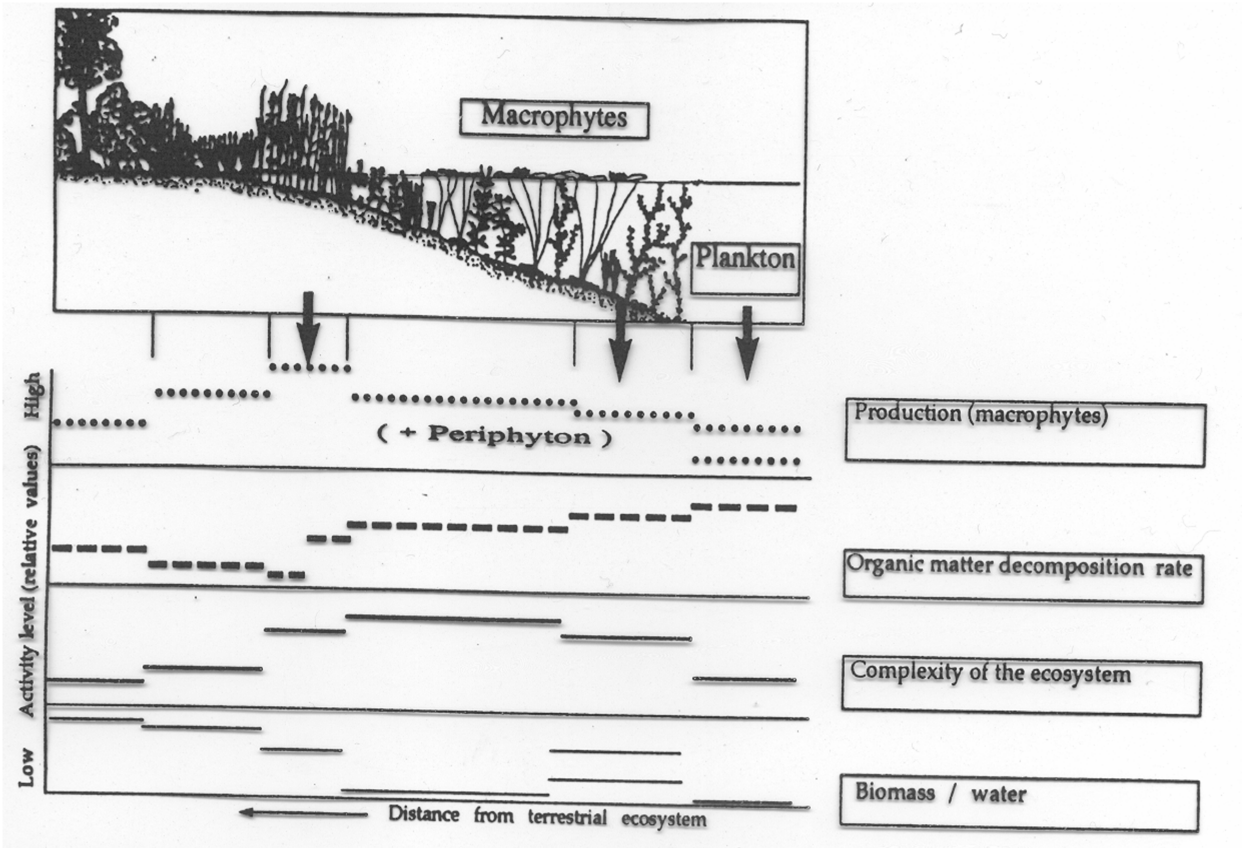


Model-II regression of NOECMS-experiment on NOECSS-experiment for similar or related species, corresponding effects parameters and similar exposure concentrations, based on 17 data pairs:

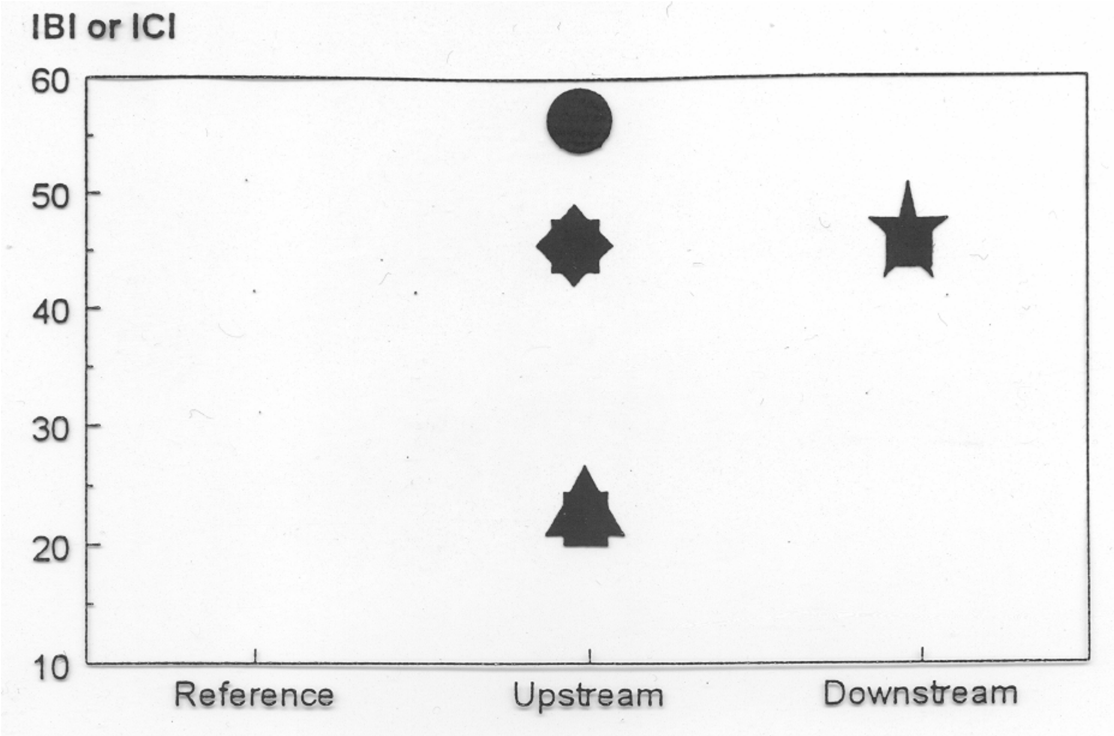
log NOECMS-experiment = 0.750 * log NOECSS-experiment + 0.263, r = 0.935.



Conceptual application of WET testing to aquatic hazard assessment; portrays the issues of laboratory-to-field scaling and exposure, surrogate species and sensitivity•, variability and false positives



Relationship between structure and functions in macrophyte-dominated ecosystems. Arrows indicate main communities of litoral ecosystem and for each terrestrial and aquatic communities, structural and functional parameters are represented by relative levels of activity: production and decomposition are functions of the system and complexity and biomass to water ratio are structural parameters.



Example **demonstrating the value of ecoregional reference conditions for assessing effluent effects** on either fish (IBI) or macroinvertebrate (ICI) community integrity (Karr et al. 1986). As an example, the downstream site would not be judged as impaired based on the ecoregional reference condition or an average-scoring upstream site (diamond). However, the downstream site would be incorrectly judged as either impaired (based on the single upstream site [circle] that was unusually species rich) or of extremely high ecological integrity (based on the single low-scoring upstream site [triangle]).

Table 7.1 A Review of Study Designs and Results Obtained in Selected Studies Using Microcosms or Mesocosms in Ecotoxicological Research (Continued)

	System Size and Morphology	Water Source	Colonization Method	Acclimation Period	Compound	Experimental Design and Replication	Exposure Length
Microcosms: But Mixing Different Toxicants (continued)							
12	Microcosms of high density polyethylene (35 × 28 × 15 cm) 1) 18 rep. microcosms had 7 l diluent H_2O 2) 18 rep micro with 1 l sediment from KY Lake + 6 l H_2O	From an embayment of Kentucky Lake	Natural microbial community collected on polyurethane foam substrata place in the Kentucky Lake embayment (14-d exposure)	1 week before exposure	Diquat®	3 microcosms dosed at 0, 0.3, 1, 3, 10, & 30 mg/l; Substrate replaced weekly	Single application substrata exposed for 1 week
Outdoor Mesocosms							
13	Three 5 m³ volume ponds (artificial); stainless steel cylinders, interconnected by locks; Three "natural" ponds 75 m² × 80 cm deep used as well	Well water; brook water	Organisms introduced with natural lake sediment; supplemented with stocked rainbow trout	Weeks (unspecified)	Cyfluthrin as Baythroid®	Artificial ponds: untreated control and 2 dose levels; "natural" ponds: untreated control and 2 dose levels; no treatment replicates	One initial application monitoring for ~112 d

Table 7.1 A Review of Study Designs and Results Obtained in Selected Studies Using Microcosms or Mesocosms in Ecotoxicological Research (Continued)

Stream Mesocosms (continued)

	System Size and Morphology	Water Source	Colonization Method	Acclimation Period	Compound	Experimental Design and Replication	Exposure Length
44	Six, 520 m outdoor exp. stream channels with alt. pool/riffle zones; controlled flow rates	Mississippi River H_2O or a mixture of river & well H_2O	Natural colonization over time plants & invertebrates; stocked bluegills	(15 years)	Selenium as sodium selenite in softened well water	Two dose levels & controls (2 reps); random assignment	Dosing period: ~ 25 weeks 356-d study duration
45	Six, 3.96 m length × 0.58 m width × 0.27 m depth stream (for upper & lower stream sections); volume: ~ 0.62 m^3; Upper—"reservoir" function; lower—stream channel	Spring-fed woodland stream (Cheny Creek, MI)	Biota introduced along with natural substrate used to line artificial channel bottoms	1 year	Hexachlorobiphenyl (HCBP) with acetone carrier; atrazine with dimethylsulfoxide carrier	Two streams with 0.10 µg/l of HCBP; 2 w/225 µg/l atrazine; 1 acetone control; 1 dimethylsulfoxide control	Continues 30-d exposure for each (seasonal) exp. (4 different sets of experiments done seasonally)

Table 7.1 A Review of Study Designs and Results Obtained in Selected Studies Using Microcosms or Mesocosms in Ecotoxicological Research (Continued)

Microcosms (continued)

Responses/Endpoints Measured	Sampling Frequency	Statistical Test: Compared	Statistical Test: Type	Ref.	Comment
Microbial community structure and function (protozoan species richness used as an indicator of community complexity)	1) 1, 2, 3 weeks after dosing 2) 1, 2 weeks after dosing	Microbial community responses; for multi. comparisons when treatment is significantly different from control	ANOVA Dunnett's procedure	89	Discussion statistically oriented found microbial communities to be sensitive to diquat in absence of sediment; micro with sediment recovered from diquat within 2 weeks after initial disruption (adsorption occurred); when compared to other experiments, found different systems react differently to diquat; over estimation may occur with simplistic exp. design

Outdoor Mesocosms (continued)

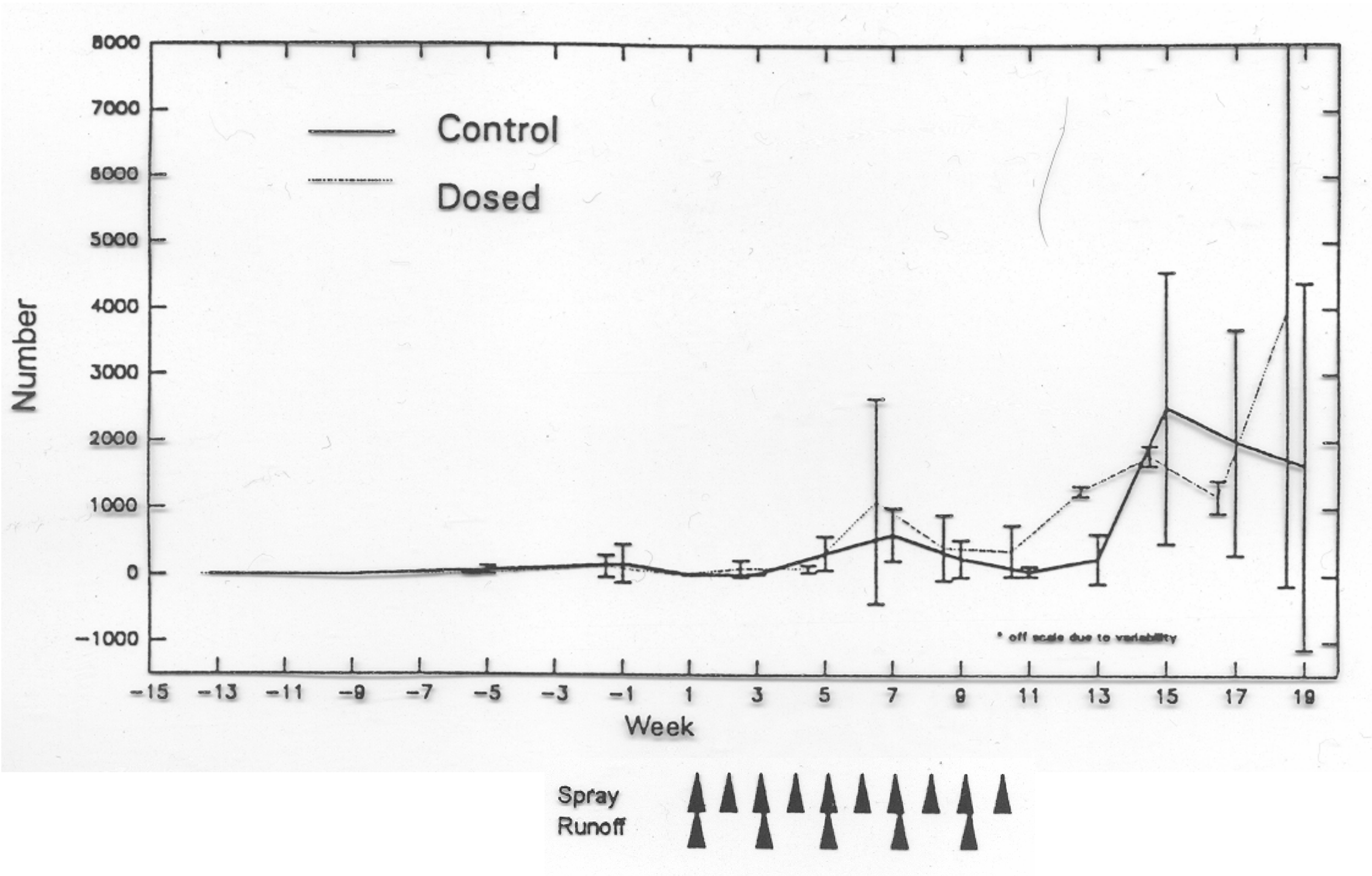
Responses/Endpoints Measured	Sampling Frequency	Statistical Test: Compared	Statistical Test: Type	Ref.	Comment
Baythroid® fate; pesticide absorption on plants & sediment; changes in phyto-, zooplankton & benthic communities; growth of trout	Weekly sampling for all parameters prior to treatment; post-treatment: variable levels	Biotic composition prior to application of Baythroid®	Similarity index; no stat. treatment of other data	51	2 dose levels + non-treated control—no treatment repl. in either pond; artif. pond results compared to larger, natural ponds

Table 7.1 A Review of Study Designs and Results Obtained in Selected Studies Using Microcosms or Mesocosms in Ecotoxicological Research (Continued)

Stream Mesocosms (continued)

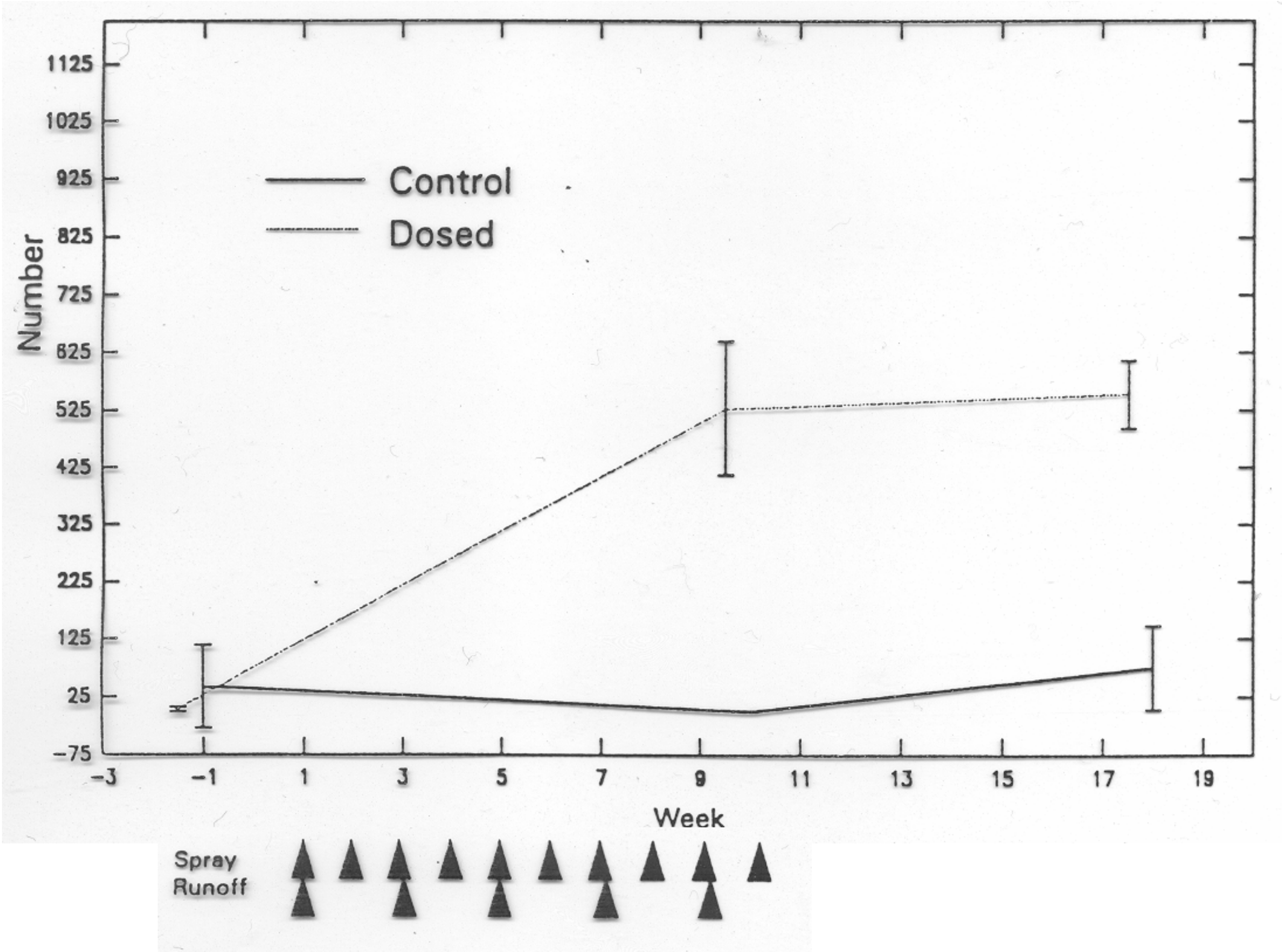
Responses/Endpoints Measured	Sampling Frequency	Statistical Test: Compared	Statistical Test: Type	Ref.	Comments
Endpoint: survival, growth, & reproduction of bluegill *Response:* selenium on adult survival & growth; spawning activity & emb. & larval survivorship selenium residues in fish tissue & whole bodies	• Selenium con. measured 2 times weekly; • Most p.-c. parameters measured biweekly; • Beginning in late May, bluegill nests checked daily; • Selenium residues in tissue May 11–Aug 22 (end of study)	Adult growth & survival; emb. & larv. prod. & mortality; etc. Single treatment to control	One-way ANOVA; protected least-significant differences	200	Examines effects of both waterborne and dietary selenium
Chemical residues in water, sediments invertebrates, fish, and plants; benthic macroinvt. species composition, abundance, & drift.; Periphyton growth (product.); primary production & respiration (community level)	Not stated 45-d intervals (pretreatment year) 30-d intervals (treatment year) 4-d intervals various no equal intervals	Toxicant effects on community-level variables; mean annual values between pretreatment & treatment years	2 × ANOVA & Duncan's MRT (4 seasons analyzed sep.); Student's *t*	98	Does the fact that these were indoor artificial streams preclude them from being mesocosms (i.e., no continuity with natural environment?); based on size alone, they are mesocosms; Wide variety of sampling frequencies

Naididae (Oligochaeta) from artificial substrates

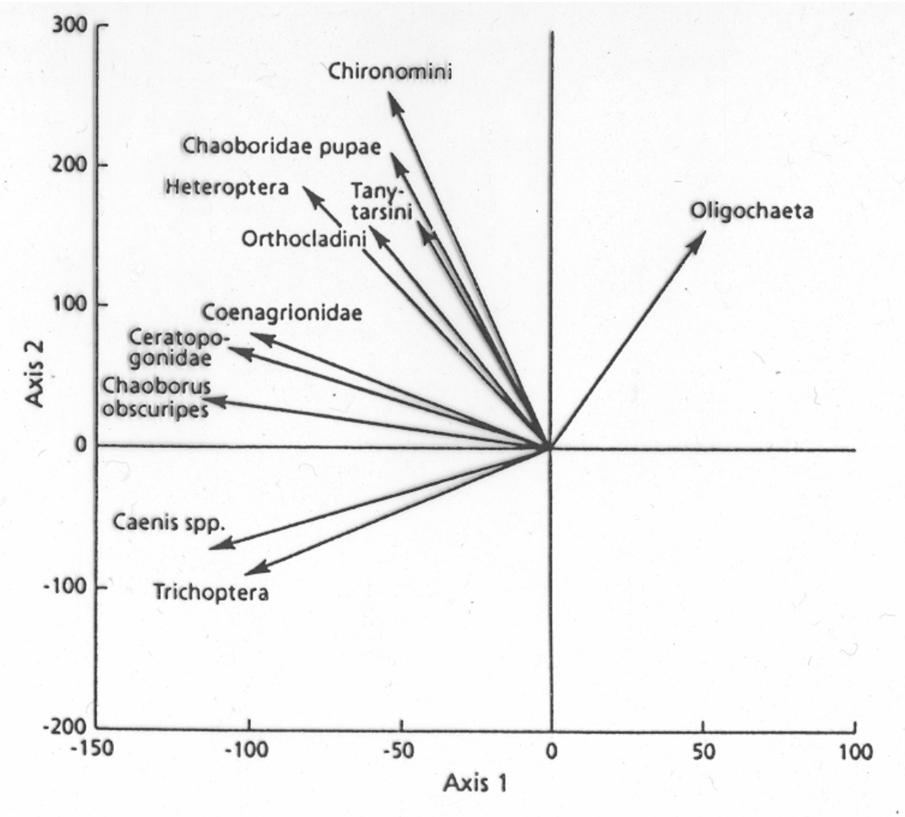


Average number (+-1 standard deviation) of Naididae (Oligochaeta) collected in experimental ponds by artificial substrates. Triangles represent application of a pyrethroid insecticide.

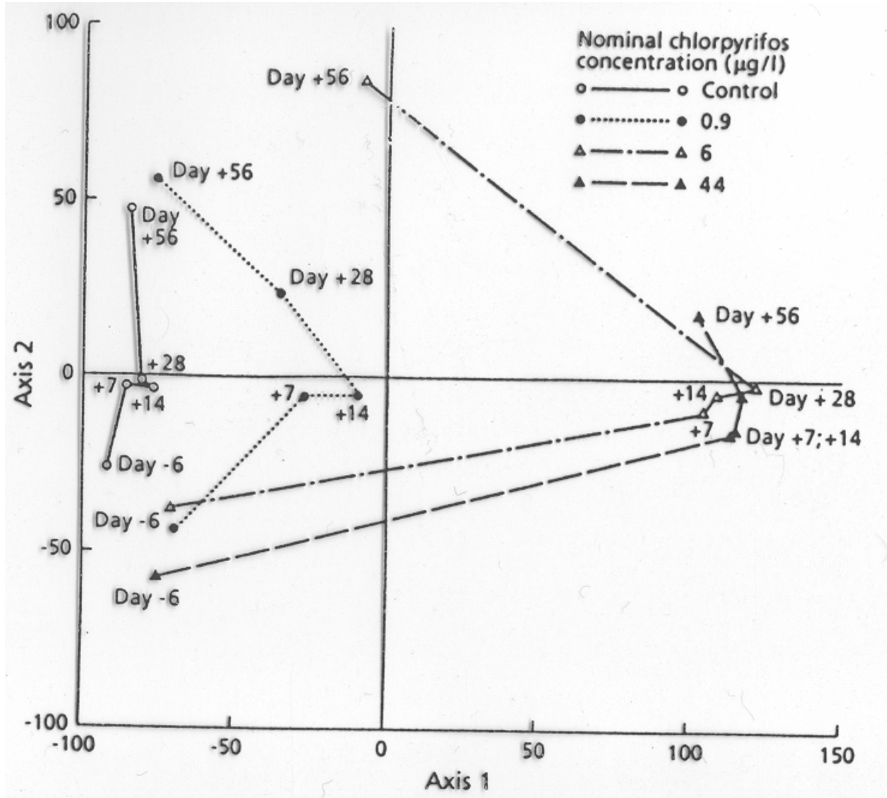
Naididae (Oligochaeta) from artificial substrates



Average number (+-1 standard deviation) of Naididae (Oligochaeta) collected in experimental ponds by Ekman Grab. Triangles represent application times of a pyrethroid insecticide.



PCA-ordination „species“ plot of the 1990 SC macroinvertebrate data set. For explanation see text and figure 7



PCA-adination 'sites' plot of the 1990 SC macroinvertebrate data set. The 'sites' of test units treated with the same concentralion at different sampling times (days 6, +7, +14, +28, and +56 p.a.) have been connected by a line. For explanation see text and Figure 6.