FischFIT
Monitoring-Projekt

Monitoring of Fish Physiology and Fish Behaviour

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AquaLife 2012

IGB
IASP

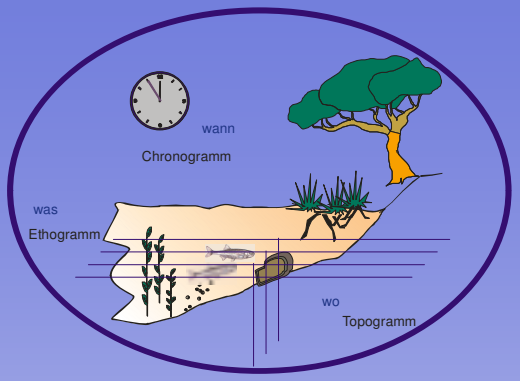
Topics

- Aim of the project
- Project partners
- Technical Principle of the FischFIT- Monitoring
- Methods of the Data Analysis
- Results
- Summary and Perspectives

Project‘s Idea and Intentions

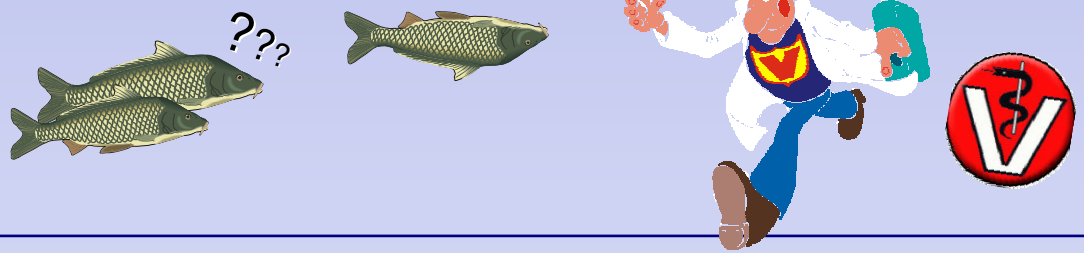
FischFIT
Monitoring-Projekt

- Basic biologic curiosity about the system ‘fish‘
  - When and where is ‘he’
  - Plus: what is ‘he’ doing
    how is ‘he’ feeling



- Special situation in aquaculture and fish raising
  - Exponential losses in case of diseases
  - Realistic calculations 20% per annum

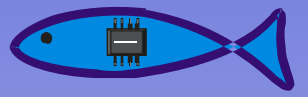
- Relatively bad monitoring and observation conditions related to the natural borders



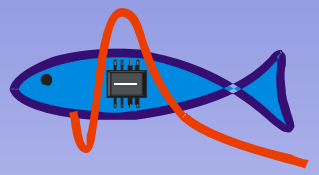
Project‘s Idea and Intentions

FischFIT
Monitoring-Projekt

- Innovative measurement and diagnostic system for an early analysis of fish health, fitness and welfare

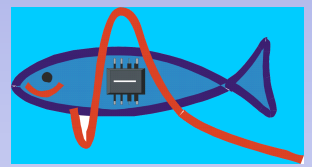


- Recording and transmitting physiological data of fish by implantable microsensor systems



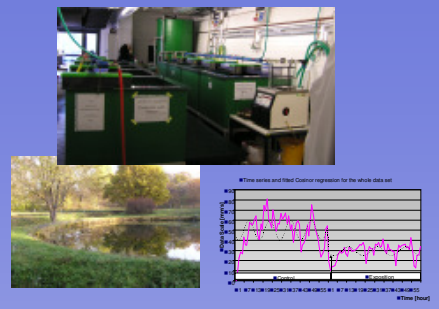
- Reliable evaluation of physiologic alterations and / or behavioural irregularities in fishes

- Therefore
  - Technically develop and test an appropriate microsystem
  - Set up experiments with defined stress situations and diseases
  - Develop data analysis solutions



Project partners – “FischFIT-Monitoring”

Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin



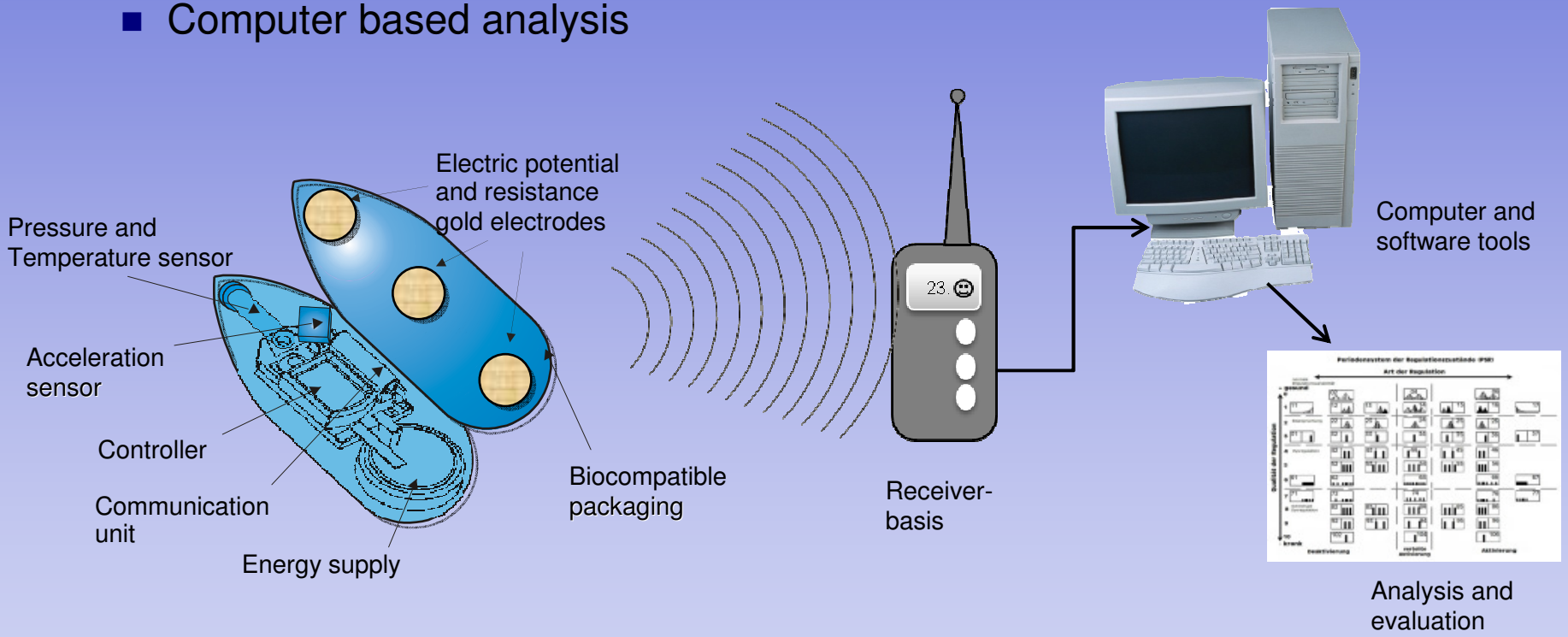
Institute of Agricultural and Urban Ecological Projects (IASP)

ELBAU Elektronik Bauelemente GmbH Berlin

Fraunhofer Institute of Reliability, System Design and Integration (IZM)

Technical Principle of the FischFIT- Monitoring

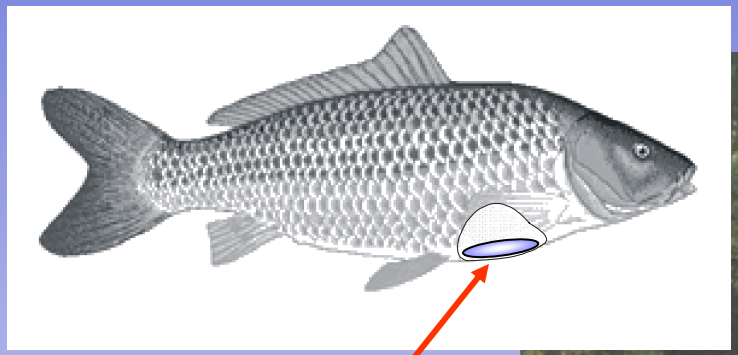
- Miniaturised multi sensor nodes (eGrains)
- Telemetric communication
- Computer based analysis



- Sample and communication rate of one second

Position of the sensor

- The sensors are implanted ventrally into the body cavity between pectoral and ventral fins



Implanted sensor-eGrains

Measured parameters

- Physiological and behavioural processes or functions

Temperature (T)	Inflammatory processes, adjustment factor
3-D- acceleration (X Y Z)	Locomotor activity, position, speed of reaction
Skin/ tissue resistance (TR)	Vegetative- emotional reaction, sympathetic nervous system
Potential of skin/ tissue (TP)	Vegetative- nerval reaction, parasympathetic nervous system
Electric Myoactivity (EMG)	Muscular reaction, locomotor activity
Breath and heart rate (BR HR)	Excitement, activity, tension, stress, exhaustion

Technical development

- Several developmental steps covering 4 generations

1st Generation (Test of main components)

size: 55 mm x 7 mm x 20 mm

2nd Generation (integrated sensor)

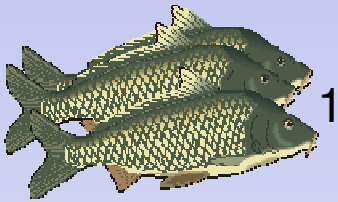
Ti; Ta; TR; TP; EMG; 3D-accelleration

size: 45 mm x 7 mm x 20 mm

3rd Generation (integrated sensor)

pressure; pressure difference (HR; BR)

size: 45 mm x 7 mm x 20 mm



1/3 Volume

4th Generation (integrated sensor)

Ti; Ta; TR; TP; EMG; 3D; HR; BR

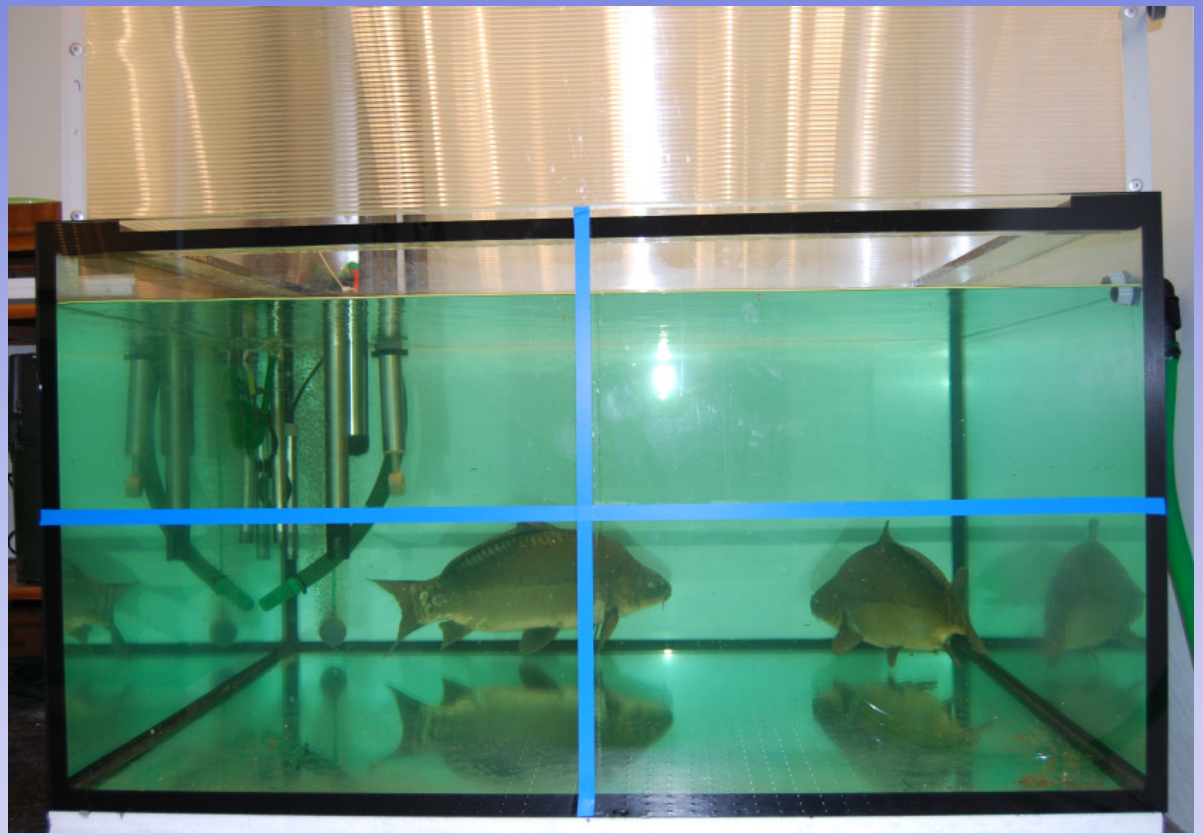
size: 30 mm x 5 mm x 12 mm

Experimental design (1)

- Aquarium (lateral view) with environmental measurement technique, receiver station and 3D-video recording

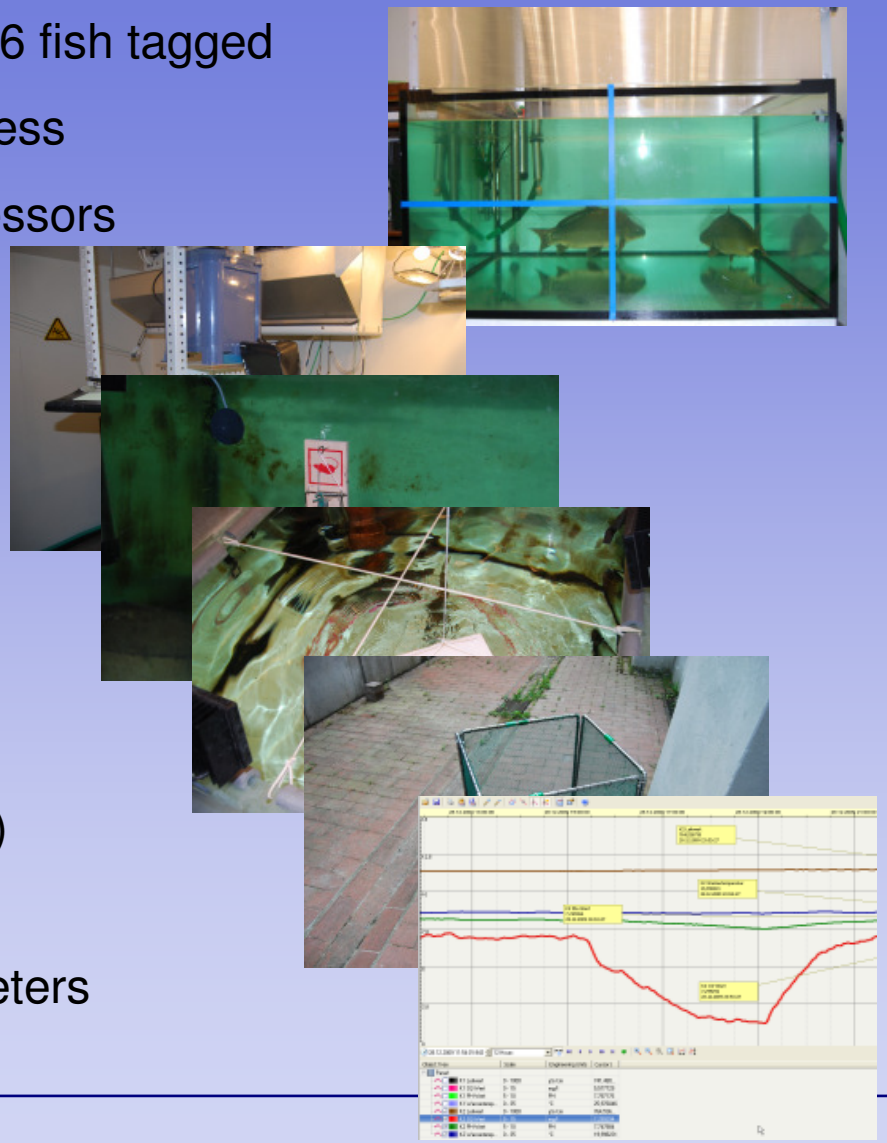
- About 1.5 x 1.5 m
- Automatic feeding
- Mechanic and biologic filters
- Open recirculation
- Climate chamber
- Dimmable light
- IR for night observ.

- Integrated experimental installations



Experimental design (2)

- Experiments made with 150 fish; 66 fish tagged
- 50 experiments with short-term stress
- 18 experiments with long-term stressors
  - Shadow moving overhead
  - Acoustic stimulus
  - Object falling on surface
  - Stocking density (cage)
  - Water quality parameters



Two approaches of data evaluation

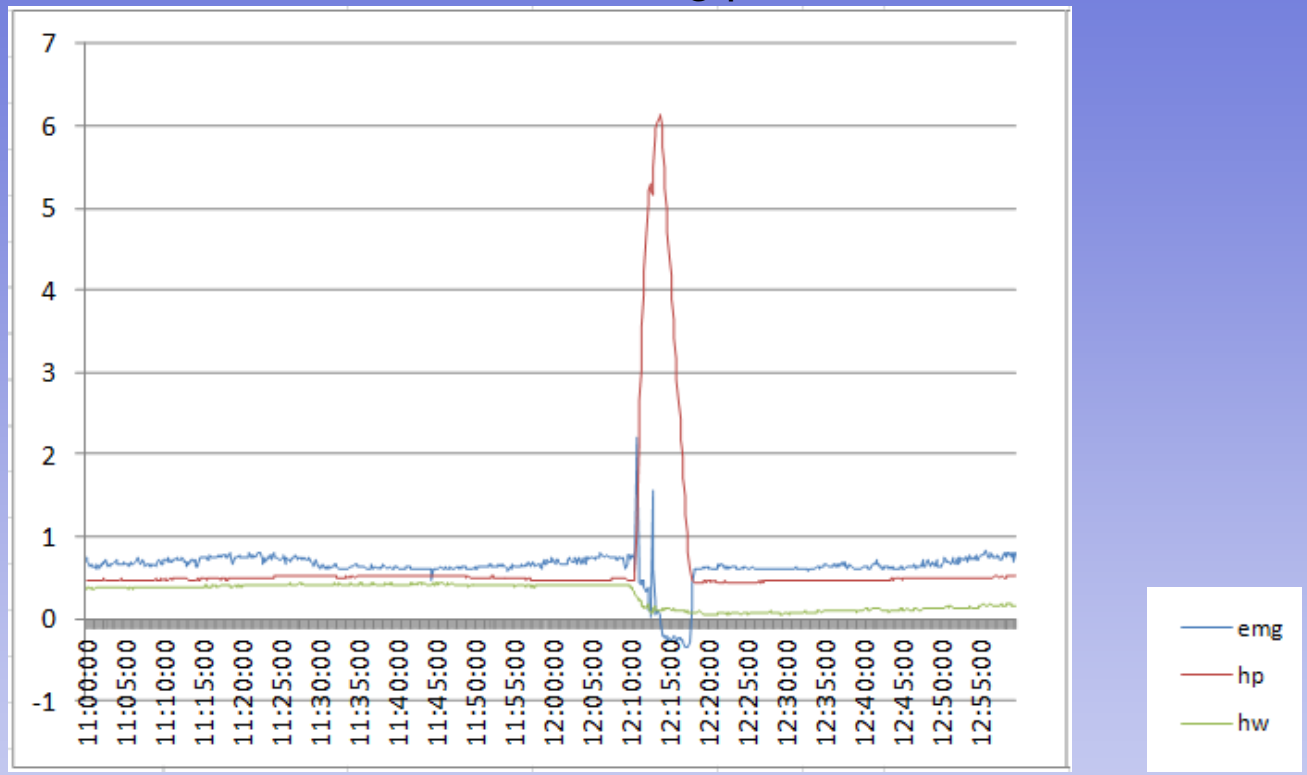
1) To demonstrate the sensor systems functions
   a primarily amplitude based method with normalized data was used

2) To reveal the health state a chronobiological method was applied

- Chronobiological regulation diagnostics,
  a primarily frequency based data evaluation
- Using an ANN to calculate the regulation states of each parameter
- Leading to regulatory pattern, useful to estimate the health state of fish

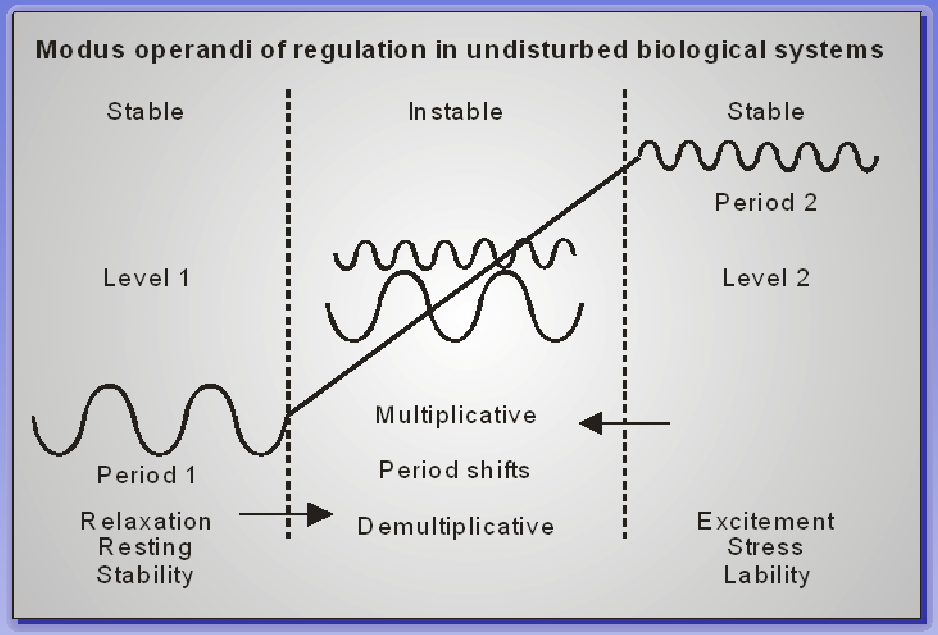
First approach of data analysis - Normalized data

- The reaction of fish on handling procedure



- Rapid increase of tissue potential of carp was noted
- EMG increased shortly after the stimulus, but then decreased rapidly after the handling stimulus

Chronobiology of physiological functions



- Physiological function tends to oscillate between maximum and minimum value
- Period length depends on the activity status of the organism
- Stressed organism: short period length, fast regulation, fast reaction
- Relaxed organism: longer period length, slow regulation, slow reaction
- Chronobiological data analysis, rhythmic regulation of the parameter

Chronobiological data analysis

- Parameter analysis bio.stream - Software

Original data → **Trend elimination** → **Model functions of time series** (ACF, Cosinor, Powerspectrum)

Dynamic analysis of periods (Comparison of models, Selection of the best fit, Main period over time…)

Stability analysis Crosscorrell. model/data Stable / instable periods

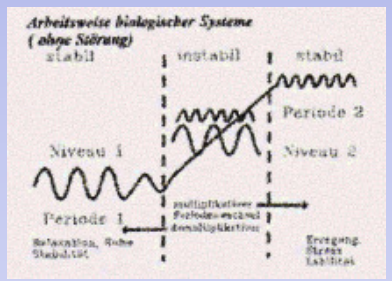
Frequency distribution (Periods in a time window)

Visuell determination of Regulatory states (selection of training series)

Training phase

Neural Network

Regulatory states
Regulatory pattern



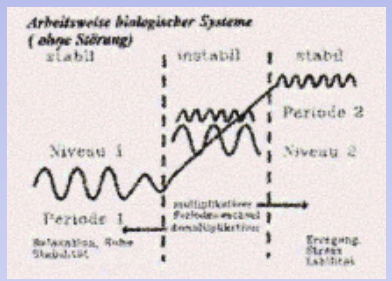
Chronobiological data analysis

- Parameter analysis bio.stream - Software

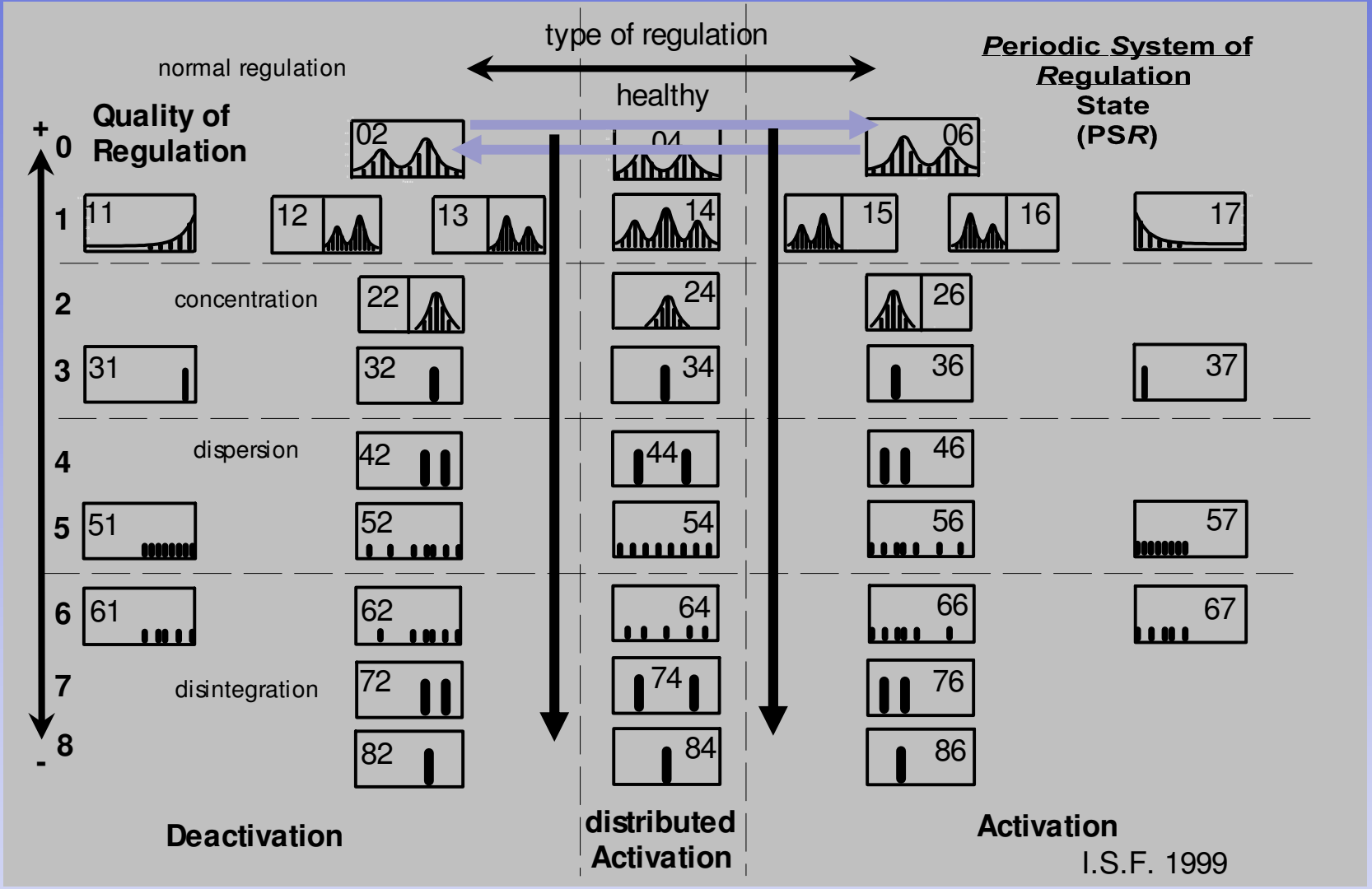
Measured data

Calculations
Black Box

Regulatory states
Regulatory pattern

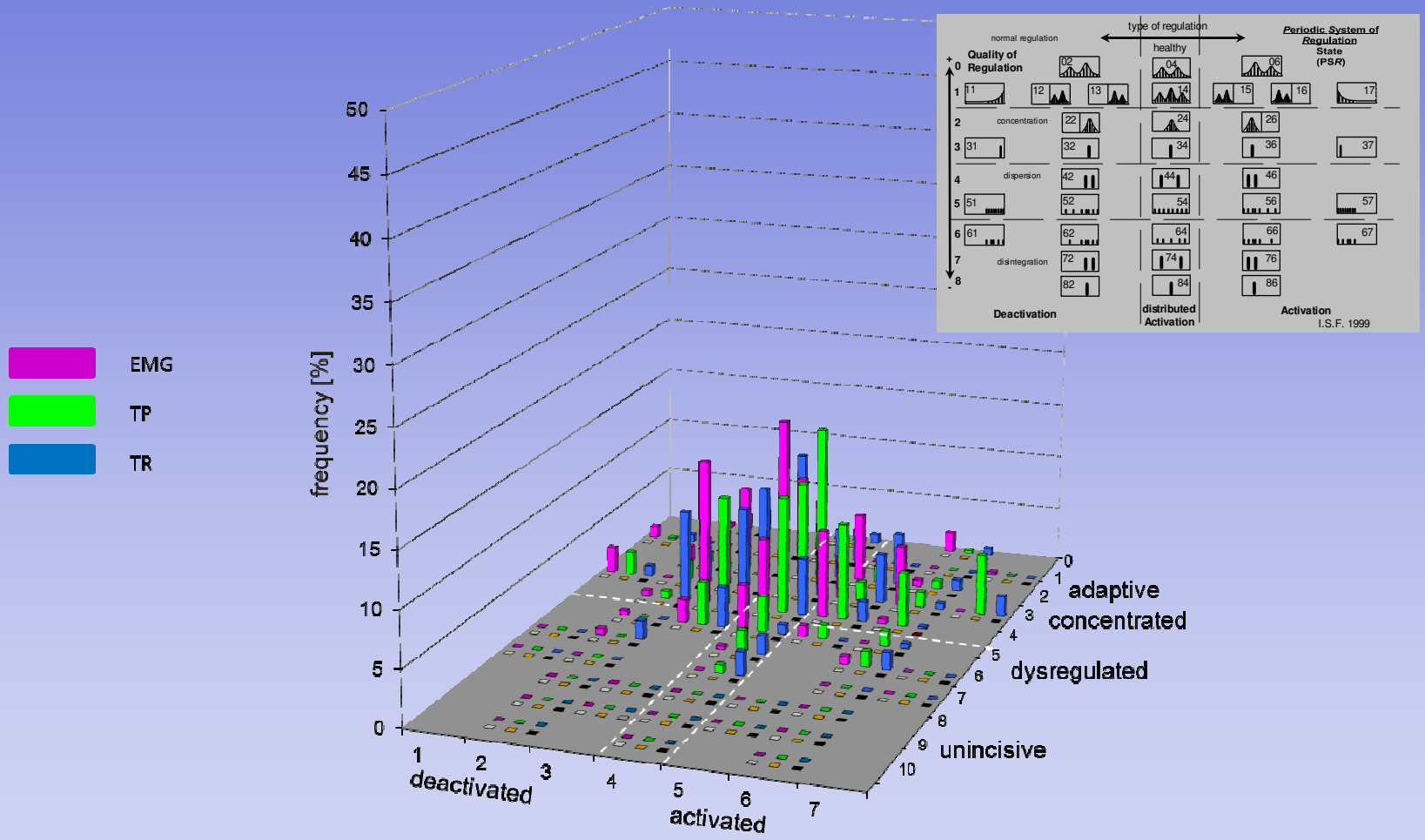


Periodical system of regulatory states



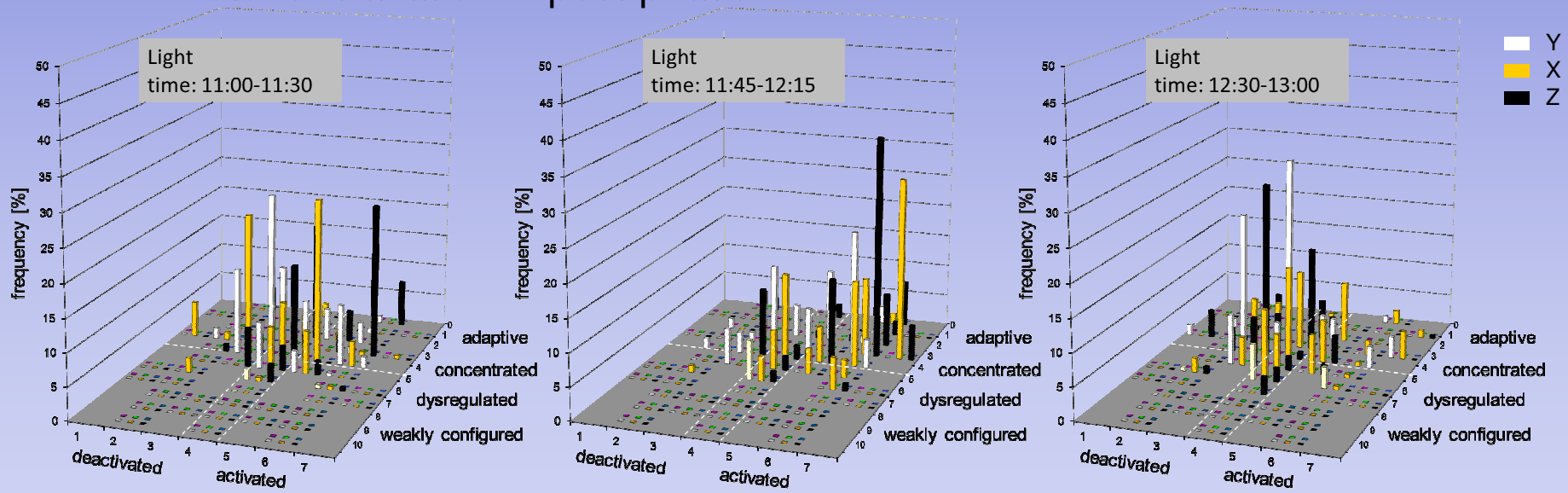
Results - regulatory pattern

- Frequency pattern of the regulatory states of measured parameters



Results – Light off and flashing (1)

- Influence of illumination changes – light off + flashing light following
- Frequency distribution pattern of the regulation states of 3D- acceleration
- 3D-acceleration shows activated, concentrated regulation states
- Especially Z-axis fast regulation states
  representing avoidance reaction towards the bottom region
- Motoric relaxation in post-phase



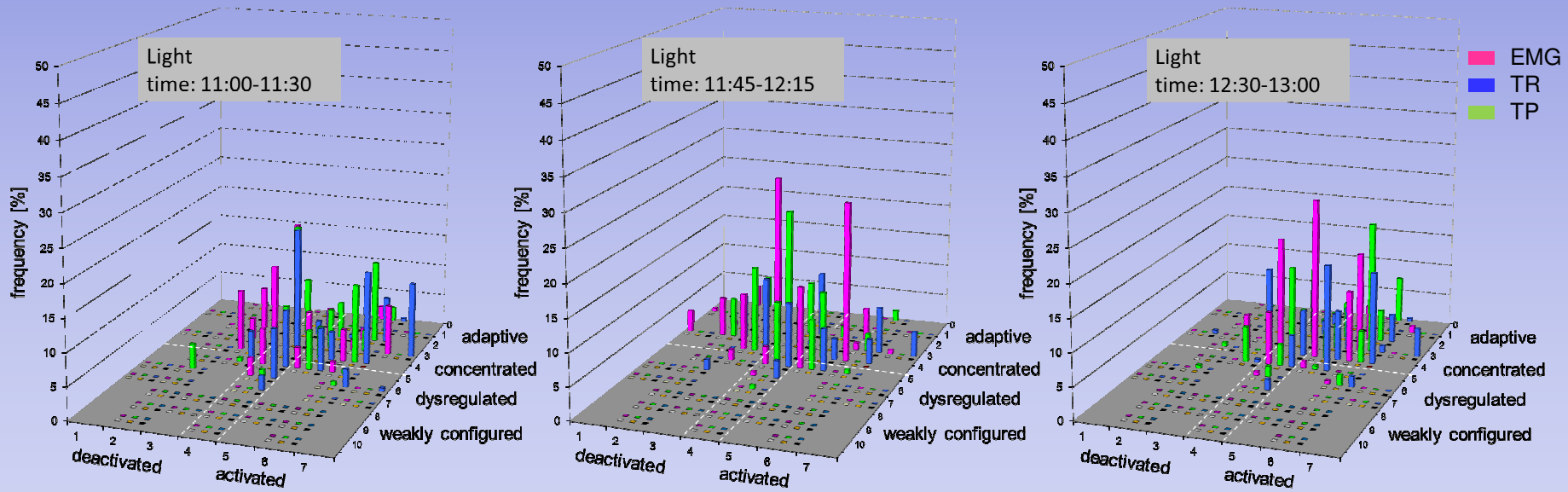
FD - 30 min before stimulus

FD – during stimulus

FD - 30 min after stimulus

Results – Light off and flashing (2)

- Influence of illumination changes – light off + flashing light following
- Slight deactivation in tissue potential and EMG
- Broadened spectrum of regulation states - uncertainty
- Shift towards concentrated and adaptive reactions
- Especially during post-phase fish alert and activated, concentrated and tense



FD - 30 min before stimulus

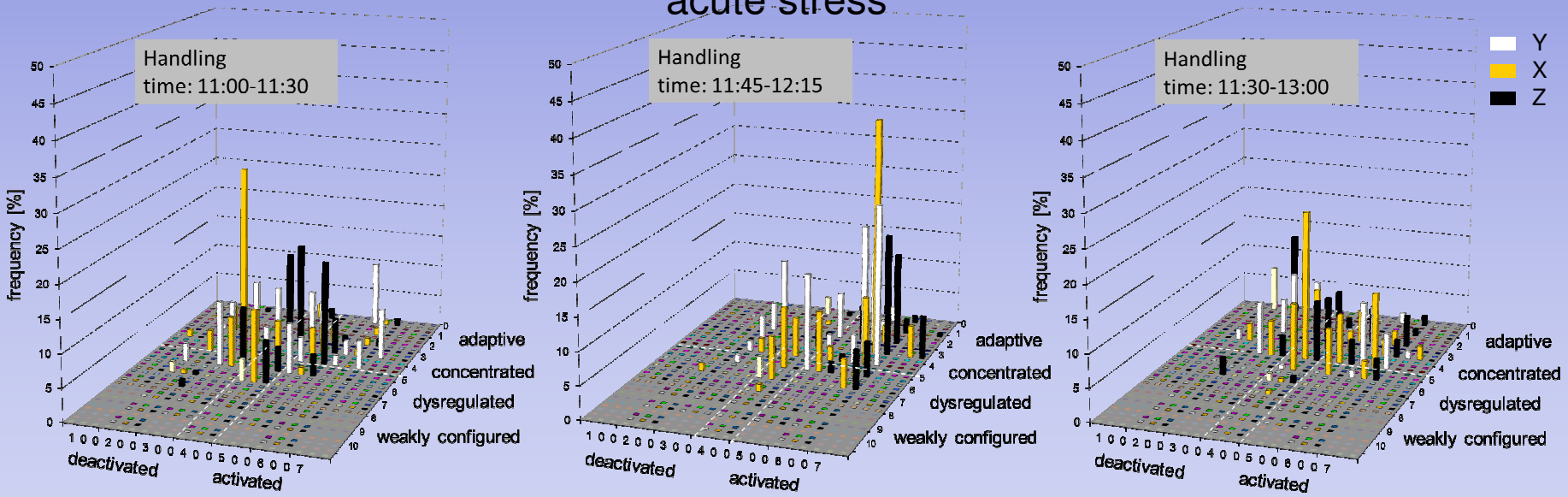
FD – during stimulus

FD - 30 min after stimulus

Results – Handling stress (1)

- Influence of handling stress – scoop netting with 5 s air contact
- 3D-acceleration shows strongly activated, concentrated and rigid regulations
- Concentrated states in post-phase
- Spectrum of regulation states broadened again

acute stress



FD - 30 min before stimulus

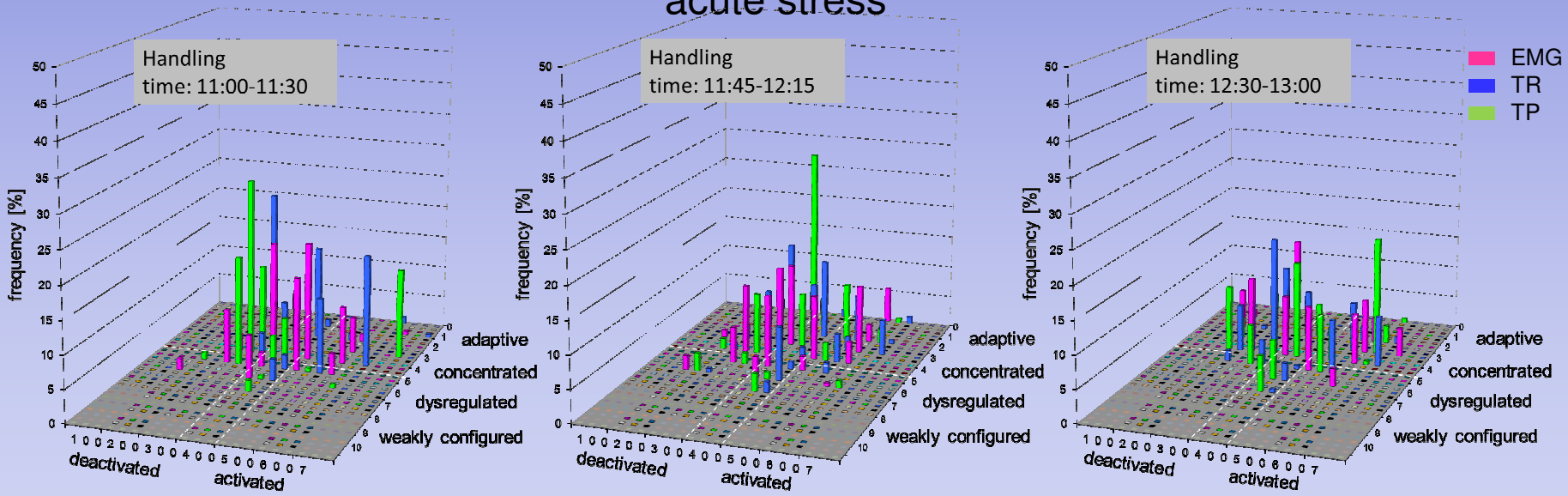
FD – during stimulus

FD - 30 min after stimulus

Results – Handling stress (2)

- Influence of handling stress – scoop netting with 5 s air contact
- EMG data tend to deactivation because of limited movements during netting
- Fear states in the TP parameter visible
- Reaction during stimulus too fast for sampling rate

acute stress



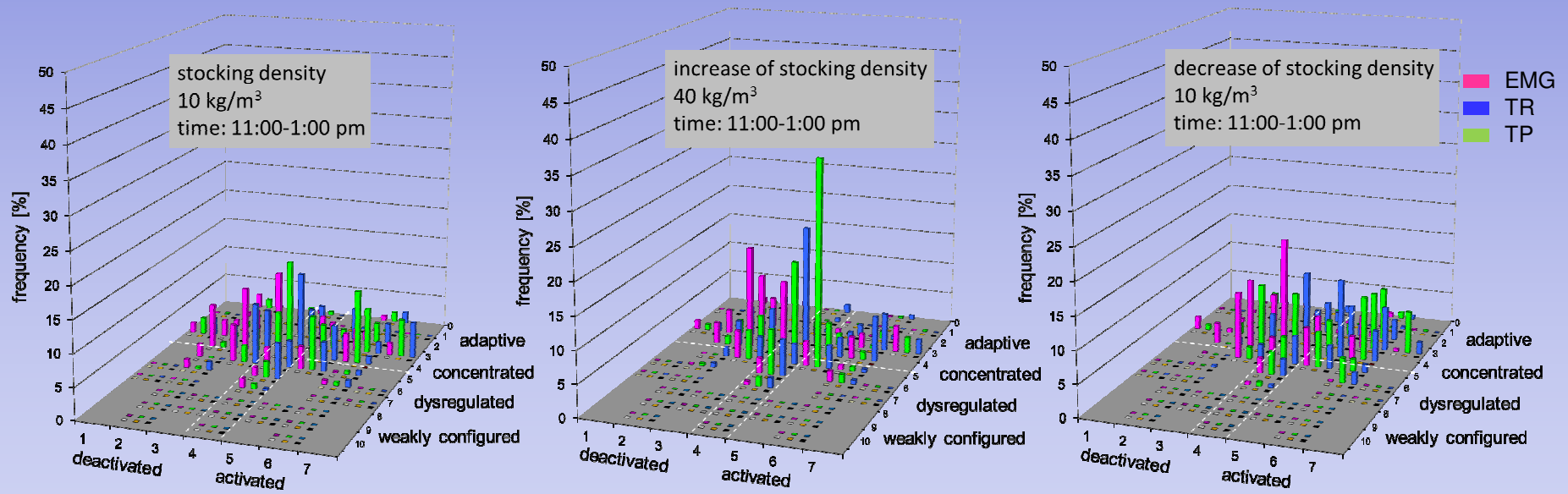
FD - 30 min before stimulus

FD – during stimulus

FD - 30 min after stimulus

Results – Stocking density

- Influence of an enhanced stocking density on fish (aquaculture)
- Fish EMG tends to more deactivated states because of the limited space for movements
- High frequencies of dysregulated states in TR and TP standing for discomfort and possibly fear



FD – normal stocking density

FD – 3rd day of enhanced stocking

FD – normal density again

Summary

- The miniaturization of the implantable system allows the integrated measurement of different physiological and behavioural parameter
- The measuring parameter reflect vegetative nervous, vegetative emotional and motoric processes
- The potential of the used data analysis system to characterise the health and welfare status of fish (in aquaculture) was evaluated
- The current stage of the monitoring system proved to be useful in restricted size aquaria, basins or smaller ponds with fresh water.

Next steps and perspectives

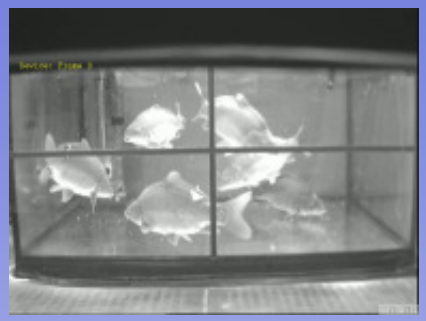
Next Steps:

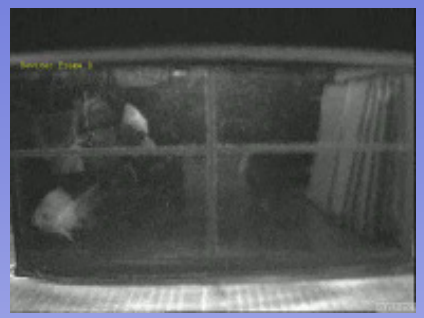
- Completing the data evaluation of experimental series
  - Statistical evaluation of treatment groups – in progress
  - Evaluation of individual differences and fish personalities
- Further development of the system
  - Optimisation of energy consumption and miniaturisation
  - Optimisation of sampling frequency and measuring time

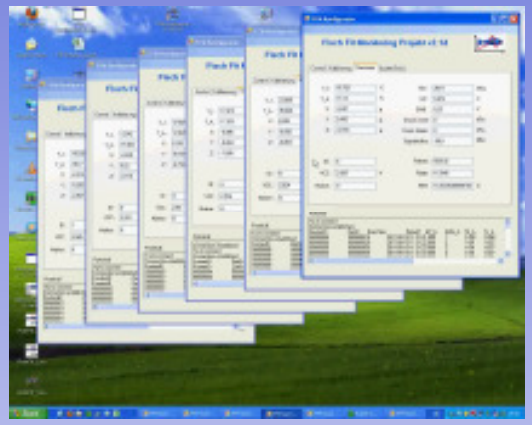
Wider perspectives for research and applications:

- Investigation in distinct behavioural types and coping strategies in fish
- Health diagnostics and disease forecast of fish (aquaculture)
- Scaling of the system from aquaria to natural systems
- Adaptation for more species of fish and different species of animals

Video - Presentations







Fish in the experimental tank

Measurements running

Thank You for Your kind attention