

# **From repeated baseline HRV monitoring to activity-and-recovery assessment in a trained dolphin: a preliminary protocol report**

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## **Abstract**

Heart rate variability (HRV) may provide useful physiological information for welfare assessment in managed dolphins. Previous preliminary work proposed HRV analysis as a potential tool for evaluating welfare-related physiological states in dolphins. As a further step, this preliminary protocol report documents the development and initial implementation of a baseline-informed activity-and-recovery protocol conducted under routine husbandry conditions.

Repeated heart rate and HRV-related baseline recordings were collected by animal care staff over multiple days across several months while the dolphin voluntarily maintained a trained stationary posture at the water surface. Based on this baseline phase, a short protocol was implemented, consisting of a brief baseline recording, a preference-based positive activity, and a short recovery recording in the same trained posture.

This report records the protocol structure as a methodological basis for subsequent HRV-based assessment of baseline state, possible anticipatory state, activity-related physiological change, and post-activity recovery. By combining individual baseline recordings, HRV-based autonomic assessment, contextual records, non-invasive physiological measures, and prior habituation or desensitization to the measurement procedure, this framework may support future interpretation of physiological changes associated with affective state, stress responses, and recovery or relaxation processes under routine husbandry conditions.

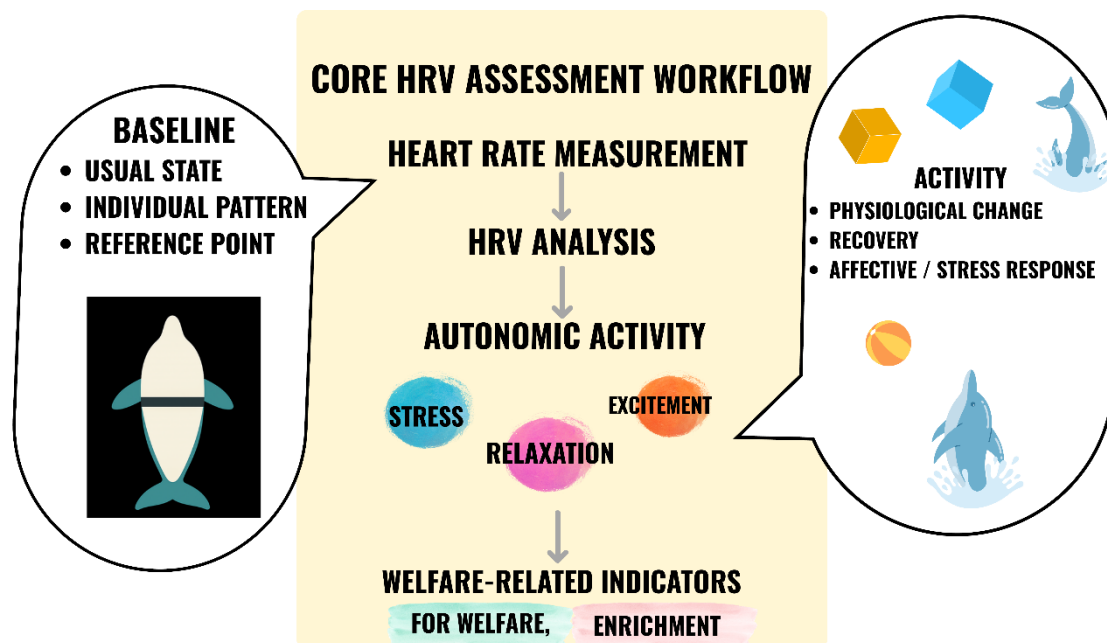
## **Introduction**

Physiological monitoring may help support welfare assessment in animals under human care. In dolphins, heart rate and HRV can provide information about physiological state during routine training and husbandry. HRV has been used as a non-invasive measure of autonomic regulation for assessing stress and welfare in farm animals (von Borell et al., 2007). Previous preliminary work described the feasibility of using HRV analysis for welfare assessment in dolphins (Shimozato, 2025).

The present report builds on that work by extending repeated baseline monitoring toward an activity-and-recovery protocol. Whereas the previous report focused on the feasibility of HRV-based monitoring during a trained stationary posture, the present report focuses on the development and initial implementation of a short protocol based on repeated individual baseline recordings. The aim was to document a practical procedure that can be incorporated into routine husbandry while reducing the burden of prolonged stationary recording.

A key aspect of this approach is that physiological changes are interpreted in relation to the individual animal's repeated baseline pattern. Interpretation of heart rate and HRV requires attention to respiration, posture, activity level, anticipation, measurement-related arousal, and the animal's habituation or desensitization to the measurement procedure. For this reason, the framework emphasizes repeated individual baseline recordings, HRV analysis, and contextual interpretation using behavioural and measurement-related records (Fig. 1).

This preliminary protocol report focuses on the development and initial implementation of the protocol. Quantitative physiological outcomes are not presented here and will be reported separately.



**Figure 1. Conceptual framework for baseline-informed HRV assessment in a trained dolphin.** Heart rate measurement during routine husbandry conditions provides the basis for HRV analysis and interpretation of autonomic activity. Repeated baseline monitoring is used to characterize the individual's usual physiological state, individual pattern, and reference point. Activity-related recordings can then be interpreted in relation to this baseline, including physiological change, recovery, and affective or stress-related responses. This framework may support the development of welfare-related indicators for welfare and enrichment assessment.

## Methods

### Animals and facility

The protocol was developed with a trained dolphin housed in a managed care setting. Facility name, individual identity, and specific dates are not reported here to protect confidentiality. The dolphin participated voluntarily in the procedures as part of routine husbandry and training.

### Baseline monitoring phase

Before introducing the activity-and-recovery protocol, repeated baseline recordings were collected over multiple days across several months. Some days included repeated measurements within the same day. Recordings were obtained by animal care staff using a belt-mounted heart rate sensor while the dolphin voluntarily responded to trainer cues and maintained a trained stationary posture at the water surface as part of a husbandry

behaviour.

During the baseline monitoring phase, the dolphin gradually became accustomed to the measurement posture and belt-mounted sensor procedure through repeated cue-guided sessions. This allowed repeated baseline recordings to be conducted under increasingly familiar husbandry conditions while reducing the influence of novelty or sensor-related arousal over time.

This baseline phase was used to understand the individual's usual physiological pattern during the trained posture. It also confirmed that repeated monitoring could be incorporated into routine husbandry and provided a basis for developing a shorter protocol.

### **Activity and recovery protocol**

Based on the baseline monitoring phase, the protocol was extended to include three phases:

- (1) a short baseline recording during a trained stationary posture;
- (2) a brief preference-based positive activity; and
- (3) a short recovery recording in the same trained posture.

The baseline phase was intended as a practical routine-training baseline. The aim was to obtain a short, repeatable recording while maintaining voluntary participation and minimizing the burden of prolonged stationary holding.

The positive activity was selected based on trainer knowledge of the individual dolphin's preferences and motivation. The specific details of the activity are not described here to protect facility and individual confidentiality.

After the activity, the dolphin returned to the same trained stationary posture, and a short recovery recording was conducted.

### **Saliva sampling and contextual records**

Saliva sampling was incorporated when feasible as an additional non-invasive physiological measure. During this procedure, the dolphin maintained a trained waiting posture in the water and voluntarily opened the mouth in response to a cue. Saliva samples were collected as material for cortisol measurement, a non-invasive endocrine-related physiological indicator previously applied in captive dolphins (Pedernera-Romano et al., 2006).

Posture, respiration, and trainer annotations were also recorded to support contextual interpretation of physiological changes.

## **Data collection and subsequent measures**

The implemented protocol was used to collect heart rate and HRV-related recordings, saliva samples, posture, respiration, and trainer annotations. Subsequent analyses will require attention to RR-interval quality, artefact handling, respiratory context, posture, activity level, behavioural annotations, and records related to habituation or desensitization to the measurement procedure.

## **Results**

The preliminary protocol was implemented as an extension of the initial baseline monitoring phase into an activity-and-recovery format. Repeated baseline recordings across multiple days were first used to characterize the individual's usual physiological pattern during the trained stationary posture. Based on this baseline phase, the protocol was organized into a brief baseline recording, a preference-based positive activity, and a short recovery recording in the same trained stationary posture. Saliva sampling and contextual records, including posture, respiration, and trainer annotations, were also incorporated when feasible.

These preliminary procedures established a practical structure for repeated assessment of baseline state, possible anticipatory state, activity-related physiological change, and post-activity recovery under routine husbandry conditions.

## **Discussion**

This preliminary protocol report documents the development and initial implementation of a short activity-and-recovery protocol in a trained dolphin. The protocol was developed from repeated baseline HRV monitoring and was designed for use under routine husbandry conditions. A practical emphasis is that animal care staff can carry out the procedure as part of ordinary training and husbandry routines.

The repeated baseline recordings have two methodological roles. First, they characterize the individual dolphin's usual physiological pattern under routine husbandry conditions. Second, they provide a reference for interpreting later physiological changes during activity-and-recovery sessions. This baseline-informed structure allows later physiological changes to be interpreted in relation to the individual animal's usual pattern. During the baseline monitoring phase, the dolphin gradually became accustomed to the measurement posture and belt-mounted sensor procedure through repeated cue-guided sessions. Therefore, later recordings can be interpreted with consideration of reduced novelty and measurement-related arousal over time, rather than primarily as responses to the measurement procedure itself.

The use of RR intervals and HRV indices supports assessment of autonomic regulation beyond simple changes in heart rate. This baseline-informed structure may support future interpretation of affective, stress-related, and recovery-related physiological changes when combined with HRV indices, posture, respiration, trainer annotations, and other contextual records.

This report documents the implemented protocol and does not aim to test activity effects at this stage. To protect facility and individual confidentiality, identifying details and detailed activity descriptions are not reported. Quantitative physiological outcomes will be addressed in subsequent analyses. Further repeated measurements and subsequent analyses will be required before drawing conclusions about cardiac recovery, cortisol patterns, complementary physiological responses, or welfare state. By recording the implemented structure before quantitative outcome analysis, this report establishes a conceptual and methodological basis for subsequent HRV-based welfare and enrichment assessment under routine husbandry conditions.

## **Conclusion**

This preliminary protocol report documents the implementation of a practical activity-and-recovery protocol developed from repeated baseline HRV monitoring in a trained dolphin. The framework emphasizes repeated individual baseline recordings, HRV-based autonomic assessment, gradual habituation or desensitization to the measurement posture and belt-mounted sensor procedure through repeated cue-guided sessions, and contextual interpretation of physiological changes.

The implemented protocol provides a basis for subsequent assessment of physiological and behavioural states, including responses to preference-based positive activities and post-activity recovery, under routine husbandry conditions. This framework represents a further step toward integrating HRV-based physiological monitoring into practical welfare and enrichment assessment for managed dolphins.

## References

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