Cumulative Effects – Multiple Stressors in Cetacean Research

Nr.	Image	Text	Zeit (sec)
1.	(Stock footage?) Videos of Marine ecosystems	Marine environments are highly exposed to threats, but there are limits to what nature can bear.	7
2.	(Stock footage?) Videos of threats (sea pollution, ship noise / propeller / engine)	Often, those threats are produced by humans and lead to stress in marine animals.	8
3.	Images of whales with statistic overlay	If the stress is relieved, ecosystems can return to their original state. But when we examine individual cases, we see that this effect does not apply across all species. For example, North Atlantic right whales are barely recovering, while other whale species have seen recoveries of 7% per year. We don't yet know why that is. Therefore, we have to ask ourselves: what research is still needed to establish why certain species recover from stresses while others do not?	22
4.	Studio / speaker Maybe text animations onscreen Stock footage: Cetaceans	Let's start by looking at what stress actually is. Stress is the internal response of the biological system to a stressor. The stressor, which can be biotic or abiotic, moves the system out of its normal operating range. Our research focuses on cetaceans – in other words, on marine animals such as whales, dolphins, and porpoises. We try to understand the impact of stressors on these cetaceans and their environments. Identifying individual stressors is challenging, especially when they combine with each other. But to develop sustainable options to manage ecosystems, we must distinguish each stressor from the others and understand its specific underlying effects.	33
5.	Animation A linear graph rises. In the end, it morphs into a sigmoidal curve.	Multiple stressors combine to produce cumulative effects. In most cases, the response of organisms to these stressors is additive. Now, one might expect that on a graph this cumulative effect takes the form of a linear function. In fact, the response function is, however, sigmoidal rather than linear, as we can see here on this graph. Such a sigmoidal function makes it	36

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		harder to predict the outcome of jointly acting stressors. Furthermore, some effects must be above a certain threshold to affect the population, so we have to keep this in mind, too.	
6.	Studio / speaker Text appears: “a) gather information b) use data from field studies”	Hypothetically, we could test animals in a controlled environment, first for each stressor individually, and then in combinations of various stressors. Such separation and combination would give us a good understanding of each individual case. However, as you might have already guessed, testing on cetaceans in controlled environments is often just not possible. What we can do though is a) gather information from similar experiments with comparable species, and b) use data from dedicated field studies on cetaceans themselves.	30
7.	Studio / speaker	After gathering data and compiling an inventory of stressors, we look for correlations to adverse effects.	8
8.	Studio / speaker Screenshots of Software	We then use this information to create models. A very helpful tool here is Population Viability Analyses, or PVA. The PVA Vortex Model uses software to compare multiple stressors relative to the population growth. Importantly, this model can also determine the degree to which we must mitigate threats to improve the rate at which the animals recover.	25
9.	Studio / speaker Images of whales / map	As you can see, there is no one-fits-all solution for every problem and every species. Solutions have to be adapted and applied on a case-by-case basis, always depending on the available data. For our North Atlantic right whales, the assumption is that their stress is linked to ship strikes, entanglements, changing food resources, harmful algal blooms and marine pollution. But we do not know how these stressors influence other species.	28
10.	Studio / speaker	In order to find out how different stressors differently influence various species, we would like to see more studies on the mechanism through which single stressors act. Understanding the mechanism underlying individual stressors may also help predict when and where cumulative effects occur. We also suggest improving research across disciplines and using diverse methods. If the scientific community joins forces in this way, we can develop an integrative,	28

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		holistic picture of the animals in question. And the more comprehensive our picture becomes, the better we will be able to contribute to sustainable management options for cetaceans in our oceans.	
11.			**3’45 min**