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Ecosystem-based fisheries management implies multiple objectives for complex and uncertain systems. Can control theory help?

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Traditional fisheries management is primarily concerned with the state of the fished stock and therefore usually adjusts catch limits in response to information about the state of that stock alone. Ecosystem-based fisheries management is also concerned with the state of other ecosystem components. For example, management of Antarctic krill fisheries must control their effects on krill predators such as penguins, whales and seals. This suggests that the state of other ecosystem components should be taken into account when deciding catch limits. Control theory can help to identify which ecosystem components to monitor and to identify the catch limits most likely to achieve management objectives given the current state of these components. However, the behaviour of ecosystems is impossible to predict with any accuracy and therefore difficult to control. We use a control theoretic approach (model predictive control) to adjust the spatially resolved catch limits in a predator-prey model that incorporates key features of the Antarctic krill-based ecosystem. We test the performance of this approach with increasing levels of uncertainty in the state estimates and the parameters used to predict future states. We discuss possible ways of reducing or compensating for the degradation of performance at higher levels of uncertainty. Ecosystem-based fisheries management implies a need to achieve objectives for multiple components in complex ecosystems with high levels of uncertainty. We conclude that integrating modern control theoretic approaches into fisheries management systems could help to achieve these objectives.