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Overfishing, Climate Change and Stock Collapse and Recovery in North Pacific and Atlantic Fisheries: a Review of with Emphasis on Herring.

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A review of most major herring stocks subjected to fishing during the last century, showed that all stocks fluctuated, and most stocks 'collapsed' one or more times. Although over-fishing is implicated in every collapse, it is probable that other factors also were important, especially climate. Except for the Hokkaido-Sakhalin stock, nearly all of the herring stocks recovered, but the present state of some is low. The influence of climate on herring stocks in the Baltic, North Sea and on Norwegian herring is well known but the effects of climate on other herring stocks, especially those in the Pacific, have not been received much attention in the scientific literature. Climate change, as a factor affecting fish stocks, usually occurs over broad geographical ranges and affects fish stocks that widely separated. Therefore climate change is implicated when there is evidence of synchronous change in different stocks separated by large geographical distance. Changes may be positive or negative, and occur in abundance, recruitment, survival, growth or other factors. For example, when changes in abundance are compared among different herring stocks, some changes appear to be positively correlated and synchronous among different stocks, both within the Atlantic and Pacific Oceans. An example is the concurrent changes in abundance within the north-western Atlantic in the 1990's, where there was a substantial increase in herring stocks in the south-west Atlantic (George's Bank, the American state of

Maine, and areas south of Maine) but a decrease in most north-western stocks (Canadian stocks, especially in the province of Newfoundland). A different observation, but one of considerable potential significance, is that the trends in abundance of the Norwegian spring spawning herring, which is the largest herring stock in the world, appear to be synchronous with several large herring stocks in the north Pacific. If so, the implication is that climate changes in the Arctic may have synchronous effects on most herring stocks occupying the extreme northern positions in both oceans, and that climate change in Arctic areas could affect northern regions in both the Atlantic and Pacific. Yet another observation is that recruitment and growth patterns may sometimes be synchronous. There is increasing evidence that years of especially good recruitment can sometimes occur synchronously among many different herring stocks, and even different species, within in the North Pacific. A general conclusion is that while there are many biological differences among herring stocks, almost all are subject to substantial fluctuations in abundance and the most severe declines are preceded or accompanied by intense fishing. Usually fishing activity stops after a 'collapse', and with only one exception, all collapsed stocks eventually recovered. The exception is the Hokkaido-Sakhalin stock, once one of the largest in the world, with nearly a million tonnes landed annually. The stock collapsed in the late 1940's, and has remained low since then. There is no clear explanation for the failure of this stock to recover. The failure of such a recovery during the last 60 years is especially puzzling because there still are small components (or fragments) of this stock spawning in some parts of the Hokkaido and Sakhalin Islands, so the population was severely reduced but not completely eliminated. Also, since the collapse, herring stocks in adjacent areas, including the Yellow Sea, have

experience one or more periods of abundance and decline. More research on the present state of this depleted and fragmented stock may be revealing, and provide explanations for the failure of the Hokkaido-Sakhalin stock to recover and may also provide useful insight about changes in abundance of other fish stocks in the western Pacific.