



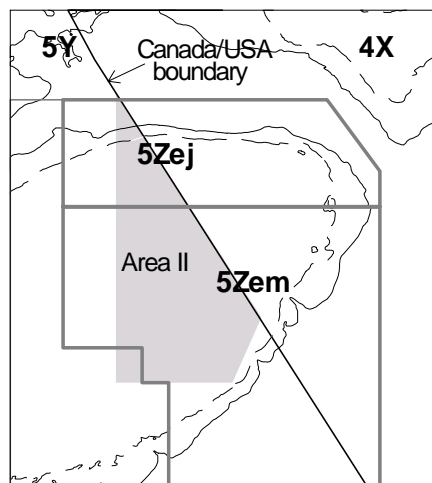
## Eastern Georges Bank Haddock

### Background

The haddock, a bottom dwelling species in the cod family, is found on both sides of the North Atlantic. In the western Atlantic, haddock range from Greenland to Cape Hatteras, with a major concentration on eastern Georges Bank.

Georges Bank haddock feed primarily on small invertebrates and are most commonly caught at depths of 45 to 240 meters (25 to 130 fathoms). Adult haddock appear relatively sedentary but seasonal movements occur. On Georges Bank, young haddock grow rapidly at first, reaching over 50 centimeters (20 inches) by age 3, but grow slowly thereafter, reaching about 75 centimeters (30 inches) by age 10. Many haddock mature by age 2 but it is uncertain if these young fish spawn successfully.

Georges Bank haddock have supported a commercial fishery since prior to 1900. Bottom trawlers have been the principal gear since their introduction in the 1920s. Landings from Georges Bank, which include the eastern Georges Bank component and the Great South Channel component, averaged about 46,000t between 1935 and 1960 and increased to over 100,000t in the 1960s under heavy exploitation. Subsequently, during the early 1970s, spawning season/area closures were introduced as a means of controlling effort and are still in use today. Following the extension of jurisdiction to 200 miles by coastal states in 1977, only Canada and the USA have fished this stock. Both Canada and the USA impose minimum fish size and mesh size regulations. Additionally, Canada establishes quotas to achieve a target exploitation rate of roughly 20% or lower of the harvestable population and the USA has instituted a year-round closure of Area II.



### Summary

- Combined Canada and USA catches in 2000 were about 5600 t.
- Biomass has increased since 1993 but remains below the 1930-55 average.
- Adult biomass (ages 3+) increased to over 40,000 t, above which better recruitment has been observed, in 2001 but little increase in biomass is expected to 2002 .
- The 1998 year-class is the strongest since 1978 and early signs for the 2000 year-class indicate it may be comparable. The 1996 and 1999 year-classes were estimated to be the third and fourth largest since 1978.
- A broad age structure is reflected in both the fishery catch and the population.
- Exploitation has been below  $F_{0.1}$  since 1995.
- Survivorship to age 1 is generally higher than that observed during the 1980s.
- The combined Canada/USA yield at  $F_{0.1}$  in 2001 would be about 9,700 t. While the biomass is not expected to decrease, the chance of a 10% increase is low.

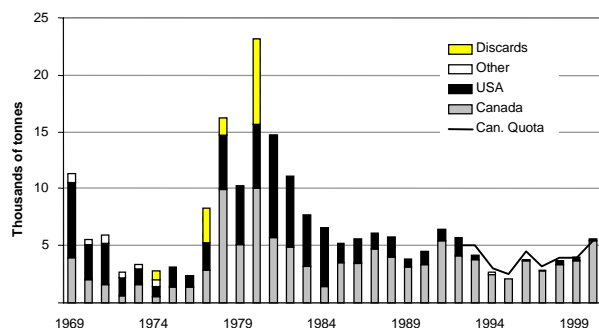
*The Fishery*

Catches (thousands of tonnes)

Year	1970-79		1980-89		1990-96		1997	1998	1999	2000
	Avg.	Avg.	Avg.	Avg.						
TAC <sup>1</sup>	-	-	4.0	4.0	3.2	3.9	3.9	5.4		
Canada	2.7	4.4	3.5	2.6	3.4	3.7	5.4			
USA	2.8 <sup>3</sup>	4.8 <sup>3</sup>	0.6 <sup>3</sup>	0.1 <sup>3</sup>	0.3 <sup>3</sup>	0.4	0.2			
TOTAL	6.1 <sup>2</sup>	9.2 <sup>2</sup>	4.2	2.7	3.7	4.0	5.6			

<sup>1</sup>Canadian quota only<sup>2</sup>Includes foreign catches<sup>3</sup>Includes discard estimates

Under restrictive management measures, **combined Canada/USA catches** declined from over 6,400 t in 1991 to a low of about 2,100 t in 1995 and have since fluctuated between about 3,000 t and 5,600 t. Greater catches in the late 1970s and early 1980s, ranging up to about 23,000 t, were associated with good recruitment. Substantial quantities of small fish were discarded in those years. Catches subsequently declined and fluctuated around 5,000 t during the mid to late 1980s.



In 1995 to 1999, **Canadian catches** were below the quota due to closure of some fleet sectors when the cod quotas were reached. The 2000 catch of 5,402 t was slightly above the Canadian quota of 5400 t. During 1994 to 2000, all Canadian groundfish fisheries on Georges Bank remained closed from January to early June to protect spawning concentrations.

Weight of all Canadian landings were monitored at dockside, and at-sea monitoring by observers accounted for 15%

of the 620 trips, from which haddock was landed and 21% of the amount landed. In 2000, samples were collected by DFO, observer and by two industry groups, Scotia Fundy Mobile Gear Fishermen's Association (SFMGFA) and High Liner Foods (HLF). Comparison of samples from all sources indicated that there was little discarding or highgrading. Discarding and misreporting have been considered negligible since 1992.

In recent years, the Canadian fishery has been primarily conducted by vessels using otter trawls and longlines with some handlines and gillnets. During 2000, all vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft and fixed gear vessels 45-65 ft operated on individual quotas while fixed gear vessels under 45 ft operated on community quotas administered by local boards. Most haddock were caught by otter trawlers less than 65 ft and longliners less than 65 ft. The catches by otter trawlers peaked in June while longline catches peaked in September. Longline catches were low in June due to a late start for that gear type.

The size and age composition of the 2000 Canadian fishery was characterised using port, at sea and industry samples from all principle gears and all seasons. The size composition of catch in the Canadian fisheries peaked at 55 cm (21 in) for otter trawlers and at 57 cm (22 in) for longliners. Gill-netters caught few haddock but they were larger. No sampling was available for discards of haddock by-catch in the Canadian scallop fishery, though in previous years, the amount caught has not been large.

**USA catches** for 2000 were derived from logbooks coupled with dealer reports, as was done for 1994-99. Effort in the USA fishery was regulated using closed areas and Days-at-Sea limits. To curtail targeting of haddock, a 500 lb trip limit was introduced

in 1994 and raised to 1,000 lb in July 1996. The trip limit resulted in an increase in the discard rate. The trip limit has been adjusted periodically and in September 1998, it was established at 3,000 lb/day, maximum of 30,000 lb/trip through to April 1999, 2,000 lb/day, maximum of 20,000 lbs/trip during May through October and raised to 5,000 lb/day, maximum of 50,000 lbs/trip in November 1999. In October 2000, the haddock daily trip limit was suspended through April 2001, with the trip limit of 50,000 lbs remaining in effect. The combination of area closures, effort restrictions, and trip limits has precluded most operators from making long trips to 5Zjm, with the result that USA catches from 5Zjm have been low since 1993. While Area II remained closed in 2000, landings from 5Zjm decreased from 1999 to 187 t in 2000 and discards again were low because the day and trip possession limits remained high.

USA port samples and ageing data from eastern Georges Bank were used to characterise the size and age composition of the USA fishery catch from eastern Georges Bank.

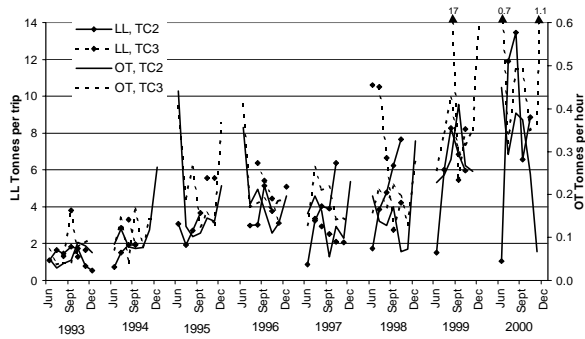
As in 1999, for the **combined Canada/USA fishery catch**, the 1996 year-class (now age 4) dominated the 2000 catch. In comparison to the age composition of the catch during various earlier periods in this century when year-classes were quickly fished down, the older age groups continue to contribute significantly to the 2000 catch. The percentage of age 2 and 3 fish in 2000 was below the historical averages but the contribution from age 2 was higher than it has been in recent years, suggesting a strong 1998 year-class. The low percentage of younger ages in the recent catches has been due in part to the type of gear used and to avoidance of areas with small fish.

### *Environmental Conditions*

Examination of the physical and biological oceanographic conditions on Georges Bank indicates that water temperatures in recent years (1998-2000) have been about 1°C above normal. The temperature conditions that were observed during the 2000 and 2001 Canadian groundfish bottom-trawl surveys are consistent with this pattern. Although the recent temperatures are above normal, they are still within the range normally associated with demersal stages of cod and haddock caught within the Georges Bank and Scotian Shelf areas. The degree of vertical mixing, as indicated by the annual mean difference in water density between 0 and 50m, has been relatively constant for the past 20 years. The shelf/slope front and Gulf Stream was closer to Georges Bank in 2000 than the long-term normals and the concentration of chlorophyll on the Bank was higher in 2000 than in 1999 or 1998. Connections between the oceanographic conditions and the status of assessed fish stocks within 5Z are still elusive and remain under investigation.

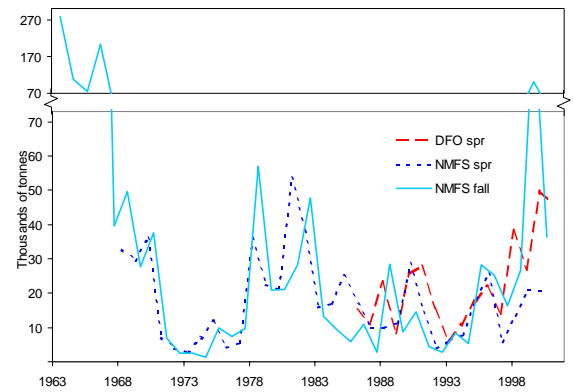
### *Resource Status*

**Catch rates** from the Canadian commercial fishery for selected trips by tonnage classes 2 and 3 otter trawlers and longliners have increased since 1993. Changes to regulations, gear modifications and varying fishing practices in recent years make comparison of catch rates from year to year difficult to interpret. Therefore, these were not used as indices of abundance.



**Surveys** of Georges Bank have been conducted by the USA National Marine Fisheries Service (NMFS) each fall (October) since 1963 and each spring (April) since 1968, and by Canada’s Department of Fisheries and Oceans (DFO) each spring (February) since 1986. The spatial distribution of catches for the most recent survey of each series was similar to the distribution over the previous 5 year period. An abundance of age 1 haddock (2000 year-class) haddock was observed on the southern flank during the DFO survey.

The **indices for ages 3-8 survey biomass** peaked at record highs during the early 1960s. After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Biomass increased from 1992 to 1996, fluctuated somewhat and increased again after 1998. The NMFS fall survey biomass for 1999 appears to have been anomalously high as the 2000 biomass is more in line with previous observations. The two spring surveys both decreased slightly.



**Survey recruitment indices** for ages 0, 1 and 2 indicate that the abundance of the 1998 year-class is the highest since the 1978 year-class. The 1996 and the 1999 year-classes were comparable to the moderate 1983, 1985, 1987 and 1992 year-classes. These year-classes were considerably smaller than the strong 1975 and 1978 year-classes and the very strong 1962 and exceptional 1963 year-classes. The DFO survey in 2001 indicates a strong 2000 year-class in contrast to the age 0 observation from the NMFS fall survey which indicated only moderate abundance.

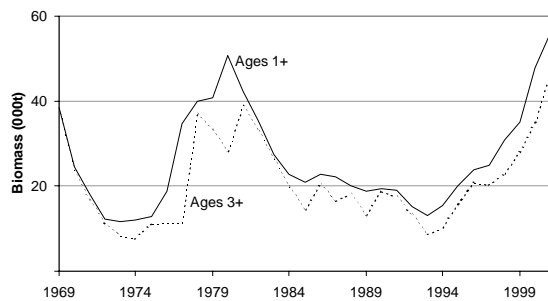
Although fishery weights at age for ages 2 and 3 are higher since 1993/1994, reflecting the change in gear selectivity which occurred, there were no persistent trends in population **weight at age** derived from the DFO surveys.



As in 2000, stock status evaluations were based on a Virtual Population Analysis (VPA) using catch statistics, sampling for size and age composition of the commercial

catch, and trends in abundance from three bottom trawl research surveys.

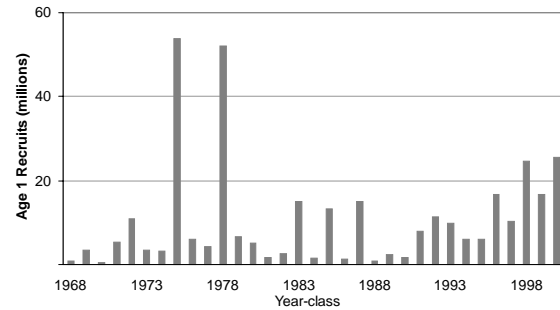
**Population biomass** (ages 1+), estimated by the VPA, has steadily increased from near historic low levels of about 13,000 t in 1993 to about 56,000 t at the beginning of 2001. The recent increase has been due to more consistent and improved recruitment and was enhanced by increased survivorship and by reduced capture of small fish in the fisheries. Since the 1991 year-class, no year-classes have been below 5 million fish. Between the 1978 and 1991 year-classes, 7 of the 14 year-classes were below 5 million fish. The biomass increase is expected to be sustained by the 2000 year-class which appears at least as good as the 1998. The adult biomass (ages 3+) trend is similar to the ages 1+ trend, with a 25% increase from 2000 to 2001, due largely to recruitment of the 1998 year-class.



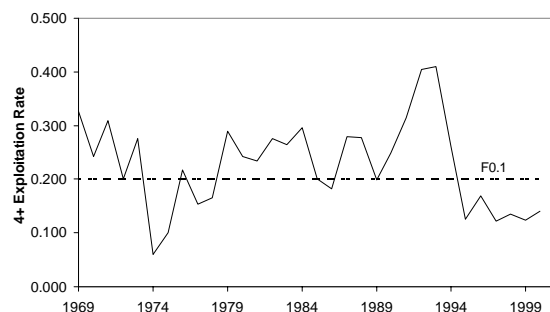
Population biomass during the late 1970s and early 1980s was about 50,000 t, due to recruitment of the strong 1975 and 1978 year-classes whose abundance was estimated at about 50 million. However, biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two year-classes were fished intensely at a young age.

**Recruitment**, estimated by the VPA, indicate the strength of the 1996 and 1999 year-classes to be about 17 million at age 1, comparable to the 1983, 1985 and 1987 year-classes, which were the strongest 3

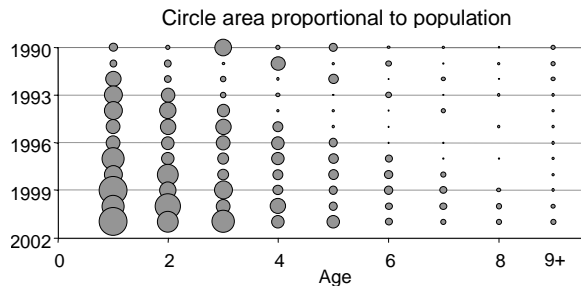
year-classes over about a 20 year time span. Preliminary indications for the 2000 year-class indicate it is about equal to the 1998 year-class which is estimated to be relatively strong at about 25 million, making them the strongest since the 1978 year-class.



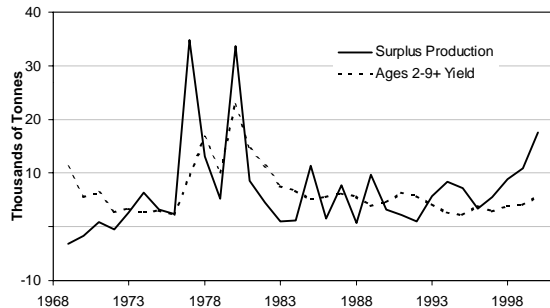
**Exploitation rate** for fully recruited ages 4+ has consistently been below that corresponding to  $F_{0.1}$  (20%) since 1995. Historically, exploitation rate has generally exceeded that corresponding to  $F_{0.1}$  and showed a marked increase between 1989 and 1993 to about 40%, the highest observed. Reduced fishing mortality in recent years has resulted in increased survival of incoming year-classes. The number of haddock of the 1992 year-class surviving to age 8 was over four times that of the equally abundant 1983 year-class, and about the same as that of the 1975 or 1978 year-classes which were more than 3 times as abundant. Avoidance of small fish has resulted in the number of fish of the 1998 year-class surviving to age 3 to be almost as many as survived to age 3 of the 1978 year-class which was twice as strong.



In both absolute numbers and percent composition, the **population age structure** displays a broad representation of age groups, reflecting improving recruitment and lower exploitation since 1995.



Since 1993, **surplus production** (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) has exceeded the fishery harvest yield, resulting in net increase. Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year-classes enter.

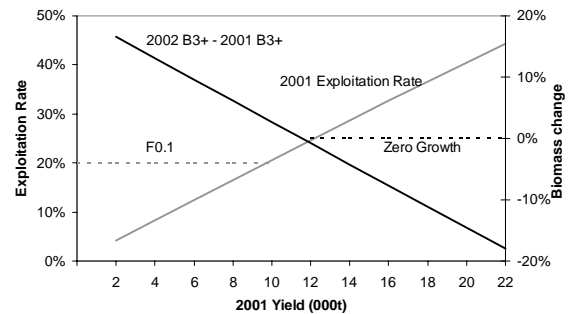


Assessments for several other stocks have identified a discrepancy between past and current estimates of stock status (retrospective pattern). This stock assessment does not suffer from a retrospective pattern.

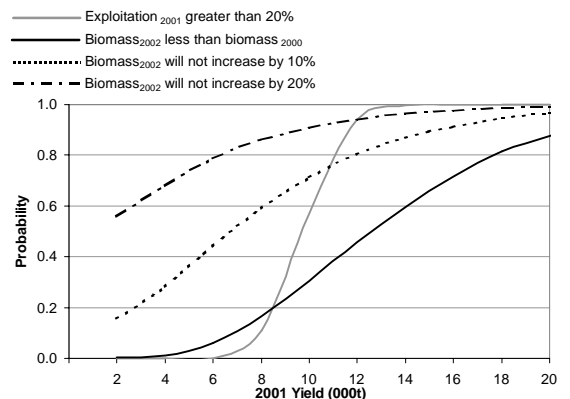
**Outlook**

**Projected total Canada/USA yield** at an exploitation rate corresponding to  $F_{0.1}$  in 2001 would be about 9,700 t. If fished at that rate in 2001, the adult biomass is projected to increase somewhat from

46,500 t to 48,000 t by the beginning of 2002. As in 2000, the 1996 year-class (age 5) is expected to comprise the highest proportion of the total 2001 yield with ages 4 and 3 (1997 and 1998 year-classes) each contributing slightly lower yields and amounting to a combined proportion of 64%. Ages 6, 7 and 8 will contribute equally at 7% each and the 9+ group will contribute slightly more at 11%.



**Uncertainty** about year-class abundance generates uncertainty in forecast results. This uncertainty was expressed as risk of achieving reference levels. For example, a combined Canada/USA catch of 8,000 t in 2001 results in about 11% probability that fishing mortality rate will exceed  $F_{0.1}$  and a low probability that the adult biomass will decrease. At this yield, there is a high probability (60%) of not achieving a 10% biomass increase and a higher probability (86%) of not achieving a 20% biomass increase. A catch corresponding to  $F_{0.1}$  in 2001 results in a probability of about 25% that the adult biomass will decrease.

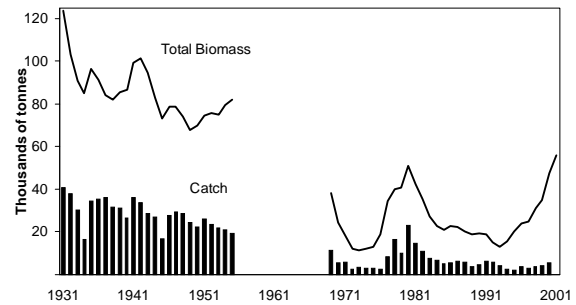


These uncertainties are dependent on the set of model assumptions and data used in the analyses. Though these assumptions were deemed most suitable, there may be other plausible assumptions. These calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect the stock dynamics closely enough. The risk profiles provide a general sense of the associated uncertainties and can assist in assessing the consequences of alternative actions.

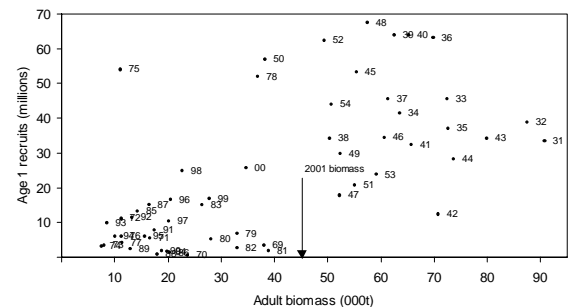
### *Management Considerations*

The Canadian quota of 5,400 t in 2000 was expected to result in a negligible chance of exceeding  $F_{0.1}$  and about an 85% chance of getting 20% growth in the stock. The Canadian catch in 2000 was very near the quota and resulted in an exploitation rate of about 14% and an increase in adult biomass of about 25% from 2000 to 2001.

Data were available to approximate the age composition of the catch from unit areas 5Zj and 5Zm in order to reconstruct an illustrative population analysis for the period between 1930 and 1955 which is suitable for comparing productivity. Total catches during the 1930s to 1950s ranged between 15,000 t and 40,000 t, averaging about 25,000 t. Catches probably attained record high levels of about 60,000 t during the early 1960s. Since the early 1970s, catches have been substantially lower, generally fluctuating between 5,000 t and 10,000 t. Although biomass has been increasing and is the highest it has been in about 30 years, it remains below the average biomass during 1930-55, when productivity was higher.



The pattern of recruitment indicates that the chance of a strong year-class is significantly reduced for adult biomass below about 40,000 t. Since 1969, only the 1975 and 1978 year-classes have been above the average abundance of year-classes observed during the period 1930-55.



Examination of the recruits per spawning biomass ratio suggests that survivorship to age 1, for several years during the 1980s, may have been lower than the norm. The present survivorship appears comparable to that of the 1930s to 1950s period, suggesting that higher recruitment might result if the biomass increases.

Exploitation rate and biomass can be used to compare consequences of alternative harvest yields. The projections above show those results. Other **attributes** like recruitment, age structure and spatial distribution reflect possible fluctuations in the productive potential and can be used to qualify reference points and acceptable risk. While conditions have improved, considering all attributes, further rebuilding is required, therefore some moderation is indicated.

The percent of biomass, ages 3-8, on the Canadian side of 5Zjm from the three surveys was summarised for recent years. During the NMFS fall (Oct.) surveys, almost all of the biomass occurred on the Canadian side. During the DFO spring (Feb.) surveys, most of the biomass was on the Canadian side although the percentage was lower in 1992, 1993 and 2000. During the NMFS spring (April) surveys, the percentage on the Canadian side was typically lower but these results were more variable.

Percentage of Biomass on Canadian Side

Year	DFO.	NMFS	NMFS
	Feb.	Apr.	Oct.
1992	66	78	100
1993	67	42	99
1994	99	100	100
1995	98	59	100
1996	95	17	100
1997	90	91	100
1998	100	68	100
1999	98	41	100
2000	78	41	100
2001	96	N/A	N/A

Cod and haddock are often caught together in Canadian groundfish fisheries. However, their **catchabilities** to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices, exploitation of haddock at  $F_{0.1}$  may compromise the achievement of rebuilding objectives for cod.

### *For more Information*

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