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Stock Discrimination of Summer Flounder (*Paralichthys dentatus*) in the Middle and South Atlantic Bights: Results of a Workshop

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts

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BIBLIOGRAPHIC INFORMATION

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The summer flounder, Paralichthys dentatus, is among the most sought after and valuable commercial and recreational species found in the Northwest Atlantic. Total United States commercial landings of summer flounder in 1981 were 10,800 metric tons (mt) with an estimated total ex-vessel value of approximately 17 million dollars. (U.S. Department of Commerce, 1982). Considerable attention has been devoted in recent years to determining the population structure of summer flounder in the Middle and South Atlantic Bights. The report describes these.

KEYWORDS: *Flatfishes, *Midatlantic Bight, *South Atlantic Bight, *Meetings, *Paralichthys dentatus.

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Stock Discrimination of Summer Flounder (*Paralichthys dentatus*) in the Middle and South Atlantic Bights: Results of a Workshop

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INTRODUCTION

The summer flounder, <u>Paralichthys dentatus</u>, is among the most sought after and valuable commercial and recreational species found in the Northwest Atlantic. Total United States commercial landings of summer flounder in 1981 were 10,800 metric tons (mt) with an estimated total ex-vessel value of approximately 17 million dollars (U.S. Department of Commerce, 1982). Estimated 1979 recreational landings were 8,626 mt with an additional 2.13 x 10^6 summer flounder captured and released by sport fishermen (U.S. Department of Commerce, 1980). A Fishery Management Plan has been developed for this species by the State-Federal Summer Flounder Scientific and Statistical Committee, approved by the Atlantic States Marine Fisheries Commission, and is currently being evaluated by the Mid-Atlantic Fishery Management Council.

Considerable attention has been devoted in recent years to determining the population structure of summer flounder in the Middle and South Atlantic Bights. Wilk et al. (1980) concluded that summer flounder north and south of Cape Hatteras, North Carolina comprise distinct populations on the basis of stepwise linear discriminant analysis of morphometric and meristic variables. Summer flounder collected throughout the Middle Atlantic Bight were statistically similar, as were fish sampled in the South Atlantic Bight. Population intermixing was most prevelant off North Carolina. Smith and Daiber (1977) analyzed summer flounder meristic data available from Delaware and Chesapeake Bays and off Beaufort, North Carolina; although no conclusive evidence of significant differences between Delaware Bay and Chesapeake Bay samples was found, anal fin ray and gill raker counts differed significantly between these locations and North Carolina samples. Ginsburg (1952) had earlier suggested that meristic characters differed between summer flounder collected in Chesapeake Bay and off Beaufort, North Carolina.

Smith (1973) suggested that two distinct spawning populations of summer flounder may occur in the Middle Atlantic Bight on the basis of egg and larval distribution patterns and that a third spawning group may exist in the South Atlantic Bight.

In an attempt to provide further insight into stock structure in the vicinity of Cape Hatteras, the State-Federal Summer Flounder Scientific and Statistical Committee initiated an analysis of morphometric and meristic data for summer flounder collected: 1) off New York-New Jersey (NY/NJ), 2) immediately north of Cape Hatteras (NNC), and 3) immediately south of Cape Hatteras (SNC) (Figure 1). Data collection and preliminary analyses were undertaken in a workshop sponsored by the National Marine Fisheries Service (NMFS) and held at the Northeast Fisheries Center's Sandy Hook Laboratory during September 22-26, 1980.

MATERIALS AND METHODS

Summer flounder were collected from coastal locations in New York, New Jersey, and North Carolina (Figure 1) by members of the State-Federal Scientific and Statistical Committee in late summer-fall (Table 1). Specimens were obtained specifically for this analysis and were immediately frozen and stored prior to the workshop. A total of 18 morphometric and meristic characters were measured or counted from each specimen (Table 2). Total length and body depth were measured to the nearest millimeter; remaining measurements were made to the nearest 0.5 mm using dividers and a metric ruler.

Measurements and counts were taken by four teams, each comprised of two individuals. An attempt was made to standardize measuring techniques carefully prior to data collection. To reduce potential measurement bias further, specimens from each geographical group were randomly assigned among teams, i.e., teams worked simultaneously on specimens from each location.

Initial analyses indicated no significant sex-related differences in morphometrics or meristics (ANOVA; $p > 0.05$), accordingly, data were combined by sex. To standardize for differences in length composition among samples, variables were expressed as the ratio of each morphometric character to total length. Ratios for each variable within each area were regressed on total length and the resulting regression lines tested for zero slope (t-test; $p < 0.05$). Prior to analysis, each proportion was treated with an arcsine square-root transform (Sokal and Rohlf, 1969). Regressions for four variables exhibited slopes which differed significantly from zero for two or more groups and these variables were not used in subsequent analyses. For all remaining variables, it was assumed that growth was allometric within the size ranges available for analysis. Residuals from remaining regression equations were examined for possible bias with no evidence of nonlinear trends noted.

Stepwise linear discriminant analysis was employed to differentiate among fish collected in the three areas using Biomedical Computer Program BMD07M (Dixon, 1971). The five variables which contributed most significantly to the three-group discriminant analysis were subsequently used in a two-group linear discriminant analysis (BMD04M) to compare summer flounder collected off New York-New Jersey with those obtained south of Cape Hatteras.

RESULTS

Samples collected off New York-New Jersey were clearly differentiated from those obtained south of Cape Hatteras using the three-group stepwise linear discriminant analysis (Figure 2). Samples collected immediately north of Cape Hatteras could not be reliably classified as a discrete group;

however, the number of specimens available for analysis was small.The classification matrix of observed and predicted group membership was:

	Predicted		
Observed	NY/NJ	SNC	NNC
NY/NJ	113	23	35
SNC	16	92	15
NNC	8	11	20

The relatively high level of misclassification for the northern North Carolina samples (NNC) may be indicative of intermixture of northern and southern groups.

The five variables chosen for construction of the two-group discriminant analysis were: 1) ventral eye width, 2) body depth, 3) posterior margin of dorsal eye, 4) standard length, and 5) dorsal eye width. These five morphometric variables provided a significant ($F = 39.94$; d.f. = 5.288; $p < 0.01$) discriminant function (Table 3). No meristic variables were chosen as discriminators for this analysis. Discriminant scores were -0.0252 and -0.0349 for the New York-New Jersey and south of Cape Hatteras groups, respectively. Individuals with discriminant scores greater than -0.0301 were assigned to the northern group and those with scores less than this value were classified as southern fish. The Mahalanobis (1936) distance measure (D^2) derived from the two-group discriminant analysis was 2.830, implying a probability of correct classification of approximately 80% by the method of Rao (1952).

DISCUSSION

Results of this analysis support the findings of Wilk et al. (1980) that summer flounder north and south of Cape Hatteras are statistically separable on the basis of morphometric characters. In the vicinity of Cape Hatteras, apparent intermixing of northern and southern contingents occurs. Summer flounder collected immediately north of Cape Hatteras could not be reliably identified as a discrete group; however, the number of specimens available for analysis was small, possibly obscuring differences among groups. Wilk et al. (1980) reported, however, that summer flounder obtained north of Cape Hatteras were aligned more closely with Middle Atlantic Bight samples than those collected in the South Atlantic Bight. Intermixture of northern and southern groups in the North Carolina areas was evident in this analysis. A recent tagging study conducted off North Carolina (J. Gilliken[1], pers. comm.) indicated a northerly trend in movements during spring and summer, i.e., fish released off North Carolina during winter were primiarly recaptured in Chesapeake Bay in summer.

Phenotypic plasticity due to environmental effects cannot be discounted and no attempt to ascribe genotypic differences for these morphometric characters is made. Despite an attempt to standardize measurements to account for possible differences in size composition among the samples, it is possible that size-related effects were not completely eliminated, contributing to the observed differences among areas.

The probability of correct classification based on the discriminant function derived in the present study was lower than that obtained by Wilk et al. (1980), possibly due to smaller sample sizes. Despite attempts to standardize measuring techniques carefully, additional variability may have resulted from the use of several measurers.

Results of this study support the findings of Ginsburg (1952), Smith and Daiber (1977), and Wilk et al. (1980) in identifying meristic and morphometric differences in summer flounder in the Middle and South Atlantic Bights.

Wilk et al. (1980) suggested that Cape Hatteras forms a zoogeographical barrier resulting in reproductive isolation of summer flounder.

We were unable to examine adequately the hypothesis of multiple stocks in the Middle Atlantic Bight. Smith (1973) identified concentrations of summer flounder eggs off Long Island, Delaware-Virginia, and North Carolina. However, distribution of summer flounder eggs and larvae was essentially continuous throughout the Middle Atlantic Bight and apparent concentrations may have been due to sampling variability.

A recent tagging study conducted off North Carolina revealed interesting differences in movement patterns relative to previous summer flounder mark-recapture experiments. No evidence of an offshore autumn migration was obtained in the North Carolina experiment, while studies conducted off New York (Poole, 1962), New Jersey (Murawski, 1970), and Southern New England (Lux and Nichy, 1980) have consistently demonstrated an offshore movement to the outer continental shelf during fall and a subsequent return to coastal locations in spring. It should be noted that the number of recaptures in the North Carolina study was low relative to previous summer flounder mark-recapture experiments, possibly due to tag induced mortality (J. Gilliken[1], pers. comm.). It is probable that summer flounder in the southern segment of the range undertake less extensive migrations due to the relative proximity of the continental shelf break and the less drastic temperature extremes characteristic of more southerly latitudes.

Further work on summer flounder stock identification in the Middle Atlantic Bight is clearly indicated to resolve current uncertainties. Further comparisons of meristic and morphometric characters collected throughout the Middle Atlantic Bight should be made and coupled with concurrent electrophoretic and/or tagging experiments.

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FOOTNOTE

[1]John W. Gilliken, Jr., North Carolina Division of Marine Fisheries, Morehead City, North Carolina 28557.

Table 1. Sample locations and number of specimens used in analysis of summer flounder, *Paralichthys dentatus*, morphometric and meristic data.

Area	Sample size
New York	89
New Jersey	82
North Carolina (South of Cape Hatteras)	123
North Carolina (North of Cape Hatteras)	39

Table 2. Description of morphometric and meristic variables used in linear discriminant analysis of summer flounder, *Paralichthys dentatus*.

Variable	Description
Standard length	
Body depth	Distance between base of dorsal to base of ventral fin at deepest part of body.
Maxillary union	Distance from anterior tip of snout to posterior margin of maxillary union.
Maxillary	Distance from anterior tip of snout to posterior margin of maxillary.
Preoperculum	Distance from anterior tip of snout to most distant point of preopercular membrane.
Head length	Distance from anterior tip of snout to most distant point of opercular membrane.
Dorsal snout length Ventral snout length	Distance from anterior tip of snout to anterior margin of orbit.
Posterior margin dorsal eye Posterior margin ventral eye	Distance from anterior tip of snout to posterior margin of orbit.
Interorbital width	Minimum distance between dorsal and ventral eye orbits.
Dorsal eye length Ventral eye length	Distance between anterior and posterior margins of eye.
Dorsal eye width Ventral eye width	Distance between dorsal and ventral margins of eye.
Preanal length	Distance between measuring board end plate to anterior margin of anus.
Upper gill rakers	Number of epibranchial gill rakers.
Lower gill rakers	Number of ceratobranchial gill rakers.

Table 3. Variables used in two-group linear discriminant analysis separating summer flounder, *Paralichthys dentatus*, collected off New York-New Jersey (NY/NJ) and south of Cape Hatteras (SNC) including resulting discriminant coefficients.

Variable	Discriminant coefficient
Ventral eye width	-0.29458
Body depth	0.18112
Posterior margin of dorsal eye	-0.17239
Standard length	-0.00121
Dorsal eye width	-0.26484

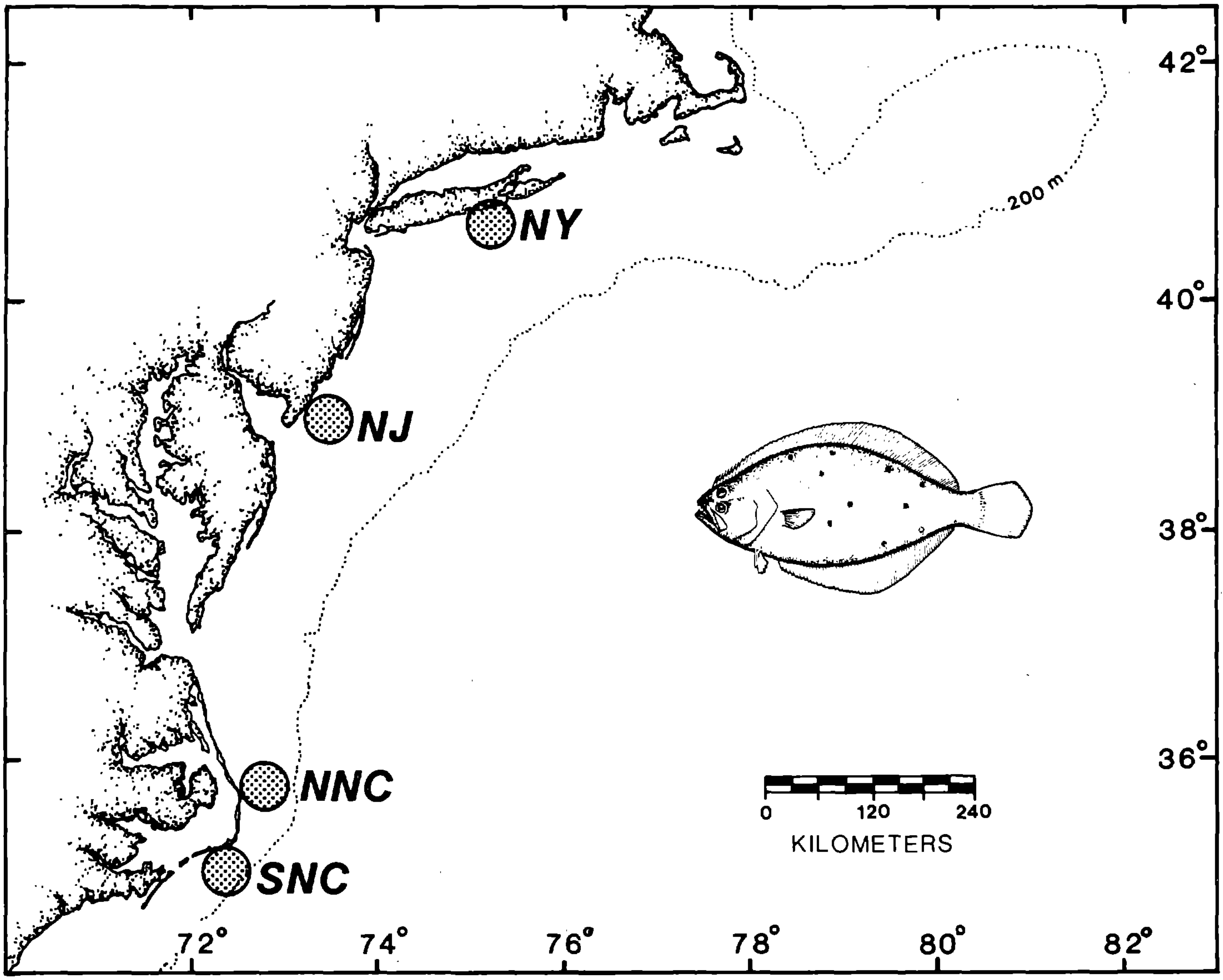

Figure 1. Location of sample collection sites for summer flounder, *Paralichthys dentatus*, stock discrimination analyses (NY = New York, NJ = New Jersey, NNC = northern North Carolina, and SNC = southern North Carolina).

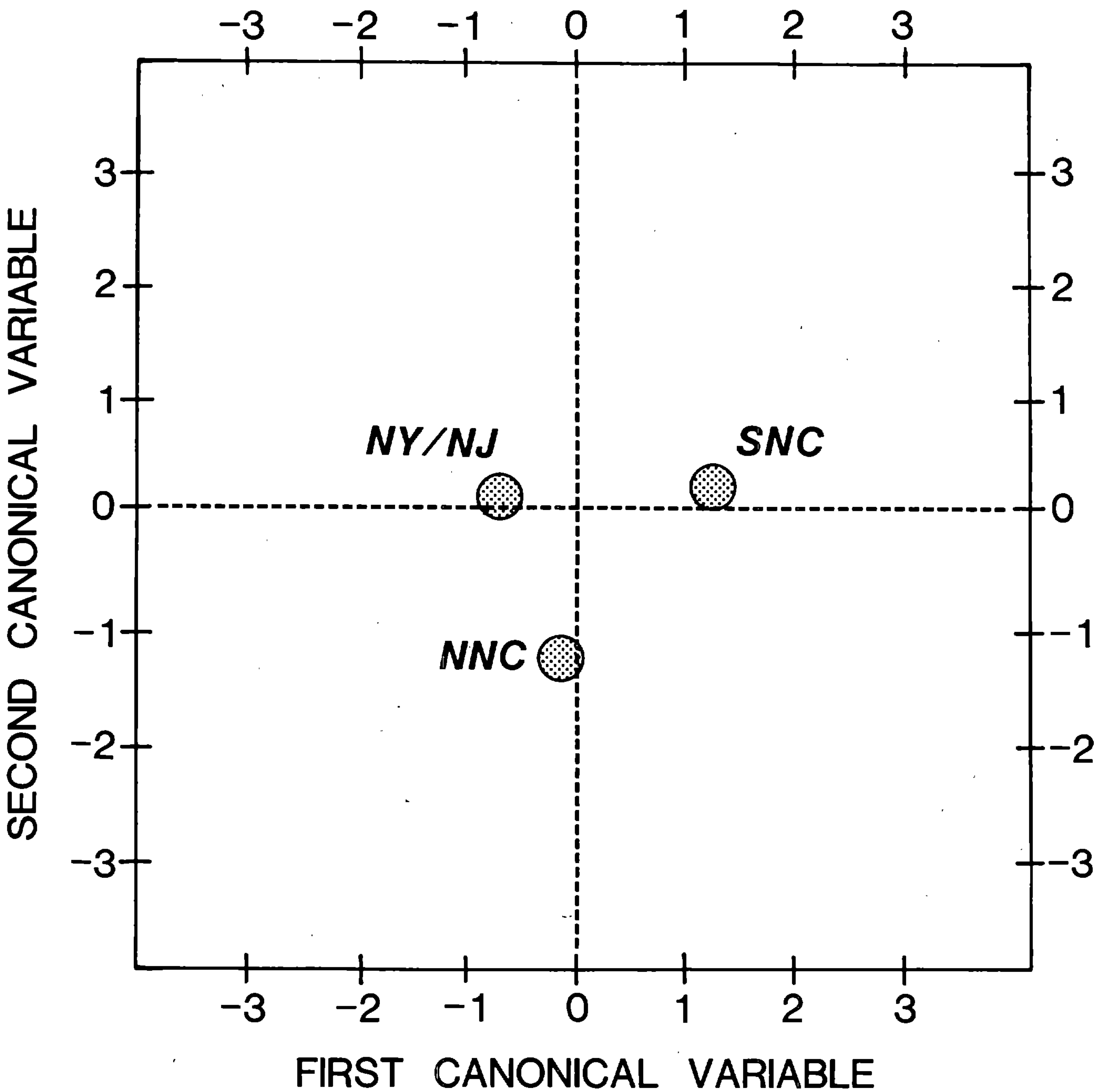

Figure 2. Canonical variable plot of summer flounder, Paralichthys dentatus, group centroids for New York-New Jersey (NY/NJ), northern North Carolina (NNC), and southern North Carolina (SNC) based on stepwise linear discriminant analysis.

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8. *Phytoplankton Community Structure in Northeastern Coastal Waters of the United States. I. October 1978.* By Harold G. Marshall and Myra S. Cohn. August 1981. Revised and reprinted October 1981. v + 14 p., 4 figs., 1 app.

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10. *Annual NEMP Report on the Health of the Northeast Coastal Waters of the United States, 1980.* Northeast Monitoring Program Report No. NEMP IV 81 A-H 0043. August 1981. Revised and reprinted January 1982. xxi + 79 p., 23 figs., 4 tables, 5 app.

11. *Proceedings of the Summer Flounder (Paralichthys dentatus) Age and Growth Workshop, 20-21 May 1980, Northeast Fisheries Center, Woods Hole, Massachusetts.* By Ronal W. Smith, Louise M. Dery, Paul G. Scarlett, and Ambrose Jearld, Jr. December 1981. iv + 14 p., 10 figs., 6 tables.

12. *Status of the Fishery Resources Off the Northeastern United States for 1981.* By Resource Assessment Division, Northeast Fisheries Center. January 1982. iii + 114 p., 44 figs., 44 tables.

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