



MONASH University
Accident Research Centre

**EVALUATION OF THE
BICYCLE HELMET WEARING LAW
IN VICTORIA DURING
ITS FIRST 12 MONTHS**

by

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Abstract:

From 1 July 1990, cyclists in Victoria were required by law to wear an approved helmet whilst cycling. Wearing rates for bicyclists in Victoria had risen from 5% in 1982/83 to 31% in 1989/90, and then rose to 75% in 1990/91 following introduction of the helmet wearing law. Surveys conducted in 1990 and 1991 revealed a 36% decrease in cycling by children between the two years, but a comparison of the 1991 survey results for adults with a similar survey in 1987/88 showed that adult bicycle use had increased by 58%. Analysis of bicyclist injury data showed a large reduction (37-51%) in the number of bicyclists killed or admitted to hospital with head injuries during the first 12 months of the law (1990/91). There were, however, also substantial (21-24%) reductions in the number of severely injured bicyclists who did not sustain head injury. Nevertheless, the percentage of severely injured bicyclists who suffered a head injury during the post-law period was significantly below that which would have been expected had pre-law helmet wearing rates continued unchanged. There is an indication that increased helmet wearing in the post-law period has not been as effective in reducing the risk of head injury to crash-involved cyclists as would have been predicted from relationships observed during pre-law years.

Key Words:

(IRRD except when marked*)
bicycle, crash helmet, cyclist,
evaluation (assessment), injury,
traffic regulations, statistics,
regression analysis, safety,
collision, head.

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EXECUTIVE SUMMARY

Introduction

From 1 July 1990, bicyclists in Victoria were required by law to wear an approved helmet whilst cycling. The intention of the law was to increase helmet wearing rates for all groups of cyclists in the State and to reduce the risk of severe head injury to cyclists involved in crashes. An unintended effect of the law may have been a reduction in cycling, and this was also investigated in this study.

The primary objectives of the study were:

1. To investigate helmet usage since the introduction of the bicycle helmet wearing law,
2. To determine whether bicycle use has decreased following the introduction of the law, and
3. To evaluate the effect of the law on bicyclist head injuries and assess whether there has been a reduction in risk of head injury for cyclists involved in accidents.

Helmet Wearing

Helmet wearing surveys conducted by VIC ROADS, MUARC and Melbourne University students were assimilated and used to estimate trends in overall wearing rates. The average wearing rates for bicyclists in Victoria rose from 5% in 1982/83 to 31% in 1989/90, and then to 75% in 1990/91 following introduction of the helmet wearing law.

Bicycle Use

Surveys conducted by MUARC in 1990 and 1991 revealed a 36% decrease in cycling by children between the two years. Whilst bicycle use decreased by only 15% for the 5-11 year olds, it declined by 44% for the teenage group during the post-law period. A comparison of the 1991 survey results for adults with a similar survey in 1987/88 (while a less direct comparison because of the nearly four year gap and different times of the year) showed that adult bicycle use had increased by 58%. The increase in adult cycling appears to have off-set the decrease in child cycling. Preliminary results from the 1992 survey conducted by MUARC indicate that these trends have been maintained.

Bicyclist Injuries

Analysis of bicyclist injury data showed a large reduction (37-51%) in the number of bicyclists killed or admitted to hospital with head injuries during the first 12 months of the law (1990/91). There were, however, also substantial (21-24%) reductions in the number of severely injured bicyclists who did not sustain head injury.

Nevertheless, the percentage of severely injured bicyclists who suffered a head injury during the post-law period was statistically significantly below that which would have been expected had pre-law helmet wearing rates continued unchanged.

These findings suggest that the reduction in severely injured cyclists with head injury following introduction of the helmet wearing law was achieved by two mechanisms:

- . a reduction in the number of cyclists involved in crashes resulting in severe injury (ie. killed or admitted to hospital), and
- . a reduction in the risk of head injury for cyclists who were severely injured.

Reduction in bicycle use appears to be at least a partial explanation for the reduction in crash involvement, though it is also possible that the wearing of helmets has made cyclists more conspicuous, that the helmets and associated publicity have made cyclists ride more carefully, or that the publicity has made drivers more aware of cyclists.

Reduced Effectiveness of Helmets

Based on the relationship between the percentage of severely injured cyclists who sustained a head injury, and the helmet wearing rates established in the pre-law period, there is an indication that increased helmet wearing in the post-law period has not been as effective in reducing the risk of head injury to crash-involved cyclists as would have been predicted. The reduced effectiveness appeared to apply predominantly to adult cyclists and, to a lesser extent, to those aged 11-17. If true, this could be due to helmets being less securely adjusted or fastened by those cyclists who did not previously wear them (perhaps mainly the teenage group), or possibly to the greater proportion of lighter, foam-only and microshell helmets being worn as a result of the amendment to the Australian Standard for bicycle helmets in 1990 (perhaps mainly affecting the adult group). Further study of these issues is warranted.

Conclusions

The mandatory bicycle helmet wearing law implemented in Victoria on 1 July 1990 has been successful in building on past efforts to promote helmet use by bringing helmet wearing rates to new high levels for all cyclist age groups, both in Melbourne and country Victoria.

The introduction of the law has been accompanied by an immediate large reduction in the number of bicyclists with head injuries. Apparently this has been achieved both through a reduction in the number of cyclists involved in crashes (at least partly through a decrease in bicycle use) and a reduction in the risk of head injury of cyclists involved in crashes.

EVALUATION OF THE BICYCLE HELMET WEARING LAW IN VICTORIA DURING ITS FIRST 12 MONTHS

1. INTRODUCTION

From 1 July 1990, bicyclists in Victoria were required by law to wear an approved helmet whilst cycling. The requirement is specified in the Road Safety Bicycle Helmets Regulations 1990, under the Road Safety Act 1986, and provides exemptions for participants in authorised bicycle races and people who would find it extremely difficult to comply with the requirements, generally because of a medical condition. A general exemption has also been granted to Postal Delivery Officers riding bicycles whilst delivering mail (Leicester et al 1991). In practice, exemptions have been difficult to obtain and it is understood that fewer than 50 have been granted to date.

The background to the introduction of the law and further details of its legislative basis are given by Wood and Milne (1988), Leicester et al (1991) and Vulcan et al (1992).

The intention of the law was to increase helmet wearing rates for all groups of cyclists in the State and to reduce the risk of severe head injury to cyclists involved in crashes.

Because it was felt that an unintended effect of the law has been a possible reduction in cycling, it was decided to conduct an observational survey of bicycle usage in May/June 1991, based on the same methodology used in two previous surveys undertaken by the Monash University Accident Research Centre (MUARC) for VIC ROADS. During November-January 1987/88 a survey of 105 sites in Melbourne during 8am to 6pm on all days of the week had been conducted to study the relative safety of footpath cycling and measurements of cycling exposure were collected (Drummond and Jee 1988). In May/June 1990 a survey of 80 sites selected from the 1987/88 survey was undertaken to examine child traffic behaviour (both as pedestrians and cyclists) in terms of exposure and accident risk (Drummond and Ozanne-Smith 1991). The 1990 survey focussed on child behaviour, however results on bicycle helmet wearing rates were reported for both children and adults. The timing of this observational survey was very relevant as it was conducted about five weeks prior to the introduction of the bicycle helmet wearing law. This survey was repeated in May/June 1991 and May/June 1992 at 64 of the sites used during the 1990 survey, to enable comparisons to be made between bicycle use prior to the law and after the law (Finch et al 1992).

2. OBJECTIVES

There are three primary objectives of the current project evaluating the bicycle helmet wearing law, namely:

1. To investigate helmet usage since the introduction of the bicycle helmet wearing law,

2. To determine whether bicycle use has decreased following the introduction of the law, and
3. To evaluate the effect of the law on bicyclist head injuries and assess whether there has been a reduction in risk of head injury for cyclists involved in accidents.

3. HELMET WEARING

In order to measure progress in helmet wearing due to various educational and promotional activities during the 1980's, VIC ROADS conducted a series of observation surveys at specific types of sites in February/March each year, but made no attempt to sample cyclists in a way which represented the total population of cyclists (Wise 1989, Sullivan and Wise 1990, Morgan et al 1991).

Since 1983 surveys of helmet wearing rates for primary school aged, secondary school aged and adult commuter cyclists have been undertaken in Melbourne. The metropolitan surveys were of adult commuter cyclists on arterial roads near the Central Business District and of primary and secondary school students on the approaches to a sample of schools. Therefore the results of the student surveys could be biased towards higher wearing rates (Heiman 1987) as it is known that some students only wear their helmets when leaving home and on approaching school.

Since 1985 similar surveys were conducted in a selected sample of Victorian country towns and, since 1987, surveys of recreational cyclists were also included in both the Melbourne and country annual surveys. In general, cyclists were considered to be riding for recreational purposes if they were observed in residential streets between 4pm and 6pm on weekdays, or during periods which varied from survey to survey on weekends.

In 1990 VIC ROADS carried out additional special surveys in July and November to measure the immediate effects of the law on helmet wearing rates, however these were of a smaller scale and the number of cyclists observed was significantly less than those normally observed in the annual February/March surveys (inclement weather during the July survey also resulted in a small number of observations).

All three of the MUARC bicycle use surveys also collected data on helmet wearing from a representative sample of bicyclists observed in Melbourne during the period 8am to 6pm. The survey design and data collection are described by Drummond and Jee (1988), Drummond and Ozanne-Smith (1991) and Finch et al (1992).

Helmet wearing surveys were also conducted in Melbourne during March, June, (before the law) August and November 1990 (after the law) by four groups of 5th Year Medicine Students from Melbourne University. Each comprised about 36 hours of observation. In most cases observations made by the two "after" groups of students were at the same locations and times (8am - 9am and 4pm - 5pm) as the two "before" groups.

3.1 Comparison of surveys in Melbourne

Figures 1 and 2 show the helmet wearing rates observed in the VIC ROADS surveys in Melbourne for commuting (including to/from school) and recreational cyclists, respectively. The substantial increase in helmet wearing by all age groups on both types of trip following the introduction of the law can be clearly seen. However the March 1991 survey results represent the situation some eight months after introduction. The special VIC ROADS and Melbourne University surveys allow examination of wearing rates during this intervening period, and the MUARC surveys provide an opportunity to confirm the effects on overall wearing rates measured from a representative sample.

Because VIC ROADS conducted separate surveys for both commuter cycling and recreational cycling, whereas the MUARC and Melbourne University surveys did not distinguish between them, the VIC ROADS survey results for both commuter and recreational cycling in the metropolitan area were combined by calculating weighted averages in order that meaningful comparisons could be made.

The method was based on the proportions of commuter and recreational cycling derived from the 1988 and 1991 MUARC exposure surveys (the proportion in the 1988 survey was applied to each of the pre-law years, whereas the 1991 survey proportion was used to combine the 1991 wearing rates). Cycling by primary and secondary school aged children observed between 8am to 10am (the nearest two hour interval to 7.30am to 9.30am used in the VIC ROADS surveys) and 3pm to 5pm on weekdays (Monday to Friday), and by adults at any time (during the period 8am to 6pm) on the same days, was considered to be "commuter"; cycling observed at any other times or days of the week was considered to be "recreational". From the 1988 survey, it was estimated that 53% of cycling across all age groups was recreational. This agrees exactly with estimates from a telephone survey of bicycle use in Melbourne (and also country Victoria) conducted in 1989, reported in State Bicycle Committee (1991). From the 1991 survey, the proportion of recreational cycling was estimated to have decreased to 39%.

The method was applied to the VIC ROADS wearing rates for each age group and then comparison was made with the corresponding wearing rates measured by the other survey sources (Figures 3-5). Whilst the sample sizes, the methods used and the observation periods all varied amongst the surveys, the patterns of the changes in helmet wearing rates are nevertheless very similar, indicating large increases in wearing rates for all age groups after the introduction of the law.

For both child age groups, the MUARC surveys' wearing rates were in good agreement with the combined VIC ROADS results during 1987-91. The apparent inconsistencies in the adult age group may be explained by the assumption that all adult weekday cycling (during the period 8am to 6pm) is commuter cycling for the purpose of combining commuter and recreational wearing rates. It may also reflect the specific focus of the VIC ROADS adult commuter cycling wearing surveys on cyclists approaching the central business district, who may not be representative of all adult commuter cyclists.

FIGURE 1

Helmet wearing rates for Melbourne commuting cyclists:
1983 - 1991

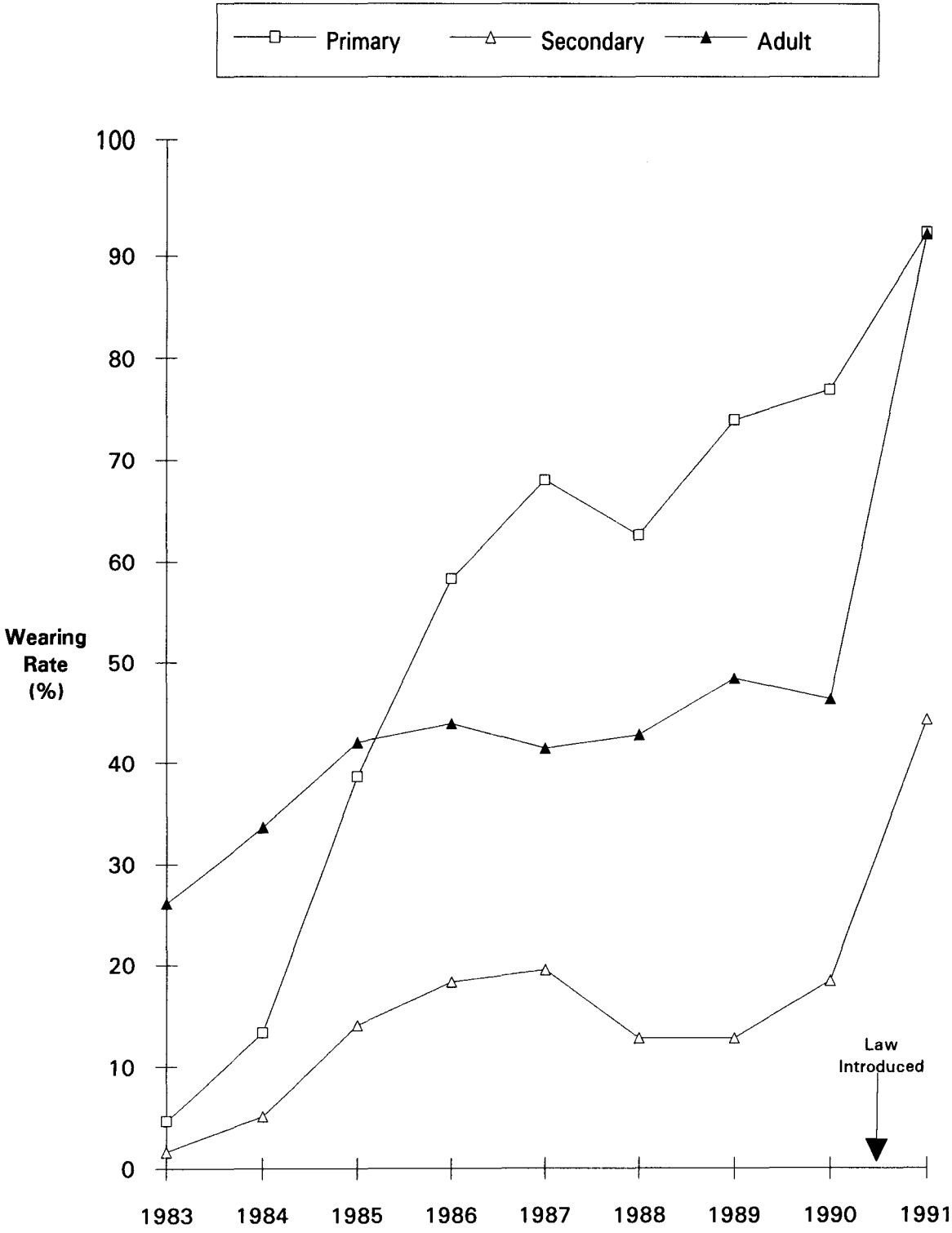


FIGURE 2

Helmet wearing rates for Melbourne recreational cyclists:
1987 - 1991

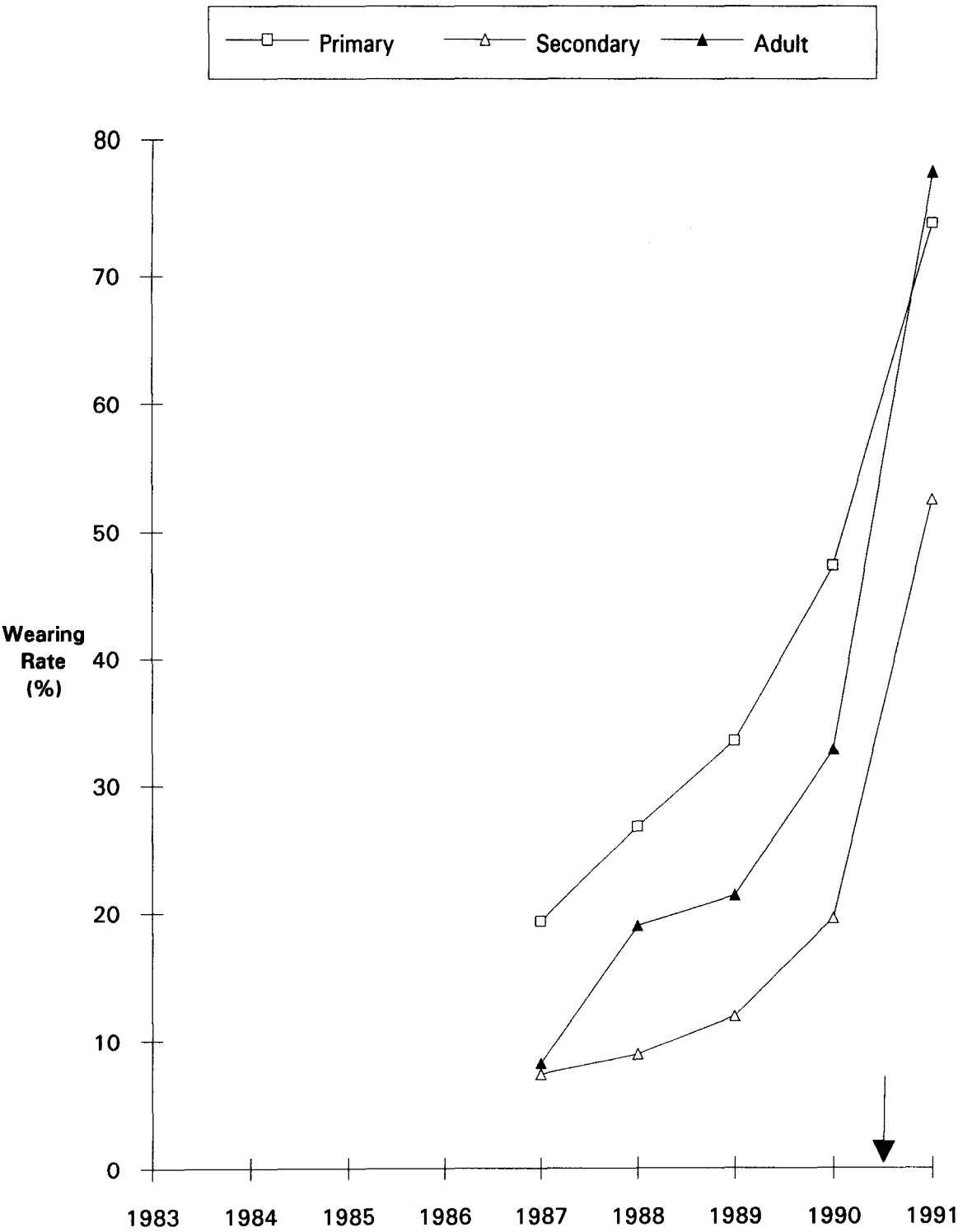


FIGURE 3

HELMET WEARING RATES - 5-11 YEARS OLD
MELBOURNE METROPOLITAN AREA

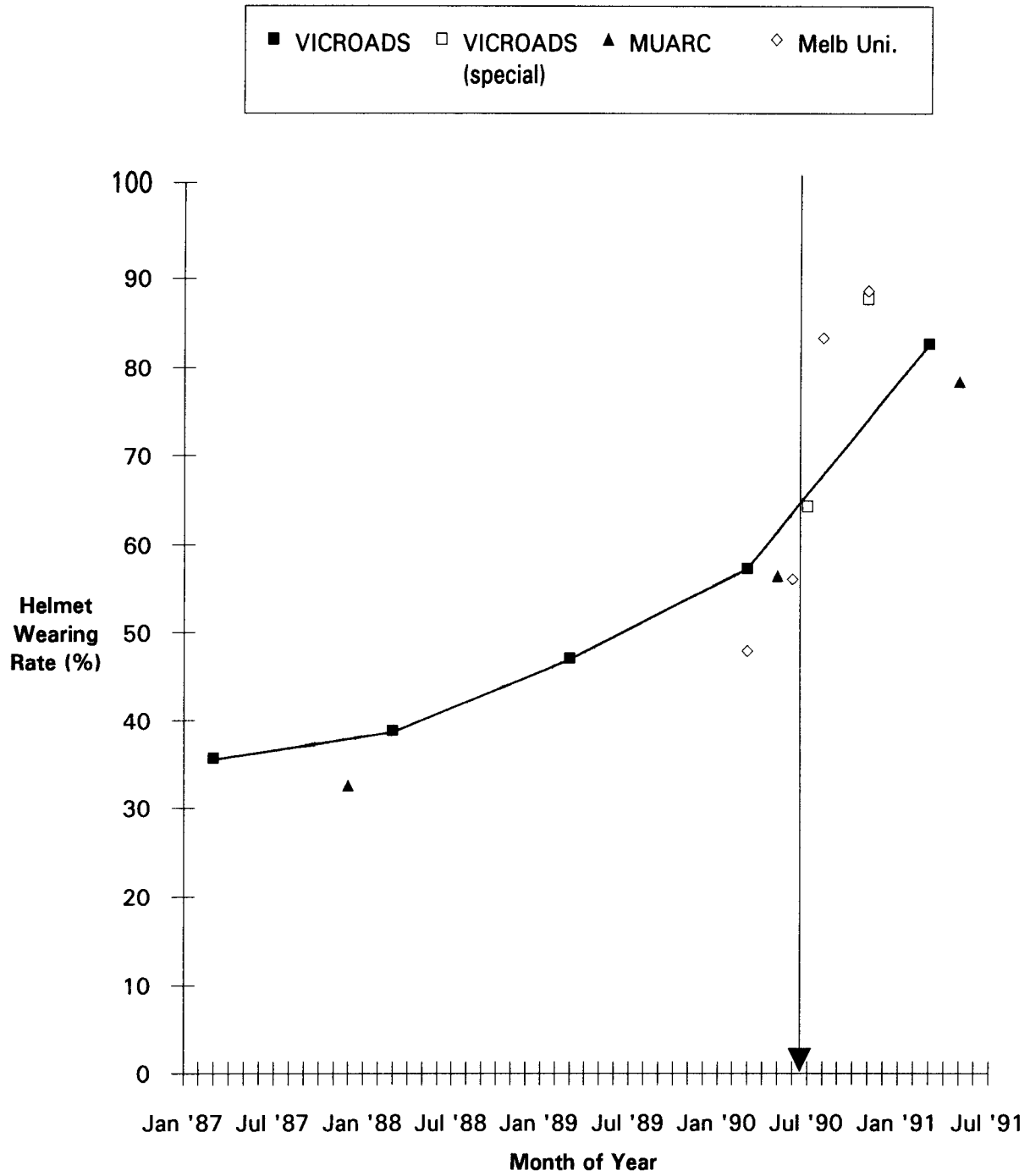


FIGURE 4

HELMET WEARING RATES - 12-17 YEARS OLD
MELBOURNE METROPOLITAN AREA

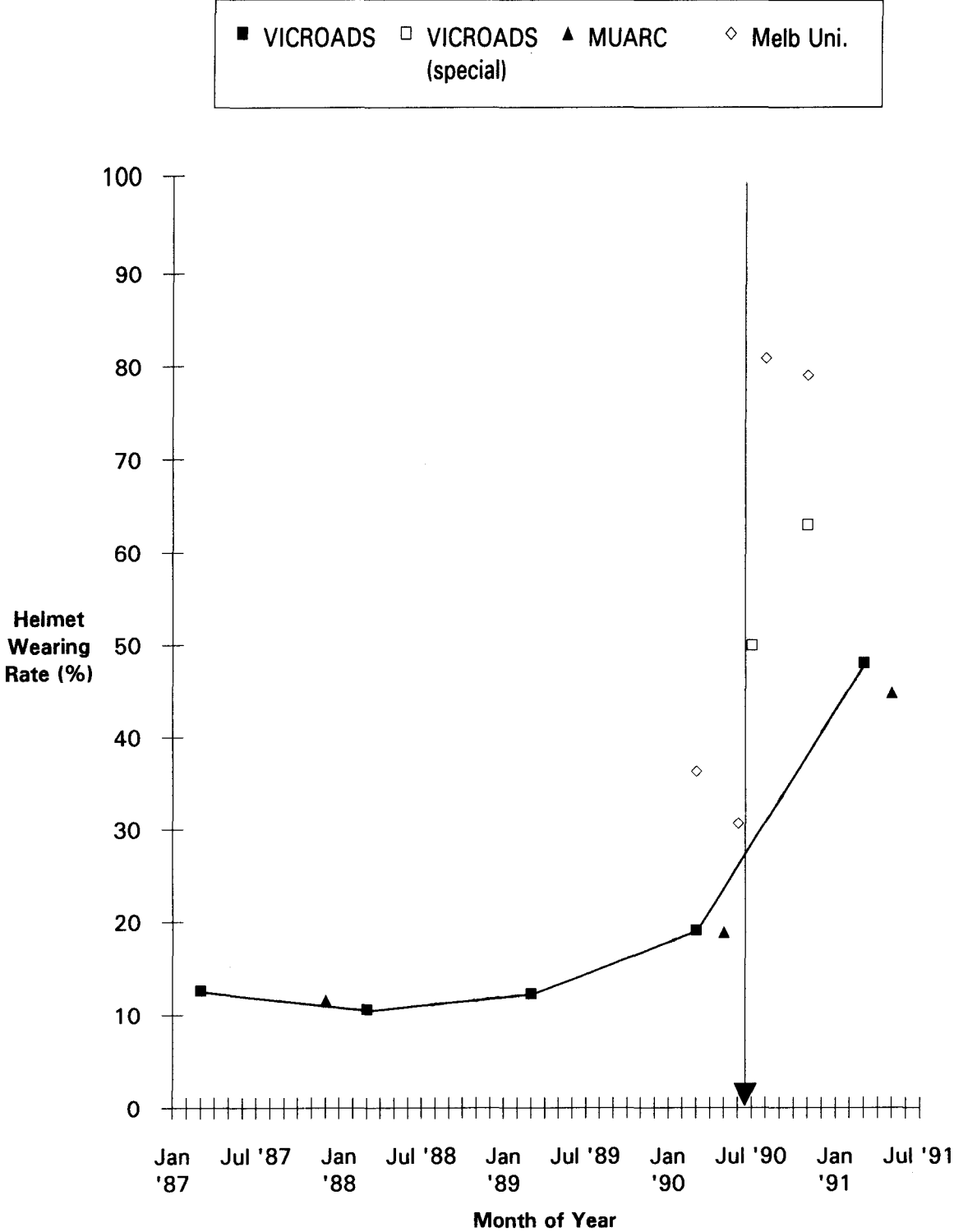
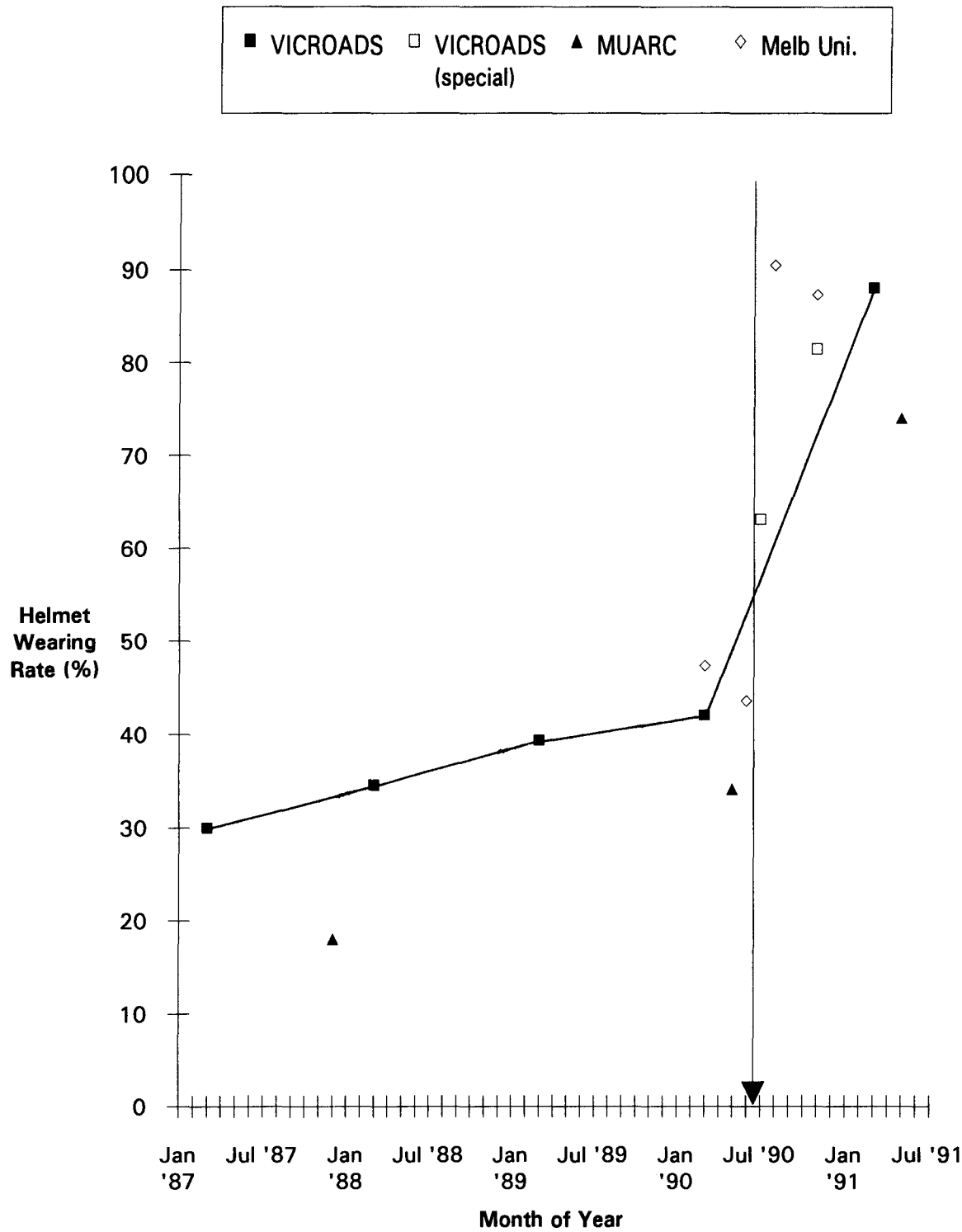


FIGURE 5

HELMET WEARING RATES - 18 YEARS AND OVER
MELBOURNE METROPOLITAN AREA



Nevertheless, there were relatively high wearing rates observed in the VIC ROADS special surveys and the Melbourne University surveys, immediately following the commencement of the law, compared with the combined results from the 1991 standard VIC ROADS surveys and the MUARC survey in the same year. This was apparent in all age groups, and especially for cyclists aged 12-17 years (Figure 4). However each of these surveys sampled fewer cyclists than the annual VIC ROADS surveys.

3.2 Surveys in country Victoria

Neither MUARC nor Melbourne University included country cyclists in their surveys. Figures 6 and 7 highlight the substantial increase in post-law helmet wearing rates across all age groups for country cyclists, as shown by the VIC ROADS surveys in March 1990 and March 1991. The magnitude of these increases is surprising as traditionally the wearing rates for the country cyclists had in general been lower than those of their metropolitan counterparts.

3.3 Estimates of overall wearing rates

Overall wearing rates in Melbourne were estimated by combining the rates in each age group (see Section 3.1) from the VIC ROADS annual surveys according to the age-specific proportions of bicycle use observed in the 1988 and 1991 MUARC surveys. Recreational wearing rates prior to 1987 were estimated from the commuter cyclist rates by assuming that the ratio of the recreational to commuting wearing rates during 1983-86 was the same as that observed during 1987.

Overall helmet wearing rates for cyclists in country Victoria were estimated by combining the VIC ROADS country commuting and recreational rates in the same way as those for Melbourne (ie. using the ratio of commuting to recreational riding in Melbourne as a proxy for country towns - the telephone survey of bicycle use in 1989 reported by State Bicycle Committee (1991) indicated that this was a reasonable assumption). Country rates prior to 1985 were estimated from the Melbourne rates by assuming that the ratio of country to Melbourne rates during 1983 and 1984 was the same as that calculated during 1985.

The estimated wearing rates for Melbourne and country Victoria were combined in the ratio 70:30 to produce overall wearing rate estimates for Victoria from 1983 to 1991. The ratio corresponds to the population distribution of the State during 1986-90 and also to the distribution of bicycle use estimated from the telephone survey in 1989 (State Bicycle Committee 1991). The trends in overall wearing rates in Victoria and the two regions of the State are shown in Figure 8.

Estimated overall wearing rates for bicyclists in Victoria rose from 5% in 1982/83 to 31% in 1989/90, and then to 75% in 1990/91 following introduction of the helmet wearing law.

3.4 Enforcement of helmet wearing

The number of Penalty Notices (ie. Traffic Infringement Notices) issued for a bicycle offence increased from 2836 to 19,229 between 1989/90 and 1990/91 (ie. 1 July to 30

FIGURE 6

**Helmet wearing rates for country commuting cyclists
Victoria : 1985 - 1991**

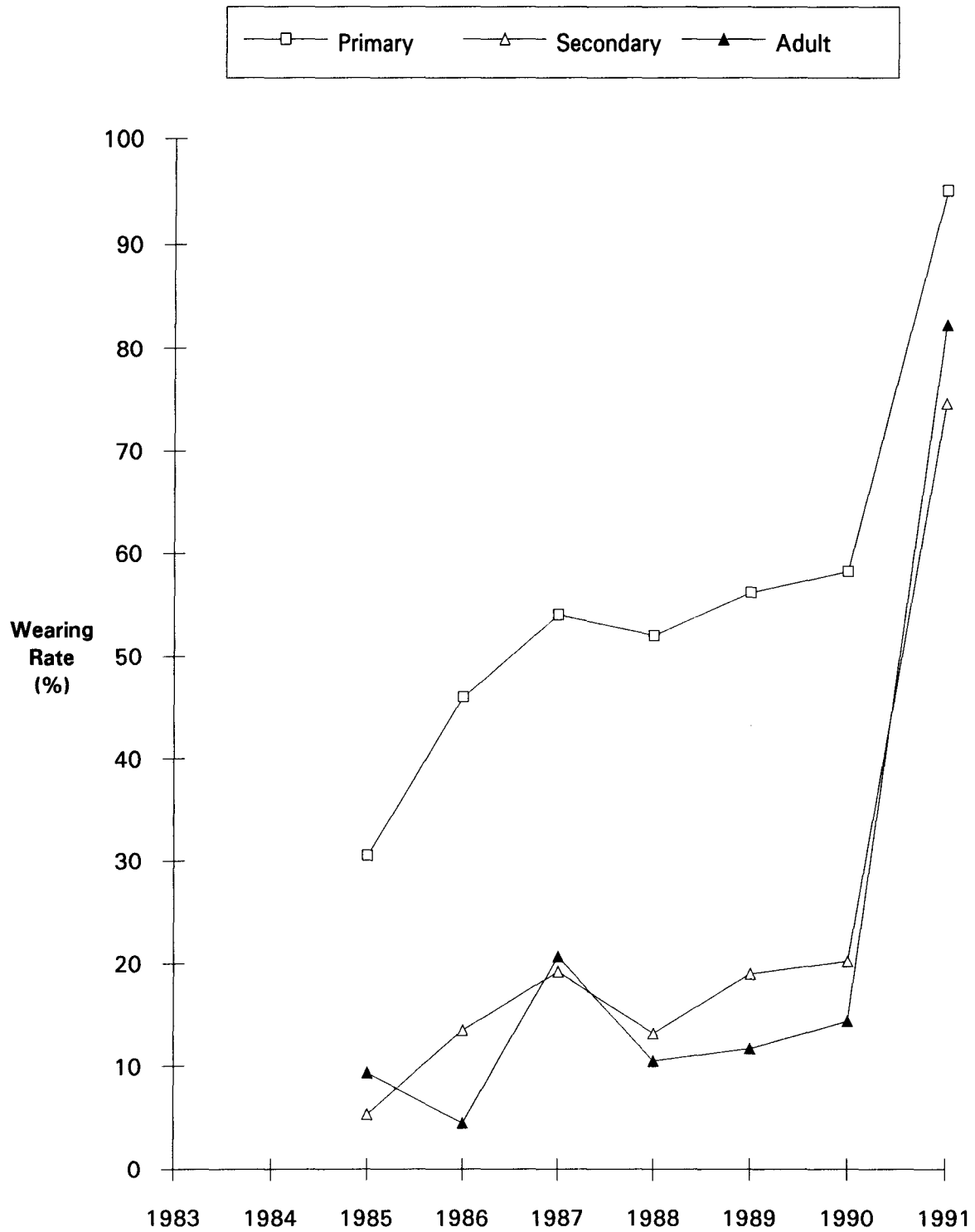


FIGURE 7

**Helmet wearing rates for country recreational cyclists
Victoria : 1987 - 1991**

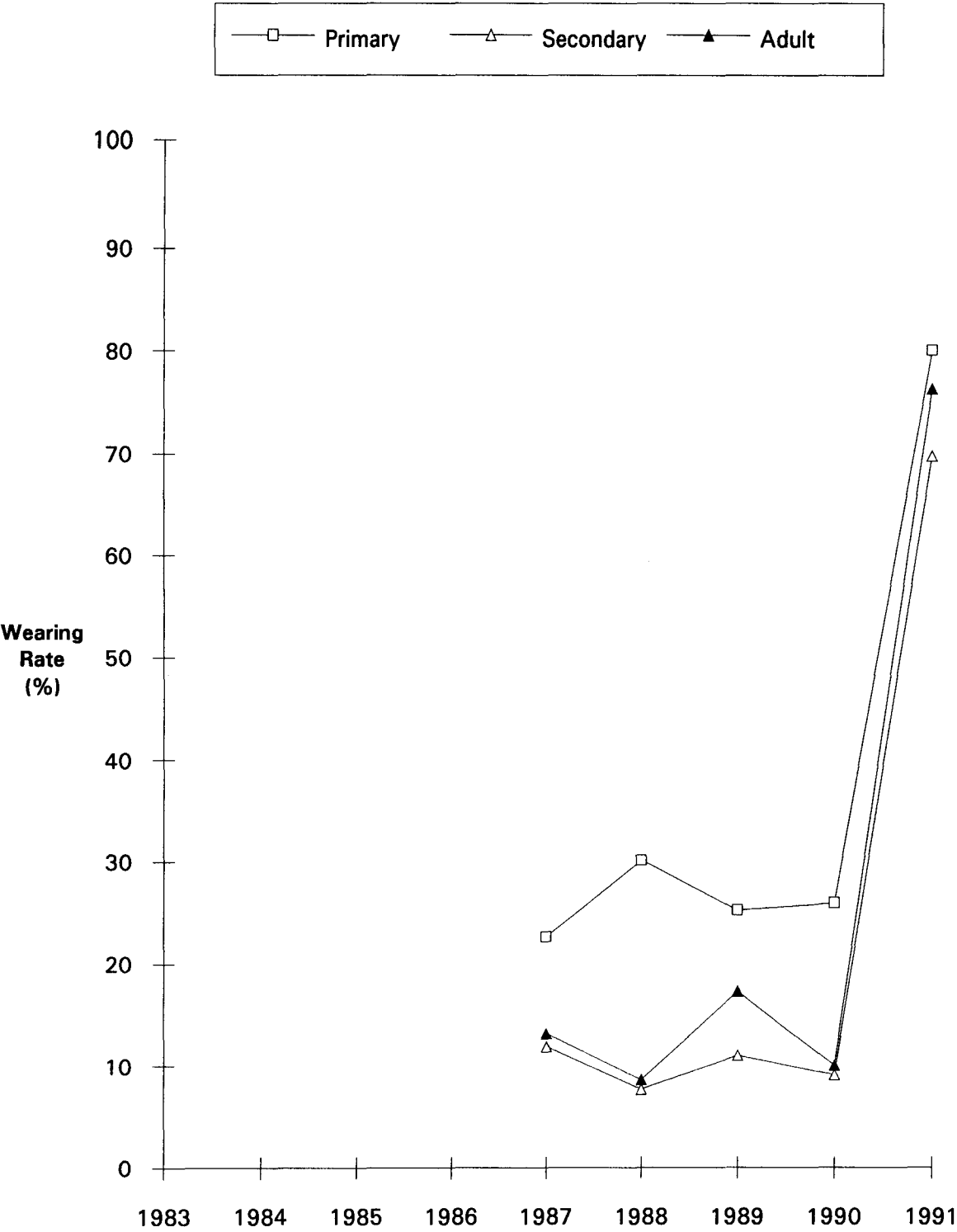
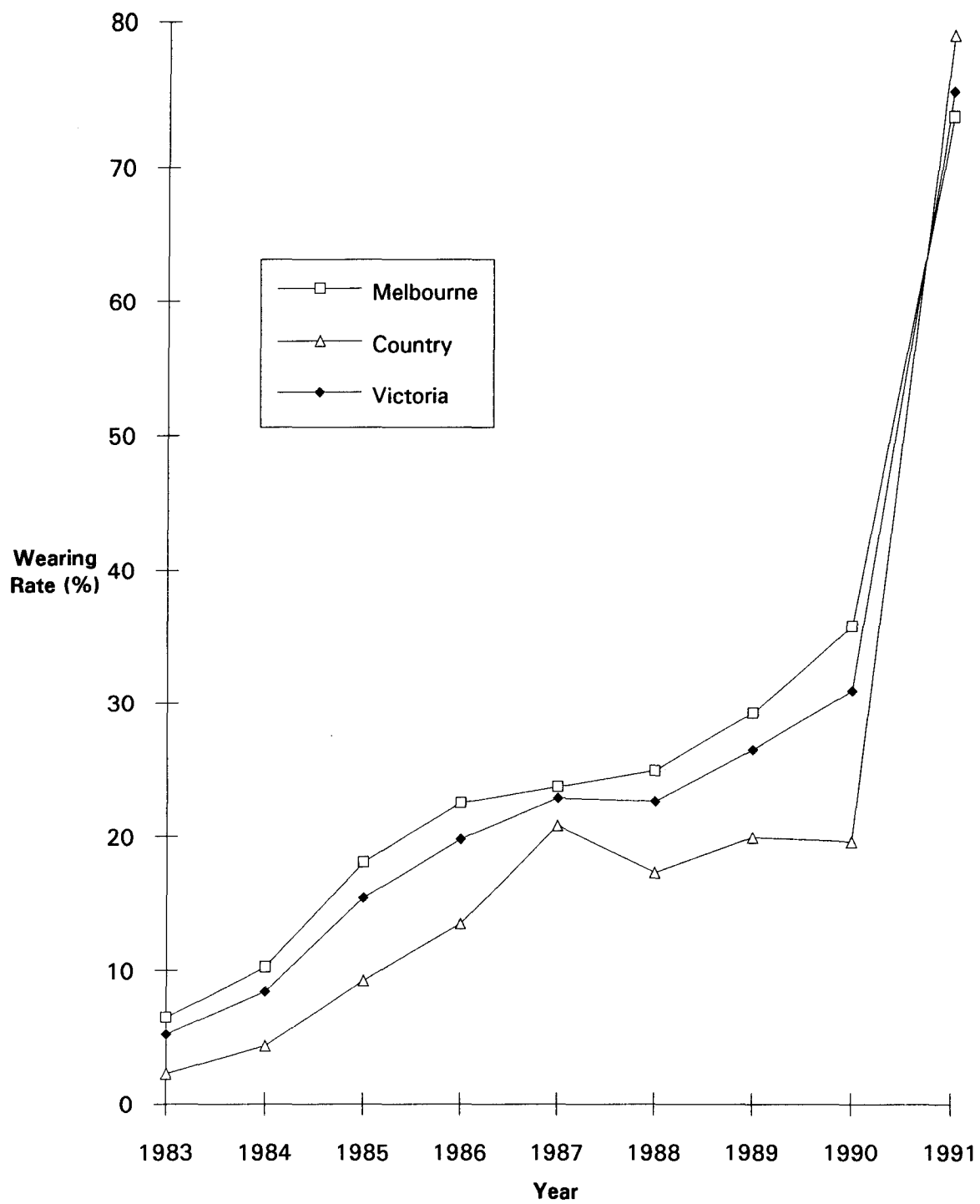


FIGURE 8

Helmet Wearing Rates



June), while Bicycle Offence Reports increased from 1743 to 5028. While it is likely that most of this increase relates to helmet wearing offences, the extent to which other bicycling offences also increased is not known. In the context of a bicyclist population of over 2 million, this could be regarded as a relatively moderate level of enforcement, particularly when compared with a total of more than 925,000 traffic offences detected during 1990/91.

The increases in helmet wearing rates after introduction of the law are remarkable, especially given the level of enforcement. They confirm that if the community understands the benefits of a safety measure and a reasonable proportion have been persuaded to adopt it voluntarily, then considerably increased use can be achieved through a law, even with relatively moderate levels of enforcement.

4. BICYCLE USE

An observational survey of bicycle use in Melbourne was carried out during 1991 in order to determine whether cycling (on roads or footpaths) had decreased following introduction of the helmet wearing law. The results were compared with similar surveys conducted in 1987/88 and also in 1990, just prior to the introduction of the law. A further survey has been carried out during 1992 to establish whether the post-legislation changes observed in the 1991 survey have been maintained (only preliminary results from the 1992 survey were available for this report).

4.1 Survey method

In order to make valid comparisons between the observational data from the 1991 survey and that of the 1990 survey, the same time of year (May/June) and method was used for both. Greater detail of the 1990 survey design is given by Drummond and Ozanne-Smith (1991).

The 1991 survey used 64 randomly selected sites in the Melbourne metropolitan area, which were chosen from the list of 80 sites used in the 1990 survey. Sites were drawn from five regions around Melbourne, representing the total metropolitan area, and cyclists were observed over two weeks in May/June. The results for cycle use from each region were scaled up to the whole region in order to estimate total cycle use (in seconds of cycling) in that region. In this way cycle use in each region could be aggregated to provide an estimate of use in the Melbourne metropolitan area for one week in May/June 1991.

To achieve the scaling up of the bicyclist observations from each randomly selected observation zone to the total population of observation zones, a weighting factor was devised which accounted for the relationship between the length of the observation zone and the total length of the road network (either arterial or non-arterial roads) in the particular region surveyed. The factors also accounted for the relationship between the number of times a particular time block was sampled in a particular region and the total number of those particular time blocks in a week.

Each site was observed over two sessions of five hours each, resulting in a total of 128 sessions representing 640 hours of observation. Sessions were held in the morning from 8am to 1pm and in the afternoon from 1pm to 6pm. Observers were

required to note cycling time and helmet wearing for all cyclists seen passing through the observation zone for each hour of the five hour session. The overall sample size was 2019 cyclists. During the 1990 survey a total of 3709 cyclists were observed (at 80 sites) over a similar two week period.

4.2 Results

Detailed results from the 1991 and 1992 surveys will be included in a separate report (Finch et al 1992) which will also provide a comparative analysis with the 1990 (pre-law) results. The report will measure the changes in bicycle use since the introduction of the legislation and, to assess changes in risky behaviour, cyclists will be categorised according to the factors which relate to cyclist accident risk.

Bicycle use was measured in billions of seconds (ie. 1 billion = 1 thousand million) during weeks outside holiday periods. The use data represents total cycling time in the Melbourne metropolitan area over a one week period in May/June 1990 or in May/June 1991. As bicycle use data for adult cyclists was not collected in 1990, a comparison between the 1987/88 and 1991 results for the adult group was made instead.

4.2.1 Total bicycle use in Melbourne

Total bicycle use for all child cyclists aged 5-18 (ie. excluding adults) decreased by 36%, from 20.5 billion seconds per week in 1990 (Drummond and Ozanne-Smith 1991) to 13.1 billion seconds per week in 1991.

Comparison of the 1987/88 and 1991 surveys allows the change in total bicycle use by all cyclists aged five and above to be seen. Total use did not change over the period, being estimated as 23.7 billion seconds per week in both surveys (the 1987/88 figure is based on a re-analysis of the data analysed by Drummond and Jee (1988), excluding cyclists aged less than five and of unknown age). However, this comparison was made at different times of the year and nearly 3 1/2 years apart, and hence should be considered tenuous.

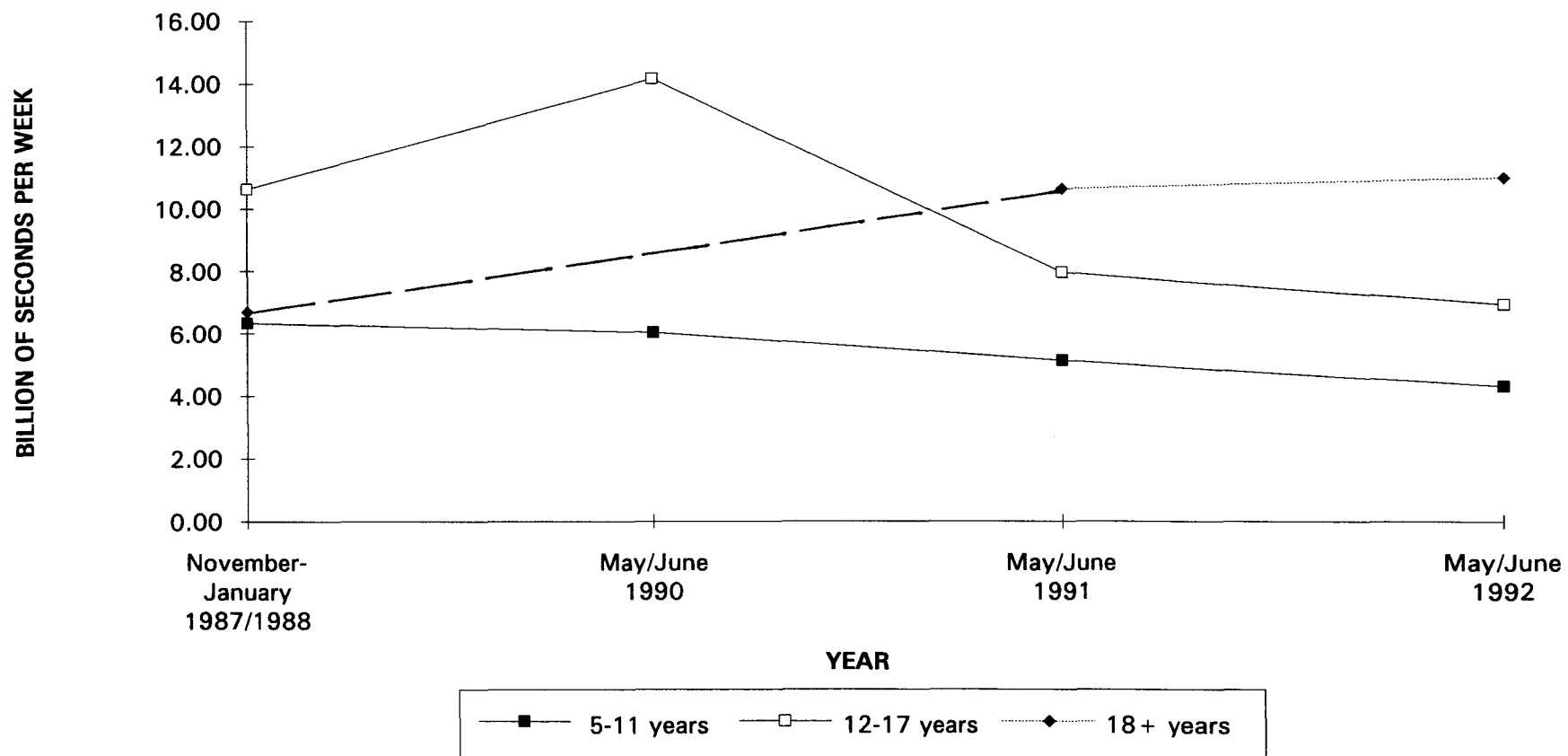
A preliminary analysis of the results from the 1992 survey has indicated that total bicycle use has fallen slightly since 1991. Total use by cyclists aged five and above was estimated as 22.3 billion seconds per week, a decrease of 6%.

4.2.2 Age group

The substantial decrease in child bicycle use between 1990 and 1991 varied by age group of the child. Whilst bicycle use decreased by only 15% for the 5-11 year old group between 1990 and 1991, it decreased by 44% for the teenage group (Figure 9). Both VIC ROADS' and MUARC's helmet wearing surveys have shown that the secondary school aged cyclists have the lowest wearing rates (Figure 4). Some of this group may have been discouraged from cycling by the helmet use law. Preliminary results from the 1992 survey indicate that child bicycle use decreased by a further 14% between 1991 and 1992, but by similar proportions in each age group (Figure 9).

FIGURE 9

ESTIMATED BICYCLE USE IN MELBOURNE BY AGE OF CYCLIST



Total cycling time for the adult group estimated in 1987/88 amounted to 6.7 billion seconds per week (Drummond and Jee 1988), whereas in the 1991 survey the corresponding figure was 10.6 billion seconds per week, an increase of 58%. Preliminary figures from the 1992 survey indicate that adult cycling use continued to increase slightly, by 4%, between 1991 and 1992.

4.2.3 Purpose of trip

The results from the 1987/88 and 1991 surveys allow a comparison of changes in bicycle use by purpose of trip (defined as described in Section 3.1) for each age group (Table 1).

Table 1: Percentage change in bicycle use (seconds of cycling per week) between November-January 1987/88 and May/June 1991, during non-holiday weeks.

Age of Cyclist	Purpose of Trip		
	Commuting	Recreation	Total
5-11	14%	-36%	-19%
12-17	-8%	-39%	-25%
18 & above	75%	28%	59%
Total	29%	-25%	0%

The decrease in bicycle use by child cyclists in 1991 was predominantly in their recreational trips. While adult bicycle use appeared to increase during 1991, there was a smaller increase in bicycle use for recreational purposes compared with commuter trips. Over all age groups, bicycle use in total was essentially unchanged between between 1987/88 and 1991.

Preliminary results from the 1992 survey indicate that the further fall in child bicycle use between 1991 and 1992 was predominantly in their commuter trips, with some increase in bicycle use for recreational purposes among teenage cyclists (Table 2). Adult cyclists appear to have increased their recreational cycling substantially during 1992, but this was off-set by a decrease in commuter trips.

Table 2: Percentage change in bicycle use (seconds of cycling per week) between May/June 1991 and May/June 1992 (prelim.), during non-holiday weeks.

Age of Cyclist	Purpose of Trip		
	Commuting	Recreation	Total
5-11	-35%	1%	-16%
12-17	-42%	22%	-13%
18 & above	-19%	61%	4%
Total	-28%	28%	-6%

5. BICYCLIST INJURIES

The initial effects of the helmet wearing law on bicyclist injuries have been measured by examining data from three sources:

1. Transport Accident Commission (TAC) claims for "no fault" injury compensation from cyclists killed or hospitalised after collision with a motor vehicle in Victoria.
2. Health Department records of acute presentations by bicyclists to Victorian public hospitals resulting in admission, after collisions either involving or not involving a motor vehicle.
3. Victorian Injury Surveillance System (VISS) records of child cyclist (less than 15 years) presentations treated in Emergency Departments of (as well as those admitted to) three Melbourne hospitals, following crashes either involving or not involving a motor vehicle.

5.1 TAC Claims

TAC claims records for killed or hospitalised bicycle accident claimants in Victoria were disaggregated according to injury type, that is, whether the injuries sustained by the claimant included a head injury or did not include a head injury (called "other injury") or were unknown. Head injuries included fractures to the skull, brain injuries and lacerations to the head or scalp.

The data was also disaggregated by the location of the accident producing the injuries, into those sustained in the Melbourne metropolitan area and those in the rest of Victoria ("country Victoria").

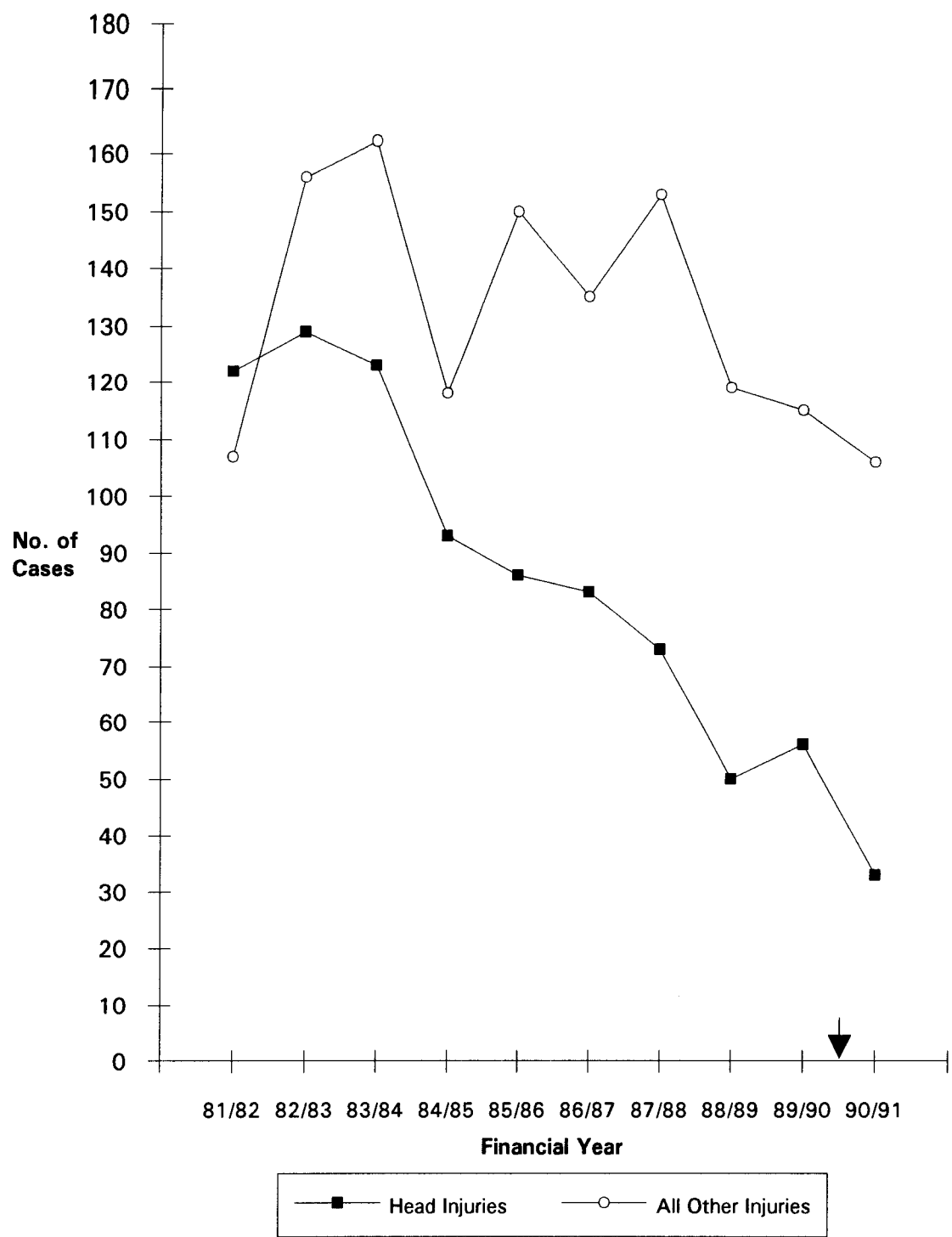
5.1.1 Bicyclist injuries in Melbourne

Figure 10 shows that the number of cyclists killed or admitted to hospital with head injuries in Melbourne fell progressively between July 1981 and June 1990 as the usage of helmets increased. In the 1990/91 financial year following the introduction of the mandatory wearing law (July 1990 to June 1991), the number with head injuries decreased by 41% relative to the corresponding period during 1989/90. This decrease suggests that, other things being unchanged, the substantially increased level of helmet use due to the law has reduced the risk of head injury to cyclists.

The number of Melbourne cyclists sustaining severe injuries other than to the head increased during the early 1980's, then fluctuated about a constant value (Figure 10). However during 1990/91, the number decreased by 8% relative to 1989/90. This decrease was somewhat unexpected, because a reduction in head injuries through helmet use would have led to some cyclists with multiple body region injuries now being classified as "other than head injuries". It suggests that the number of cyclists involved in crashes with motor vehicles has decreased during the post-law period, either due to a reduction in bicycle use or a reduction in the risk of crash involvement. The first of these possible explanations will be examined explicitly later. The second possibility is consistent with the general reduction in all road deaths and hospital admissions in Victoria, which fell by 12% between 1989/90 and 1990/91.

FIGURE 10

**Number of Severe Bicyclist Casualties Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991**



Because of the fall in non-head injuries as well as head injuries, the effect of helmet use for cyclists involved in crashes was addressed by examining the percentage of killed and admitted cyclists who sustained a head injury (Figure 11). It was found that there was a statistically significant correlation (Pearson's $R = 0.87$) between these percentages and the estimated overall helmet wearing rates for Melbourne (see Section 3.3) during the years prior to the law (Figure 12). The relationship also appeared linear, which is the form of the relationship between head injury and helmet wearing which would be expected if the effectiveness of helmets in reducing head injuries is constant, and the cyclists saved from head injury sustain other severe injuries requiring hospital admission.

A linear regression was fitted and used to predict the expected percentage of cyclists with a head injury (assuming that a linear relationship is appropriate) in the case where the helmet wearing rate was 73%, the actual post-law level estimated for all cyclists in Melbourne during 1990/91. The predicted percentage head injured was 9.6%, but the actual percentage (23.7%) was higher and above the upper 95% confidence limit for the prediction. This finding suggested that the percentage head injured had not decreased by as much as would be expected if the helmets had continued to be equally effective as they appeared to be during the pre-law period. However the fitted linear relationship itself must be questioned when extrapolated to high wearing rates, because it suggests that the percentage head injured would fall to zero before helmet wearing rates reach 100% (an alternative relationship is examined in Section 5.1.4).

The linear regression was also used to predict the percentage head injured which would have been expected in 1990/91 in the absence of the law, assuming that the 1989/90 wearing rate had continued unchanged (Figure 11). In addition, 95% confidence limits for the prediction were calculated. The percentage head injured during 1990/91 (23.7%) was below the percentage predicted (29.9%) and fell just within the confidence limits. However the actual percentage was statistically significantly below the prediction when a decrease in head injury risk was tested ($p < 0.05$; one-tailed Normal one-sample test).

5.1.2 Bicyclist injuries in country Victoria

The number of severely injured cyclists sustaining head injuries in country Victoria has fallen less consistently during the pre-law years (Figure 13) compared with the progressive fall in Melbourne. However following the introduction of the helmet wearing law, the number with head injuries fell by 63% during 1990/91 compared with 1989/90. This fall was accompanied by a 48% reduction in severely injured cyclists with injuries other than to the head in the same region.

Figure 14 shows that the percentage of severely injured cyclists who sustained a head injury has had a downward trend in country Victoria, though less steep than in Melbourne (Figure 11) where the largest increases in helmet wearing rates were observed during the pre-law years. While the country estimates of overall wearing rates were based on a larger number of assumptions than those for Melbourne (especially in the earlier pre-law years; see Section 3.3), nevertheless a statistically significant correlation (Pearson's $R = 0.69$) between the percentage head injured and

FIGURE 11

Percentage of Severe Bicyclist Casualties Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991

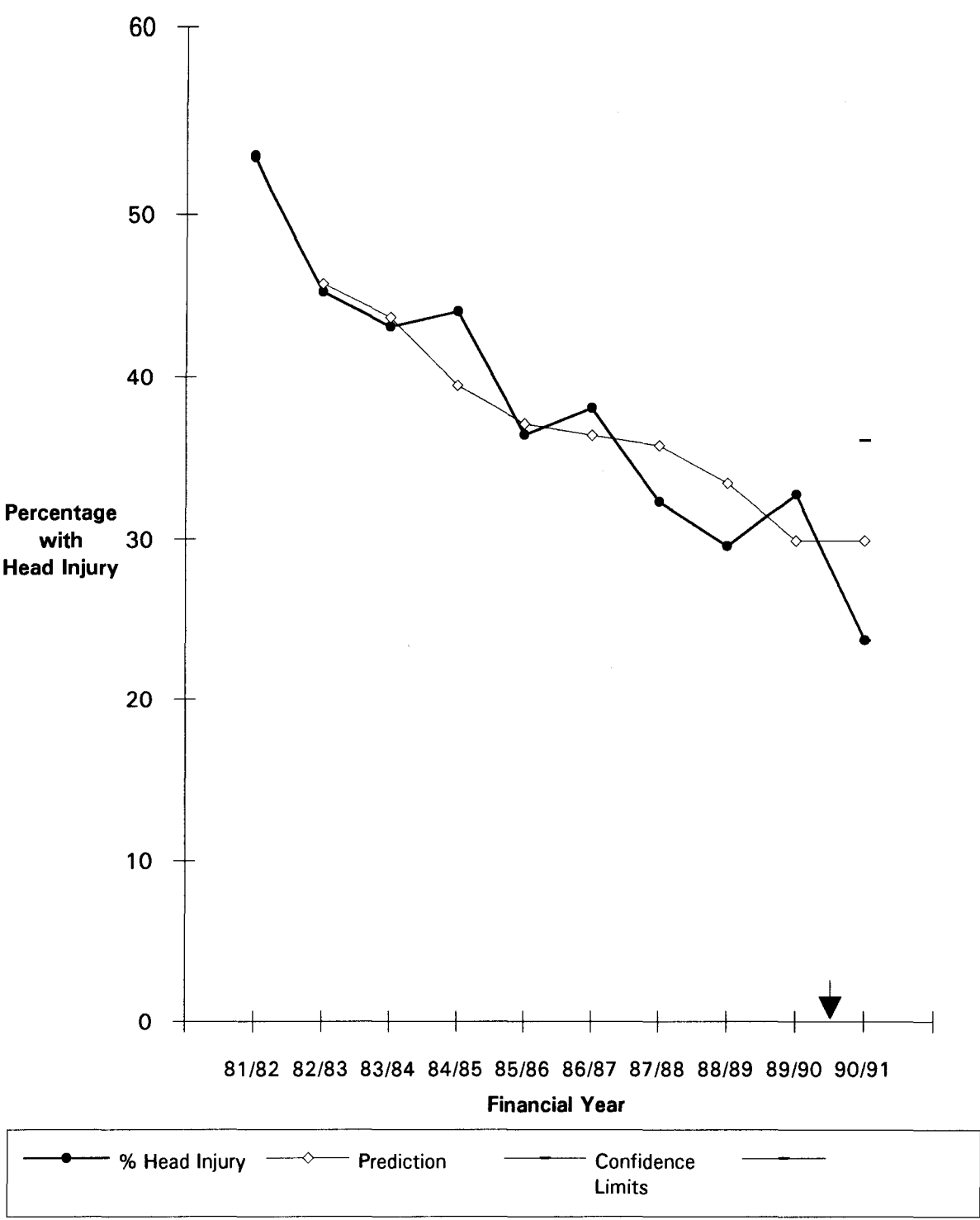


FIGURE 12

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties: Melbourne: July 1981 - June 1991

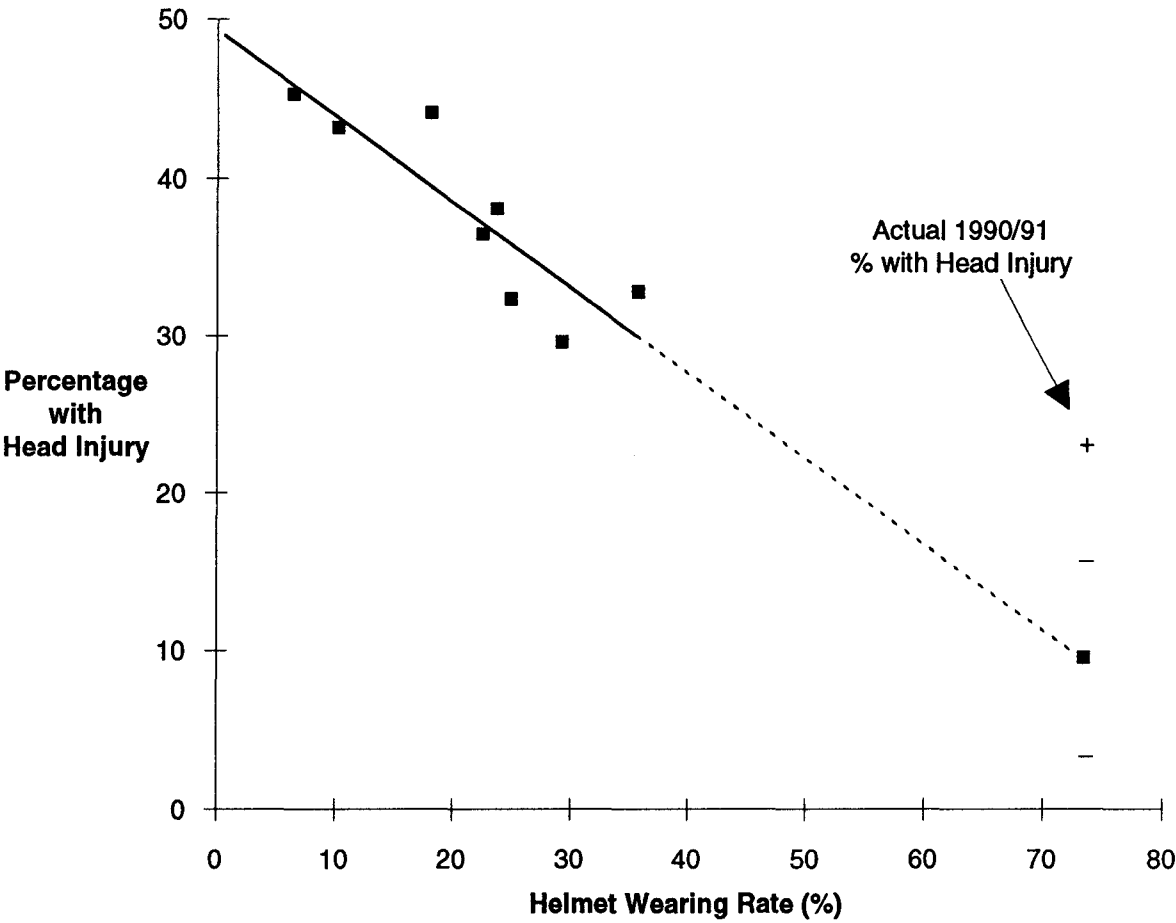


FIGURE 13

**Number of Severe Bicyclist Casualties Registered with TAC
Country Victoria : July 1981 - June 1991**

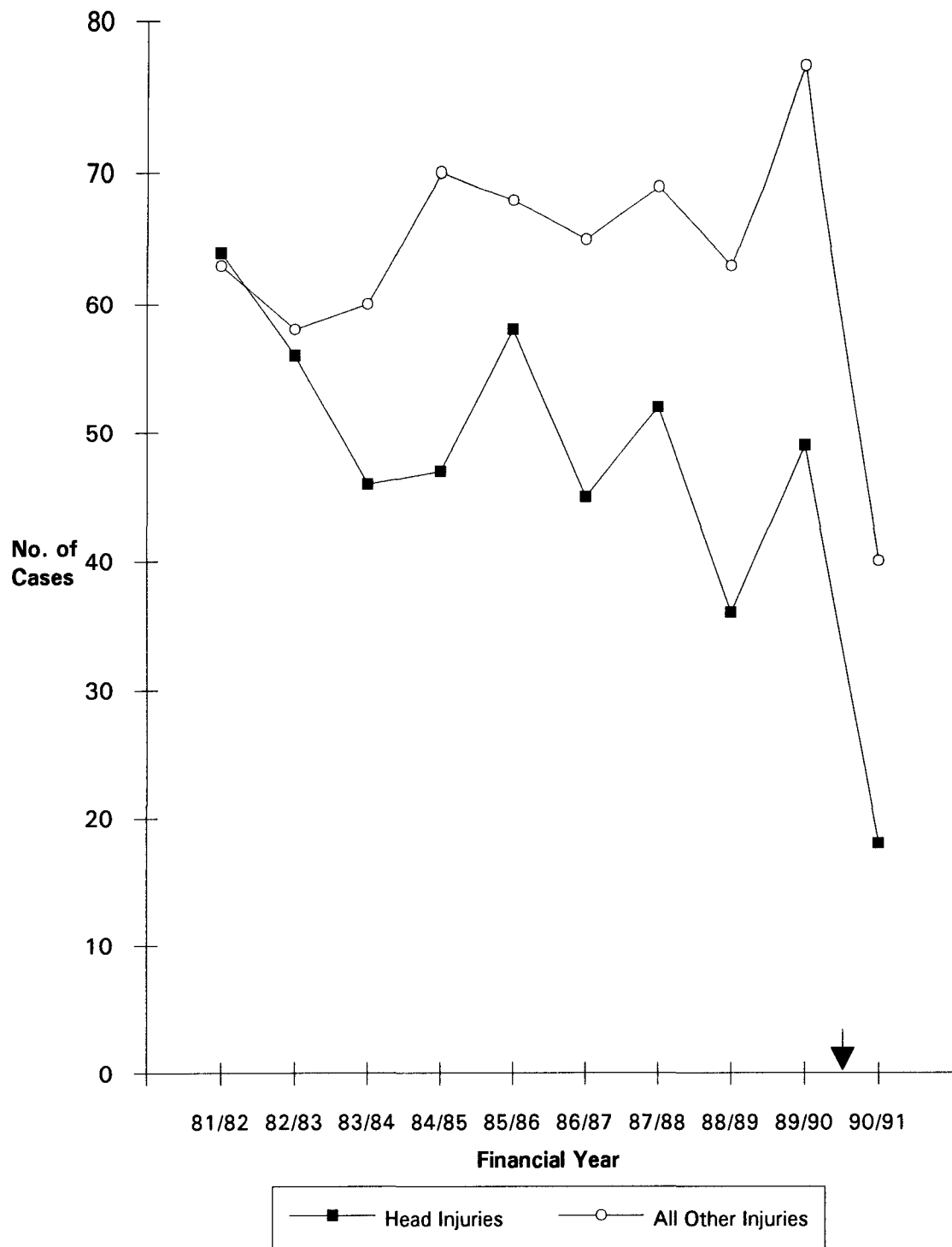


FIGURE 14

Percentage of Severe Bicyclist Casualties Registered with TAC
Country Victoria : July 1981 - June 1991

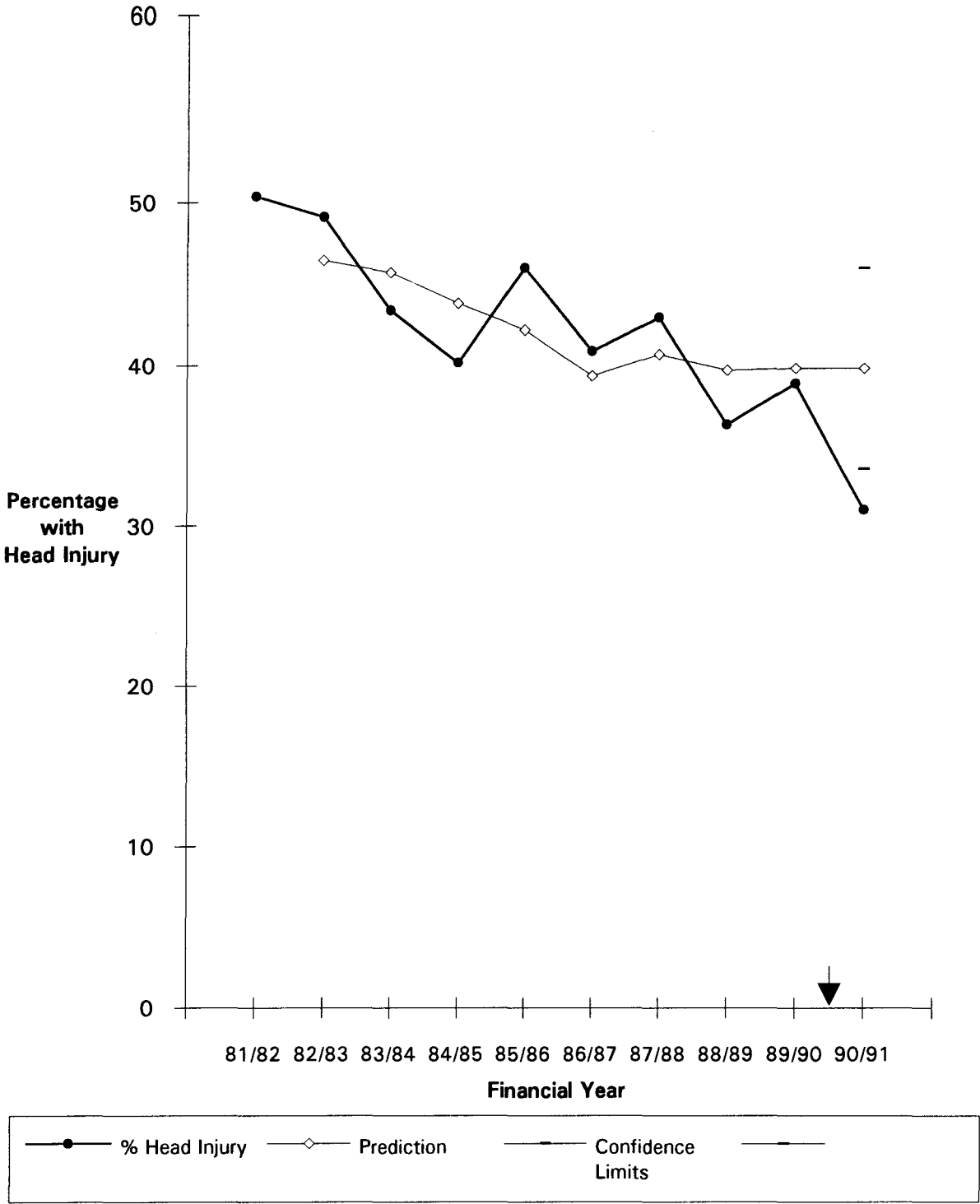
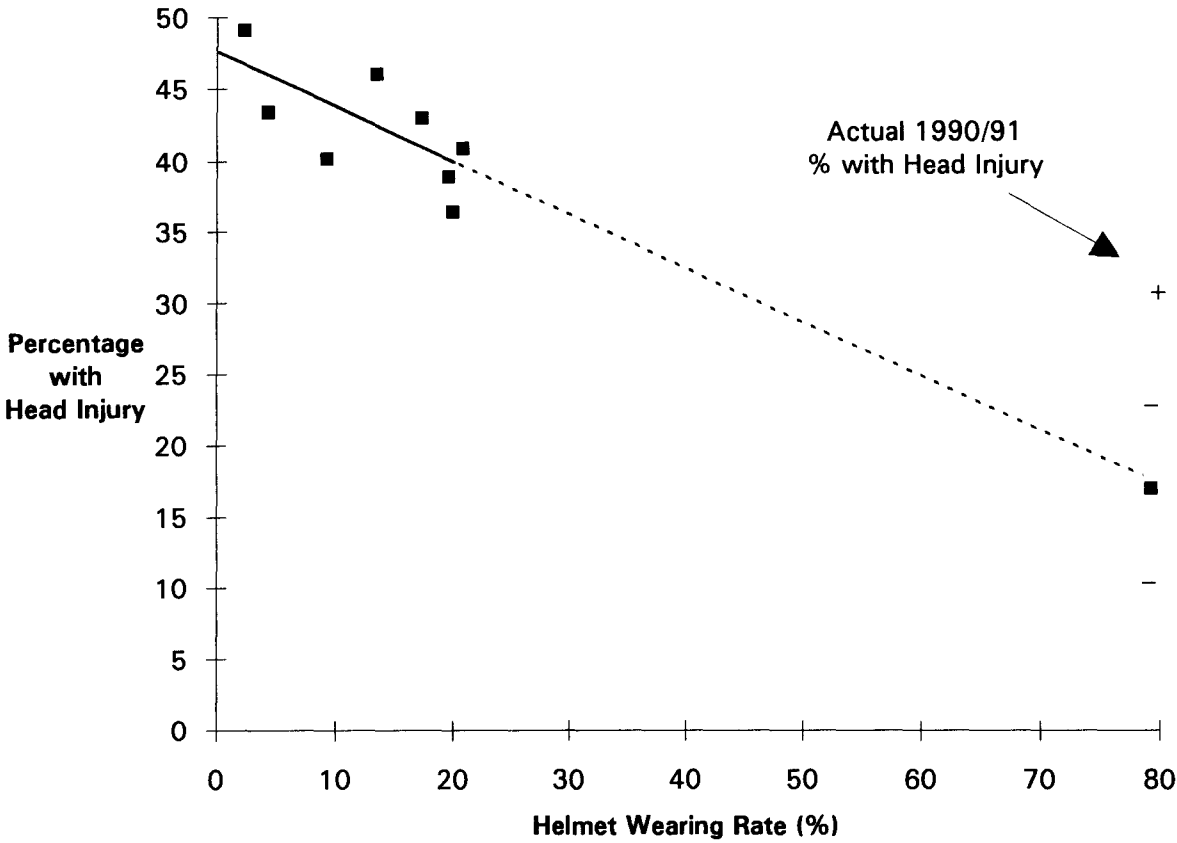


FIGURE 15

**Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties: Country Victoria: July 1981- June 1991**



the country wearing rates was still found and a linear regression was fitted (Figure 15).

The actual percentage head injured during 1990/91 in country Victoria (31.0%) was compared with the percentage predicted from the linear regression if the 1989/90 helmet wearing rate had continued unchanged (39.8%). The actual percentage was below the lower 95% confidence limit for the prediction (Figure 14) and the decrease was highly statistically significant ($p < 0.01$; one-tailed Normal one-sample test). However, as was found for bicyclist injuries in Melbourne, the actual percentage was above the upper 95% confidence limit of the expected 16.9% with head injury predicted from the linear regression (ie. assuming a linear relationship) for the 79% overall wearing rate in country Victoria during 1990/91 (Figure 15).

5.1.3 Bicyclist injuries in Victoria

Similar findings were observed when the TAC claims from severely injured cyclists involved in crashes in the whole of Victoria were examined (Figure 16). The number of killed or hospitalised cyclists with head injury fell by 51% between 1989/90 and 1990/91, and the number with severe injuries other than to the head fell by 24% over the same period.

A statistically significant correlation (Pearson's $R = 0.91$) between the estimated overall helmet wearing rates and the percentage of severely injured cyclists who sustained a head injury anywhere in Victoria was found and a linear regression fitted. The actual percentage of severely injured cyclists with a head injury during 1990/91 in Victoria (25.9%) was compared with the percentage predicted (33.5%) if the 1989/90 helmet wearing rate had continued unchanged (Figure 17). It was below the lower 95% confidence limit for the prediction and the decrease was very highly statistically significant ($p < 0.001$; one-tailed Normal one-sample test). However, as was found for each separate region of Victoria, the actual percentage was above the expected 12.0% with head injury which was predicted from the linear regression (ie. assuming a linear relationship) for the 75% overall wearing rate estimated for all Victorian cyclists during 1990/91 (Figure 18).

5.1.4 Alternative relationships between head injury and helmet wearing

The linear relationship between the percentage head injured and helmet wearing rates which was fitted to the data on severely injured cyclists crashing in Melbourne must be questioned because the regression line suggests that head injuries would fall to zero before helmet wearing rates reach 100%. A similar question must be asked about the relationship fitted to those cyclists crashing anywhere in Victoria, but not in the case of cyclists crashing in country Victoria.

It was suggested that the true relationship should asymptote towards a zero or low percentage head injured with increased helmet wearing, and may be of the negative exponential type (ie. concave up). Another possible relationship would arise if the head injuries prevented by helmet use resulted in the cyclists not being hospitalised, ie. they sustained no other severe injury requiring hospital admission; in this case the relationship would be concave down.

FIGURE 16

**Number of Severe Bicyclist Casualties Registered with TAC
Victoria: July 1981 - June 1991**

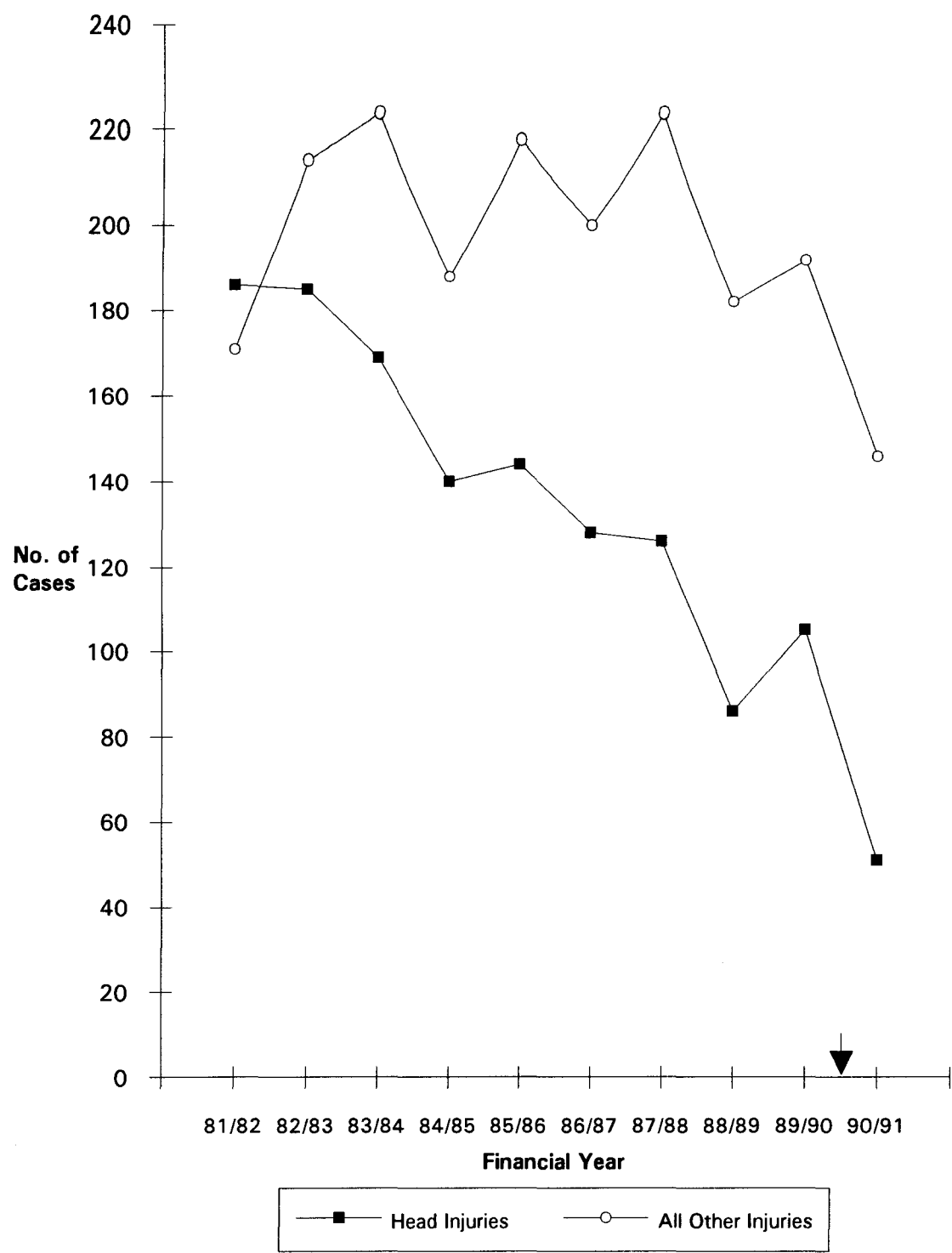


FIGURE 17

Percentage of Severe Bicyclist Casualties Registered with TAC
Victoria: July 1981 - June 1991

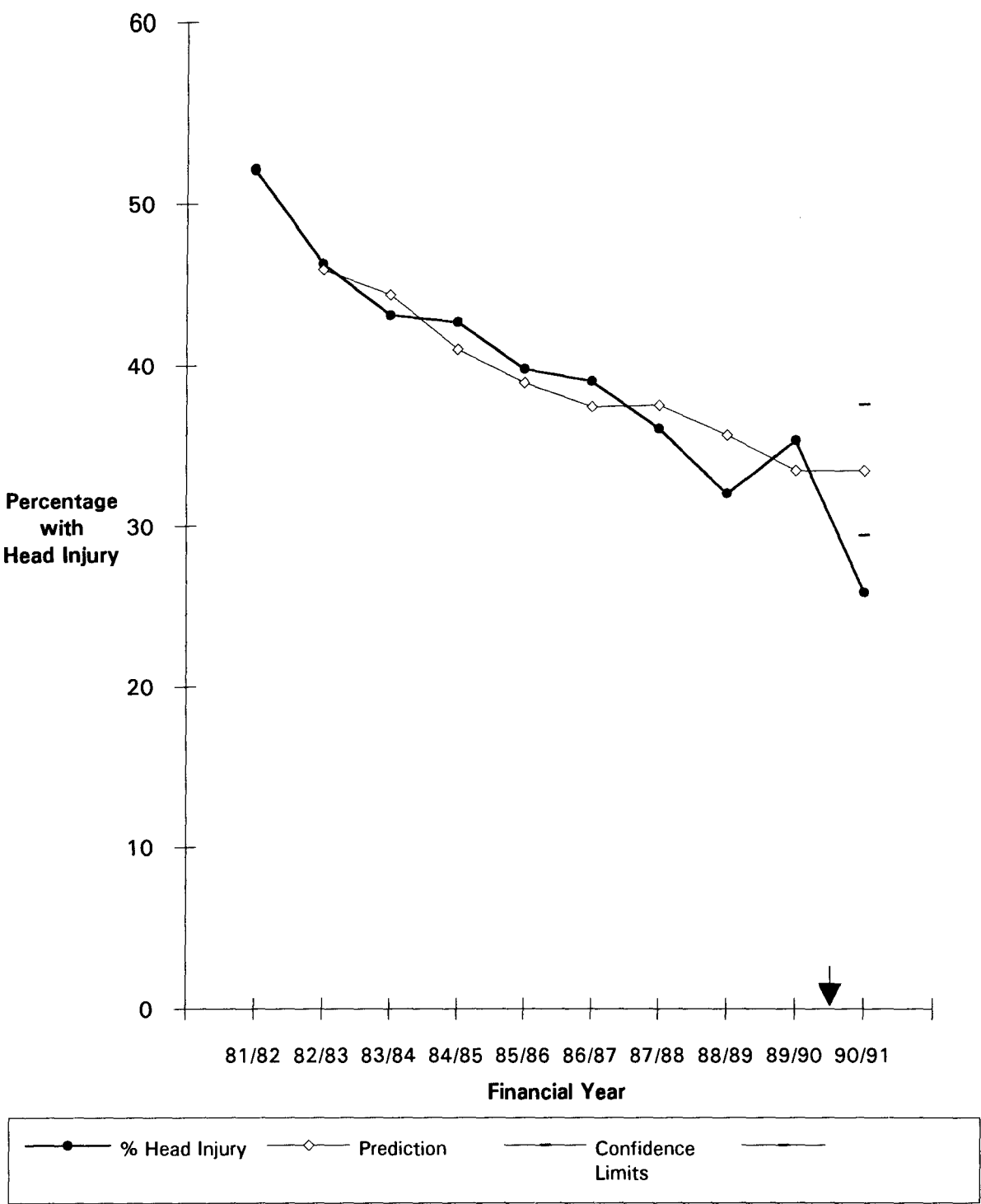
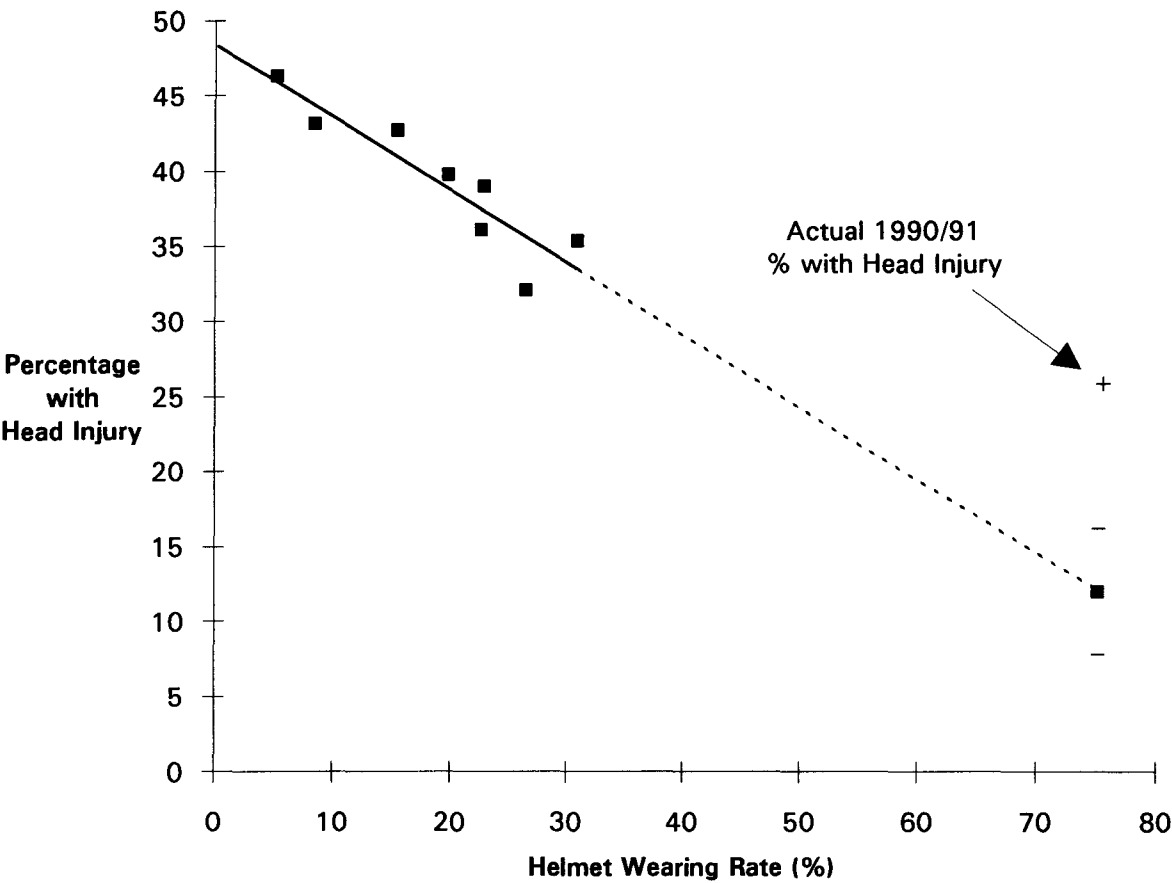


FIGURE 18

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties: Victoria: July 1981- June 1991



To test the implications of a negative exponential model for the relationship, it was fitted by the mathematically equivalent process of taking logarithms of the percentage head injured during each of the pre-law years and then fitting linear regressions with the estimated helmet wearing rates. The results for the separate analyses of severely injured cyclists crashing in Melbourne, country Victoria, and anywhere in Victoria are shown in Appendix A.

The correlation coefficients (Pearson's R = 0.86, 0.69, and 0.89, respectively) were all statistically significant and only slightly smaller than the correlation coefficients when simple linear regressions were fitted (see Sections 5.1.1 to 5.1.3). In each case the actual percentage head injured during 1990/91 was above the upper 95% confidence limit of the expected percentage which was predicted when the negative exponential relationship was extrapolated to the post-law wearing rate estimated for 1990/91 (Appendix A). However the difference between the actual and expected percentage was considerably less when a negative exponential relationship was assumed, compared with a simple linear relationship (Table 3).

Table 3: Comparison of actual and expected percentages of severely injured cyclists who were head injured during 1990/91, by extrapolating two different relationships with helmet wearing rates, fitted during the pre-law years 1982/83 to 1989/90.

	% Head Injured	Linear Relationship with Helmet Wearing Rates		Negative Exponential Relationship	
Region	Actual	Expected	Actual - Exp.	Expected	Actual - Exp.
Melbourne	23.7	9.6	14.1	17.6	6.1
Country	31.0	16.9	14.1	23.3	7.7
All Victoria	25.9	12.0	13.9	19.5	6.4

This alternative analysis provides further support for the suggestion that bicycle helmets may not have been as effective in preventing head injury during 1990/91 as they appeared to be during the pre-law period. This issue will be examined further in the following section dealing with separate age groups of cyclists.

5.1.5 Bicyclist injuries by age group

Because of the changed pattern of bicycle use by age group after the law, and their different trends in helmet wearing rates, it was decided to examine the injury trends and their relationships with helmet wearing rates for each age group of cyclists separately. The analysis principally focused on cyclists injured anywhere in Victoria to maximize the reliability of the comparative results, but separate analysis for Melbourne and country Victoria is also presented in Appendix B to provide background information. However, it is considered that when disaggregated by both region and age group, the number of bicyclist injuries may be too small to allow meaningful analysis.

There were downward trends during the pre-law years in the number of severely injured cyclists sustaining head injuries in each of the three age groups considered, namely: 5-10 year olds (Figure 19), 11-17 year olds (Figure 20), and those aged 18

FIGURE 19

Number of Severe Bicyclist Casualties
Aged 5 to 10 Registered with TAC
Victoria : July 1981 - June 1991

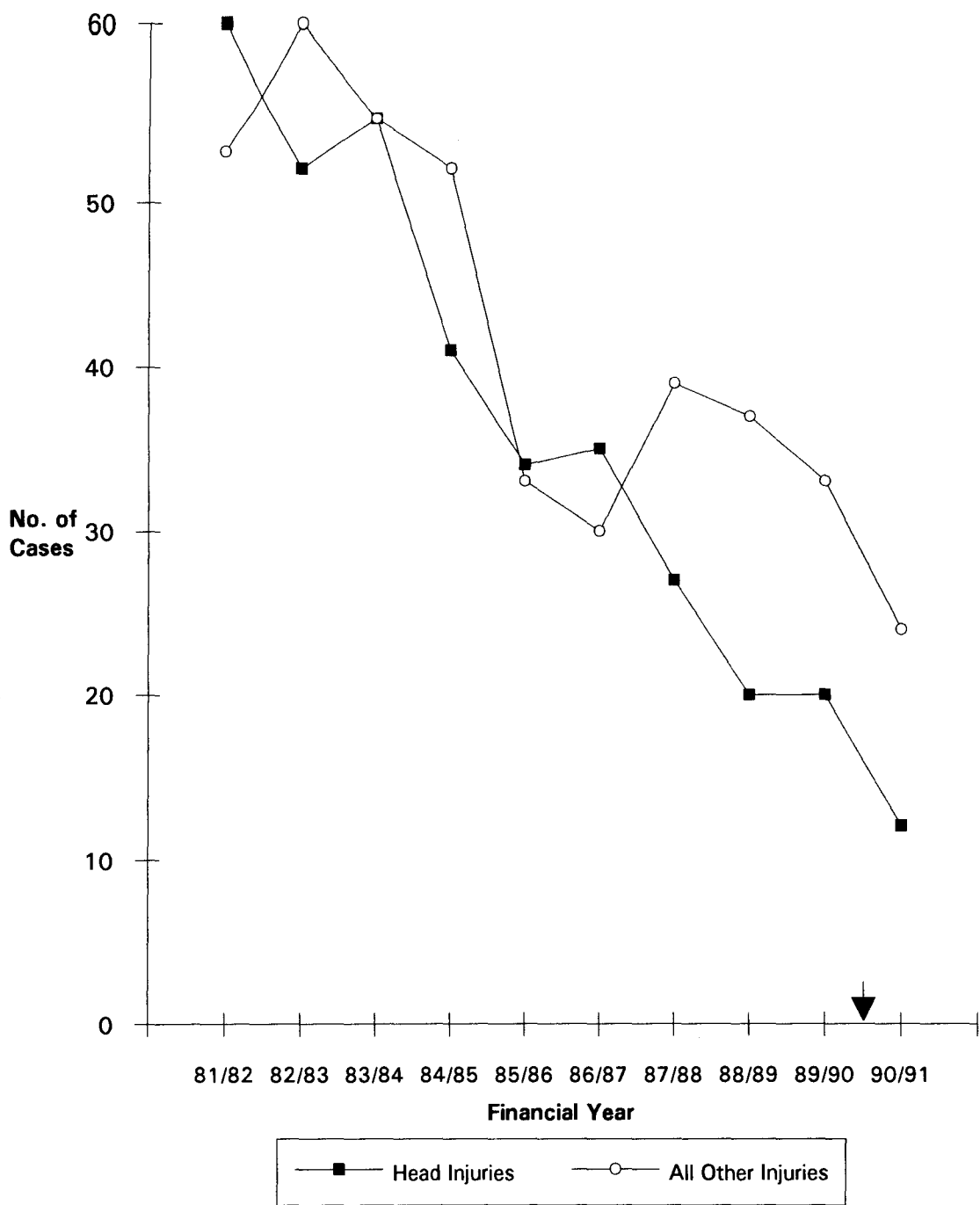


FIGURE 20

**Number of Severe Bicyclist Casualties
Aged 11 to 17 Registered with TAC
Victoria : July 1981 - June 1991**

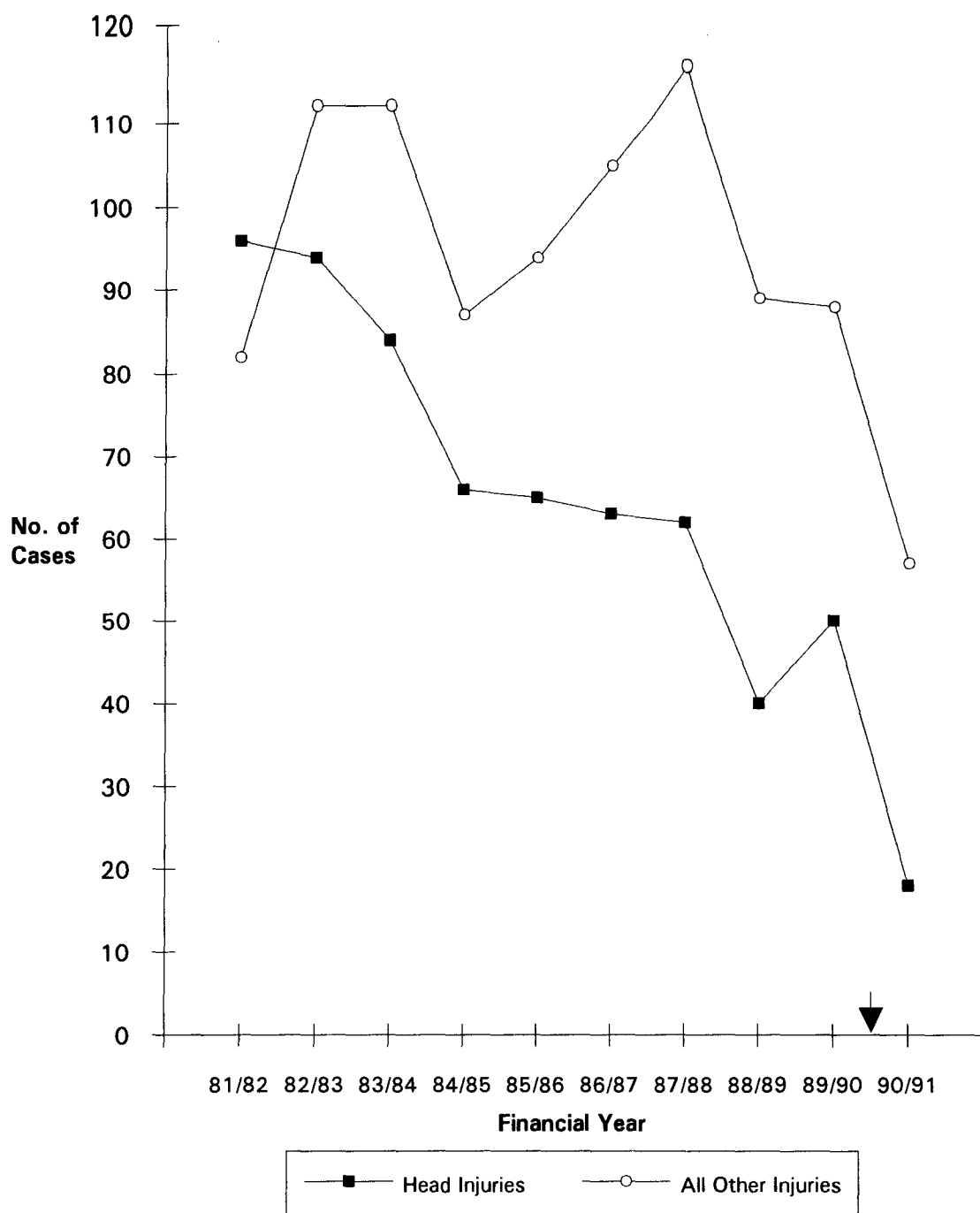
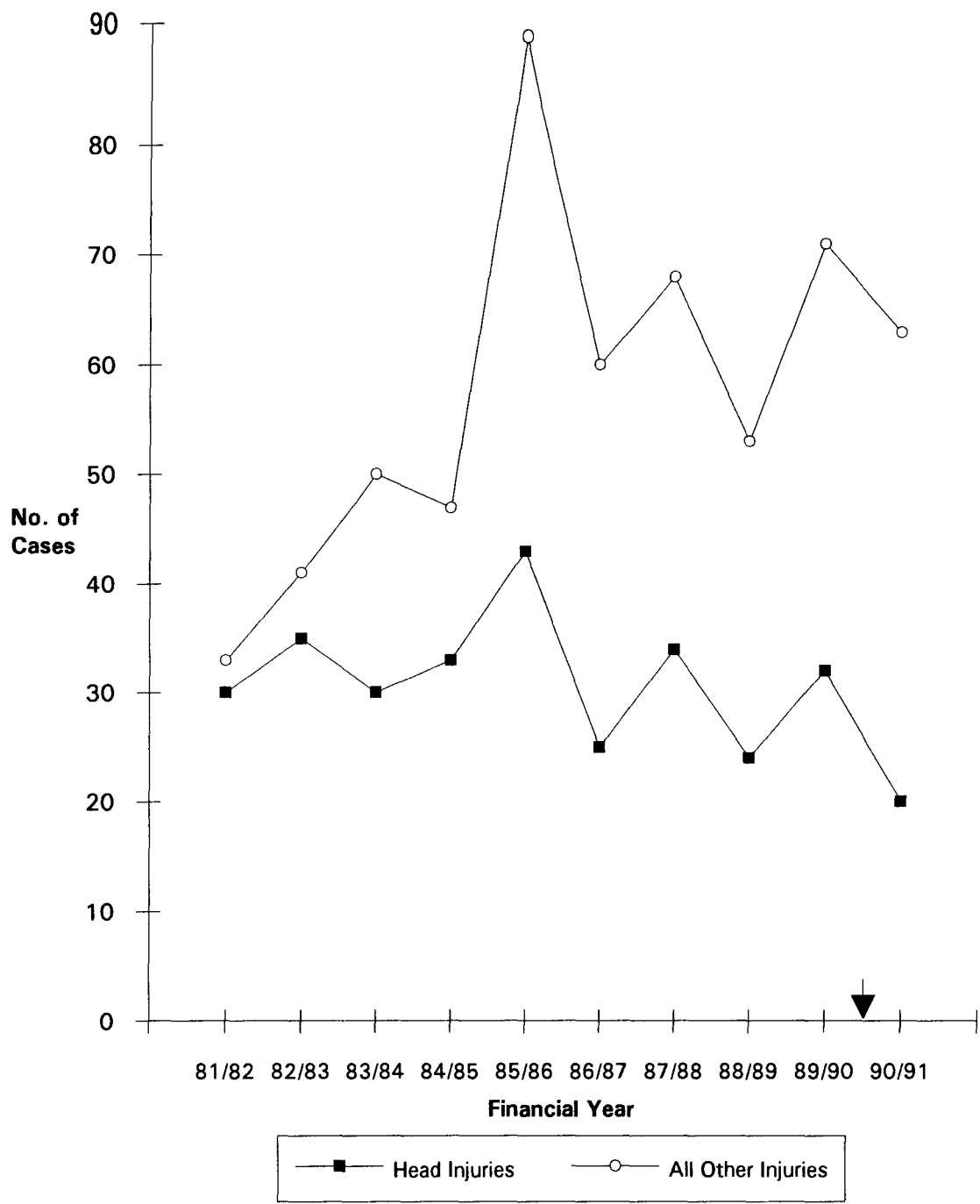


FIGURE 21

Number of Severe Bicyclist Casualties
Aged 18+ Registered with TAC
Victoria : July 1981 - June 1991



and above (Figure 21). The adult cyclists displayed the smallest downward trend, reflecting their relatively small increases in helmet wearing during the pre-law years.

During the post-law year 1990/91 compared with 1989/90, the number of severely injured cyclists with head injury in each age group fell by 40%, 64% and 38%, respectively. In contrast the numbers with severe injuries other than to the head fell by 27%, 35% and 11%, respectively.

When the percentage of severely injured cyclists with head injury was examined within each age group (Figures 22-24), there were indications of a downward trend in each case. Linear relationships with the estimated overall helmet wearing rates during the pre-law years were sought, but the relationships were statistically significant only in the cases of the 11-17 and adult age groups. The Pearson correlation coefficients were $R = 0.53$, 0.76 , and 0.81 , respectively (compared with $R = 0.91$ when all age groups were combined; see Section 5.1.3). When the fitted linear regressions were used to predict the expected percentage head injured during 1990/91 for each age group if its 1989/90 helmet wearing rate had continued unchanged, only the 11-17 year old actual percentage was outside (and below) the 95% confidence limits for the prediction (Figure 23).

The fitted linear relationship for each age group was extrapolated to predict the expected percentage head injured when the actual 1990/91 helmet wearing rate applies (Appendix C). For the 5-10 year old group, the actual 1990/91 percentage head injured was almost identical to that expected. In the case of the 11-17 year old group, the actual percentage was outside (and above) the 95% confidence limits for the expected percentage. However in the case of the adult group, the predicted percentage head injured was negative, indicating that the fitted linear relationship was clearly inappropriate at the high level of helmet wearing estimated for adult cyclists during 1990/91.

Because of this and the general concern about the appropriateness of linear relationships when extrapolating to high helmet wearing rates, it was decided to also fit a negative exponential relationship in the case of each age group (based on a logarithm transformation of the percentage head injured, following Section 5.1.4). Using this approach, the actual percentage head injured was outside (and above) the 95% confidence limits for the expected percentage in the case of the 11-17 and adult age groups, whereas the actual and expected were again almost identical for the 5-10 year old group (Appendix C). The differences in the actual and expected percentage head injured, based on each of the assumed relationships, are shown in Table 4.

When Table 4 was compared with Table 3, it was apparent that the disparity between the actual percentage head injured during the post-law year 1990/91 and that predicted from the relationships with helmet wearing during the pre-law years lies predominantly in the adult age group and, to a lesser extent, in the 11-17 year old group. The actual percentage for the 5-10 year old group during 1990/91 was almost exactly that which would have been predicted from the pre-law experience.

FIGURE 22

Percentage of Severe Bicyclist Casualties
Aged 5 to 10 Registered with TAC
Victoria : July 1981 - June 1991

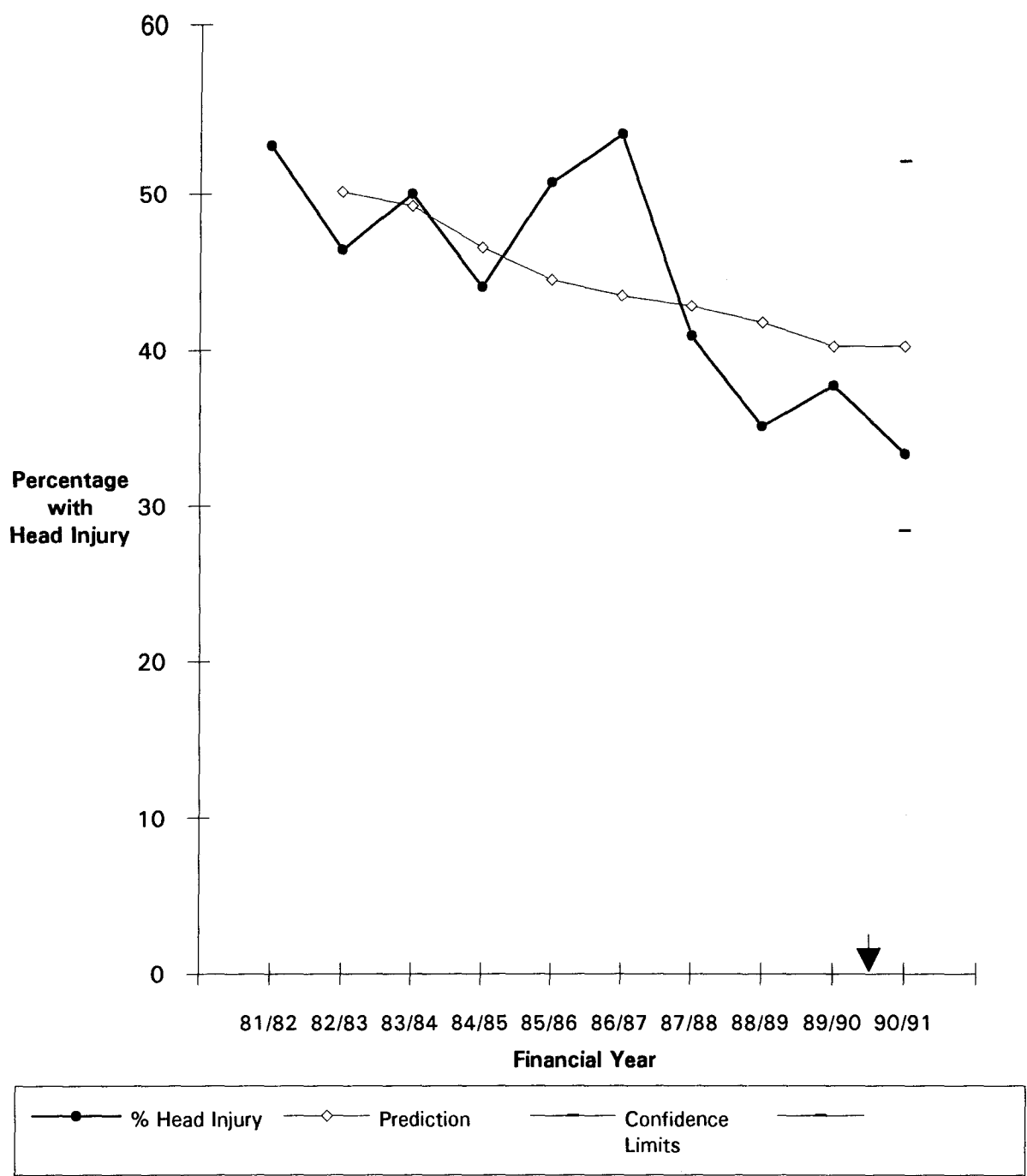


FIGURE 23

Percentage of Severe Bicyclist Casualties
Aged 11 to 17 Registered with TAC
Victoria : July 1981 - June 1991

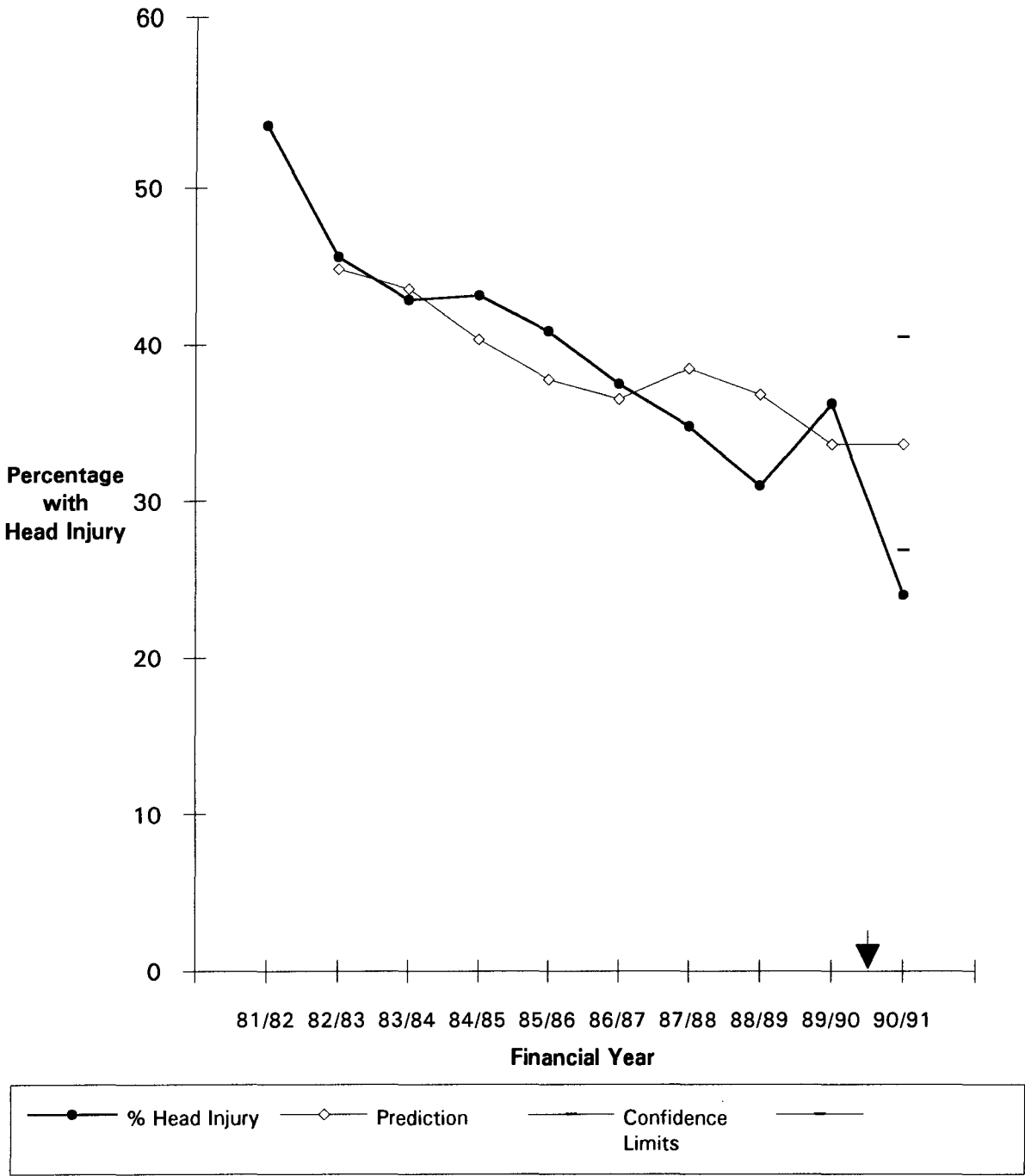


FIGURE 24

Percentage of Severe Bicyclist Casualties
Aged 18+ Registered with TAC
Victoria: July 1981 - June 1991

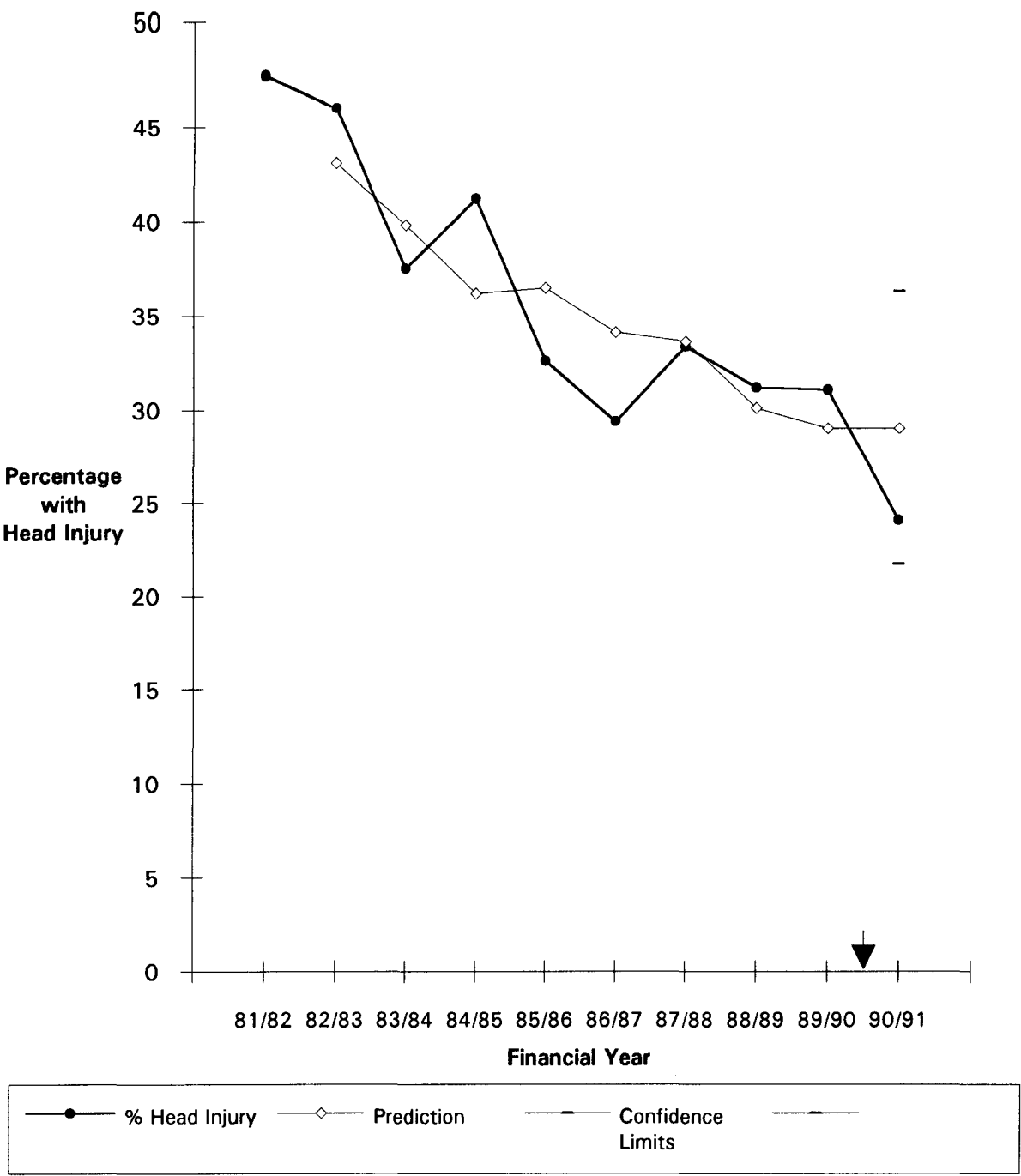


Table 4: Comparison of actual and expected percentages of severely injured cyclists who were head injured during 1990/91, by extrapolating two different relationships with helmet wearing rates, fitted during the pre-law years 1982/83 to 1989/90.

	% Head Injured	Linear Relationship with Helmet Wearing Rates		Negative Exponential Relationship	
Age Group	Actual	Expected	Actual - Exp.	Expected	Actual - Exp.
5-10	33.3	33.6	-0.3	33.8	-0.5
11-17	24.0	8.5	15.5	17.8	6.2
18 & above	24.1	-11.6*	35.7	9.9	14.2

* The expected percentage head injured when the fitted linear regression was applied to the 1990/91 helmet wearing rate for this age group is clearly inappropriate and hence should not be interpreted literally as having negative value.

5.2 Admissions to Public Hospitals

Acute admissions by bicyclists were classified into those sustaining a head (excluding face) injury, and those sustaining any other injury, on the basis of up to five injury codes recorded using the ICD-9 system. Some 75% of the admissions arose from crashes not involving a motor vehicle, whereas the remainder did. Information was not available prior to July 1986.

Figure 25 shows that the number of bicyclist admissions with head injury fell substantially during the post-law period, as did the number with other injuries. When the 1990/91 figures were compared with 1989/90, cyclists with head injuries decreased by 37% and the number with other injuries decreased by 21%.

Figure 26 shows that the percentage of bicyclist admissions who sustained a head injury has fallen during the period July 1986 to June 1990, in line with the increase in the estimated helmet wearing rates during this period, and a satisfactory regression line linking these two variables was able to be fitted (Pearson's R = 0.59). The percentage head injured during 1990/91 (27.3%) was compared with the percentage predicted (31.4%) if the 1989/90 helmet wearing rate had continued unchanged. The actual percentage head injured fell just within the 95% confidence limits for the prediction. The decrease in the actual percentage was almost statistically significant (p < 0.06; one-tailed Normal one-sample test).

These findings were consistent with those found based on TAC claims from severely injured cyclists after collisions with motor vehicles, indicating that the mandatory helmet use law had similar effects on cyclist collisions not involving motor vehicles as well.

5.3 VISS Records of Child Cyclist Presentations to Hospital

Figure 27 shows that the number of child cyclists (less than 15 years old) presenting to VISS hospitals in Melbourne with head injuries has been steadily decreasing in

FIGURE 25

**Number of Bicyclist Admissions to Public Hospitals
Victoria: July 1986 - June 1991**

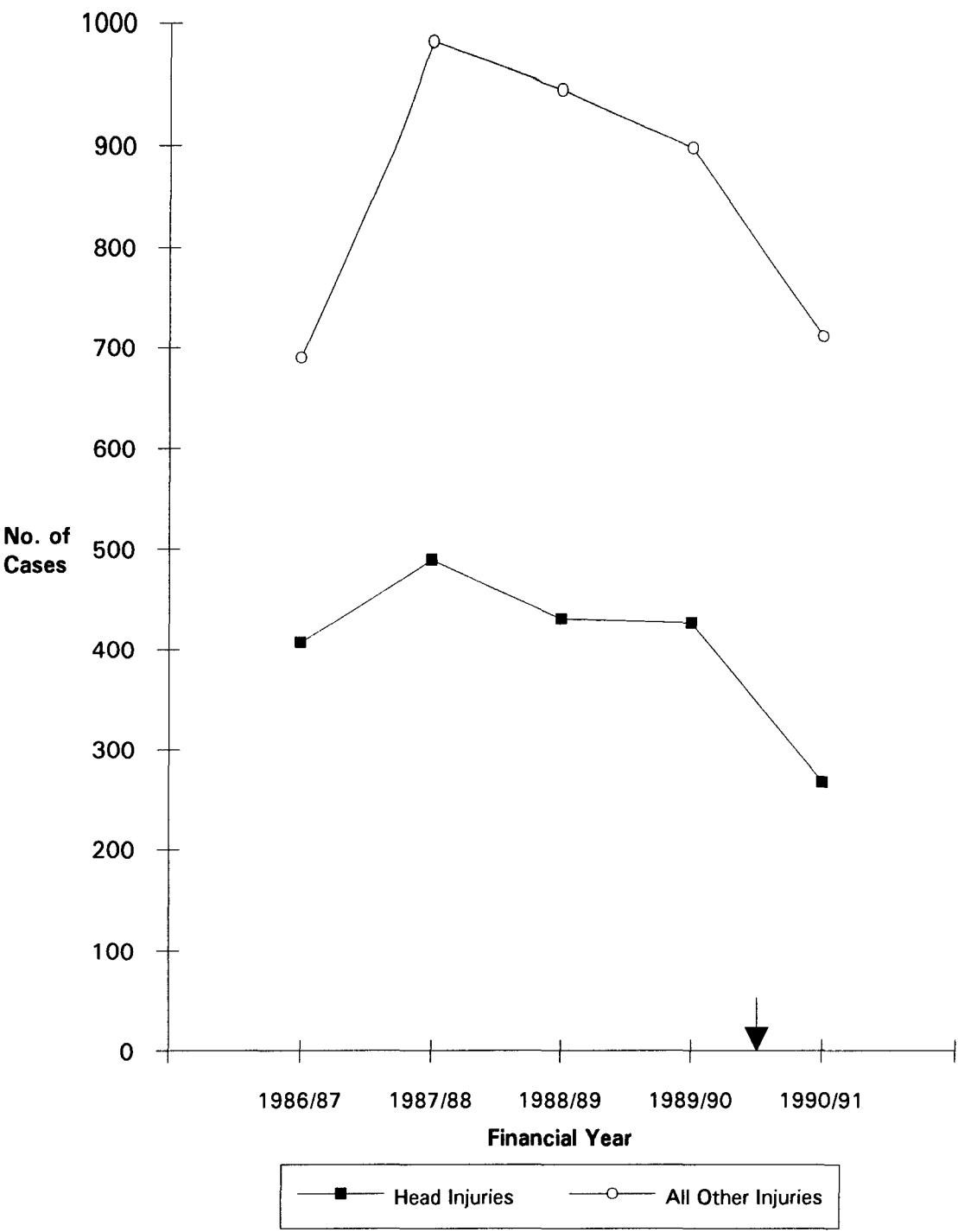
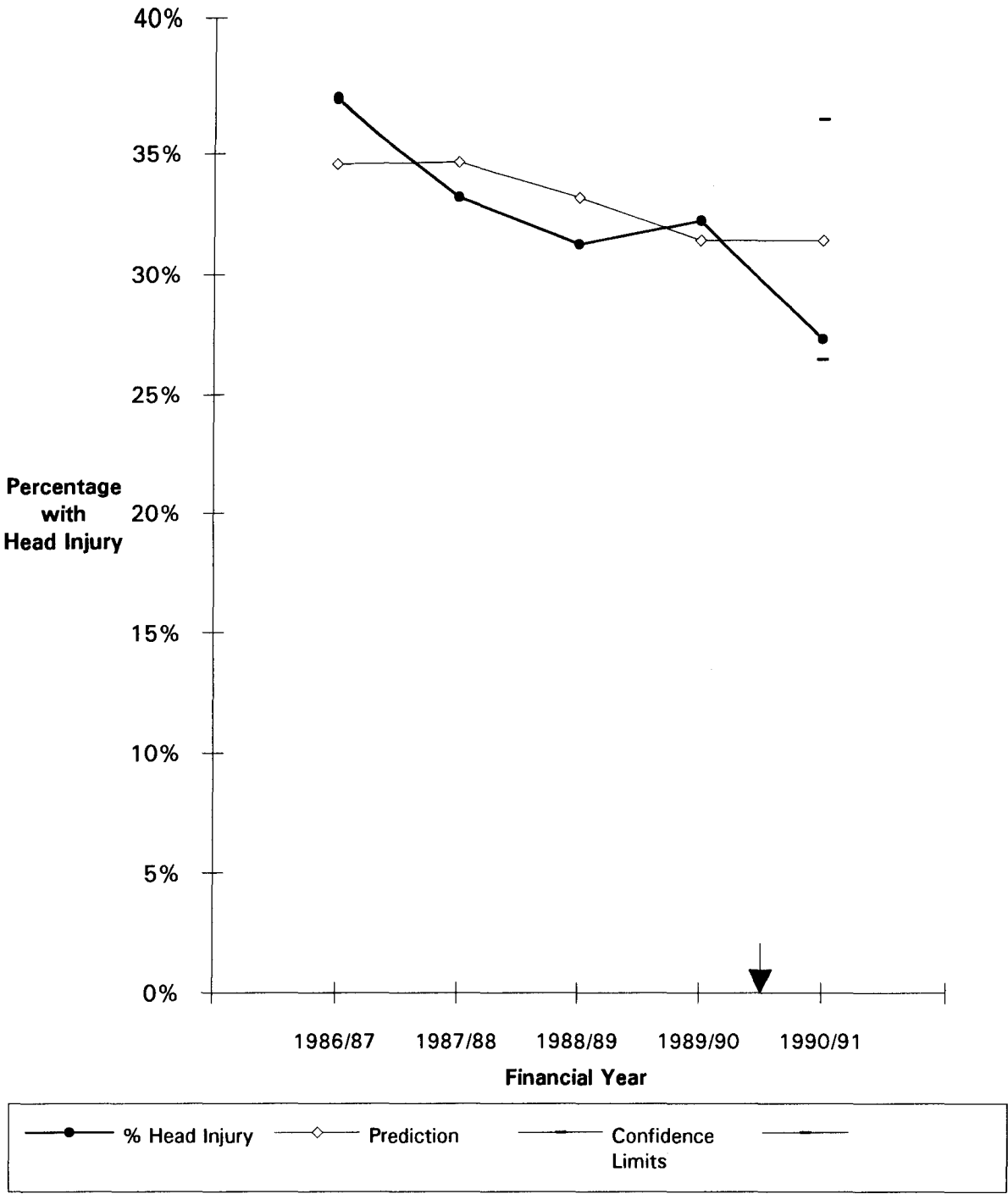


FIGURE 26

Percentage of Bicyclist Admissions to Public Hospitals
Victoria: July 1986 - June 1991



each half-yearly period since January 1989 (allowing for the fact that numbers in the first half of each calendar year are larger than those in the second half)

During the twelve month post law period there was a 32% decrease in the number of child cyclists with head injuries compared with the corresponding pre-law period. There was also a 46% decrease in the number with head injuries during 1991 (6-18 months after the law) compared with 1989.

The number of cases of cyclists presenting with other injuries showed some fluctuations in each six-month period (Figure 27). However, allowing for the fact that the numbers are larger in the first half of the calendar year than the second, it is apparent that this number has also been steadily decreasing since January 1989. There was a 22% decrease in this number during the twelve-month post-law period compared with the corresponding pre-law period. There was also a 30% decrease in the number with other injuries during 1991 (6-18 months after the law) compared with 1989.

Relative changes in the number of cyclist presentations with head injury compared to those with other injuries were tested for statistical significance using 2x2 Chi-square tests. Changes over time (before versus after the law) were assessed by comparing 1990/91 with 1989/90 and 1991 with 1989. The Chi-square test statistics (on one degree of freedom) were 0.55 and 2.14, respectively (both were not significant).

The trend in the percentage of child cyclist presentations with head injury was analysed using quarterly data (Figure 28). It was apparent that the percentages of cyclists with head injuries have fluctuated above and below the trend lines since January 1989. From this data source, there were too few pre-law estimates of the percentage head injured to establish any relationships with helmet wearing rates in Melbourne.

When the pre-law trend line was extrapolated to estimate the percentages of head injuries expected, had the law not existed, it was found that the decreases in the percentages of head injuries below the trend line during the post-law quarters were not statistically significant.

6. DISCUSSION

VIC ROADS, MUARC and Melbourne University students all conducted helmet wearing surveys before and after the introduction of the bicycle helmet wearing law in July 1990. Whilst the sample sizes, methodology and observation periods all varied amongst the surveys, the patterns of increase in helmet wearing rates were nevertheless very similar, showing large increases in wearing rates for all age groups.

The bicycle use surveys conducted by MUARC in 1990 and 1991 revealed a 36% decrease in cycling by children between the two years. Whilst bicycle use decreased by only 15% for the 5-11 year olds, it declined by 44% for the teenage group during the post-law period. Both VIC ROADS' and MUARC's helmet wearing surveys revealed that the latter group has the lowest wearing rates. Some of this group may have been discouraged from cycling by the helmet use law and this may explain their large reduction in cycling. Predominantly recreational cycling by children appears to

FIGURE 27

Child Bicyclist Presentations to VISS Hospitals (Melbourne):
Before (Jan 1989-Jun 1990) V. After (Jul 1990-Dec 1991)

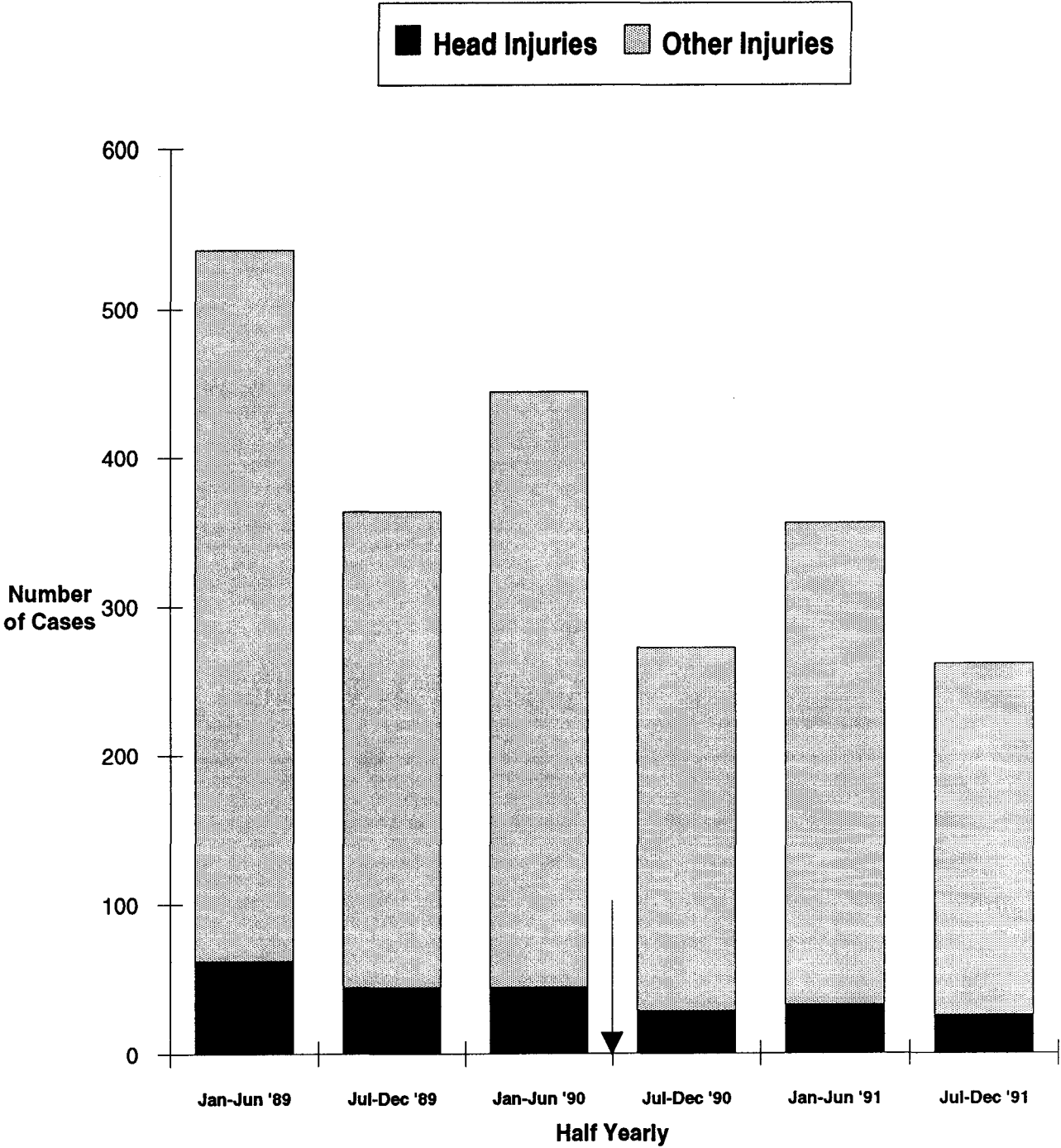
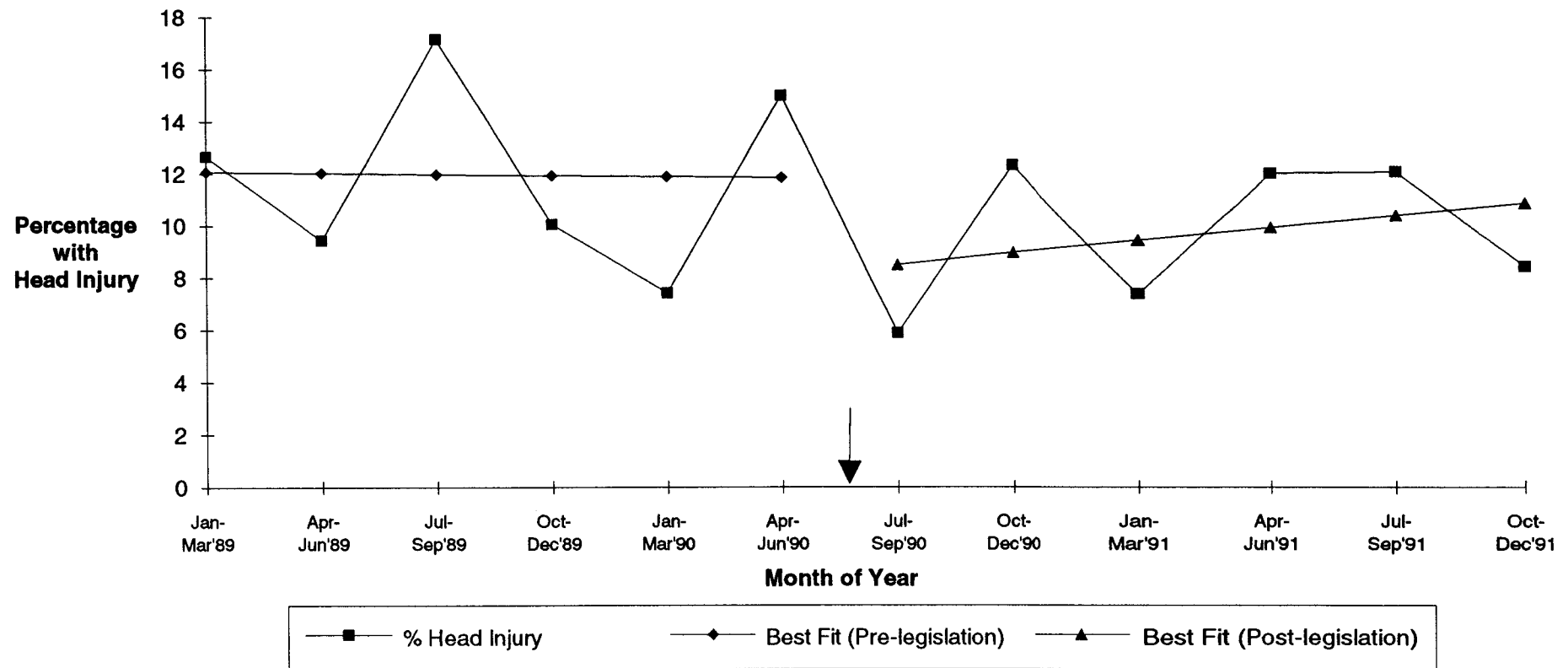


FIGURE 28

**Percentage of Child Bicyclist Presentations with Head Injury
VISS Hospitals (Melbourne): January 1989 - December 1991**



have been reduced, though preliminary evidence suggests that this had recovered somewhat for the teenage cyclists by 1992.

A comparison of the 1991 survey results for adults with a similar survey in 1987/88 (while a less direct comparison because of the nearly four year gap and different times of the year) showed that adult bicycle use had increased by 58%. This substantial increase in adult cycling appears to have off-set the decrease in child cycling following the introduction of the law. Preliminary data suggests that adult cycling continued to increase slightly during the second year of the law.

Analysis of bicyclist injury data showed a large reduction (37-51%) in the number of bicyclists killed or admitted to hospital with head injuries during the first year after the introduction of the mandatory helmet wearing law in Victoria on 1 July 1990. However, the mechanisms by which this reduction was achieved seem to be two-fold:

- . a reduction in the number of cyclists involved in crashes resulting in severe injury (ie. killed or admitted to hospital), and
- . a reduction in the risk of head injury for cyclists who were severely injured.

The extent of the reduction in bicyclist claims to TAC for severe injuries other than to the head (24%) supports the first mechanism. This mechanism is also supported by the estimated 21% reduction in hospital admission of cyclists with injuries other than to the head. In addition, there is evidence that bicycle use by children fell during the post-law period (although there is also some, less direct, evidence that bicycle use by adults increased, off-setting the decrease in child use). Reduction in bicycle use appears to be at least a partial explanation for the reduction in crash involvement, though it is also possible that the wearing of helmets has made cyclists more conspicuous, that the helmets and associated publicity have made cyclists ride more carefully, or that the publicity has made drivers more aware of cyclists.

In addition, major initiatives directed at drink/driving and speeding were introduced in Victoria in December 1989 and March 1990, respectively. The total number of persons killed and admitted to hospital resulting from all road trauma during the year commencing July 1990 was 12% below the number for the previous year. This could account for some of the reductions in bicyclist trauma during this period.

There is also clear evidence that the risk of head injury to cyclists involved in crashes has been reduced (the second mechanism). The percentage of severely injured bicyclist claimants to TAC who suffered a head injury during the post-law period was statistically significantly below that which would have been expected had pre-law helmet wearing rates continued unchanged. This finding was found for the whole State of Victoria, as well as for Melbourne and country Victoria separately. Essentially similar results were found when the percentage of bicyclist admissions to public hospitals who sustained a head injury was examined in the same way.

Based on the relationship between the percentage of severely injured cyclists who sustained a head injury, and the helmet wearing rates established in the pre-law period, there is an indication that increased helmet wearing in the post-law period has not been as effective in reducing the risk of head injury to crash-involved cyclists as

would have been predicted. The reduced effectiveness appeared to apply predominantly to adult cyclists and, to a lesser extent, to those aged 11-17. If true, this could be due to helmets being less securely adjusted or fastened by those cyclists who did not previously wear them (perhaps mainly the teenage group), or possibly to the greater proportion of lighter, foam-only and microshell helmets being worn as a result of the amendment to the Australian Standard for bicycle helmets in 1990 (perhaps mainly affecting the adult group).

It may also be a result of the assumptions which had to be made in combining a range of helmet wearing data, and fitting and extrapolating relationships with head injury, to make the predictions. Although relationships of two different types connecting head injury and helmet wearing were fitted to pre-law data, it is possible that neither adequately represents the true relationship when extrapolated to high levels of helmet wearing. Further study of these aspects is warranted, particularly the extent to which they relate to the actual effectiveness of helmets discussed in the previous paragraph.

7. CONCLUSIONS

The mandatory bicycle helmet wearing law implemented in Victoria on 1 July 1990 has been successful in building on past efforts to promote helmet use by bringing helmet wearing rates to new high levels for all cyclist age groups, both in Melbourne and country Victoria.

The introduction of the law has been accompanied by an immediate large reduction in the number of bicyclists with head injuries. Apparently this has been achieved both through a reduction in the number of cyclists involved in crashes (at least partly through a decrease in bicycle use) and a reduction in the risk of head injury of cyclists involved in crashes.

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APPENDIX A

NEGATIVE EXPONENTIAL RELATIONSHIPS BETWEEN PERCENTAGE HEAD INJURED AND HELMET WEARING RATES MELBOURNE, COUNTRY VICTORIA AND ALL VICTORIA

FIGURE A1

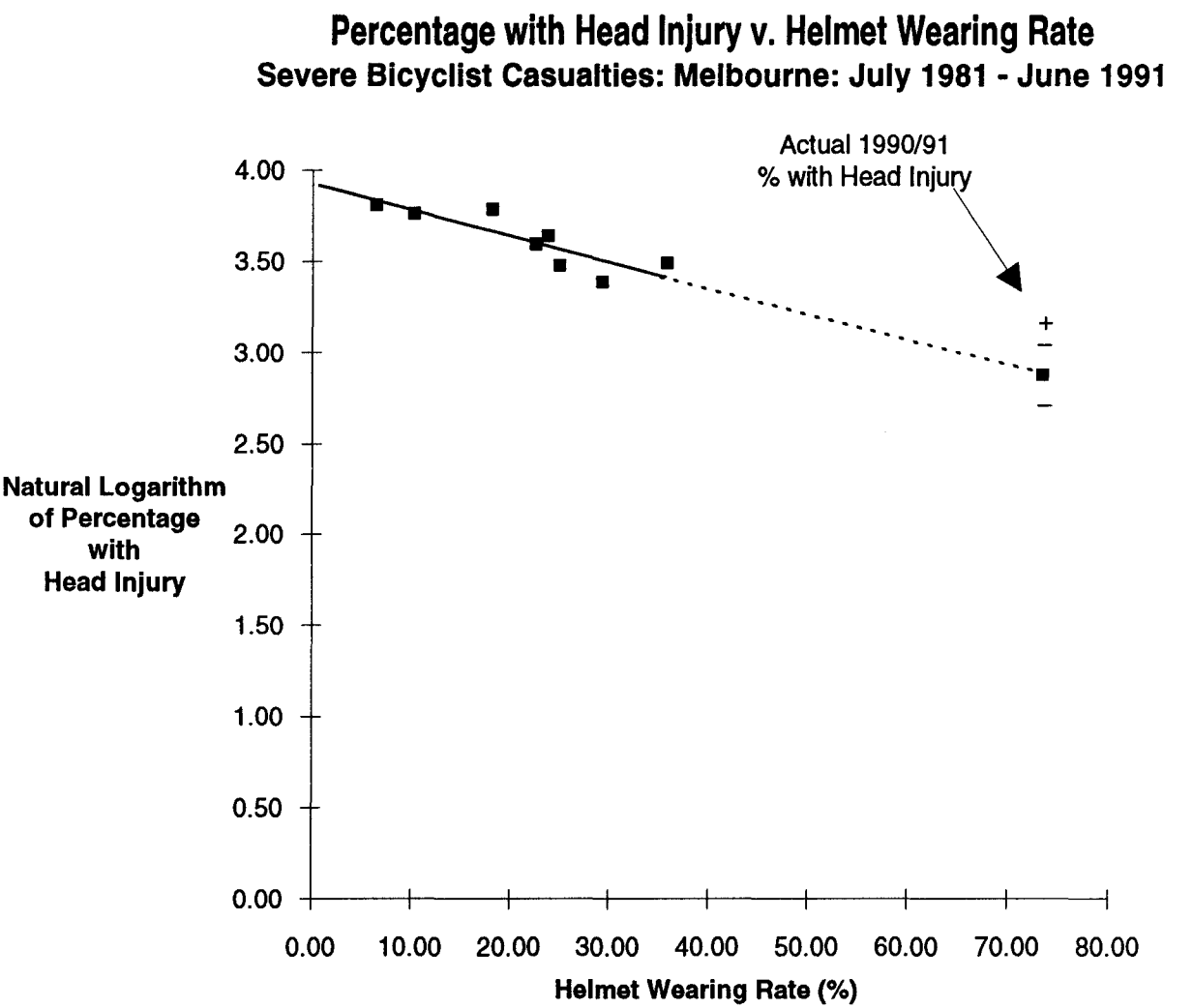


FIGURE A2

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties: Country Victoria: July 1981- June 1991

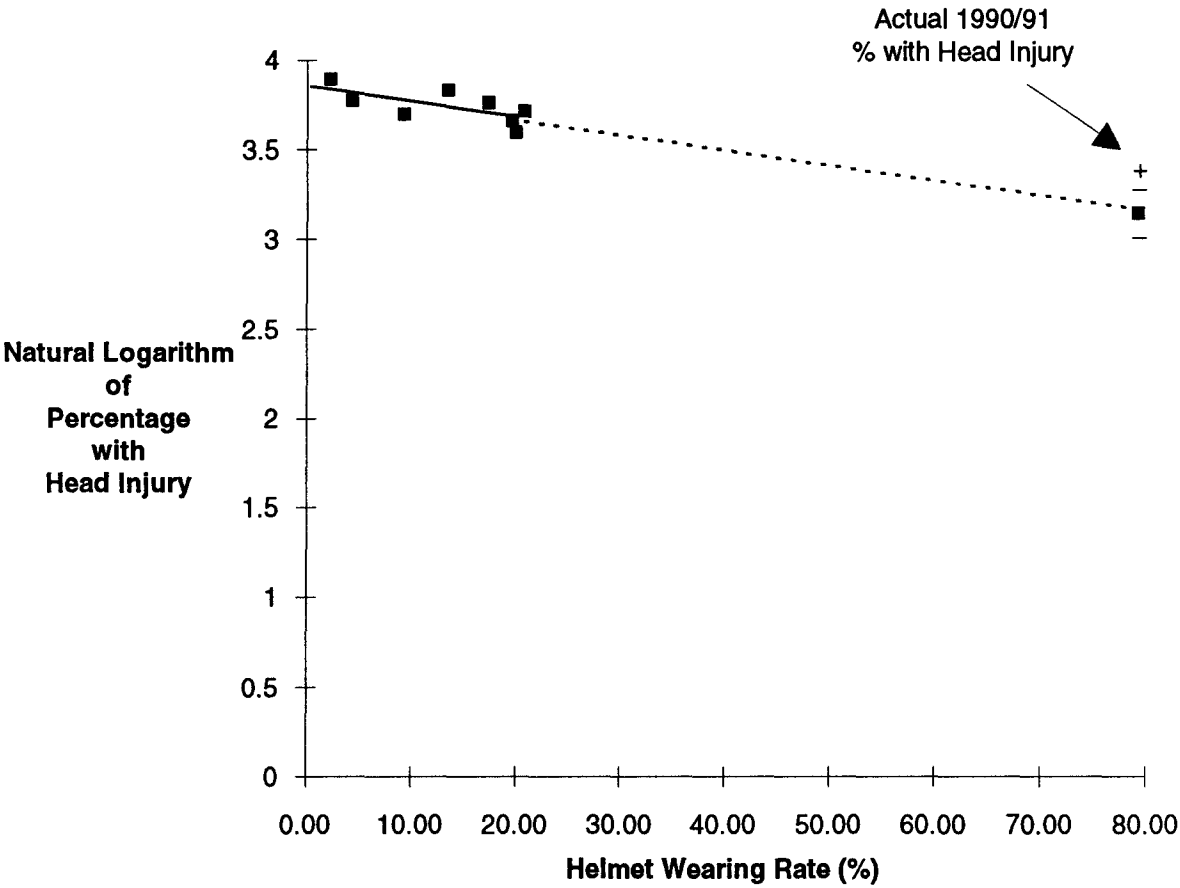
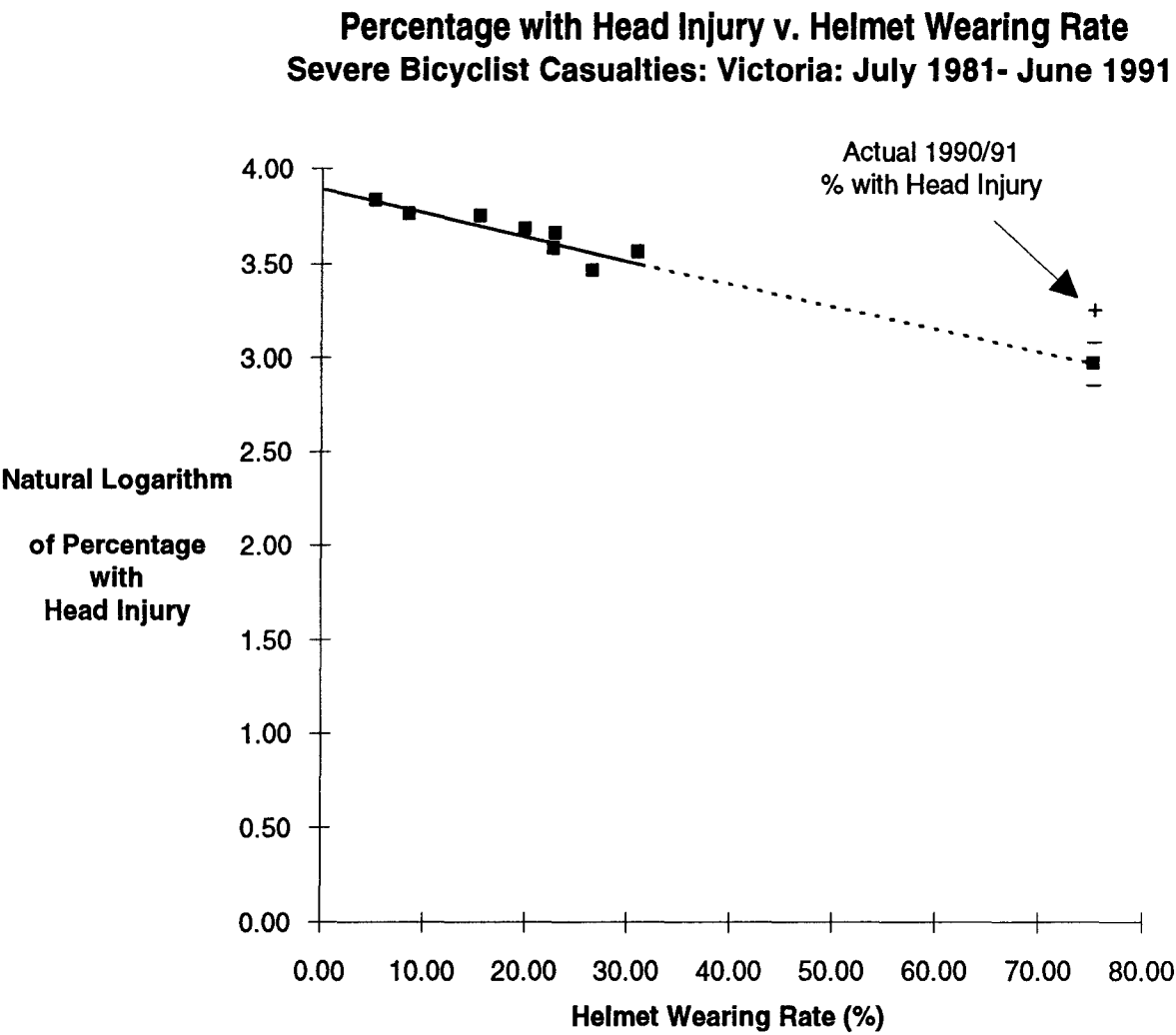


FIGURE A3



APPENDIX B

**NUMBER OF SEVERE BICYCLIST CASUALTIES
AND PERCENTAGE HEAD INJURED
BY AGE GROUP**

**MELBOURNE AND
COUNTRY VICTORIA**

FIGURE B1

**Number of Severe Bicyclist Casualties
Aged 5 to 10 Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991**

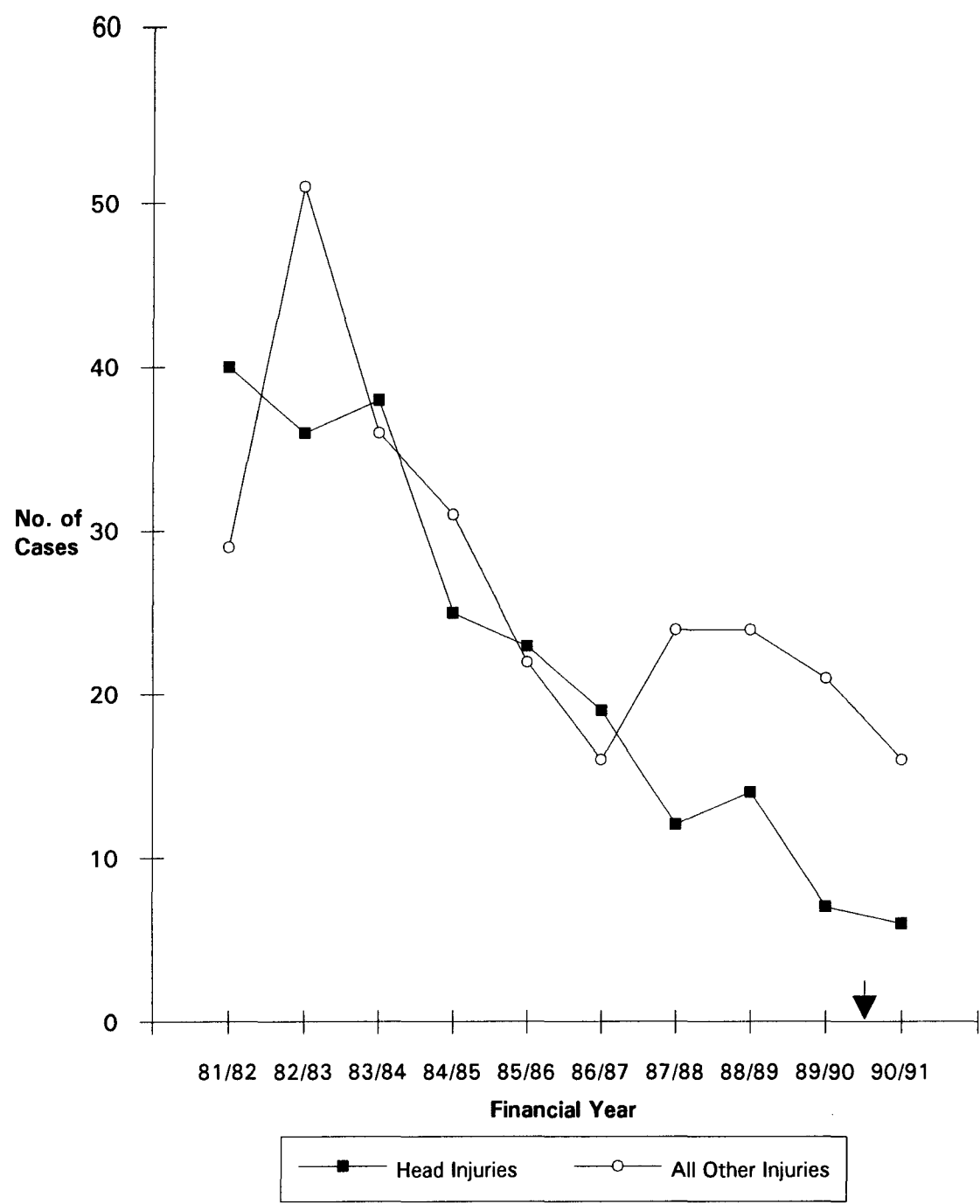


FIGURE B2

Percentage of Severe Bicyclist Casualties
Aged 5 to 10 Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991

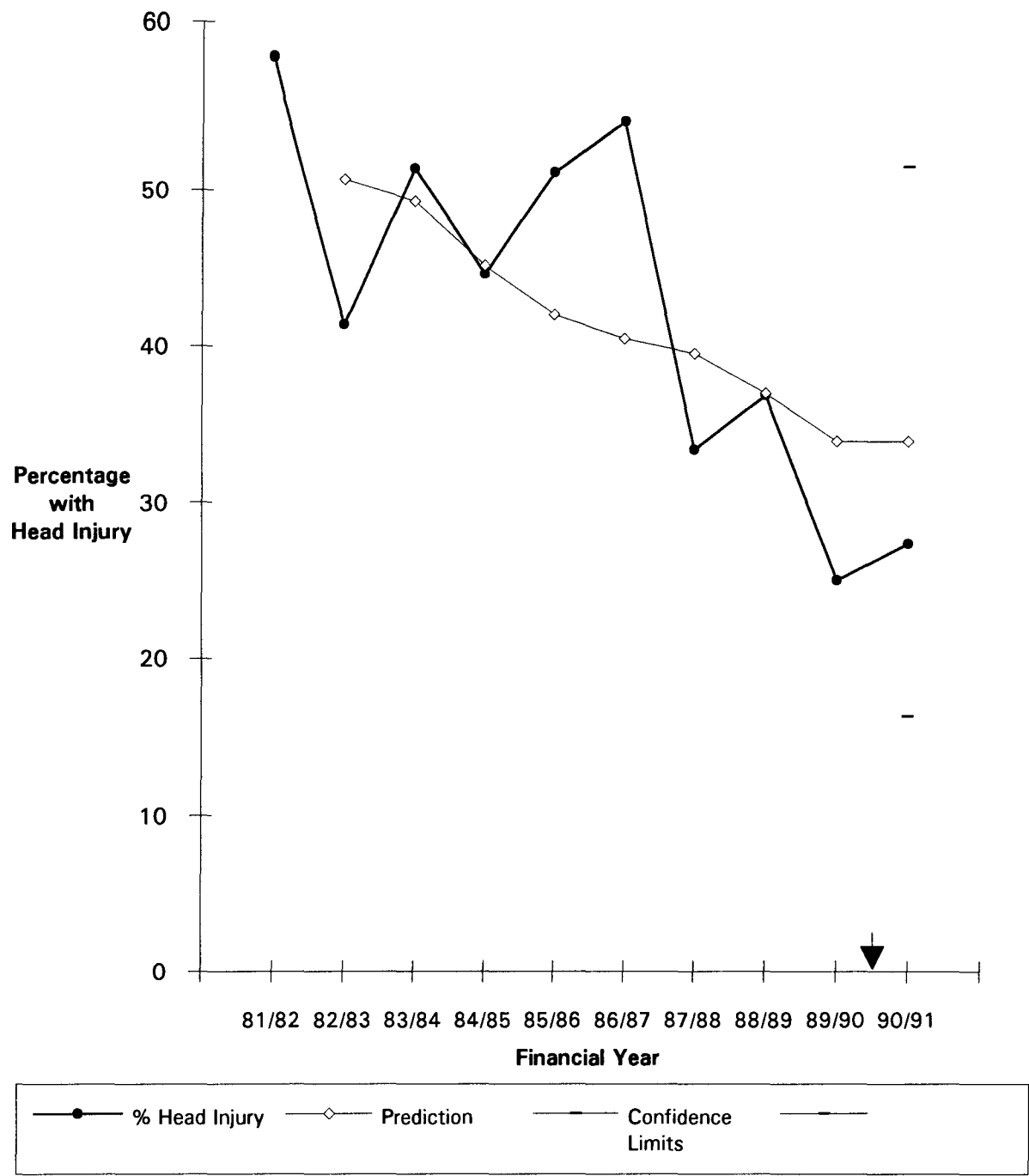


FIGURE B3

**Number of Severe Bicyclist Casualties
Aged 11 to 17 Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991**

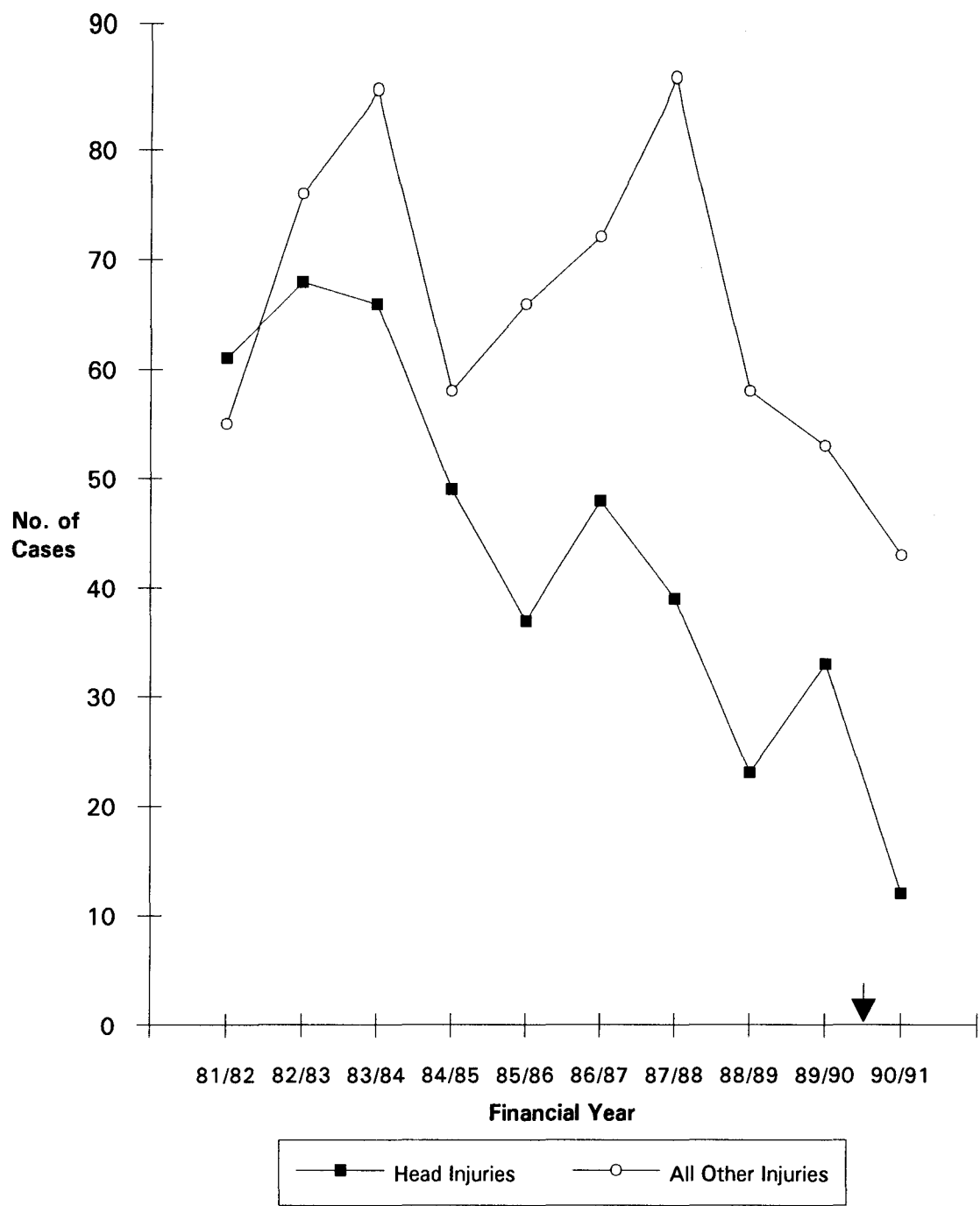


FIGURE B4

Percentage of Severe Bicyclist Casualties
Aged 11 to 17 Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991

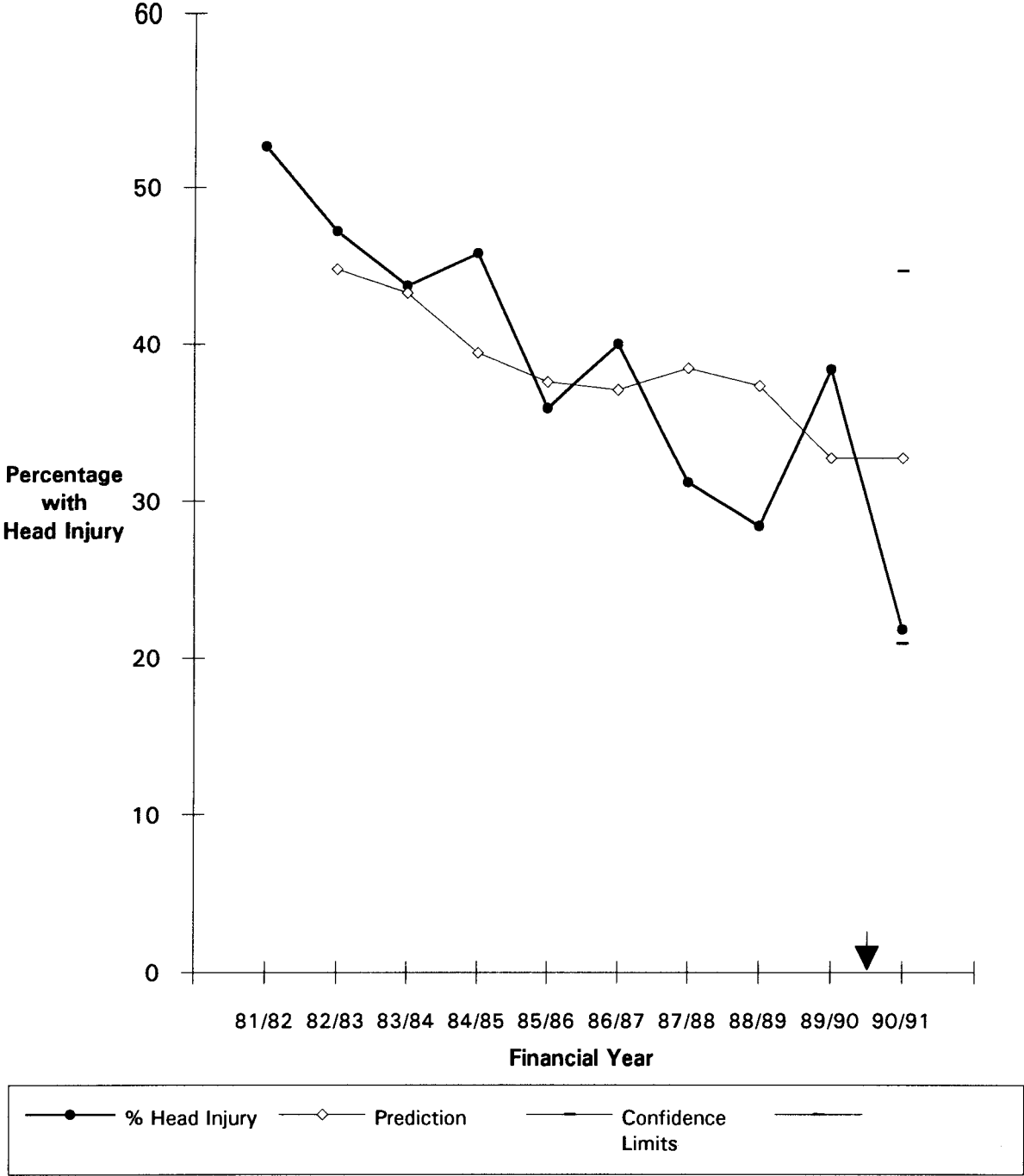


FIGURE B5

**Number of Severe Bicyclist Casualties
Aged 18+ Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991**

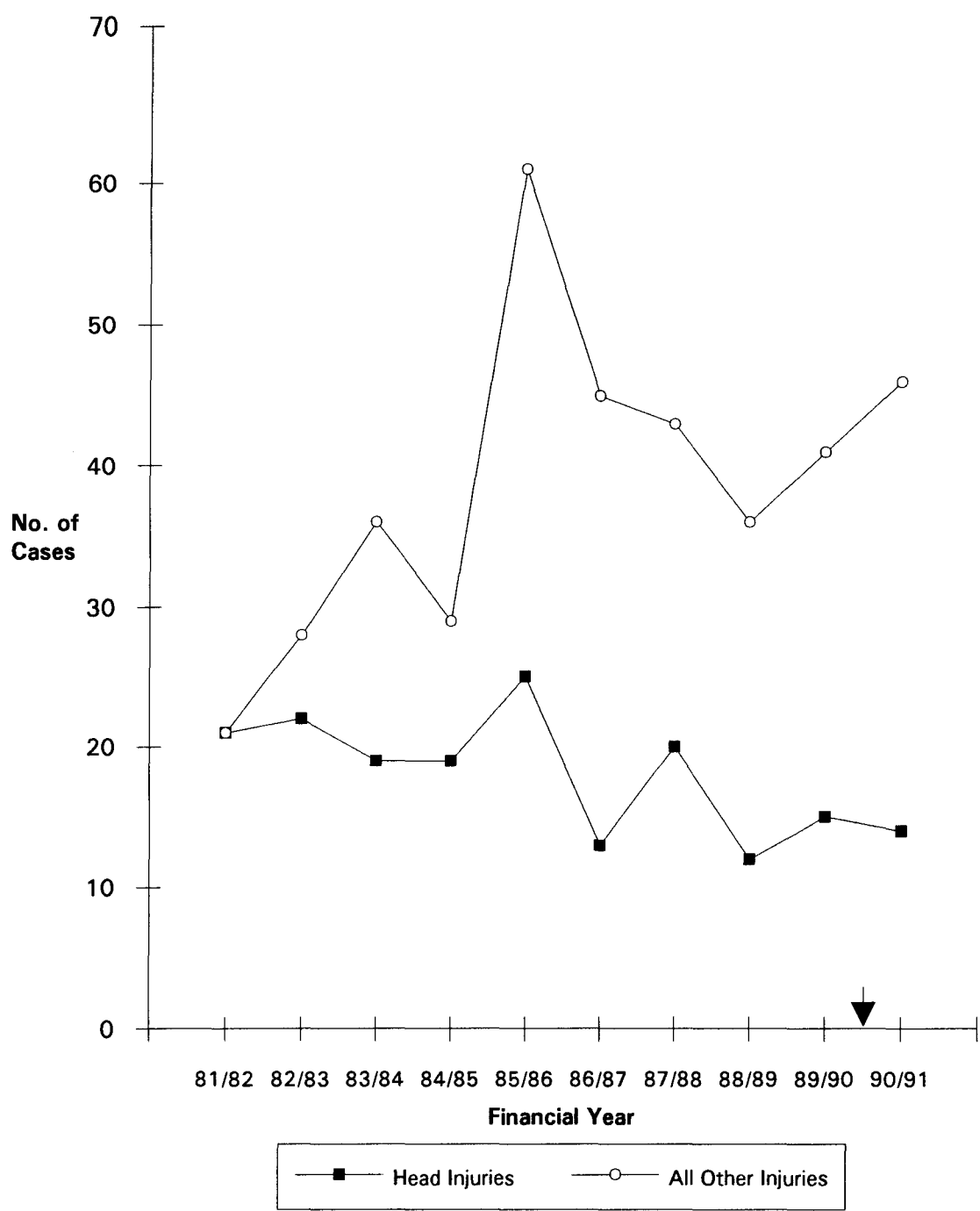


FIGURE B6

Percentage of Severe Bicyclist Casualties
Aged 18+ Registered with TAC
Metropolitan Melbourne: July 1981 - June 1991

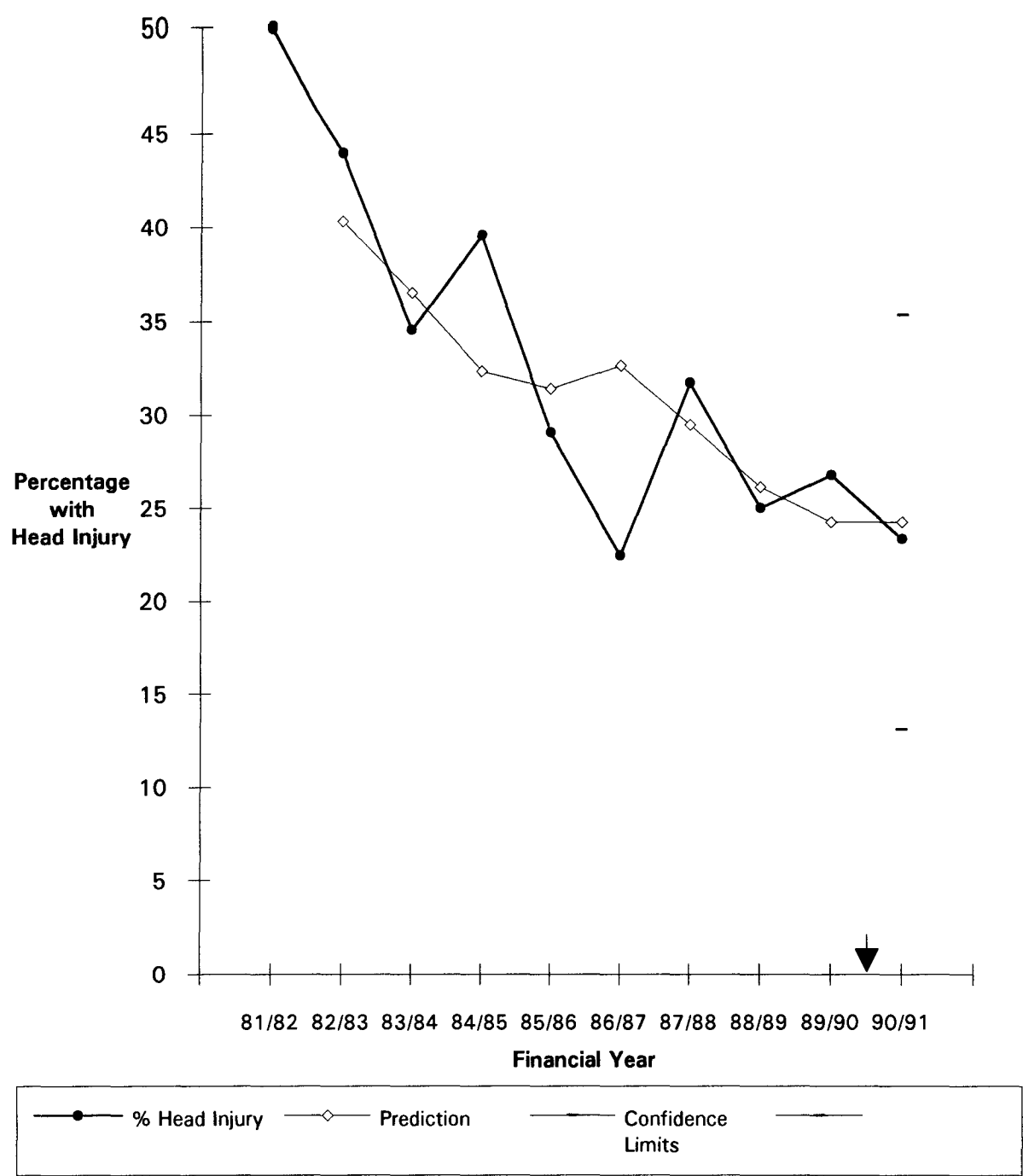


FIGURE B7

**Number of Severe Bicyclist Casualties
Aged 5 to 10 Registered with TAC
Country Victoria: July 1981 - June 1991**

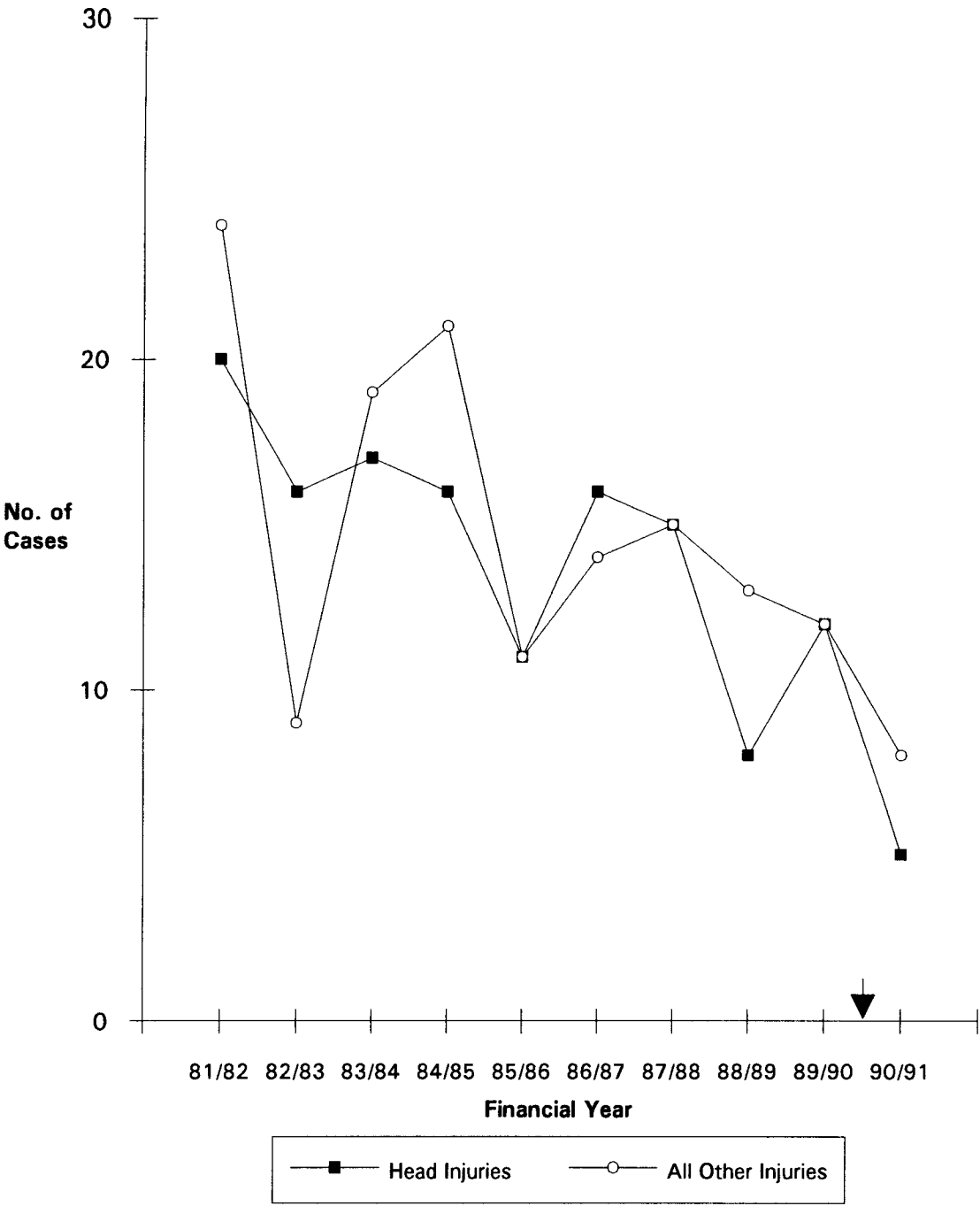


FIGURE B8

Percentage of Severe Bicyclist Casualties
Aged 5 to 10 Registered with TAC
Country Victoria: July 1981 - June 1991

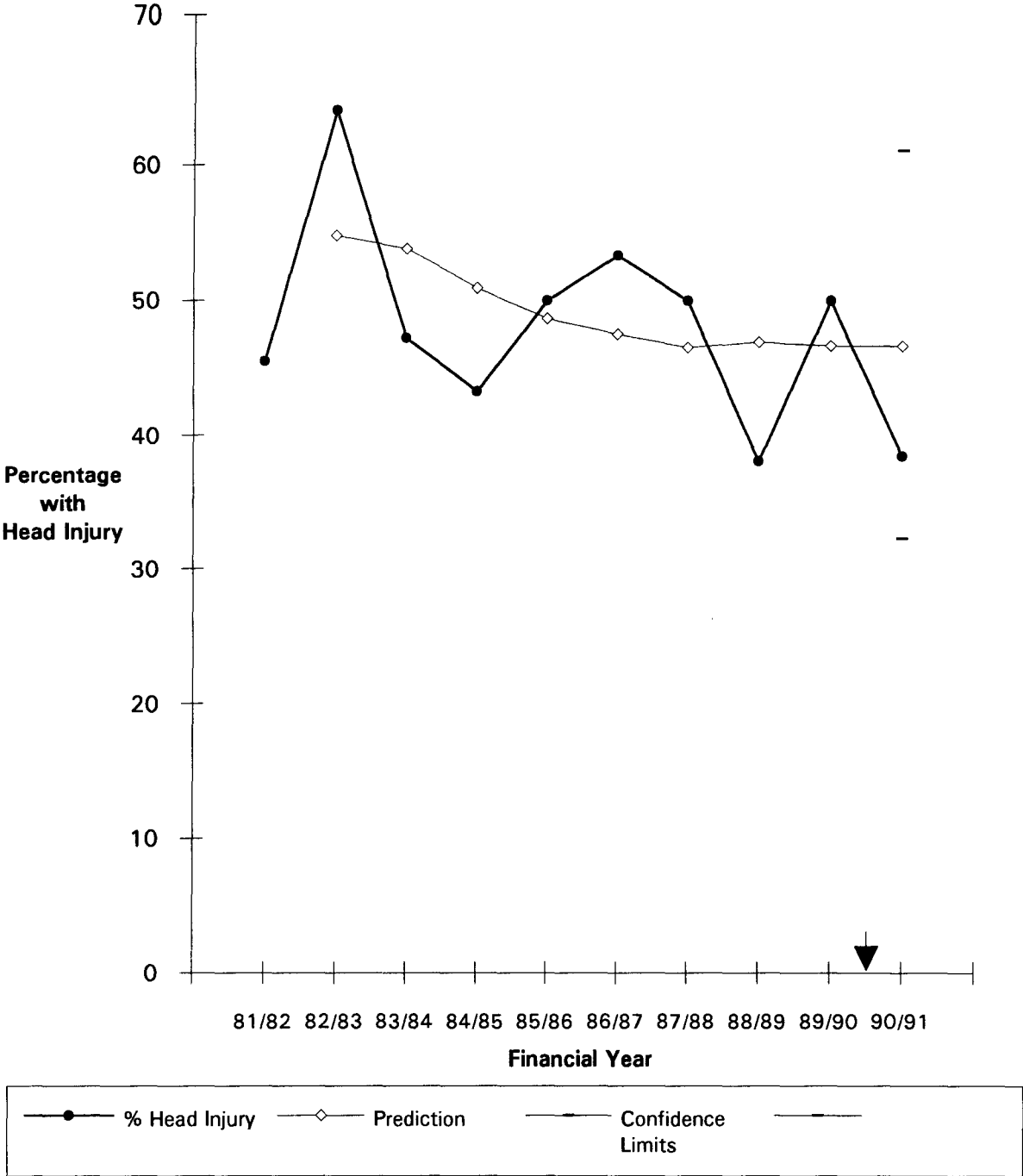


FIGURE B9

**Number of Severe Bicyclist Casualties
Aged 11 to 17 Registered with TAC
Country Victoria : July 1981 - June 1991**

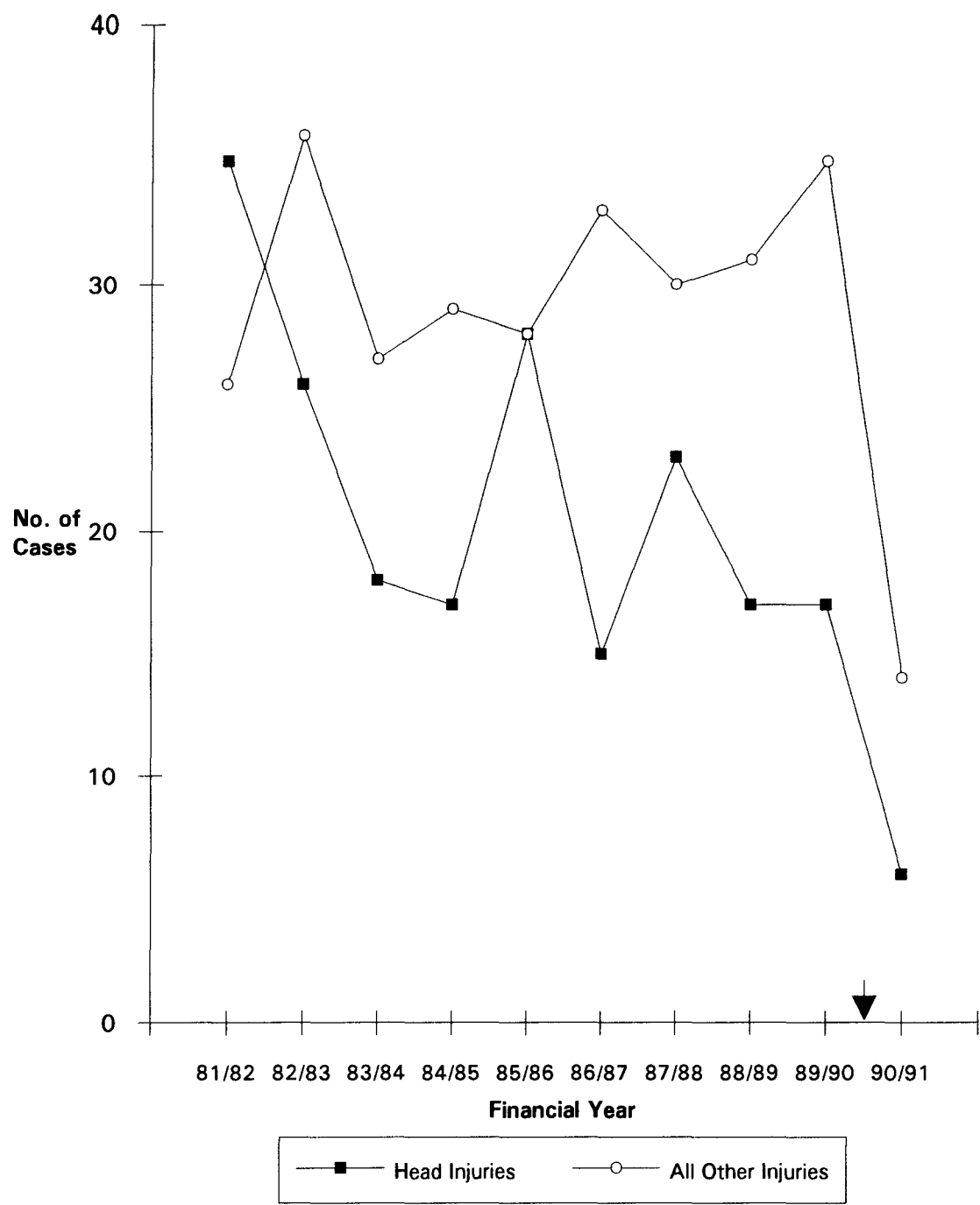


FIGURE B10

Percentage of Severe Bicyclist Casualties
Aged 11 to 17 Registered with TAC
Country Victoria : July 1981 - June 1991

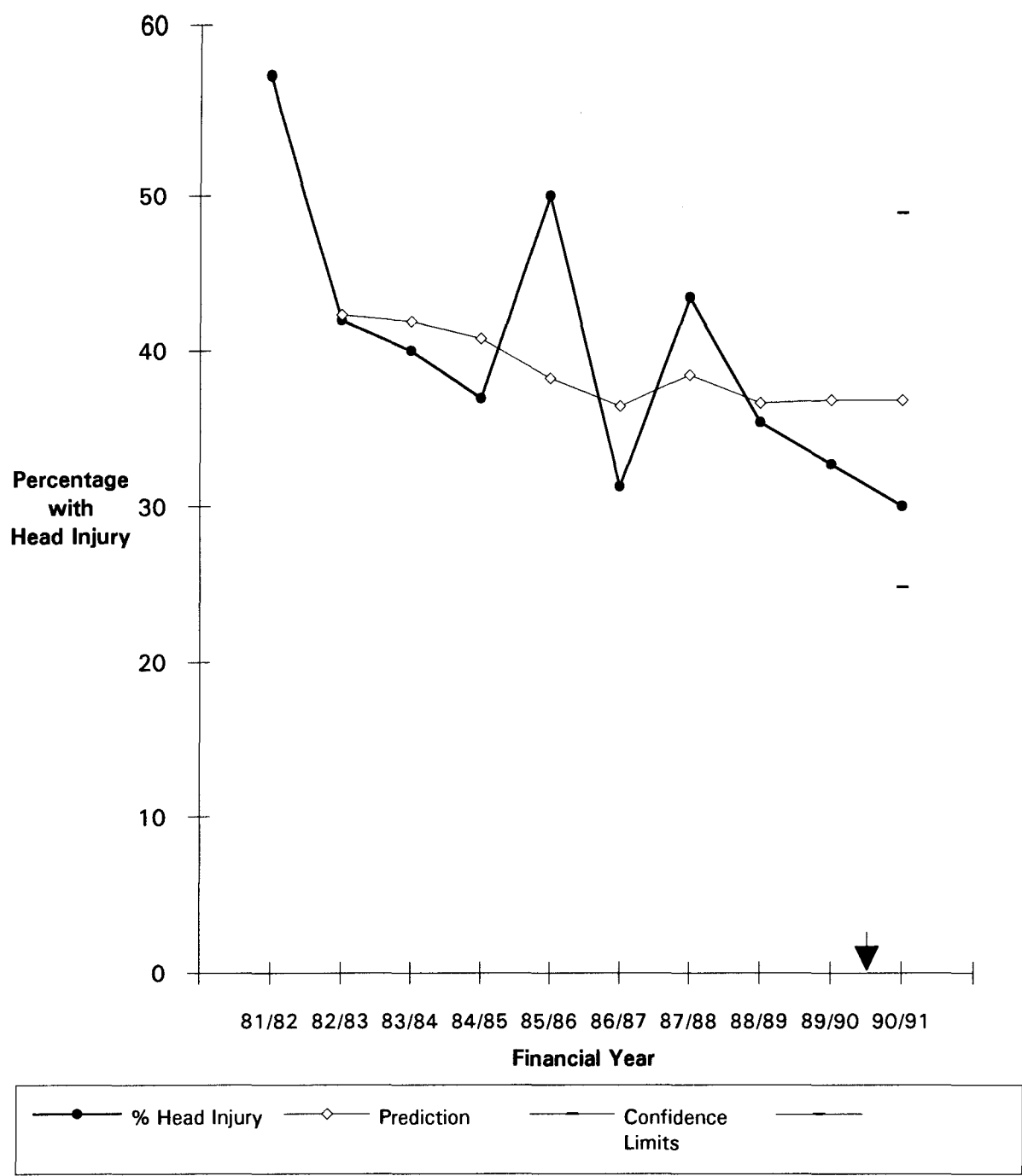


FIGURE B11

**Number of Severe Bicyclist Casualties
Aged 18+ Registered with TAC
Country Victoria: July 1981 - June 1991**

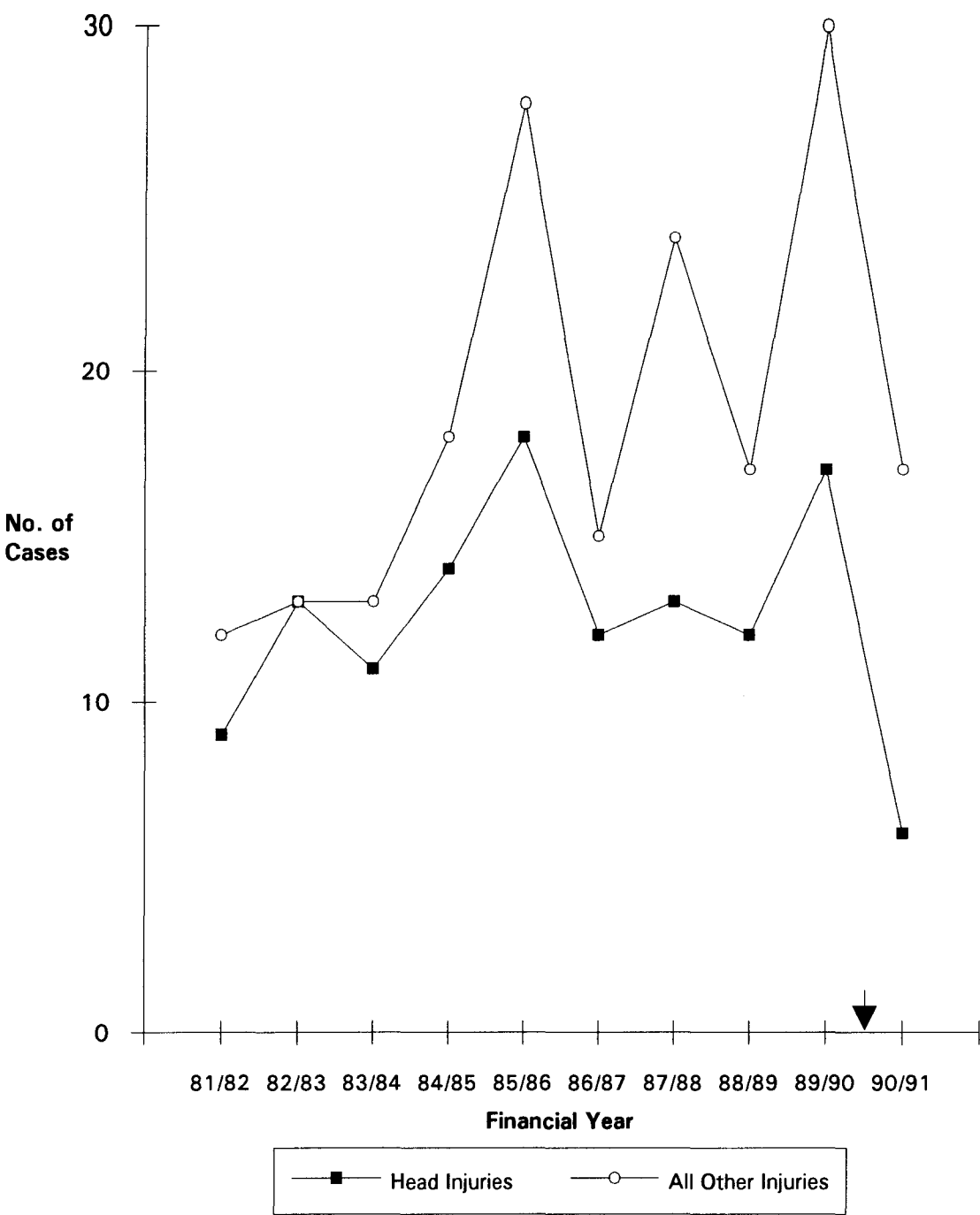
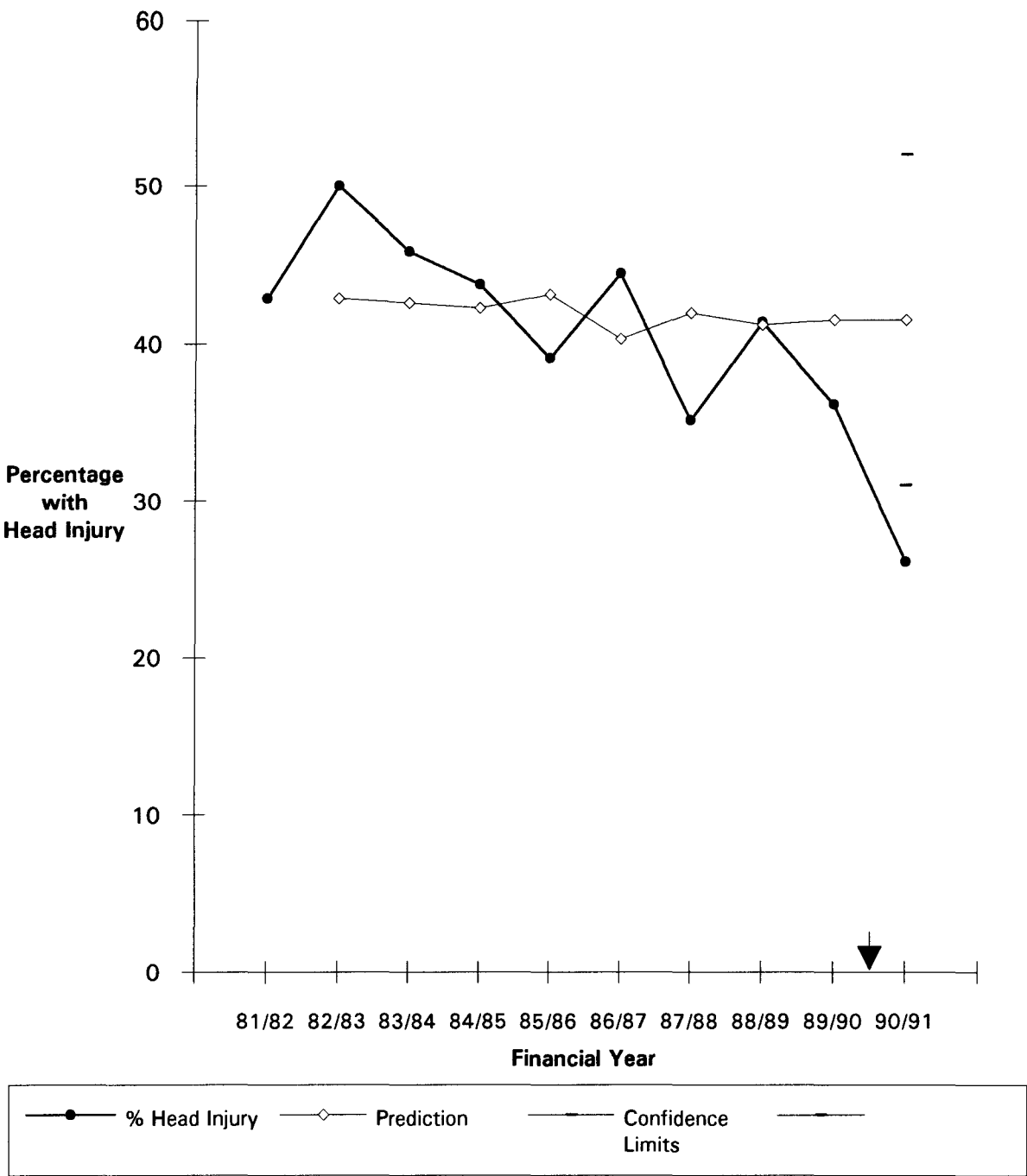


FIGURE B12

Percentage of Severe Bicyclist Casualties
Aged 18+ Registered with TAC
Country Victoria : July 1981 - June 1991



APPENDIX C

LINEAR AND NEGATIVE EXPONENTIAL RELATIONSHIPS BETWEEN PERCENTAGE HEAD INJURED AND HELMET WEARING RATES ALL VICTORIA BY AGE GROUP OF CYCLIST

FIGURE C1

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties aged 5 to 10 :
Victoria: July 1981 - June 1991

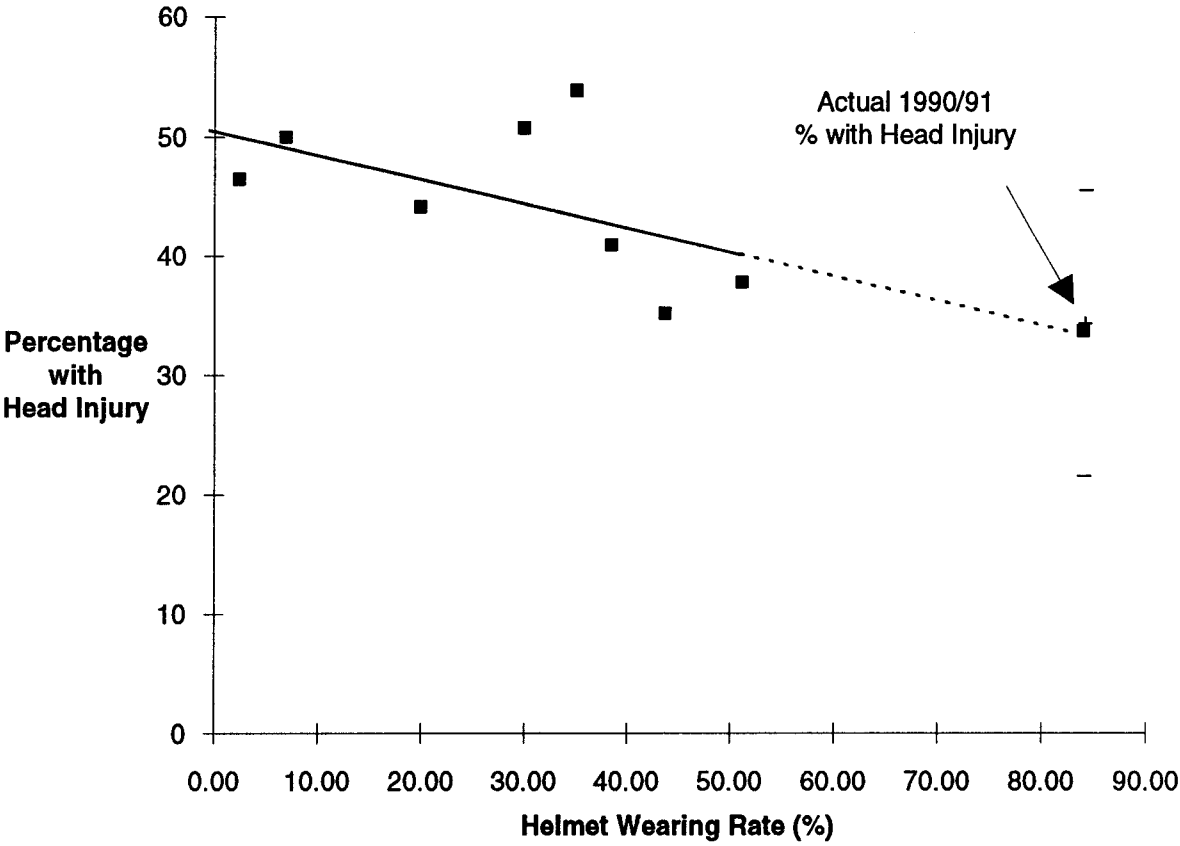


FIGURE C2

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties aged 11 to 17 :
Victoria: July 1981 - June 1991

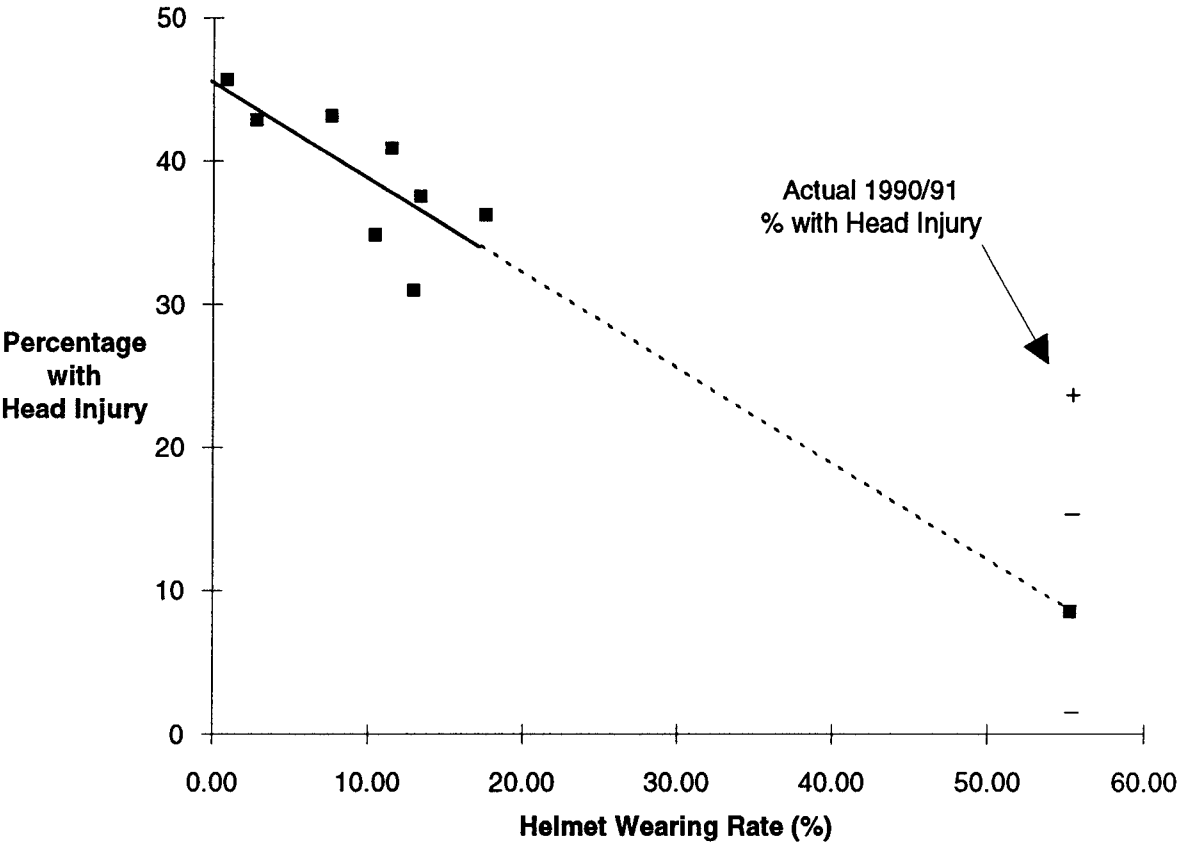


FIGURE C3

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties aged 18+ :
Victoria: July 1981 - June 1991

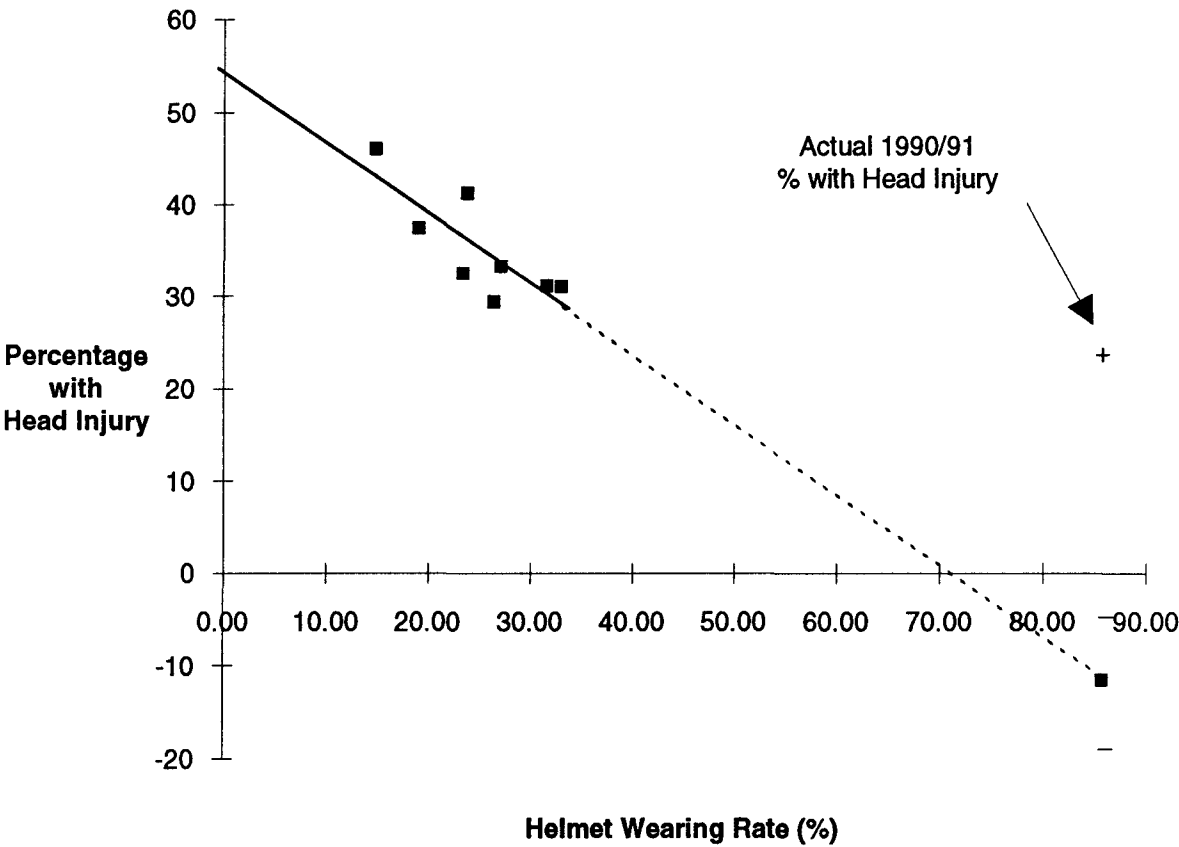


FIGURE C4

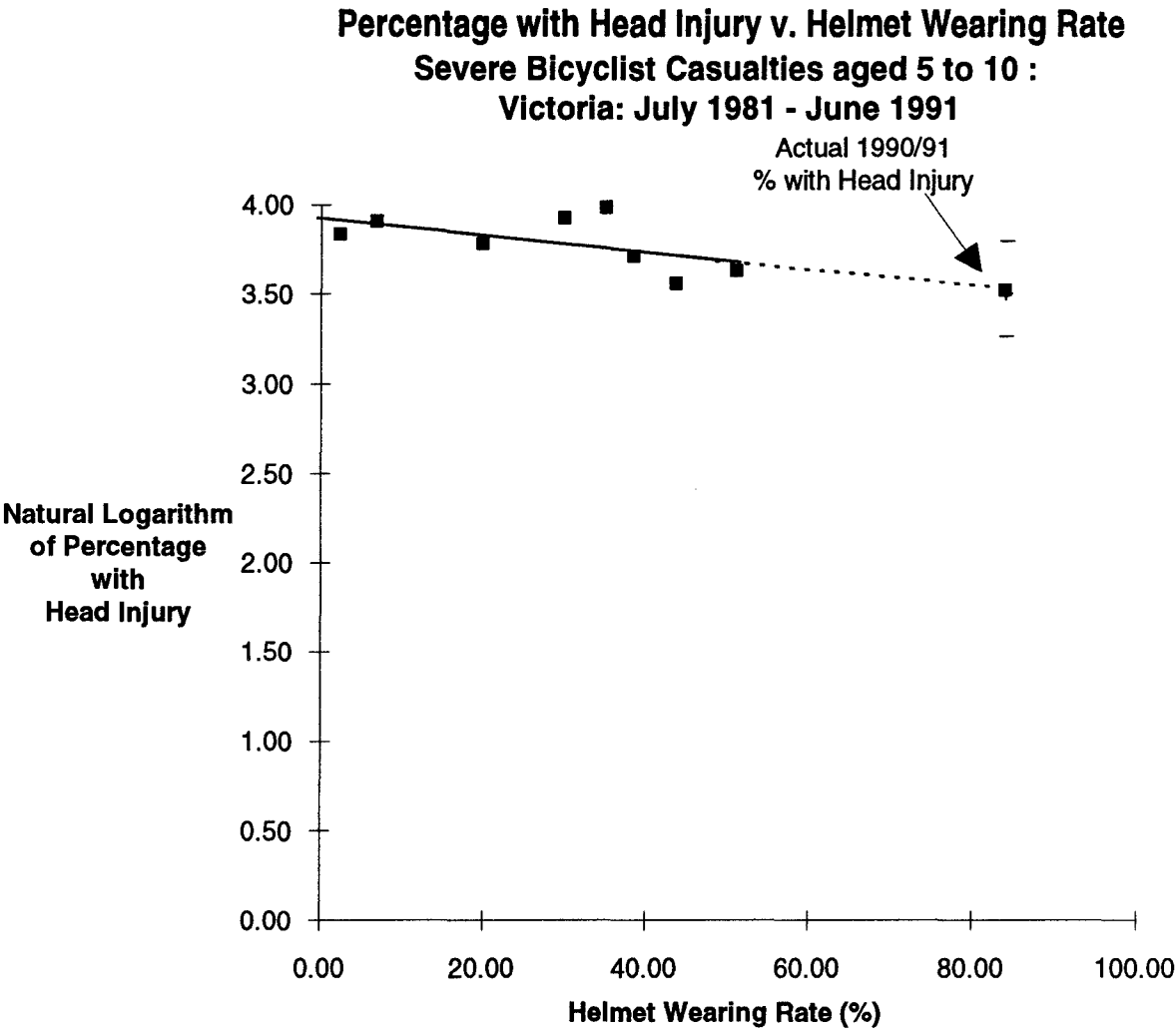


FIGURE C5

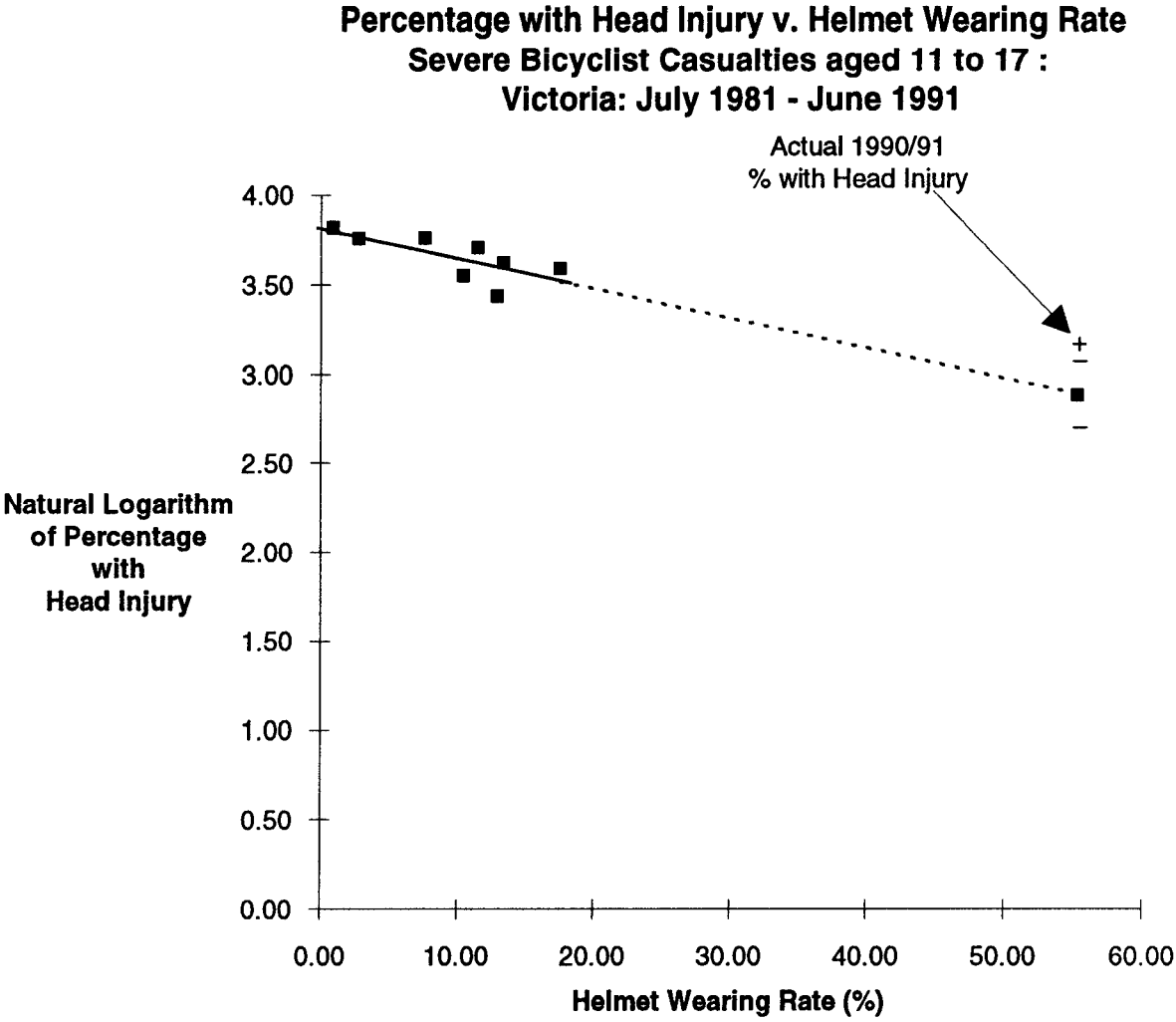


FIGURE C6

Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties aged 18+ :
Victoria: July 1981 - June 1991

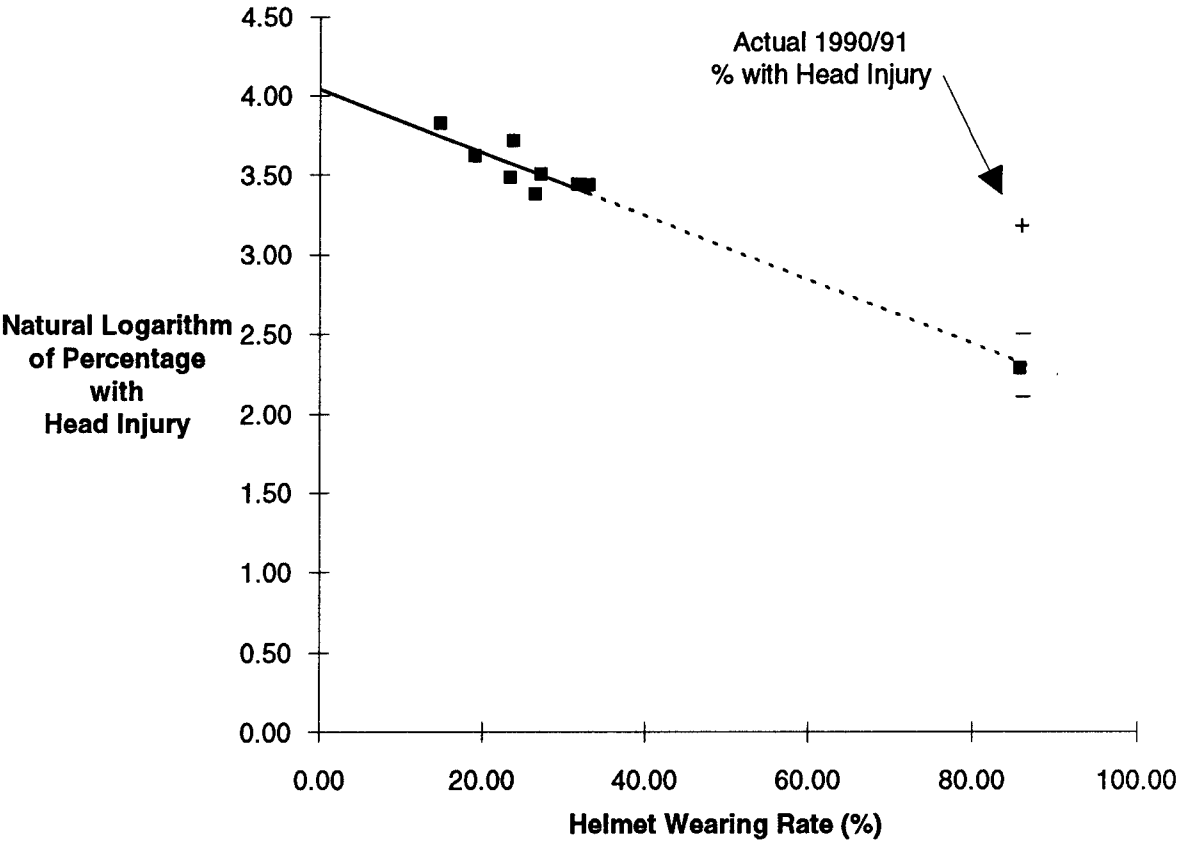


FIGURE C6

**Percentage with Head Injury v. Helmet Wearing Rate
Severe Bicyclist Casualties aged 18+ :
Victoria: July 1981 - June 1991**

