Measuring Pocket Area

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1. Introduction

In the NFL, a lot can change in a second. With nine minutes left in the fourth quarter, John Wolford (#13) and the LA Rams faced a 3rd and 8th. For two and half seconds, the Rams offensive line keeps the New York Giants' four pass rushers at bay, providing a pocket area of approximately 23 square yards for Wolford to work within. Over the next second, Giants DT Dexter Lawrence (#97) beats his blocker Oday Aboushi (#63) to create pressure up the middle. Wolford, who has already dropped back almost nine yards from the line of scrimmage, delivers his throw at the last second possible, only for it to be intercepted by Xavier McKinney (not shown in Figure 1).

Even though Wolford had open pocket area to his left and right, the proximity of Lawrence substantially limited his options to extend the play and the usable pocket area dropped tenfold to just 2.3 square yards.

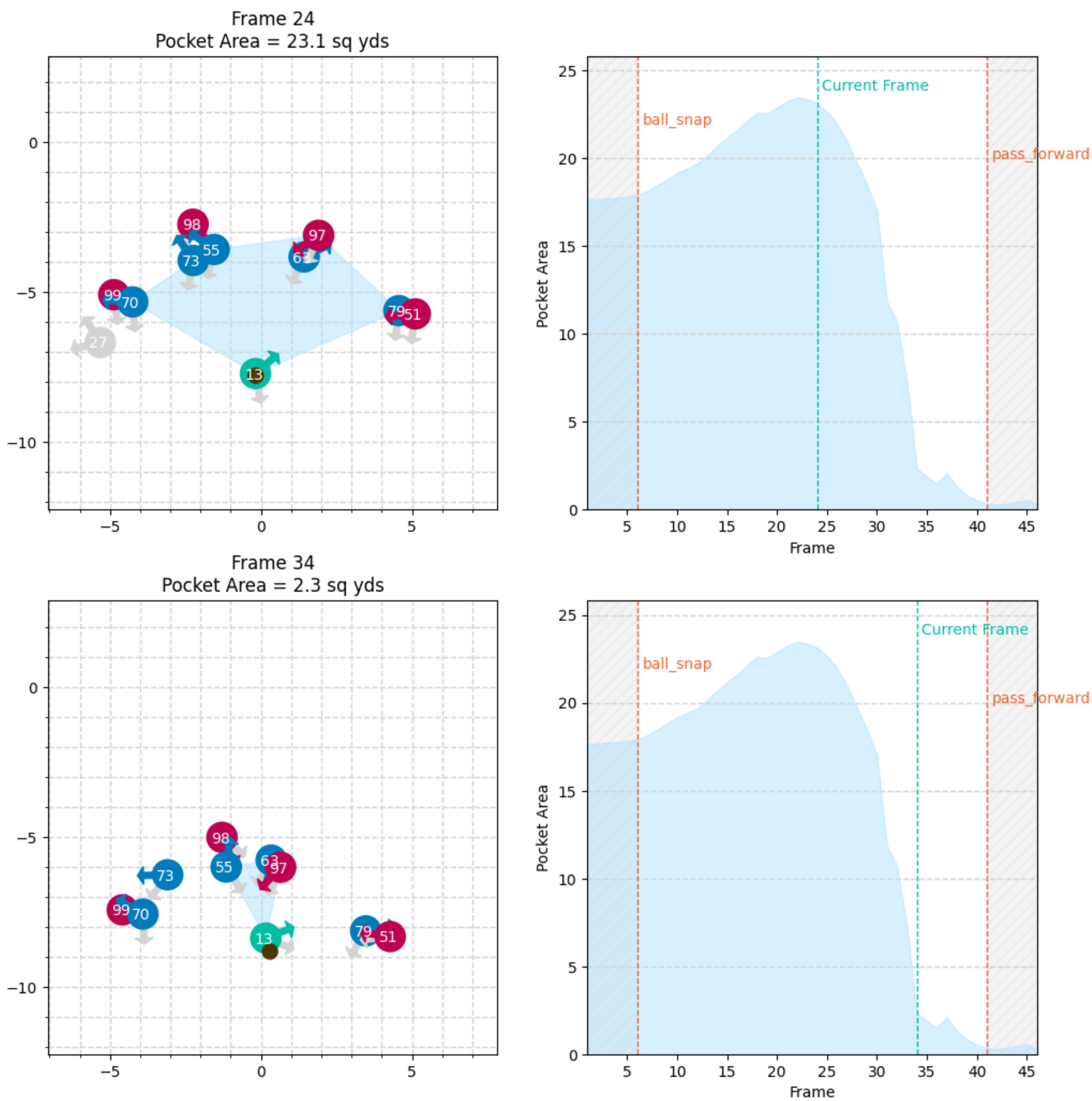


Figure 1. Pocket area on field and over time using the adaptive convex hull algorithm. J.Wolford pass deep middle intended for C.Kupp INTERCEPTED by X.McKinney at NYG 47. X.McKinney to NYG 47 for no gain (R.Woods).

Linemen do not always get the credit they deserve. On this play, the defensive pressure from Lawrence helped force the interception. Four of the offensive linemen held their blocks, but with a 3-on-2 on the left, Aboushi had no help on the inside right. Should the quarterback have shifted within the pocket? Should the team have chosen a play with routes that develop quicker?

To enable analytics to assist with these kinds of questions, we need a metric that captures what the line achieves during the play, separate from the ultimate result of the play. We propose an algorithm to measure the area of the pocket, with two goals:

1. Quantify how much space the line gives the passer.
2. Identify lines who are overrated or underrated by sack rate and time in pocket.

This metric can be used on any play, but is best suited for traditional drop-back passing plays. We can use this metric to measure the performance of both offensive and defensive lines.

2. Methodology

The full code for our analysis is available on our GitHub repository. We ran the data pipeline on all 8 weeks of data in this Kaggle notebook.

We describe the two main pocket area algorithms we developed. Both can be computed on any frame. To assess the pocket area for an entire play, we take the median of area across all frames from when the pocket begins to an event that causes the pocket to end, like a forward pass, scramble, or fumble. We chose the median to reduce skew.

2.1. Voronoi Rushers Graph

This algorithm relies on Voronoi graphs. This algorithm considers points representing players in the pocket and divides the field into separate regions where each represents the area that is closest to its corresponding point. We use the region that corresponds to the passer as the pocket. The approach is as follows:

1. Filter out all of the players that are not either a passer, rusher, or blocker.
2. Plot the passer, rushers, and blockers on a graph as coordinate points.
3. Plot 4 additional “ghost” points on the graph with one 2 yards behind the passer, one in front of the passer on the line of scrimmage, one 10 yards to the left of the passer, and one 10 yards to the right of the passer. These “ghosts” are used to artificially limit the size of the pocket.
4. Use all of the points on the graph to create a Voronoi diagram.
5. Label the region that corresponds to the passer as the pocket.

A strength of the Voronoi diagram is that it calculates all the space that is closest to a point, creating an accurate representation of all the space that the passer could reach freely. We can easily see how each player affects the pocket since each edge is the perpendicular bisector of the passer and blocker/rusher.

The downside is that blockers only get credit for half of the area they are defending. If every rusher is engaged with a blocker, the pocket’s vertices should arguably be the blockers. However, because the pocket is defined as only the space that is closest to the passer, the vertices will instead be approximately halfway between the blockers and passer. As the distance between the passer and blockers increases, the area that the blockers are not getting credit for also increases. This shows that the bias in the algorithm becomes more exaggerated as the pocket grows.

Figure 2 shows a reasonable pocket area at the start of the play, but as the passer scrambles away from the line, the pocket inflates, with only some of the increase captured by the Voronoi graph.

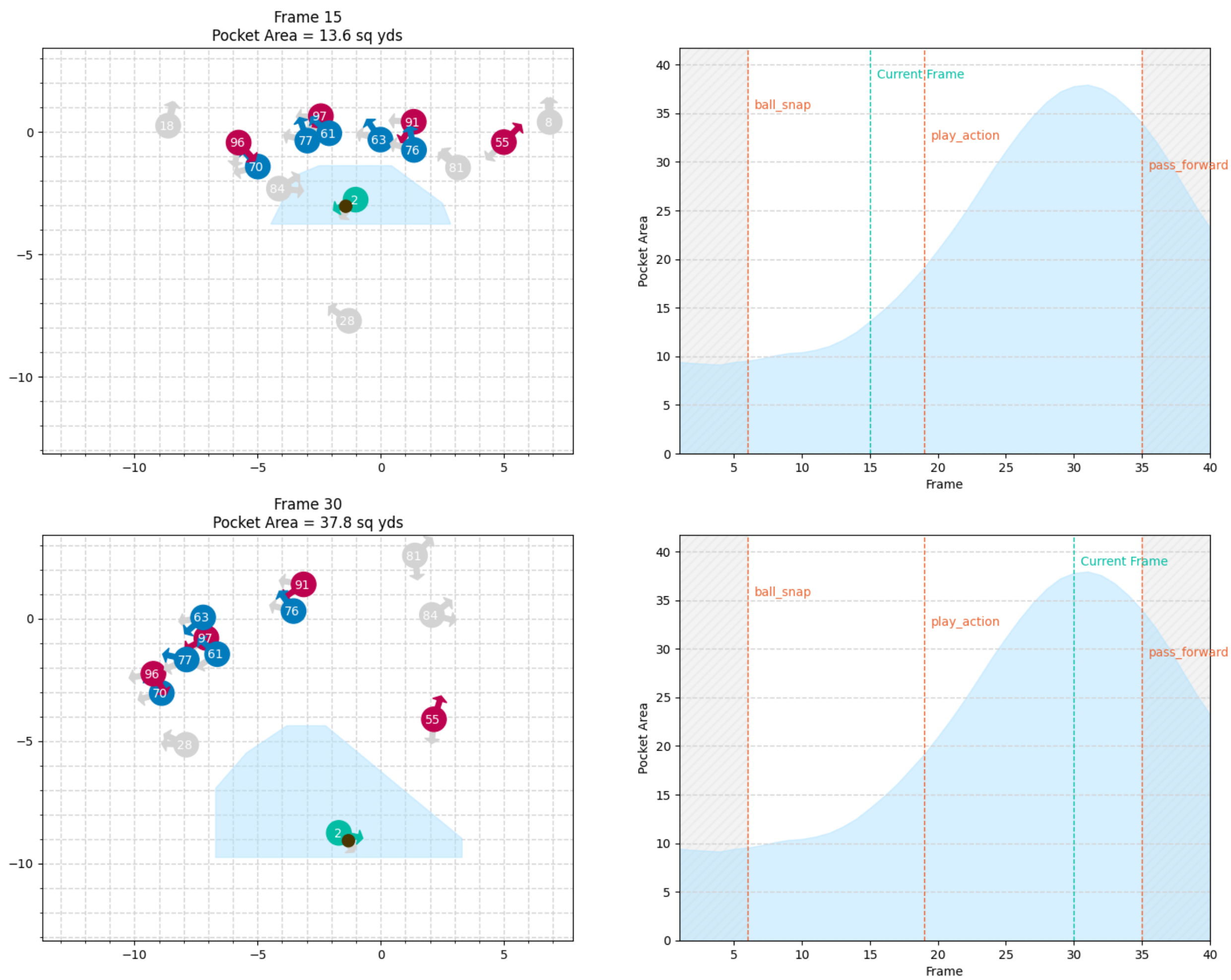
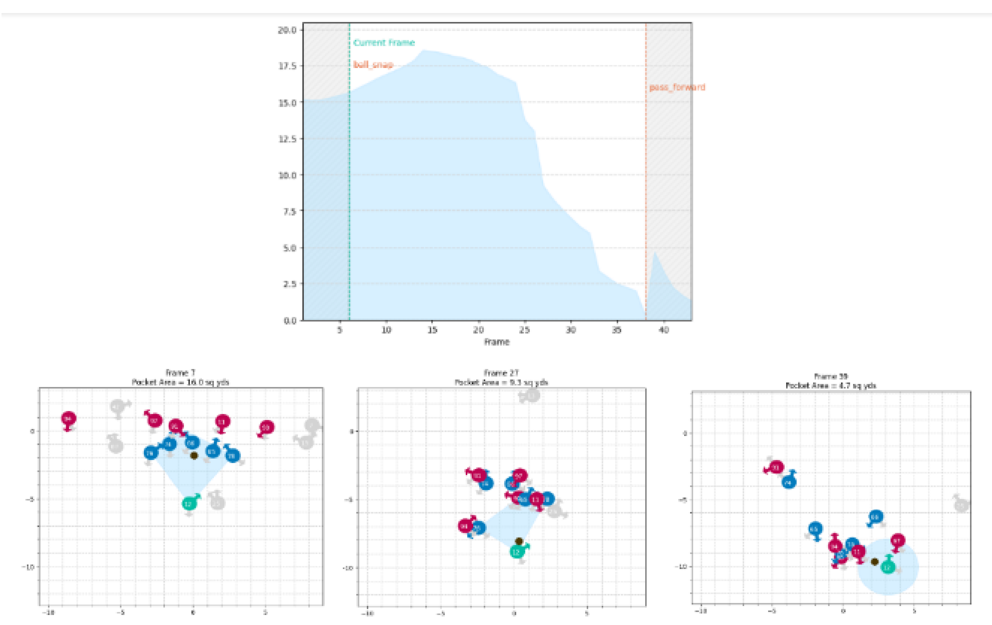


Figure 2. Voronoi rushers graph example, Falcons vs Eagles, M. Ryan completion.

2.2. Adaptive Convex Hull

The Adaptive Convex Hull-Radius algorithm is an interesting variance from the other pocket algorithm. This time, the pocket is outlined based on where lineman feet are positioned in each frame. There is an emphasis this time on looking at blockers and rushers who actually have a chance in making a difference in the play. Here is a breakdown of the algorithm:

1. Finding the nearest rusher to the quarterback.
    - If there are no rushers, the pocket is undefined
2. Make a list including the passer, nearest rusher, and any offensive lineman that is at least nearly as close to the passer as the nearest rusher
    - For example, if the nearest rusher is 5 yards away from the passer, we are including all offensive lineman at 5.5 yards away
3. If this list includes only the nearest rusher and a quarterback go to step 3a, otherwise go to step 3b
    - 3a. Build a circle around the quarterback with the radius as the distance to the rusher. The pocket will be ⅓ the area of the circle, making the passer's pocket 60 degrees to both his left and right.
    - 3b. Build a Convex Hull using the position of players in the list. A convex hull is the smallest polygon that encloses all the points presented. The vertices of the pocket are located where the lineman stand.



Frame 7: Ball is snapped, the nearest rusher right now is the left DT and the convex hull is constructed

Frame 27: Demarcus Lawrence (90) makes a move to cut across Alex Cappa (65) face, shores up the pocket significantly

Frame 39: Osa Odighizuwa (97) is in Tom Brady's (12) face! Right now, the rest of the pocket doesn't matter. Goal is to get rid of the ball.

Figure 3. Adaptive convex hull example, Cowboys vs Buccaneers, T.Brady incompletion.

The benefits of this algorithm is that it is constantly based on where lineman are positioned. That way, when rushers make moves that shortens the pocket area, we will know immediately! A drawback to this method is that a mobile quarterback can make a pocket look really good when they evade rushers who leak through the o-line.

3. Results

Ultimately, we chose the adaptive convex hull algorithm, then ranked all 32 NFL teams and their offensive lines from most to least median pocket area protected in figure 4. Data is limited to traditional drop-back plays for games through week 8.

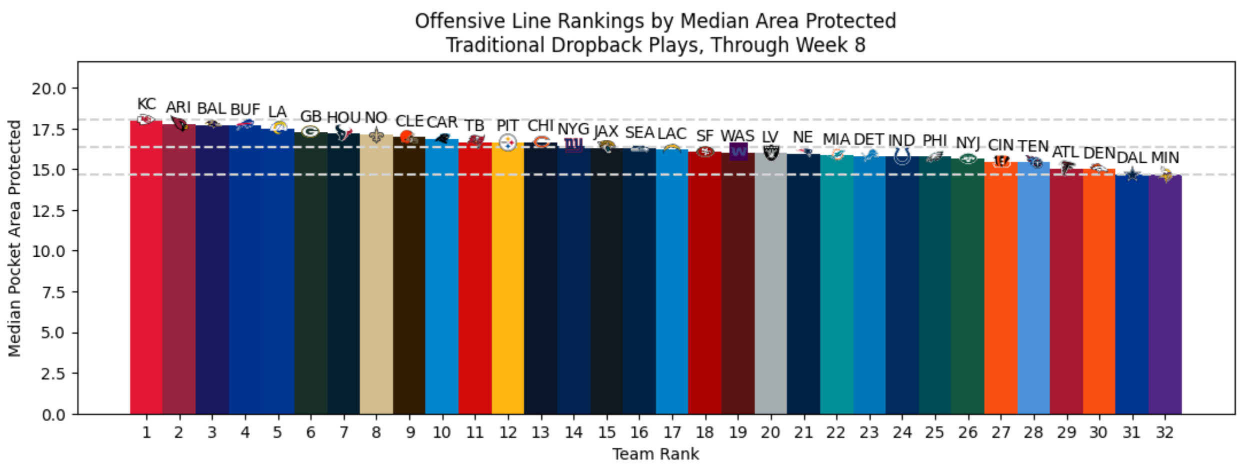


Figure 4. Offensive line rankings from most to least median pocket area protected. Dashed lines from top to bottom indicate the maximum, average, and minimum median area per team across the league.

In aggregate, the difference in area protected between the top team and the lowest team is approximately three square yards. However, the outcomes that teams achieve with those pocket areas vary.

When comparing pocket area protected to time in the pocket, we expect that offensive lines that generate more pocket area will allow their passer more time in the pocket. Figure 5 generally matches this trend.

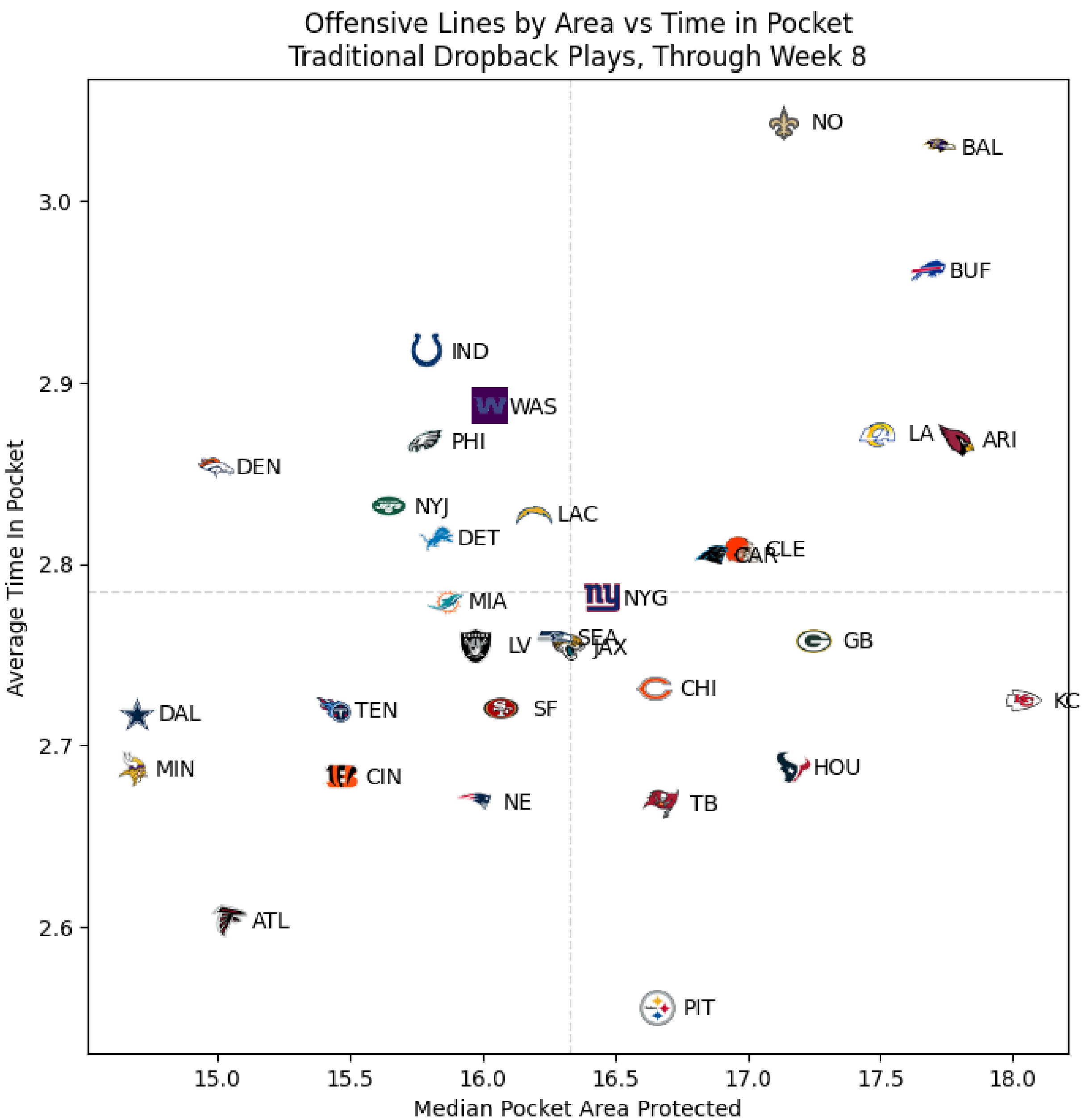


Figure 5. Offensive lines by median pocket area protected compared to average time in the pocket. Dashed lines indicate the league average for each metric.

Teams that deviate from this expected relationship could fall into one of two broad groups:

- Teams like Kansas City and Green Bay protect above-average pocket area around their passer, but spend below-average time in the pocket. These teams may be taking advantage of quick passing plays or designed roll-out plays to achieve this. Since their offensive line protection affords more pocket area, they might look to introduce longer-developing routes or progress to later reads.
- Teams like Denver and Indianapolis protect below-average pocket area, but spend above-average time in the pocket. These teams may be trying to execute plays from pockets that are too small, putting their passer at risk. They may look to shore up their protection or use faster-developing plays.

When comparing pocket area protected to sack rate, we expect that offensive lines that generate more pocket area will allow fewer sacks. Figure 6 somewhat matches this trend.

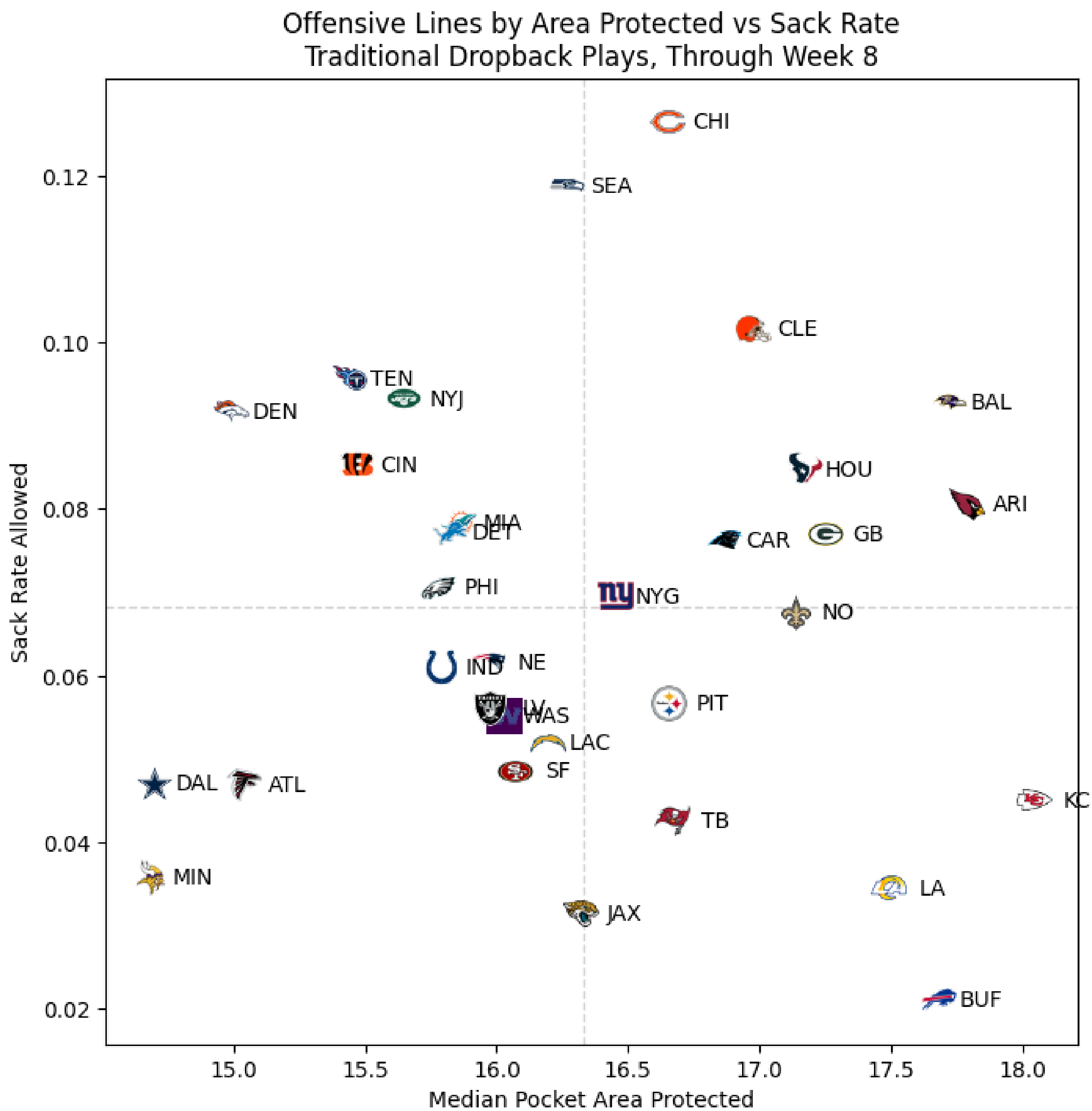


Figure 6. Offensive lines by median pocket area protected compared to sack rate allowed. Dashed lines indicate the league average for each metric.

Teams that deviate from this expected relationship could fall into one of two broad groups:

- Teams like Cleveland and Baltimore protect above-average pocket area, but allow above-average sack rates. Their passers might drift in the pocket, exaggerating the pocket area but putting them at risk or their pocket area might have a high median, but quickly collapse near the end of the play.

- Teams like Minnesota and Dallas protect below-average pocket area, but have below-average sack rates. These teams may be finding success with tighter formations and faster-developing plays. Alternatively, they could be putting their quarterback under undue pressure and setting themselves up for risk later in the season.

We also rank defensive lines by measuring pocket area allowed to opposing offenses. Figure 7 shows the 32 NFL teams ranked from least to most pocket area allowed. Data is limited to traditional drop-back plays for games through week 8.

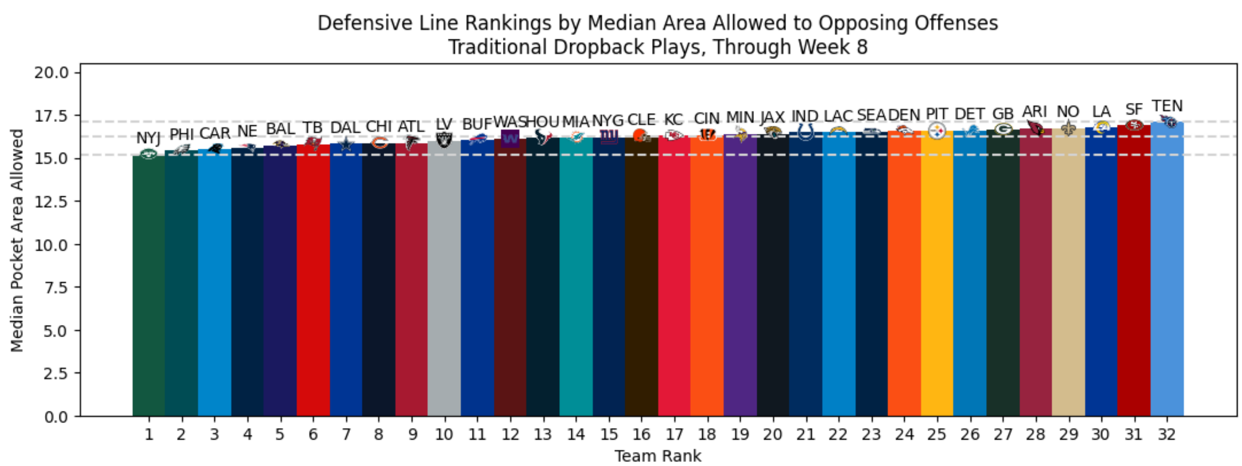


Figure 7. Defensive line rankings from least to most median pocket area allowed to opponents. Dashed lines from top to bottom indicate the maximum, average, and minimum opponent median area per team across the league.

To understand which teams are winning the battles in the trenches, we can compare the pocket area protected by a team's offensive line for their own passer against the pocket area allowed to opposing teams by that team's defensive line. This leads to four quadrants of teams in figure 8.

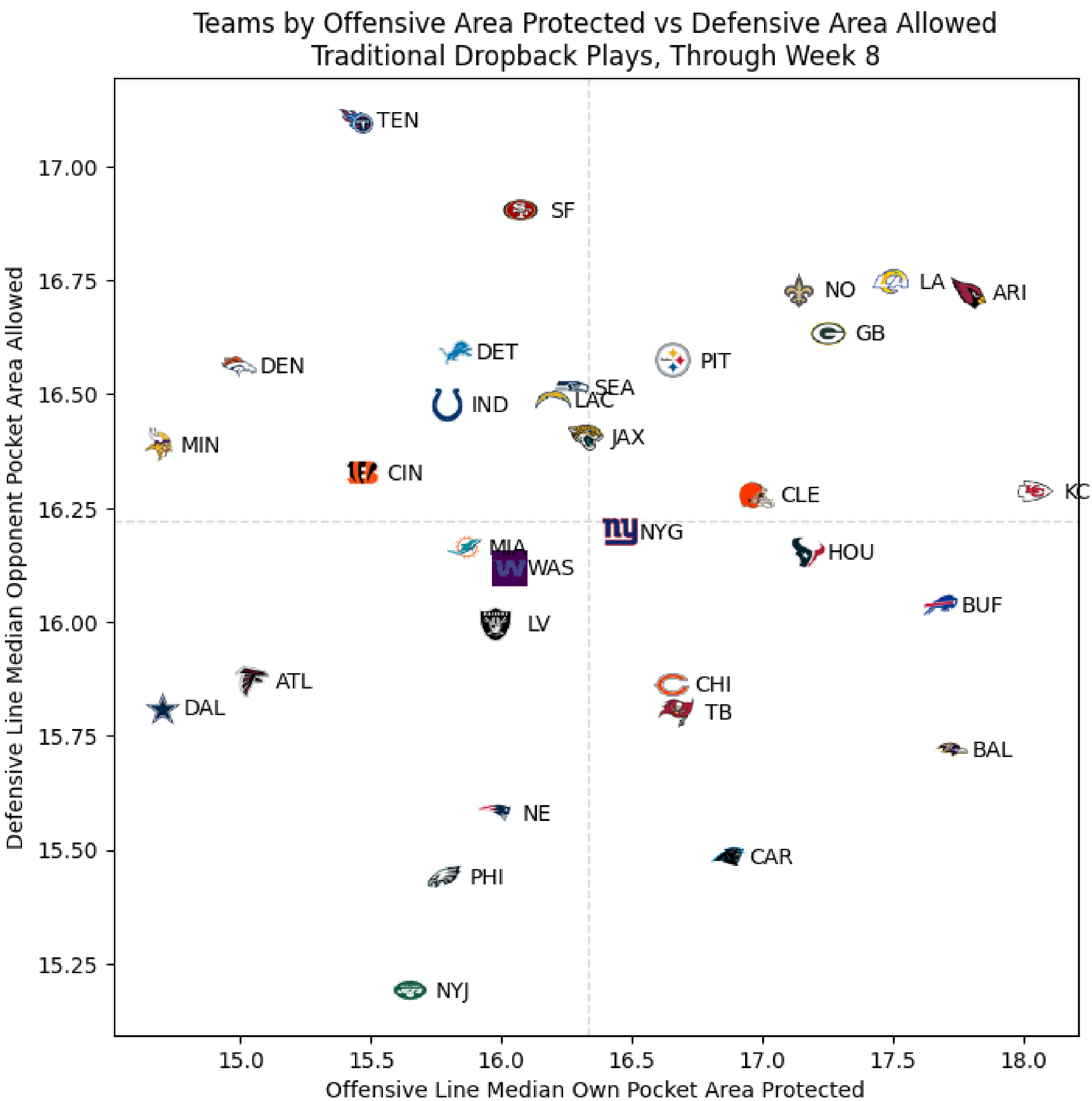


Figure 8. Teams by median own pocket area protected on offense compared to median opponent pocket area allowed on defense. Dashed lines indicate the league average for each metric.

- Top Left Quadrant: Teams like Tennessee and Denver protect below-average pocket area for their own passer and allow above-average pocket area for their opponents.
- Top Right Quadrant: Teams like Los Angeles and Arizona protect above-average pocket area for their own passer, but allow above-average pocket area for their opponents.
- Bottom Left Quadrant: Teams like Dallas and the New York Jets protect below-average pocket area for their own passer, but allow below-average pocket area for their opponents.

- Bottom Right Quadrant: Teams like Baltimore and Carolina protect above-average pocket area for their own passer, and allow below-average pocket area for their opponents.

When comparing pocket area allowed on defense to sack rate of the opposing passer, we expect that defensive lines that allow less pocket area will generate more sacks. Figure 9 somewhat matches this trend.

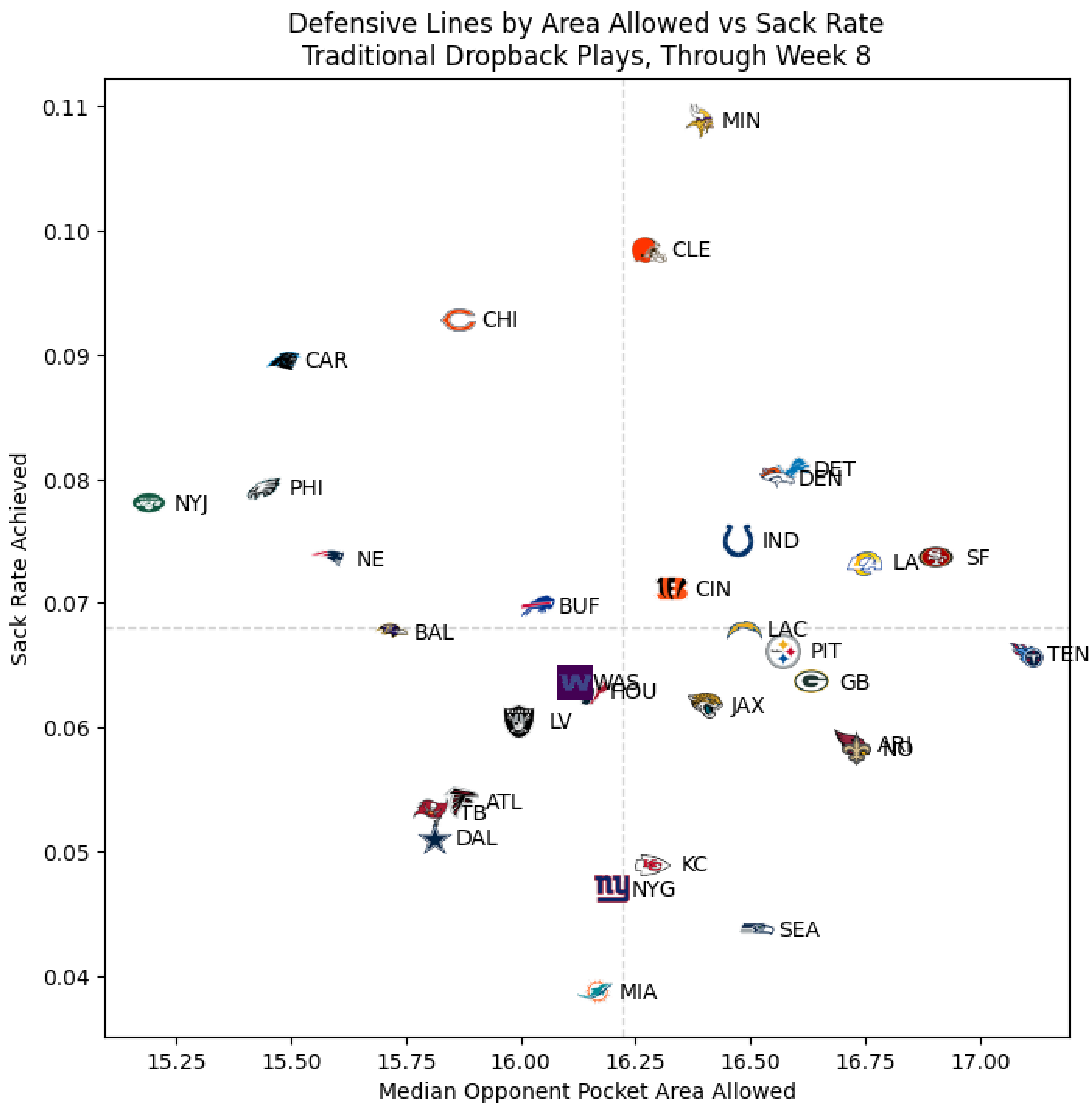


Figure 9. Offensive lines by median opponent pocket area allowed compared to sack rate achieved. Dashed lines indicate the league average for each metric.

Teams that deviate from this expected relationship could fall into one of two broad groups:

- Teams like Minnesotra and Detroit allow above-average pocket area to opponents, but achieve above-average sack rates. They may have plays that enable them to quickly collapse the pocket or take advantage of passer tendencies or pass coverage to sack the quarterback. Or they may be over-performing and could struggle to keep up their sack rate as opposing offenses exploit their tendencies and matchups.
- Teams like Dallas and Tampa Bay allow below-average pocket area to opponents but achieve below-average sack rates. They may generate pressure with fewer rushers or face mobile quarterbacks. They may be under-performing and could see better results if they can consistently limit opposing pocket areas.